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Essentials of Orthopaedics and Applied Physiotherapy

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ESSENTIALS OF ORTHOPAEDICS AND APPLIED PHYSIOTHERAPY

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PHYSIOTHERAPY APPROACH TO ORTHOPAEDICS

The advancements in the methods of the evaluation technology of investigations and surgical procedures have revolutionised the orthopaedic management of a patient. Physiotherapy, with its unique non-pharmacological, exercise-oriented natural approach has assumed the role of a non-separable entity from the body of Orthopaedic Sciences. Today, orthopaedic physiotherapy stands out as a distinct and independent speciality. To quote one of the most reputed orthopaedic surgeons of India, Prof. P. Chandra, emeritus Professor of Orthopaedics, All India Institute of Medical Sciences, " Orthopaedic surgeon should never pick up a knife unless he has a competent physiotherapist."

This situation also calls for an excellence in this speciality to live up to the responsibilities and the status of a specialist.

The factors like highly sedentary mechanical life-style, and ever increasing incidence of trauma due to modernisation, industrialisation and the increased number of automobiles are the challenges faced by the orthopaedicians and the physiotherapists. The science of physiotherapy has tremendous potential to face these challenges because of its preventive, therapeutic as well as restorative functions.

Orthopaedic physiotherapy falls into two major categories depending upon the severity of an ailment:

1. Short-term physiotherapy patients.
2. Long-term physiotherapy patients.

1. Short-term physiotherapy patients

This category includes patients with minor neuro-musculo-skeletal lesions. The lesion could be traumatic involving simple soft tissue injuries, simple fractures or it could be non-traumatic. Such patients need out-patient physiotherapy for a short duration to get well.

2. Long-term physiotherapy patients

This category refers to the more complicated diseases of the musculo-skeletal origin (e.g. rheumatoid arthritis), major fractures (hip, spine) which may result in severe physical disability and complications like paraplegia, tetraplegia or may need surgical procedures of major joints. These patients need longer sessions of extensive physiotherapy and usually are non-ambulatory.

Physiotherapy approach to short-term physiotherapy patients

The majority of the patients in this category have only a localised problem. This can be adequately managed by simple physiotherapy procedures.

The approach of physiotherapy:

1. Thorough evaluation through physical examina-

tion of the extent and the nature of the localised lesion.
2. Selection of the appropriate modality.
3. To correlate the patient's problem in relation to the daily routine and offer sound advice on the postures and movements detrimental to the problem (ergonomics).
4. Brief, simple but specific exercise.
5. Guidance for the simple home treatment programme which may include easy methods of fomentation or cryotherapy for pain relief.
6. Re-evaluation at discharge.
7. To provide guidelines to avoid recurrence.

Physiotherapy approach to long-term physiotherapy patients

Giving due consideration to the severity of the lesion, the prognosis of recovery, or the type of surgical procedure the physiotherapy approach in these cases falls into two categories.

1. Extensive physiotherapy for a short time. This group includes patients with good prognosis of recovery following major surgery or those with partial lesions.
2. Second category includes those who suffer permanent damage and the chances of recovery are feeble.

Both these categories need vigorous physiotherapy sessions. However, in the first category normal to near normal function is expected. The second group needs a different approach where the compensatory mechanisms, aids, etc. are usually needed to achieve the restoration of function.

Both groups need evaluation-oriented approach:

(a) Critical and thorough objective evaluation is needed to assess the ability as well as the disability.
(b) The treatment programme is planned on the basis of physical examination, prognosis of recovery, patient's age, occupation and potentials. Setting the goal and the period for the maximum achievement of physical independence.
(c) Periodical reassessment of the efficacy of the therapeutic regime, making alterations whenever necessary.
(d) Educating on the home and work management programmes.
(e) Thorough assessment at discharge.
(f) On the spot assessment of the management at home or at the place of work.
(g) Re-evaluation, further advice, regular follow-up.

Role of Physiotherapy in the Total Rehabilitation

Physiotherapy contributes significantly not only in the achievement of physical independence but indirectly acts as a main augmenting force to improve vocational potentials and psychological status leading to the attainment of social security.

The vocational placement of a patient is directly dependent upon the degree of restoration of physical independence and the working capacity. Both are achieved with physiotherapy only. The factors like personal touch, longer association during the therapeutic sessions, feeling of betterment following exercise and the words of encouragement not only improve the motivation and morale of a patient but also greatly enhance his psychological status. Achievements on these three aspects, i.e., physical, vocational and psychological, in turn, lead to the attainment of social security (Fig. 1.1).

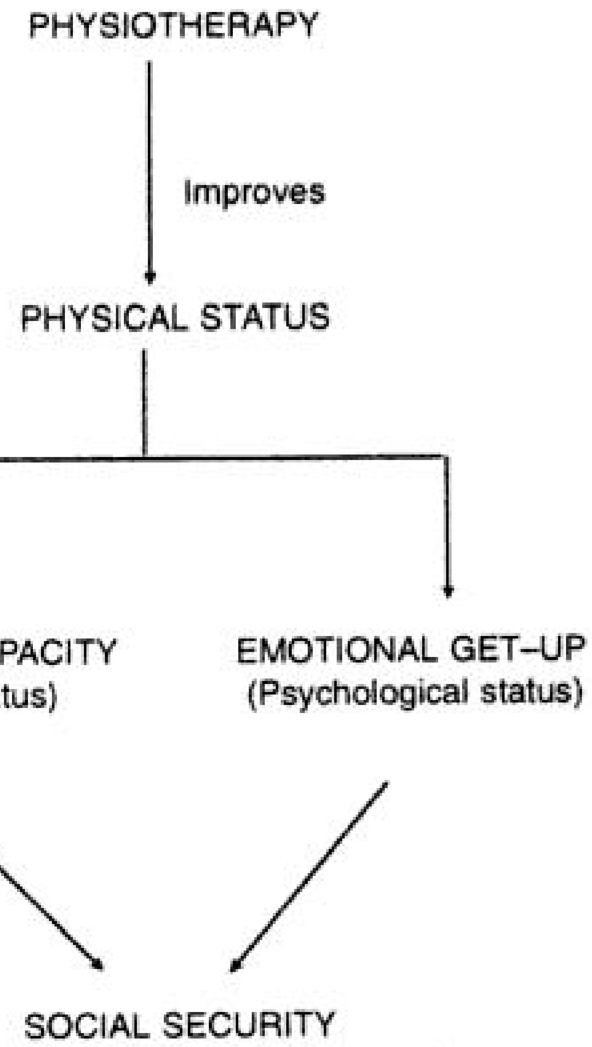

Fig. 1.1. Role of physiotherapy in the total rehabilitation of a physically handicapped patient.

Therefore, during initial evaluation and subsequent therapy the physiotherapist must always keep in mind this predominant multidisciplinary role in the concept of total rehabilitation and the responsibilities associated with it.

Planning of Specific Therapeutic Programme

For the planning of the therapeutic programme there are certain pre-requisites.

Knowledge

One must be well equipped with the basic knowledge not only of physiotherapy but also of the other branches of medical sciences related to physiotherapy. It is essential to understand the underlying pathology of the ailment and its influences on the body systems.

Evaluation

A thorough clinical evaluation through physical examination is of primary importance. In fact, the approach to a patient should be evaluation-oriented. It should start while the patient is entering the room, keen observation should be made of the various attitudes or postural deviations at the first sight. This is followed by a thorough examination of the neuro-musculo-skeletal system. It is important to examine functional abilities as well as the disabilities, if any.

The process of evaluation should include systematic documentation of the objective data. Many of our routine tests are accompanied by numerous psycho-social influences. Objective measures are developed from the subjective data so that ordinal scales are added to our methods of evaluation. One such example of progressively rationalising the codes in to the ordinal scale from the subjective data as reported by Gabell and Simmons, to evaluate the degree of static balance, is illustrated in Table 1.1.

Self-evaluation. Subjective self-evaluation is done by a patient, initially as well as at regular intervals, and recorded.

Interpretation

The correct interpretation of the data from the subjective and objective examination should be skilfully correlated to the other clinical investigations. As such, adequate know-how to interpret various diagnostic tests like CT scan, MRI, X-rays, laboratory investigations is a must. This helps in diagnosis and should be interpreted with the extent of dysfunction and the overall influence of the ailment.

Table 1.1. Static balance

Static Balance	*Points*
Unsafe sitting	1
Steady standing 20 seconds with aid	2
Steady standing 20 seconds without aid but with a wide base	3
Steady standing 20 seconds without aid and with a narrow base	4
Steady standing 20 seconds without aid but with a long base	5
Steady standing 20 seconds without aid with a long base but with eyes closed	6

Narrow base	—	Distance between the feet not more than 10 cm.
Wide base	—	Feet not less than 20 cm apart.
Long base	—	Normal stride length as in walking.

Planning therapy

The mode of physical therapy, specific to the dysfunction, should be planned on the basis of the clinical evaluation of the patient and the appropriate modality available. Exercises, which form the foundation of our therapeutic programmes, need special emphasis in the formulation of the therapeutic regime.

Exercise

Inborn lethargy towards exercise, even in health, is compounded further by pain, weakness and generalised depression. Moreover, exercise needs to be done several times. Under such difficult situations, motivating and educating a patient to perform exercises with efficiency calls for certain principles to be followed during the planning. These are :

1. Explain the role and the need of exercise.
2. Demonstrate the correct pattern of exercise preferably on the sound limb, using diagrams or audiovisual aids.
3. Keep the number of exercise to the minimum.

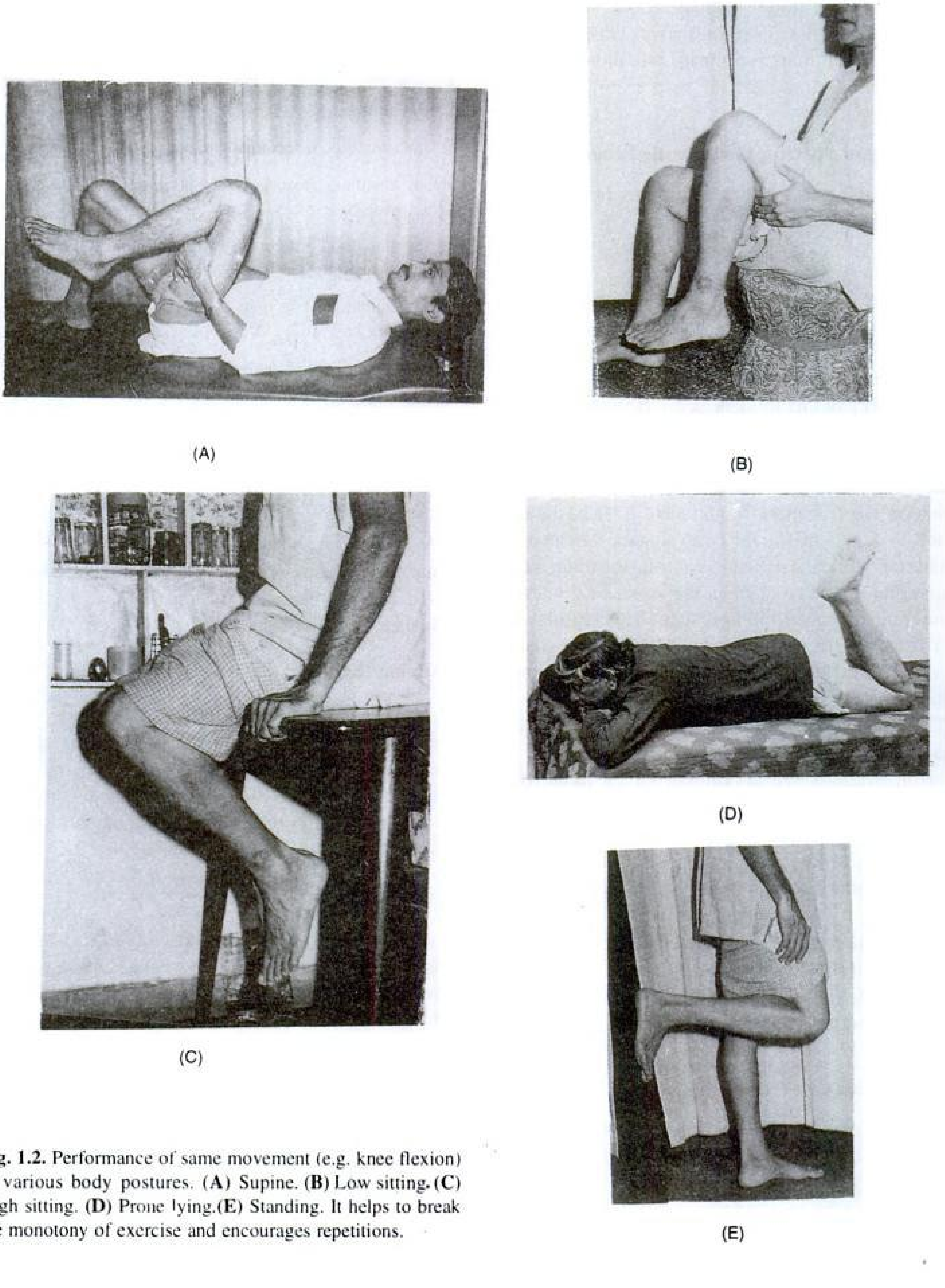

Fig. 1.2. Performance of same movement (e.g. knee flexion) in various body postures. (**A**) Supine. (**B**) Low sitting. (**C**) High sitting. (**D**) Prone lying. (**E**) Standing. It helps to break the monotony of exercise and encourages repetitions.

4. Choose the simplest possible exercise to begin with and progress gradually.
5. Plan the regime of exercise in a preferential order as per the demands of the patient's condition.
6. Teach only one exercise at each sitting beginning with a passive mode, so that the exact groove and the pattern of movement is learnt. Remember that the process of learning correct exercise needs longer time than we presume.
7. Check the specificity of exercise before proceeding to the next exercise.
8. As far as possible the exercise regime should be competitive and should include the activities of daily routine.
9. To ensure repetition at the regular interval and to break the monotony, the exercise to the same muscle group, or the same movement should be taught in each of the fundamental postures of the body, e.g., lying, sitting, standing (Fig. 1.2).
10. Strong and exerting exercise should be followed by relaxation to ensure the feeling of betterment to achieve motivation.

By this approach, even if a patient learns and is motivated to do only a few correct exercises it is much more effective.

The areas needing special consideration

To facilitate the process of adequate treatment and early rehabilitation, certain areas need an extra emphasis. They are:

1. Early referral,
2. Preoperative physiotherapy,
3. Early ambulation and
4. Preventive role.

1. Early referral

On many occasions the patients are referred late. This leads to development of various types of complications, thereby increasing the period of rehabilitation and also causes uncalled for misery to a patient. As a routine, a patient with POP immobilisation, when reports for check up the next day should be referred for physiotherapy to avoid such complications. For example, an elderly person with a Colles' fracture, if not taught adequate exercises soon after immobilisation, for his shoulder, elbow and fingers, may result in *painful shoulder-hand syndrome*.

2. Preoperative physiotherapy

Preoperative evaluation, training and education of the patient on the postoperative regime of physiotherapy is absolutely necessary for whom a major surgical procedure is planned. This is effective not only in the prevention of common postoperative complications but is invaluable in early return of function. Preoperative evaluation enables to assess preoperative status of the patient. Preoperative education is of great significance, especially in all the patients on whom either tendon transfers or reconstructive surgery is planned. This pre- operative evaluation, training and education needs considerable time and efforts but looking at its advantages, it should never be neglected.

3. Early ambulation

The modern trend is to lay over emphasis on the early ambulation. Ambulation, undoubtedly, has various advantages; however, ambulation without the achievement of its prerequisites leads to patient's discomfort and disinterest besides a bad-gait. In certain patients when ambulation is not causing much discomfort, there is a general tendency for the patients to neglect strengthening as well as ROM exercises. This results in the inadequate return of full function which is otherwise possible. Therefore, more time should be devoted to achieve the ROM, muscle power, good balance and safe and painless transfers before ambulation. To achieve the advantages of ambulation, well supported long standing sessions as well as arm and trunk exercises in the standing posture could be initiated early.

Therefore, even though the patient feels happy and excited by early ambulation, this concept of early ambulation, without adequate strength, endurance, balance and ROM, deserves to be given a serious thought.

4. Preventive role

The role of physiotherapy as a preventive discipline is well recognised. It plays a significant role in primary, secondary as well as tertiary prevention.

This area needs concentrated efforts and education of the masses on a large scale. It includes:

The common *non-traumatic musculo-skeletal disorders* like neck pain or so-called *cervical spondylosis, adhesive capsulitis* at the *gleno-humeral joint, tennis*

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Integration of CPC

The detailed physical evaluation of the orthopaedic problem should be analysed in relation to the prerequisites of conditioning.

Warm up phase

According to the CPC needs of this phase, weak or involved limb/limbs can be included in the exercise programme, as the exercises during this phase are to be performed with lower intensity.

Stimulus or conditioning phase

This phase needs continuous, intensive and vigorous exercise. Therefore, stronger components of the body should form the basis during this phase.

Cool down phase

This phase involves active slow stretching procedures of the musulo-skeletal structures of the involved limb. It can be used advantageously either alone or in association with the contralateral limb.

However, exercise planning for conditioning needs to be done on an individual basis and no rigid procedures can be enlisted.

Example of integration

For the planning of a therapeutic programme the basic needs of the patient's therapy are important.

A young man with traumatic paraplegia will need:

Strength—in the upper extremities to ease transfer activities and ambulation.

Endurance—to propel wheel chair, and ambulation with aids and appliances.

Flexibility—to facilitate self-care

(Maldover et al., 1990).

All these basic needs should be incorporated as per the requirements of the CPC as follows:

Warm up phase (5-10 min).

- Neck and trunk movements.
- Arm movements with light dumbells.
- Passive bilateral hip, knee flexion.

Stimulus or conditioning phase (5-30 min)

- Pulley weights.
- Prone push ups.
- Arm crank ergocycle.
- Ambulatory activities with wheel chair or aids.
- Rowing.
- Wheel chair push ups.

Cool down phase (5min)

- Back stretch–prone and supine.
- Leg stretch.
- Arm stretch.

Therefore, incorporation of CPC in our routine orthopaedic physiotherapy procedures beginning from mild neuro-musculo-skeletal dysfunction and gradually progressing to major physically handicapped patient assumes high priority. Every effort should be made, whenever possible, to practise such an integrated approach.

CHEST PHYSIOTHERAPY

Chest physiotherapy has a vital role to play not only in medical or surgical chest conditions but also in surgical procedures involving spine, pelvis, extremities and abdomen.

Chest physiotherapy plays a significant role in the prevention of the common postoperative complications or, in reducing the degree of severity when these complications occur. It is also instrumental in early return of a patient to his preoperative status.

Objectives of Chest Physiotherapy

1. To help remove secretions

Percussion—Cupped hands rhythmically applied to the thorax. Precautions include: Rib fractures; costo chondritis; hemoptysis; blood coagulation problems; dysrhythmias; pain; severe dyspnea; pneumothorax and increased bronchospasm.

Shaking—Following inspiration, a "bouncing" of the rib cage.

Vibration—Isometric co-contraction of the arms applied to the thorax; usually used in conjunction with shaking, percussion and postural drainage positioning.

2. To help clear the airway

Cough—Forcefully expelling air following a deep inhalation and closing of the glottis to expel mucus.

Forced expiration technique—One or two forced expirations with relatively low lung volumes; the glottis is not closed. Ideal for patients used with COPD.

Huffing—Similar to a cough with an open glottis. Patient may say Ha, Ha during expiration.

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Table 1.11. Gravity-assisted postural drainage positions

	Lobe			*Position*
Upper lobe	1	Apical bronchus	1	Sitting upright
	2	Posterior bronchus		
	(a)	Right	2 (a)	Lying on the left side horizontally, turned 45° on to the face, resting against a pillow, with another supporting the head
	(b)	Left	2 (b)	Lying on the right side, turned 45° on to the face, with three pillows arranged to lift the shoulders 30 cm (12 in.) from the horizontal
Lingula	3	Anterior bronchus	3	Lying supine with the knees flexed
	4 5	Superior bronchus Inferior bronchus	4 & 5	Lying supine with the body a quarter turned to the right maintained by a pillow under the left side from shoulder to hip. The chest is tilted downwards to an angle of 15°. Foot end of the bed raised to 35 cm (14 in).
Middle lobe	4 5	Lateral bronchus Medial bronchus	4 & 5	Lying supine with the body a quarter turned to the left maintained by a pillow under the right side from shoulder to hip. The chest is tilted downwards to an angle 15°. Foot end of the bed raised to 35 cm (14 in).
Lower lobe	6	Apical bronchus	6	Lying prone with a pillow under the abdomen
	7	Medial basal (cardiac) bronchus	7	Lying on the right side with the chest tilted downwards to an angle of 20°. Foot end of the bed raised to 45 cm (18 in).
	8	Anterior basal bronchus	8	Lying supine with the knees flexed, buttocks resting on a pillow and the chest tilted downwards to an angle of 20°. Foot end of the bed raised to 45 cm (18 in).
	9	Lateral basal bronchus	9	Lying on the opposite side with pillow under the hips, the chest tilted downwards to an angle 20°. Foot end of the bed raised to 45 cm (18 in).
	10	Posterior basal bronchus	10	Lying prone with a pillow under the hips and chest tilted downwards to an angle of 20°. Foot end of the bed raised to 45 cm (18 in).

wall fully relaxed. It can be given even in the high side lying position. Hands are placed on the anterior costal margins. The patient is taught to breathe out as quietly as possible sinking down the lower ribs and the abdomen without any force. It must be remembered that forced or prolonged expiration will increase work of breathing and may even increase air flow obstruction.

This is followed by a gentle, active phase of deep inspiration through the nose. Passage of air through the nose allows the air to be warm, humidified and filtered before it reaches the upper airway. During this phase of inspiration the abdomen should bulge out to its fullest extent. A careful watch is needed to ensure that the upper chest and the accessory muscles (e.g. sternomastoid, trapezius) are not over used as this may result in early fatigue due to increased oxygen consumption due to the excessive work of the accessory muscles of respiration.

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5. *Positive expiratory pressure (PEP) device*

(a) Mask device. Flak in 1984 devised a mask and reported a better sputum yield by PEP on peripheral airways and collateral channels in postoperative patients. Either low pressure (10-20 cm H_2O) or high pressure (50-120 cm H_2O) PEP may be used depending upon the degree of adherence of the secretions. It uses face mask with a one-way valve to which expiratory resistance can be applied.

(b) Flutter device. It is a simple portable device like dry spirometer with blowing pipe with a series of small openings at the top of the bowl. A small density ball-bearing is enclosed in a small cone in the bowl. Following full inspiration and a hold of 2-3 seconds air is slowly but completely blown with lips sealed around the mouth piece creating PEP. It improves lung function, oxygenation and expectoration of bronchial secretions (Liardet, 1990).

6. *Intermittent positive pressure breathing (IPPB)*

A technique which is aimed at the maintenance of positive airway pressure through the phase of inspiration. Thus, the airway pressure returns to atmospheric pressure during expiration. It reduces the work of breathing during inspiration and augments tidal volume. It helps in clearing bronchial secretions in semicomatose, neuromuscular disease patients or patients with chest infection.

7. *Continuous positive airway pressure (CPAP)*

This technique maintains positive pressure through both the phases, inspiration as well as expiration. This is possible only when the patient's inspiratory flow rate always remains at a higher level. (CPAP is produced by using a high flow generator device with mouth piece and nose clip or a mask. It reduces the work of breathing and improves FRC.)

8. *Incentive spirometry*

It is a simple mechanical device where patient breathes in slow and deep to a preset volume, then holds the breath for 2-3 seconds at full inspiration, with emphasis on the expansion of the lower chest. This device assists greatly in prevention of postoperative pulmonary complications. It prevents lung collapse by increasing ventilation to the dependant parts of the lung.

9. *Drug inhalers*

Various handy devices are available for effective inhalation of drugs. Correct technique is necessary to make inhalation reach the bronchi effectively.

After expiration, putting inhaler in the mouth, the drug should be released with slow and deep inspiration lasting to the count of 30 or approximately 10 seconds. Nebuliser which breaks solution to be inhaled into droplets, suspended in a gas, is a better device. Bronchodilators, corticosteroids, antibiotics and analgesic drugs can be effectively inhaled by this method. Use of mucolytic agents like hypertonic saline (3-7%), when inhaled before physiotherapy, has been found to be effective in the clearance of secretions.

10. *Humidification*

It may become necessary to use humidification when airway humidification or mucociliary escalator are not functioning (e.g. endotracheal on tracheostomy tube insertion). Various types of humidifiers are available. The choice depends upon the purpose. Ultrasonic humidifiers are ideal, being irritant they promote coughing.

11. *Oxygen therapy*

Impairment of tissue oxygenation needs extra oxygen during inspiration. It has to be monitored carefully by recording oxygen saturation or blood gas analysis. Oxygen therapy may be administered by a fixed performance device exceeding patient's inspiratory flow rate, or by a variable performance device, where the oxygen flow is less than patient's minute volume.

The intermittent positive pressure device (IPPB), nebulisers are many a times powered by compressed oxygen, oxygen being used as a driving gas. Portable oxygen cylinder may be used for improving ambulatory status during six-minute distance test (SMD) or training to improve breathlessness.

Caution

Critical assessment and careful monitoring of the efficacy of the alternative techniques as well as adjuncts used to facilitate chest physiotherapy is a must before deciding on any therapeutic technique on an individual basis.

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iontophoresis. Limb elevation, isometrics and elastocrepe bandage along with graded speedy isometrics help in reducing swelling. Inflammation in the sub-acute phase responds very well to superficial heating procedures like infra-red, hydrocollator packs and radiant heat, by reflex reciprocal blood flow between the integument and the deeper tissues.

(b) Anti-inflammatory drugs and analgesics are effective in reducing pain and inflammation.

(c) Strong movements to the related joints improve circulation to the inflamed part hastening its resolution.

2. Relaxation of the inflamed area

This can be achieved by guiding a patient on simple techniques of relaxation of the whole body as well as the affected area. Guidance on the diversional activities also induces relaxation.

3. Prevention of further damage and the future complications

(a) Prevention of further trauma plays an important role in hastening the resolution of inflammation. Any further trauma increases inflammation and may result in complications like joint capsule contracture due to scar tissue formation (Evans, 1980). To avoid this, especially the over-enthusiastic patients need to be educated on the proper positioning of the affected area during rest, as well as during the controlled activity.

(b) Immobilisation may result in complications like muscle-atrophy, partial loss of strength, endurance and flexibility; weakness of the ligaments with reduced tensile strength; loss of elasticity of the collagen fibers and stiffness of the joints.

All these complications can be effectively prevented by early initiation of isometrics as well as guided mobilisation. However, selection of appropriate intensity, duration and the frequency of exercise and the specific technique of exercise is the decisive factor in providing quick relief.

4. Education of the patient on self-care

Proper guidance on self-care activities of daily routine like dressing, taking bath, shaving, combing, etc. should be given which will promote healing as well as avoid any further complications.

5. Maintenance of muscle function and ROM

This can be achieved by

(a) Graduated relaxed passive ROM exercises.

(b) Continuous passive motion (CPM) equipment.

Gentle passive movements not only reduce the inflammation but are also instrumental in providing pain relief (Maitland, 1983; Barak et al., 1985).

Isometrics during total immobilisation or partial range passive exercises and assisted active movements are effective in improving or maintaining muscle function and ROM. Guidance is necessary to ensure that the joint is moving in its proper groove and the muscle action is optimal in its direction and force.

6. Guidance to perform functional activities

Activities of daily living like sitting, transfers, standing, ambulation and work requirements also need guidance to avoid overstrain to the inflamed part.

2. Chronic Inflammation

Indicate an attempt at repair of the whole process.

1. Pain is usually absent during the rest. The pain may be present over a localised area near the site of the lesion and is aggravated by specific activities which result in the stretching of the inflamed area.
2. There is presence of granulation tissue.
3. The skin temperature is not raised; effusion is absent; tenderness, if at all present, is minimal.
4. Passive range of motion is restricted but is not painful.
5. The pain is elicited only when the joint is stretched to the point of its restriction. This restriction of ROM is usually due to tendon shortening, adhesions or capsular fibrosis in the soft tissues.
6. There is a history of long standing problem, or recurrence.

Management during the chronic phase

Identification of the possible pathology of the dysfunction is essential to plan the appropriate therapeutic measures. The possible underlying pathology could be:

1. Abnormal pattern of re-modelling of the tissues

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2. Compression bandage

Compression bandage is applied with moderate and even pressure and without a gap to control the edema. Intermittent pneumatic compressive therapy has been proved to be very effective (Airaksinen, 1989).

The technique of the combination of intermittent compressive system and ice as described by Murphy (1988) should also provide an effective measure to reduce pain and oedema.

3. Positioning and movements

Elevation of the affected part and active movements of the distal body segment, and isometrics further increase the efficiency of compression bandage in reducing swelling and oedema. The patient should be educated to prevent further trauma by proper controlled positioning and transfers.

4. Pulsed electromagnetic field therapy (PEMF)

Favourable response to this modality has been reported in acute sports injuries. Megapulse are reported to accelerate the tissue healing (Braun and Lemons, 1982). It has a specific advantage: it can be given over bandage and plaster of paris. But, the lengthy duration of its application is the major disadvantage. It needs 3-10 hours of daily application for a period of 4-8 weeks.

Sustained isometrics maintain muscle strength, endurance, improve circulation, prevent disuse atrophy without putting extra strain or compression over the joints.

Speedy isometrics help in the reduction of effusion or oedema.

AFTER 24 HOURS

Pressure bandage is usually removed and various electrotherapy modalities can be used along with graduated programme of exercises.

1. Electrotherapy

(a) Ultrasound. Low power and low dosage ultrasound treatment has various advantages like:

(i) It diminishes the propagation of sensory and motor nerve fiber impulses, thus reducing the degree of pain perception and decrease tension in the muscle fiber; inducing further relaxation (Lehman et al., 1974; Griffin, 1966; Farmer, 1968).

(ii) It lessens CNS stimulation.

(iii) It causes quick and more vigorous rise in tissue temperature at the site of the lesion (Griffin, 1966).

(b) TENS. Trans cutaneous electrical nerve stimulation has gained popularity because it can be used effectively to combat pain in acute as well as in chronic situations (Santiesteban, 1985).

(c) Phonophoresis (Santiesteban, 1985). Introduction of anti-inflammatory or analgesic medical agents into subcutaneous tissues can be achieved by iontophoresis and phonophoresis to combat pain and inflammation. They decrease edema, minimise formation of fibrinous exudate, avoiding formation of adhesions with immobilisation.

(d) Diapulse or any other PEMF is very effective.

2. Massage

Gentle massage could be helpful in drainage of the inflammatory products. It has to be done proximal to the site of injury and not directly over the injured area.

3. Isometric contractions

Although the static contractions may be feeble to start with, they have to be encouraged to maintain muscle strength and to prevent atrophy (Gould et al., 1882; Fried and Shephard, 1970). Sustained and speedy may be made frequent.

Immobilisation is necessary in the early stage to abate inflammation, to avoid further trauma and the scar tissue formation. Mobilisation has to be graded and with least pain, maybe in the form of relaxed passive techniques.

4. Movement

To be initiated as relaxed passive movement at the earliest possible moment to reduce the ill-effect of immobilisation. It (1) helps in even-spreading of the synovial fluid, (2) improves circulation, (3) stimulates tonically depressed joint mechanoreceptors, (4) alleviates pain secondary to muscle ischaemia and (5) also prevents collagen cross binding (Paris, 1983; Wyke, 1972; Akeson et al., 1977).

Isometric contractions to be continued.

Non-weight bearing to be continued in case of injury to the weight bearing joint.

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3. Relaxed passive full range movements by use of sustained mild and constant stretch may be necessary to get over joint stiffness. Ultrasonics may be used to break adhesions and improve extensibility as a useful adjunct.
4. Adjustable night splints could be used for maintenance of the progress achieved in straightening the contracted joint.
5. It may be necessary to educate the patient maximum use of the concerned joint including proper gait training when the lower extremity joint is involved.

Bursitis

The function of a bursa is to reduce friction where two structures are liable to rub over each other.

A severe blow directly over the bursa will result in acute inflammation; whereas persistent minor trauma will result in chronic inflammation. Bursitis could be traumatic, due to infection, inflammation or gout. Tenderness and pain are present over the site of the inflamed bursa. There is pain as well as non-capsular type of restriction of movement with empty end-feel to passive overpressure.

The method of management depends upon the degree of inflammation and the site of inflammation. Usual sites of bursitis are:

1. Prepatellar,
2. Subdeltoid,
3. Over olecranon (minor's elbow) and
4. Around tendoachilles (achillodyn).

A demand to reduce friction may give rise to an adventitious bursa in abnormal circumstances.

Adventitious bursa could be formed over a bony point that has become unduly prominent, e.g. metatarsophalangeal joint in hallux valgus.

Acute bursitis

1. Rest by using a sling for the upper extremity and a pressure bandage in the lower limb. Painful movements and weight bearing has to be avoided.
2. Cryotherapy, TENS, diapulse could be started immediately.
3. Movements for the unaffected joints of the involved extremity.
4. Isometrics with limb in elevation are extremely effective and should be emphasised whenever possible. They should be light but sustained as well as fast.

Subacute stage or chronic stage

1. Protect the site of bursa from irritation by
   (a) Providing adequate support, e.g. felt pad, or modification of the foot wear in inflamed bursa as in following hallux-valgus.
   (b) Controlling the movements which may cause micro-trauma to the bursa, e.g. avoiding repeated and strenuous shoulder abduction in a case of sub-deltoid bursitis.
2. Movements of the affected joint could be started gradually. As the purpose of a bursa is to avoid friction between tendon and bone, it will be ideal to initiate relaxed passive movements, repeatedly performed through the exact groove of the arc of a specific movement to maintain ROM.
3. Active limited range movement with strong sustained isometric hold at the terminal range are important to strengthen the muscles. The stronger the muscle, the lesser will be the compression strain on the bursa and disuse atrophy also can be prevented.
4. Deep heating procedures like SWD and ultrasonics will improve circulation.
5. Progressive resistive exercises should be started with low resistance and worked up to full function.
6. Deep friction massage over the bursa is also effective.
7. Functional exercises to be initiated depending upon patient's routine, with caution not to produce repetitive strain on the inflamed bursa.

4. Injury to the Nerve

Injury to the nerve. Occasionally, there may be an injury or entrapment of the peripheral nerve as a result of soft tissue injury.

Nerve entrapment syndrome. Some extrinsic source may put pressure on the nerve at the point of its exit from the intervertebral foramina or a peripheral nerve may get compressed by a muscle belly or a tight fascia, e.g., median nerve in the carpal tunnel.

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or 0.5 kg dumbell, and gradually progressed to 2 lbs, 3 lbs or 1.5 to 2 kg dumbells. The aim is to achieve 15 repetitions of each movement without pain.

Patients with articular involvement respond with difficulty and usually need prolonged rest. Active movement is begun only after 3-4 weeks, if not painful.

Manipulation could be effective in cases where pain is provoked with active use of extensor muscles by Mills manoeuvre (1937). However, manipulation is contraindicated in case of pain at rest, stiffness after rest and fibrositis.

Physiotherapy following surgery

1. Measures to reduce pain and inflammation.
2. Limb elevation and speedy as well as sustained active movements to the joints free of immobilisation.

When mobilisation is allowed (1 week)

3. Begin with slow relaxed full ROM passive movements to the elbow, forearm and wrist.
4. Shoulder and shoulder girdle should be mobilised to full ROM to avoid adhesive capsulitis.
5. Begin with gradual active-assisted exercises and progress to self-resistive techniques. Ultrasonics, TENS, diapulse could be used as adjuncts to reduce pain.
6. Functional movements, carefully avoiding repeated supination, wrist extension and strong grip.
7. Progress gradually to PRE. By 5-6 weeks functionally painless elbow, forearm and wrist movements should be regained.

Golfer's elbow or medial epicondylitis

This condition is not as common as the tennis elbow. The site of tenderness being the medial epicondyle of humerus and the seat of inflammation is the common origin of the flexor group of muscles. Pain is produced by extension of the elbow, supination and valgus strain.

The physiotherapy management programme proceeds on the same lines as for common origin of the extensor group of muscles at the lateral epicondyle.

Olecranon bursitis (minor's elbow) (Fig. 2.2)

Repeated trauma to the posterior aspect of the elbow joint is the precipitating cause for olecranon bursitis, hence the name "minor's elbow". It is occasionally found in patients with rheumatoid arthritis.

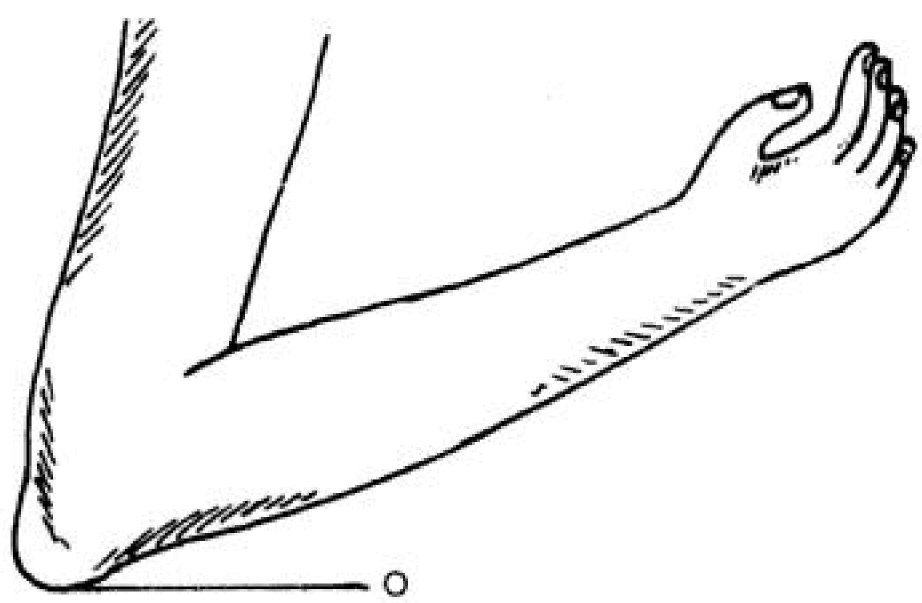

Fig. 2.2. Olecranon bursitis. O: Olecranon bursa.

It is most often painfree and it does not need any treatment except avoiding strain and friction.

It could become painful if there is associated bacterial infection.

Fig. 2.3. Ruptured tendon of the long head of biceps brachii. GB: Globular belly of biceps.

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Physiotherapy management should not only be disability-oriented but has to be pathology-oriented also to resolve both the factors.

Pathology of dysfunction

Homeostatic mechanism is responsible to maintain a perfect balance between the processes of tissue breakdown and tissue repair. The body tissue suffer breakdown due to stresses, whereas repair occurs through the formation of new tissue. The body is continuously trying to maintain perfect balance between these two processes which occur as a result of normal daily use. Whenever, there is imbalance it results in musculo-skeletal dysfunction or disorder. This imbalance could be

1. Increased rate of tissue breakdown.
2. Decreased rate of tissue breakdown.
3. Increased rate of tissue production.
4. Decreased rate of tissue production.

1. Increased rate of tissue breakdown

When the rate of tissue breakdown exceeds the rate of tissue repair, excessive stress level leads to hypertrophy of the tissues e.g. repetitive loading results in hypertrophy of muscle. Similarly, well vascularised bone will hypertrophy; however, excessive stress on the bone may lead to stress fracture.

The articular cartilage, which is poorly vascularised and has lower metabolic rate, tends to break and degenerate under the conditions of stress.

Therefore, when the excessive tissue is of the same nature as before the function improves (e.g. muscle hypertrophy following regular sessions of PRE). However, if the repair is replaced by a different type of tissue it will result in deficiency in a regular function (e.g. formation of excessive collagen will lead to lack of extensibility resulting in partial fibrosis of the joint capsule).

The therapeutic programme needs to be planned which should be sufficient to promote the process of repair. It should neither be too aggressive to disturb the repair, nor too inadequate to facilitate the process of repair by tissues other than the original one.

As circulation plays a predominant role in the process of tissue repair, dysfunction at the site where the tissue is poorly vascularised or has a low metabolic rate, needs to be protected from further break down. Circulation is augmented by limb elevation, deep heating procedures or by resistive exercises to the adjacent muscle groups, at the same time early stress on loading exercises are contraindicated.

A classical example of this is seen in supraspinatus tendinitis. The rate of breakdown at the insertion of this tendon exceeds due to fatigue and reduced vascularity. The body compensates its inability to produce new tendon by laying calculus. When exercise or activities causing extra-stress, like shoulder abduction against gravity are preformed, partial rupture may progress to complete rupture.

2. Decreased rate of tissue breakdown

Immobilisation always brings about decrease in the rate of tissue breakdown due to decrease in the stress. This sets in the disuse atrophy of the muscles, ligaments, joint capsule as well as the bones.

The approach of physiotherapy should be to impart some stress on the immobilised tissues. Proper training of the isometric exercises, vigorous exercises to the joints adjacent to the immobilised joints and early initiation of whole body movements, e.g. transfers, protected standing etc. are optimal.

3. Increased rate of tissue production

The process of repair following inflammation may lead to the excessive proliferation of collagen tissue. The new collagen tissues may be laid in to abnormal patterns resulting in interfiber cross links. This increased rate of collagen formation in the immobilised joint results in loss of extensibility leading to painful stiff joint. If the collagen is assymetrical with interfiber crosslinking, it may result in the loss of the normal groove and the character of the movement.

4. Decreased rate of tissue production

Here the process of tissue repair is prolonged due to decrease in the rate of tissue production. Change in the metabolic status is the basic factor. The tissue equilibrium is destroyed as a result of abnormal hormonal

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Bony end-feel. An abrupt end-feel which fails to yield further ROM, locking it totally, is typical of bony end-feel. It may be present following malunited fracture or in hypertrophic bony changes following degenerative joint changes.

Pathologic end-feels

Muscular spasm end-feel. Abrupt resistance with rebound to the passive range may be encountered in its arc due to reflex contractions in the muscle. However, further ROM is possible with little extra pressure. When it is present with capsular pattern of restriction, synovial inflammation of the part of the joint capsule may be suspected.

Boggy end-feel. It is a soft and mushy end-feel associated with joint effusion. Frequently it may be accompanied by the capsular pattern of restriction.

Internal derangement end-feel. Loose body in the joint or displaced meniscus results in a mechanical block to the passive ROM. This offers marked springy rebound at the terminal point of ROM. The pattern of restriction is invariably non-capsular.

Empty end-feel. The movement is suddenly stopped, not due to restriction but because of severe pain. It is noticed in painful extra-articular lesions (e.g. bursitis, neoplasm).

Pain and mobility. Presence or absence of pain and the extent of mobility provide useful guidance in detecting the lesions of the articular capsule and the major ligaments of a joint.

Pain at the extreme range of motion. The pain is elicited as a result of stretching of the painful structure itself. The lesion may be either musculo-tendinous or capsulo-ligamentous in origin. However, the movement, when resisted, will be painful in musculo-tendinous lesion, whereas it would be painfree in a capsulo-tendinous lesion.

Painful arc

Pain is felt only during certain part of the arc of passive ROM. This occurs when a painful structure is temporarily squeezed at a particular part of ROM in extra-articular lesion. Pain disappears instantaneously as soon as the passive movement is progressed further, more pressure and the pressure on the painful structures is relieved.

Passive joint play. Systematically performed passive joint play movement test produces stress on capsulo-ligamentous complex. Positive passive joint play (eliciting pain) test indicates the presence of lesion of the major ligaments or the joint capsule.

Mobility of a joint

The passive mobility of a joint may be affected either ways. It may be in excess of the normal ROM (hypermobility); or less than the normal ROM (hypomobility).

Hypermobility is present when there is loss of continuity, e.g. partial or a complete rupture of muscle or tendon.

Hypomobility indicates fibrosis. Fibrosis may occur due to adhesions, low grade inflammation in the adjacent tissues, due to excessive collagen formation, localised protective muscular spasm following acute inflammation, or chronic stress.

Inter-relationship between pain and mobility can provide useful information on the probable cause and the type of dysfunction (Table 2.3).

Table 2.3. Pain mobility and possible lesion

Pain and Mobility	*Possible Lesion*
Painfree, normal mobility	NAD
Normal mobility with pain	Minor sprain
Painless hypomobility	Contracture or adhesion of the involved structure being tested.
Painful hypomobility	Painful guarding, it may be due to acute inflammation, sprain, tear or rupture.
Painless hypermobility	Complete rupture of the structure with severence of pain conducting fibers.
Painful hypermobility	Partial tear which exerts stress on some intact fibers.

Presence of crepitus

Crepitus may be felt on passive ROM of the joints of cervial spine, shoulder and knee (patello-femoral). This indicates the presence of degenerative joint changes.

Resisted movement tests

Inter-relationship between pain and strength of a joint movement can provide guidance to detect the expected nature of the dysfunction.

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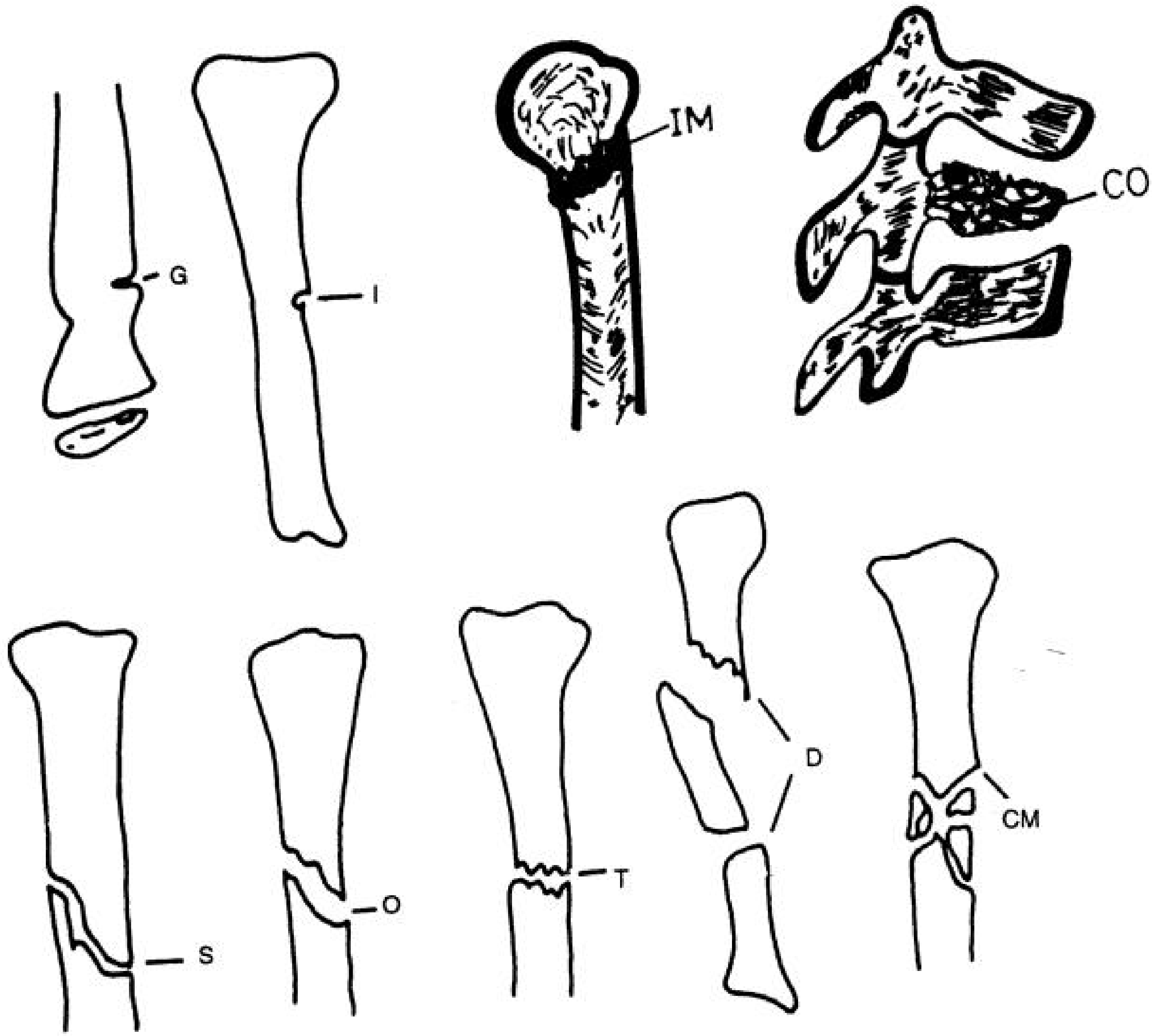

Fig. 3.1. Common patterns of fracture: G : Greenstick, I: Incomplete, IM: Impacted, CO: Compression, S: Spiral, O: Oblique, T: Transverse, D: Double, CM: Comminuted.

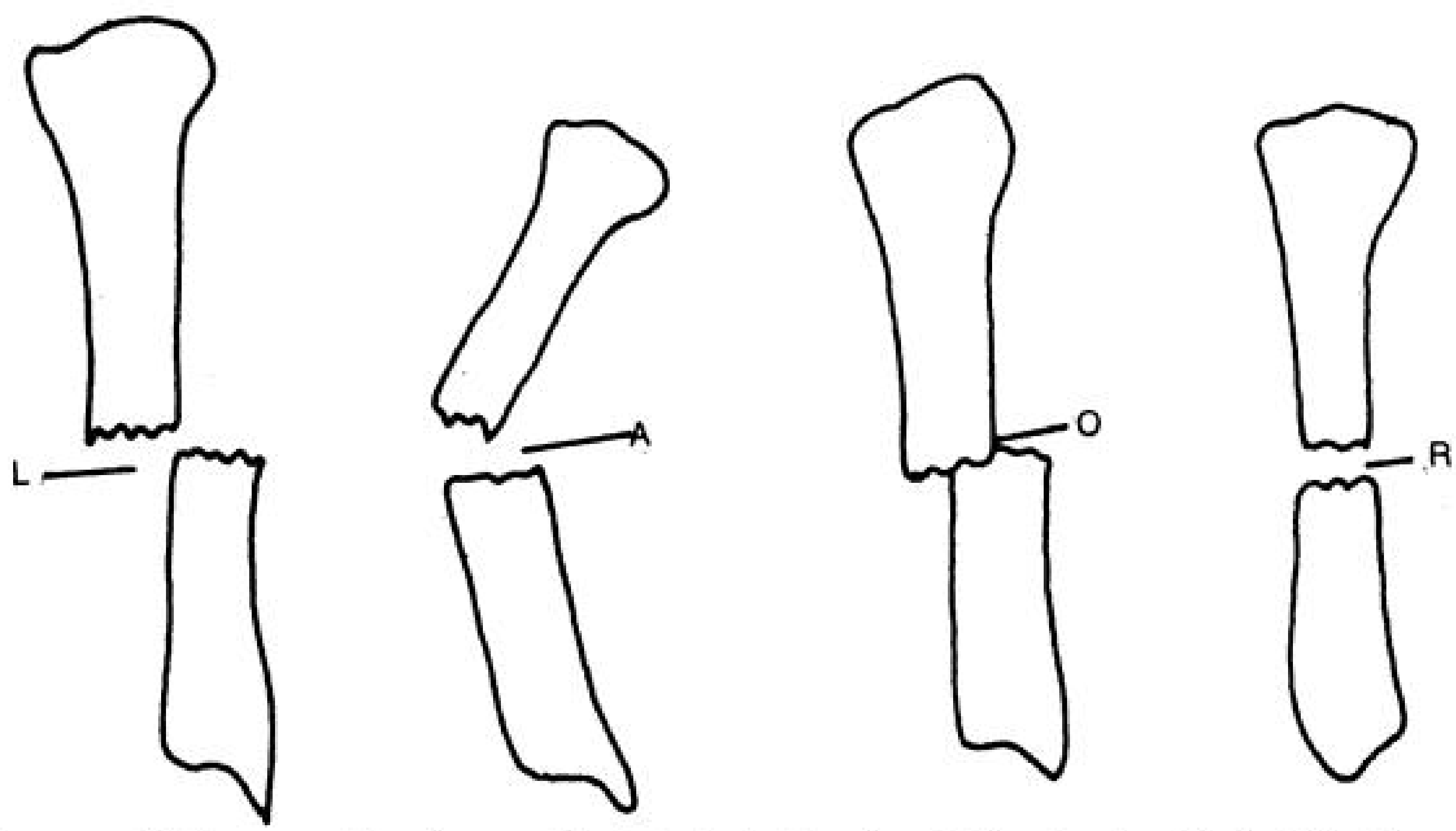

Fig. 3.2. Common displacements in a fracture: L: Lateral, A: Angular, O: Overlapping, R: Rotational.

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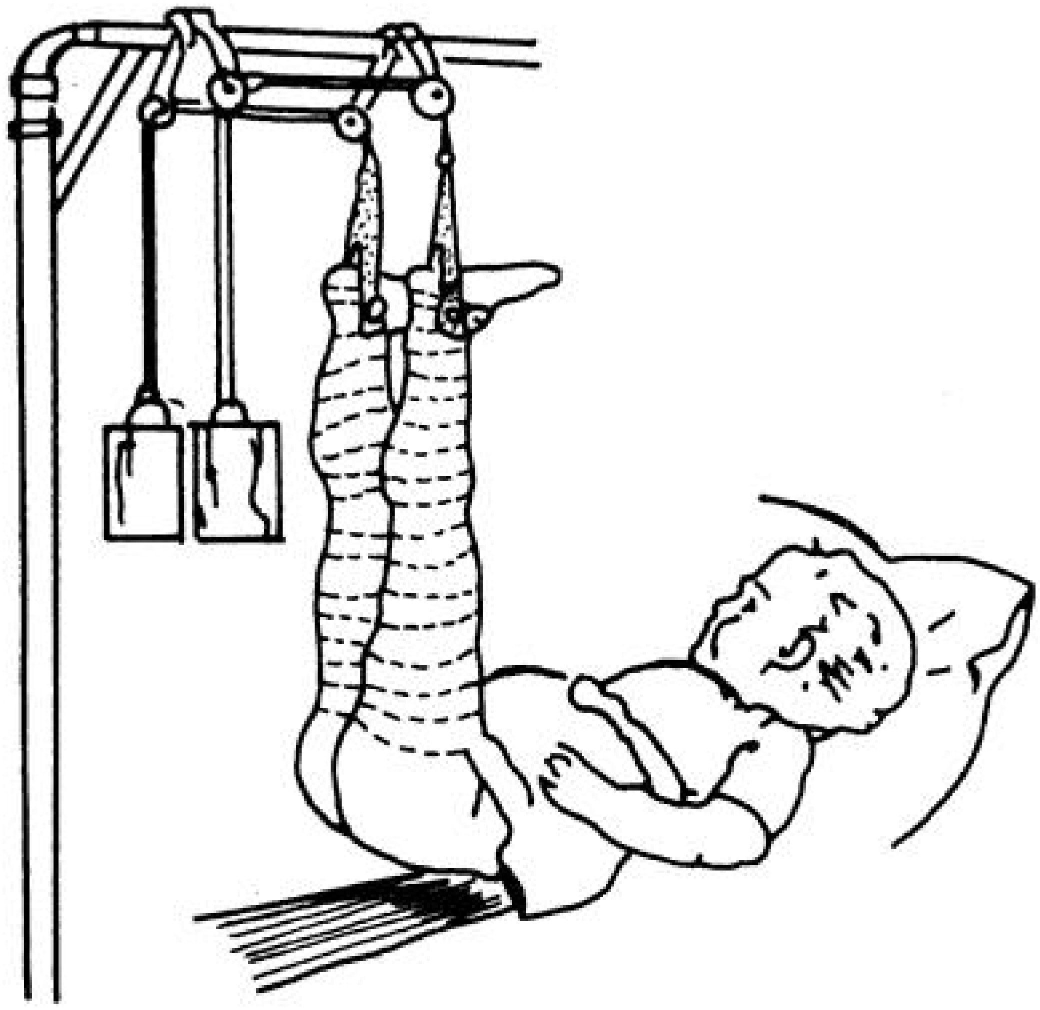

Fig. 3.6. Gallow's traction.

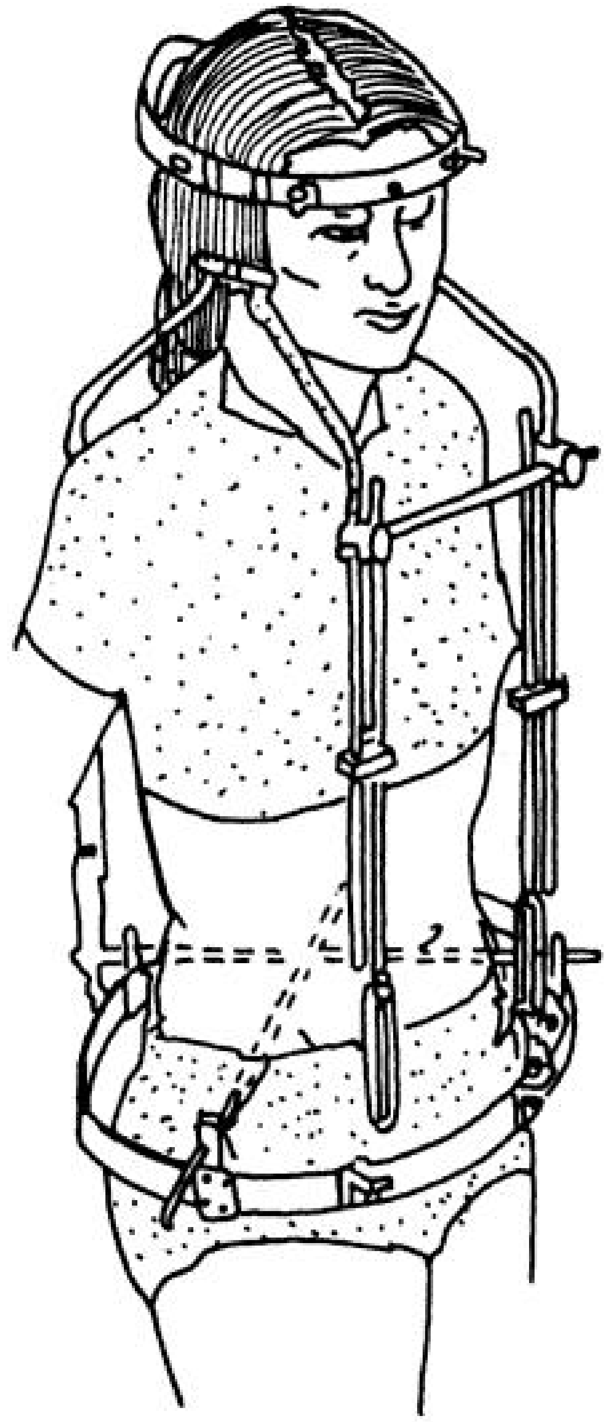

Fig. 3.8. Halo-pelvic traction.

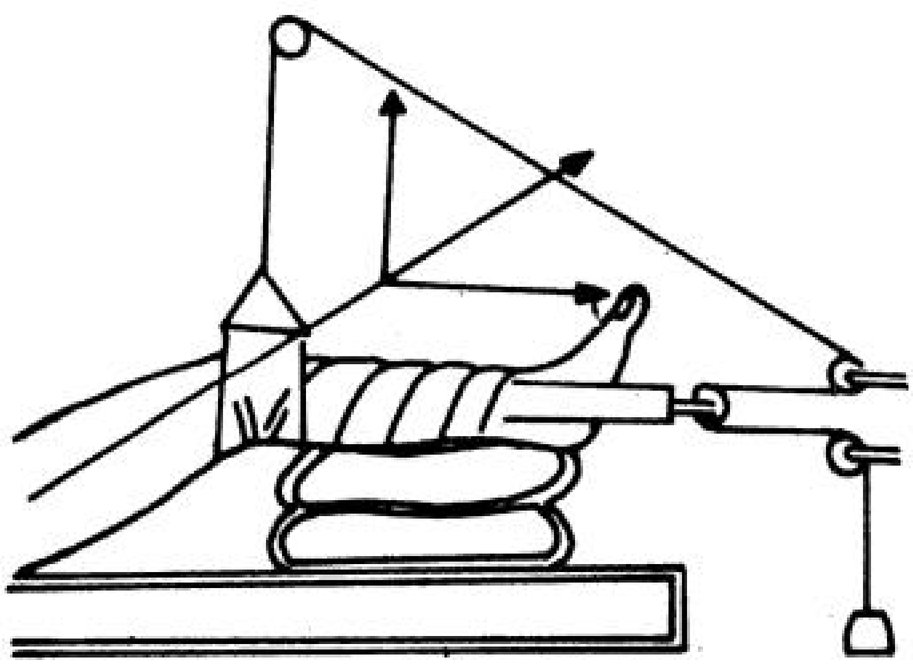

Fig. 3.7. Perkin's traction.

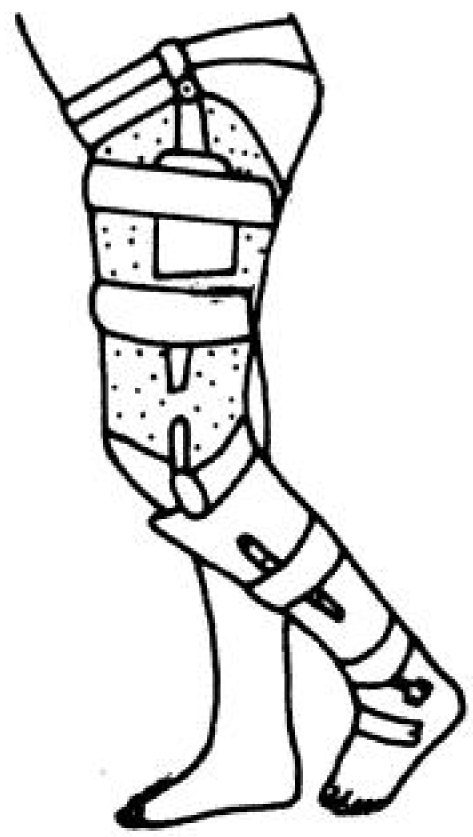

Fig. 3.9. Functional cast bracing.

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Physiotherapy management following specific methods of fracture treatment

1. Fractures treated without any splinting:
   Some fractures are occasionally treated without any splinting or reduction or when surgery is contraindicated. In such cases, the fracture is ignored; and controlled mobilisation is started at the earliest. Initiation of safe and adequate mobility to regain functional independence is the important role of physiotherapy in such fractures, irrespective of union or alignment of the fracture, e.g. compression fracture of the spine, fractures of ribs, and fracture neck of femur in a sick patient.
2. Fractures treated by traction:
   Certain fractures (e.g. trochanteric fracture) in elderly patients, where surgery cannot be done, are treated by traction of long duration.
   The physiotherapist should check the alignment and the force of the traction; should also detect development of any pressure sore or nerve palsy (the commonest being lateral popliteal nerve) due to pressure from a splint or bandage. Isometrics to the quadriceps and hamstrings and ankle movements should be given regularly. Ankle movements are particularly important as they improve the circulation in the calf veins and thereby prevent deep vein thrombosis.
3. Fractures treated by cast brace: A fracture of midshaft of femur is at times treated by a cast brace having an orthotic mechanical knee joint, It is the responsibility of the physiotherapist to check the alignment of the knee joint and begin early re-education in walking.
4. Fractures treated by internal fixation: The fracture treated by internal fixation usually does not require prolonged external immobilisation after the operation. The immobilisation is maintained only for 2-3 weeks, after which mobilisation can be started.
5. Fractures and dislocations associated with ligament injuries: Certain fractures and/or dislocations around shoulder, elbow, interphalangeal joints and ankle are associated with injury to the joint capsule and ligaments. Extensive efforts are, therefore, needed to mobilise these joints and also to treat the accompanying soft tissue damage.
6. Fractures treated by external fixator: In an compound fracture with soft tissue loss, the fracture is stabilised with an external fixator.
   The extent of injury to the soft tissues should be assessed and inspection of the open wound should be done frequently for infection. Vigorous movements should be started early to the joints free from immobilisation and even non-weight bearing crutch walking can be initiated early. The movements of the joints adjacent to the fractured bone are deferred till there is definite evidence of union of the fracture. Once the union is ascertained extensive physiotherapy measures are taken to improve mobility of the joint, strength and endurance of the concerned muscles and early functional independence.
7. Fractures treated by total joint replacement: The greatest advantage of this procedure is that, it allows early mobilisation and ambulation besides providing stability to the joint. The physiotherapy is directed to re-educate the functional activity at the earliest.

Fractures of the lower extremity: specific considerations

Physiotherapy management of the fractures of the lower extremity demands a different type of approach for two reasons:

1. For its important function of ambulation and
2. Its role in the adaption of functional positions, e.g., cross-leg sitting, floor squatting, etc.

The physiotherapist's priorities should be as follows:

1. To reduce the impact of stresses on the three major weight-bearing joints of the lower extremity,
2. To acquire the requisite range of motion and
3. To improve the strength, endurance and flexibility of the functionally important muscle groups.

1. To reduce the stresses on the weight bearing joints

The weight-bearing joints, especially the hip and the knee, are exposed to tremendous amount of stresses during ambulation and while adapting functional positions. The resultant joint force was found to be approximately four times the body weight at the hip and three times at the knee (Paul, 1967). The smooth absorption of the ground reaction forces is the primary requirement for rhythmical and effortless ambulation. When these forces are not absorbed by the weight-bearing joints, the muscles and ligaments are put to

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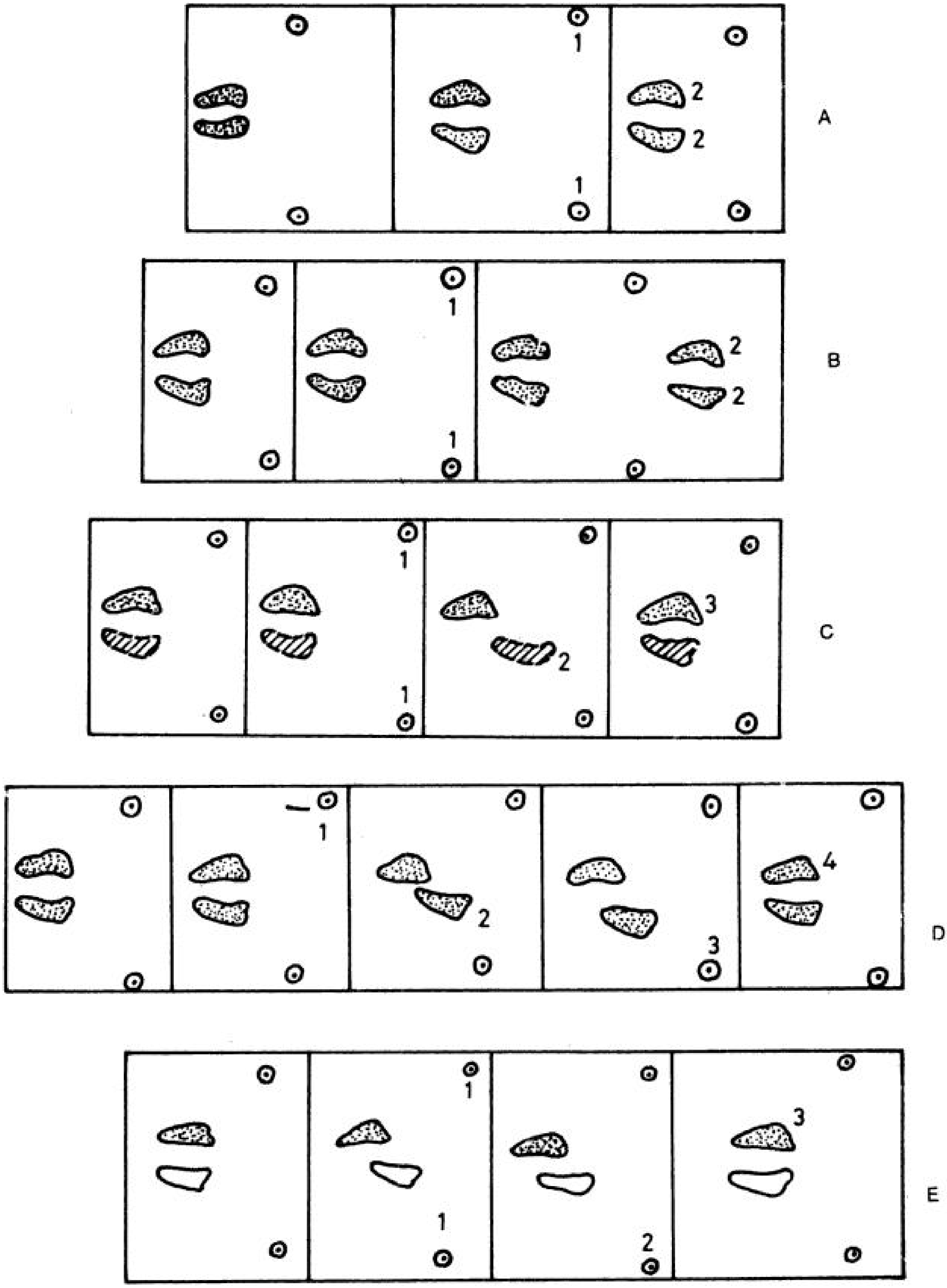

Fig. 3.15. Types of crutch gaits. **(A)** Swing to gait. **(B)** Swing through gait. **(C)** Partial weight bearing gait. **(D)** Four-point gait. **(E)** Shadow walking non-weight bearing gait.

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ured/repaired muscles and ligaments are important to estore function early.

eneral complications

a) Respiratory distress syndrome

Difficulty in breathing with increased rate of respiraion associated with drowsiness may be found in some atients following severe injury involving multiple ractures or fractures of pelvis or large bones. There is deficiency of gaseous diffusion in the lungs due to n inflammatory reaction set in due to the micro-emboli of fat released from the fracture. The analysis of lood gases shows the deficiency of both oxygen as vell as carbon dioxide. The chest X-ray may reveal nultiple opacities. Small patechiae may be seen on the hest wall. Blood pressure may drop.

Immediate measures like oxygen, tracheostomy, ositive pressure ventilation and chest physiotherapy re necessary. To avoid fatal consequences, early diagosis and chest management is a must in multiple fracures, or large bone fractures.

b) Venous thrombosis

Deep venous thrombosis in the venous plexus of the alf muscle is common after a major fracture around he hip. The thrombus formation originates at this site. A clot is formed. A small fragment of this clot (embolus) may get detached and pass onwards to the femoral, iliac or deep pelvic veins. If it passes upwards to the heart or lung, it could be fatal.

The formation of thrombus is common following vessel injury and during or following surgery. It is always aggravated by bed rest or POP immobilisation.

Deep venous thrombosis occurs as a result of

(i) Damage to the vessel wall,
(ii) Stasis or interruption of blood flow and
(iii) Changes in the clotting factor of the blood.

Signs and symptoms. Pain, tenderness and edema in the calf. Passive dorsiflexion of foot increases pain (Homan's sign). There may be a rise in temperature. It must be remembered that the thrombosis may occur without any of these signs. Therefore, the safest measure to detect thrombosis with accuracy is the venograpy or a doppler study. It should always be undertaken whenever there is slightest suspicion. The onset of thrombus can be at any time following the injury. However, classical signs manifest only by 10 to 14 days following injury or surgery.

Treatment. Drug therapy. Various drugs like heparin, aspirin, dextrans and warfarin are given to alter the clotting.

Physiotherapy. Initiation of early active movements, especially to the ankle and the foot, prevents blood stasis and formation of a clot.

If the active movements are not possible repeated passive movements to the toes and ankle should be given. Intermittent pressure devices could be used to augment venous drainage. Electrical stimulation under pressure bandage is also helpful. Light effleurage can be given to augment venous drainage. But, there is a danger of detaching the embolus by massage and as such it involves a risk.

The physiotherapist must keep a regular watch to detect the occurrence of thrombosis during the first two days following injury or surgery to prevent its consequences.

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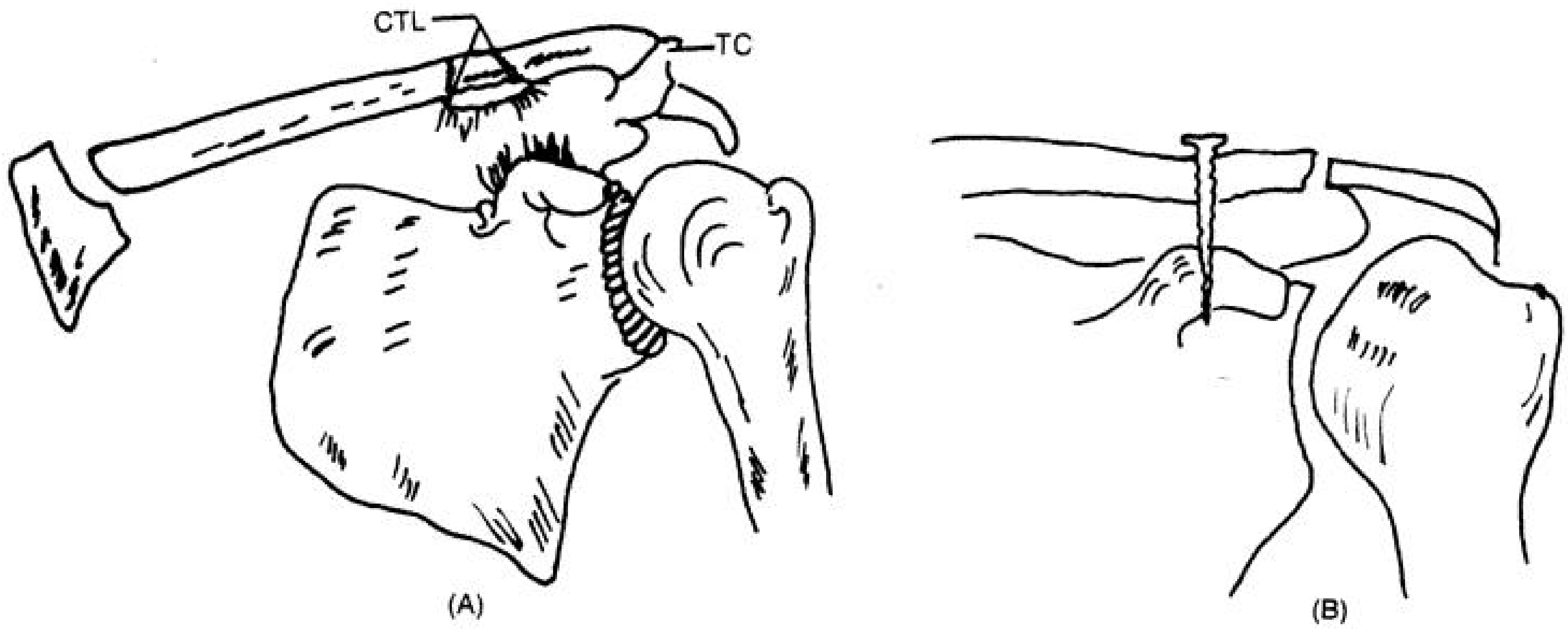

Fig. 4.3. Dislocation of acromio clavicular joint. **(A)** CTL: Torn conoid and trapezoid ligaments, TC: Torn joint capsule. **(B)** Fixation by a screw.

It is also necessary to reconstruct or repair the coraco-clavicular ligaments.

The treatment of this injury demands a balanced clinical judgement taking into account the age of the patient, whether he is right- or left-handed, and his occupation, etc. However, a relatively minor injury in an elderly person may be treated conservatively; while for a major injury in an active young person, early operative treatment will yield best results.

Physiotherapy management

Basic objective. To regain active full range of motion at the shoulder complex.

(a) Conservative treatment

During immobilisation (first 3 weeks)

As it involves strapping, movements are deferred to the shoulder joint for 2-3 weeks. (1) Careful checking of the immobilisation. (2) Full range and strong movements to the elbow, forearm, wrist and fingers should be started immediately.

Mobilisation (3 weeks onwards)

1. Start with adequately supported pendular swinging with the sling. The arc of the movement should not cause pain, at the same time the AC joint and the shoulder girdle should be well supported.

2. Relaxed passive mobilisation with the patient in supine may be initiated. More emphasis is needed on passive abduction-elevation as well as horizontal adduction and horizontal abduction. These movements put stretch on the AC joint.

3. Assisted active movements with emphasis beyond 90 degrees of abduction needs to be concentrated and regained at the earliest as the AC joint has a vital role to play in the range of abduction-elevation beyond 135 degrees.

4. Appropriate thermotherapy modality may be used as an adjunct to relieve pain and induce relaxation. Sling should be discarded and exercises to be progressed to self-resistive regime at home and by using graduated dumbells in the department.

Full range, strong active function should be regained by 6-8 weeks.

(b) Surgical treatment

As the procedure involves internal fixation and repair of the coraco-clavicular ligament, the approach of physiotherapy differs slightly.

1. The shoulder mobilisation is to be started after 4 weeks of surgery.

2. The movements are more painful and there is greater reluctance by the patient towards mobilisation. This could be helped by thermotherapy before and

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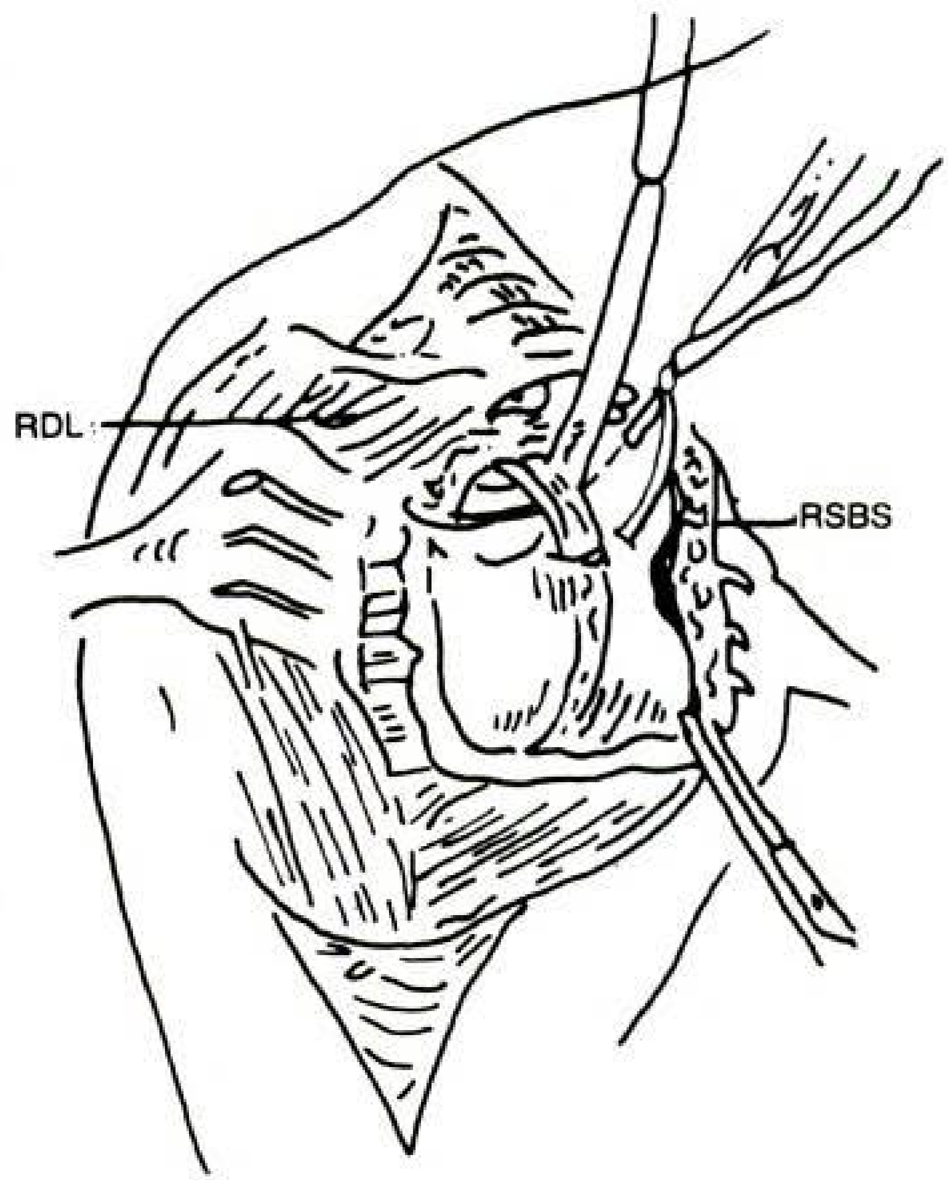

Fig. 4.5. Putti-Platt operation for recurrent anterior dislocation of shoulder. RDL: Retracted deltoid muscle, RSBS: Resected subscapularis retracted with the joint capsule.

1. To strengthen the ligaments and muscles crossing the shoulder joint to the optimum level.
2. To regain full passive ROM of all the movements. Physiotherapy regime involves hard conscientious efforts for a long time and extra caution to avoid recurrence of dislocation. Therefore, proper selection of the patient is very important.

Strengthening procedure. To be successful, it needs several repetitions. The best approach is to teach the patient self-resisted eccentric, as well as isometric contractions (reversal technique) for all the shoulder movements. The exercises should be taught in standing or sitting so that they can be conveniently performed several times. Self-resisted small range reversal technique for various agonists and respective antagonist groups is very well accepted by the patient (Fig. 4.6).

In the department, weighted dumbells, or weight belts may be used so that the progress and the extent of muscular strength can be assessed and monitored at regular intervals.

Fig. 4.6. Self-resisted reversal technique of exercise to strengthen muscles around shoulder.

To achieve and maintain full range passive motion. Initially it has to be done by a physiotherapist with the patient in supine. The arc of movements of abduction-elevation, flexion-elevation and external rotation need to be done gradually and carefully. To assure total relaxation it is ideal to use some thermotherapy or cryotherapy adjunct before initiating these movements. Once the near-normal or full range is achieved, the patient is taught to carry out these movements. Extra care should be taken during the terminal range of elevation and external rotation. As adequate stabilisation of the shoulder-girdle facilitates relaxation of the gleno-humeral joint, the patient should be advised to get some assistance at home while performing these movements. However, proper guidance to stabilise the shoulder girdle has to be learnt from the physiotherapist before carrying it out at home.

For the success of this regime of prevention, long standing efforts (3 to 6 months) and skilful education of the patient are essential.

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an "axillary muff and collar and cuff". No movement at the shoulder is permissible up to 3 weeks.

Therefore, the chances of developing a painful stiff shoulder are quite high and need early attention.

Deep heating thermotherapy procedures like short wave diathermy, ultrasonics, or relaxing thermotherapy, e.g. hot packs and relaxed passive movements are important.

Maximum emphasis has to be given in educating the patient for repeated relaxed auto-assisted shoulder movements with due stress on abduction, starting with pendular movements.

A regular watch needs to be kept to assure improvement in the range of abduction.

Once the active range is achieved resisted exercises can be started.

Good functional results can be achieved by 6-8 weeks.

Fractures managed surgically

Open reduction and internal fixation is done for younger patients. Keeping in view the functional requirements and the possibility of early healing the approach of treatment has to be more vigorous. Full advantage needs to be taken of the shorter period of immobilisation, i.e. 2 weeks. Emphasis should be laid on isometric exercises to the deltoid and strengthening exercises at the earliest.

Relaxed passive as well as auto-assisted exercises by the use of contralateral normal upper extremity should be taught to the patient immediately after the sling is removed, for regaining strength as well as full range of all movements.

Quicker rate of progression from active to active resisted movements and functional use to be ascertained. Excellent results can be obtained by 6-8 weeks.

FRACTURE OF THE SHAFT OF HUMERUS
(Fig. 4.10 A-D)

The mode of injury may be (a) direct or (b) indirect trauma.

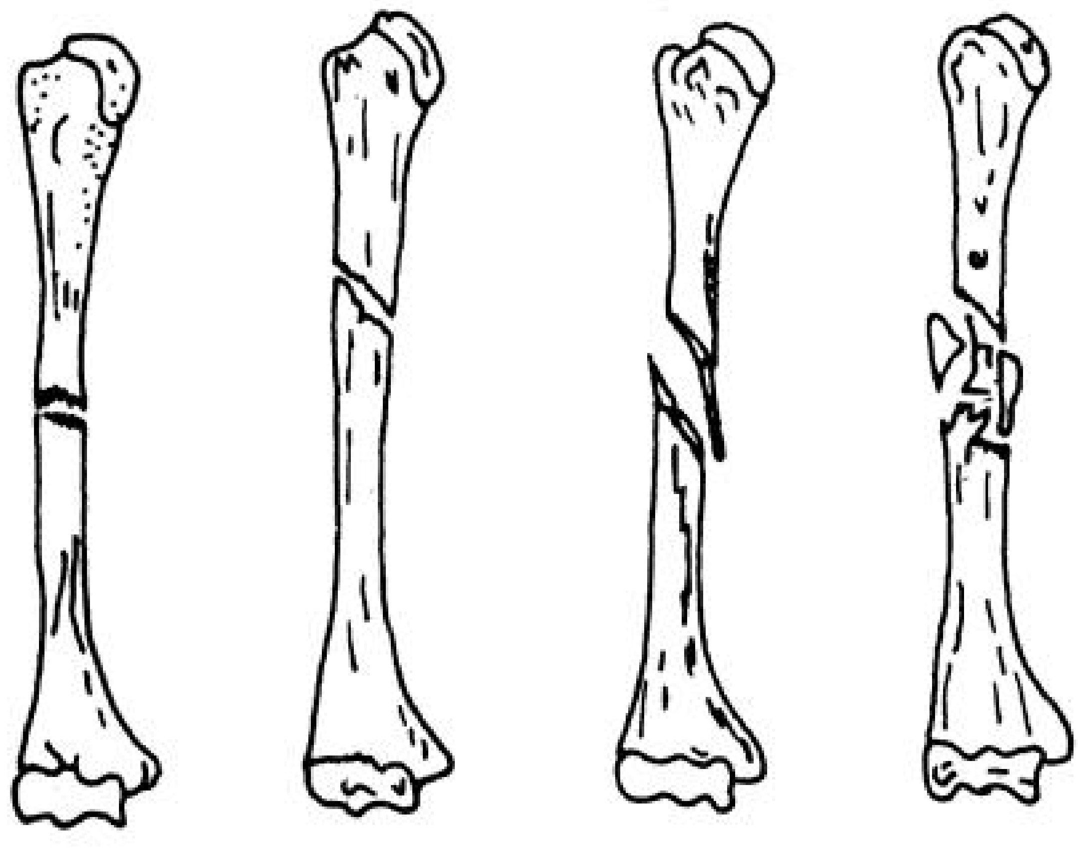
Direct injury will cause a comminuted fracture while an indirect trauma will result in a spiral or oblique fracture.

The fracture in the mid shaft of the humerus has a tendency to lateral angulation; the proximal fragment being abducted by the strong pull of the deltoid muscle.

Treatment

The fracture of the shaft of humerus may be treated by the following methods:

1. POP-U-slab. The fracture is manipulated with the patient in sitting position. The elbow is held in 90°



(A) (B) (C) (D)

Fig. 4.10. Fractures of the shaft of humerus. **(A)** Transverse. **(B)** Oblique. **(C)** Spiral. **(D)** Comminuted.

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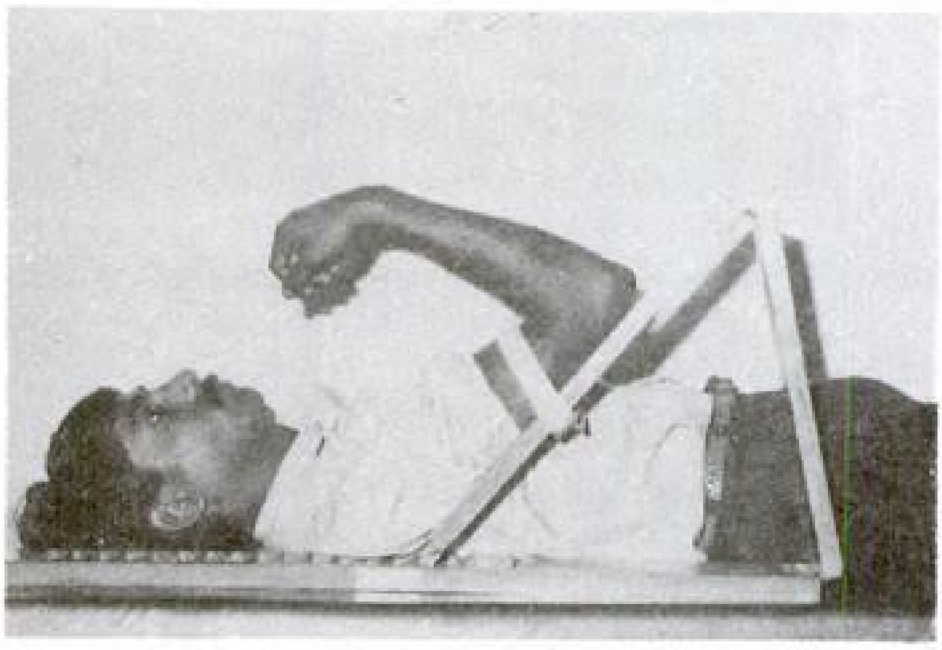
(A)



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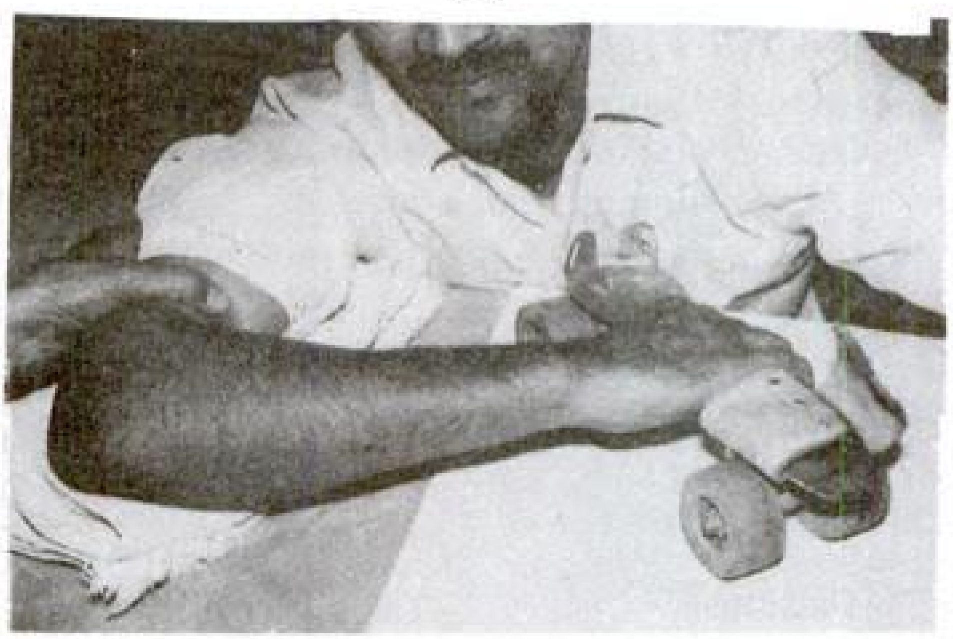

(C)

Fig. 4.13. **(A)** Relaxed active free elbow flexion-extension in prone. **(B)** On knee rachet. **(C)** With roller skates.

the patient in prone with elbow over the edge of the treatment table. During this movement the shoulder is placed in 90° of abduction (Fig. 4.13A).

(c) Relaxed active free flexion can be further progressed by the modified use of knee rachet (Fig. 4.13B). Use of roller skates on a powdered sunmica board is ideal (Fig. 4.13C). The same method can be used to improve the range of elbow extension.

(d) The forearm pronation and supination should be initiated as rhythmic active assistive or free active movement by keeping the forearm fully supported on the thigh with elbow in flexion (Fig. 4.14).

When the pain is substantially reduced active movement could be begun by using a wand. It can apply gentle stretch to regain extreme range of all the four movements (Fig. 4.15) by contralateral hand.

Functional use of elbow and forearm has to be emphasised except lifting heavy objects.

Caution

By 5 weeks following the injury or 2 weeks following mobilisation, if there is no appreciable improvement of elbow ROM, elbow should be carefully examined for suspected bony block. This may need surgical intervention.

B. Fractures managed by excision of the displaced fragment

The regime of physiotherapy management, in the event of excision of the bony fragment, follows the same pattern as outlined for conservative management.

The patients treated surgically may have persistent pain for a longer time. Home treatment with exercises in warm water and use of whirlpool or steam pack in the department may be useful.

Acceptable range of all the four movements should be regained by 5-6 weeks following injury.

SUPRACONDYLAR FRACTURE OF THE HUMERUS

It is one of the commonest fractures in children. This fracture results from a direct injury, e.g. fall on the point of elbow, or an indirect injury, e.g. fall on the outstretched hand. The distal fragment may be displaced posteriorly (extension type of fracture) or anteriorly (flexion type of fracture). The former is the commonest type (Fig. 4.16).

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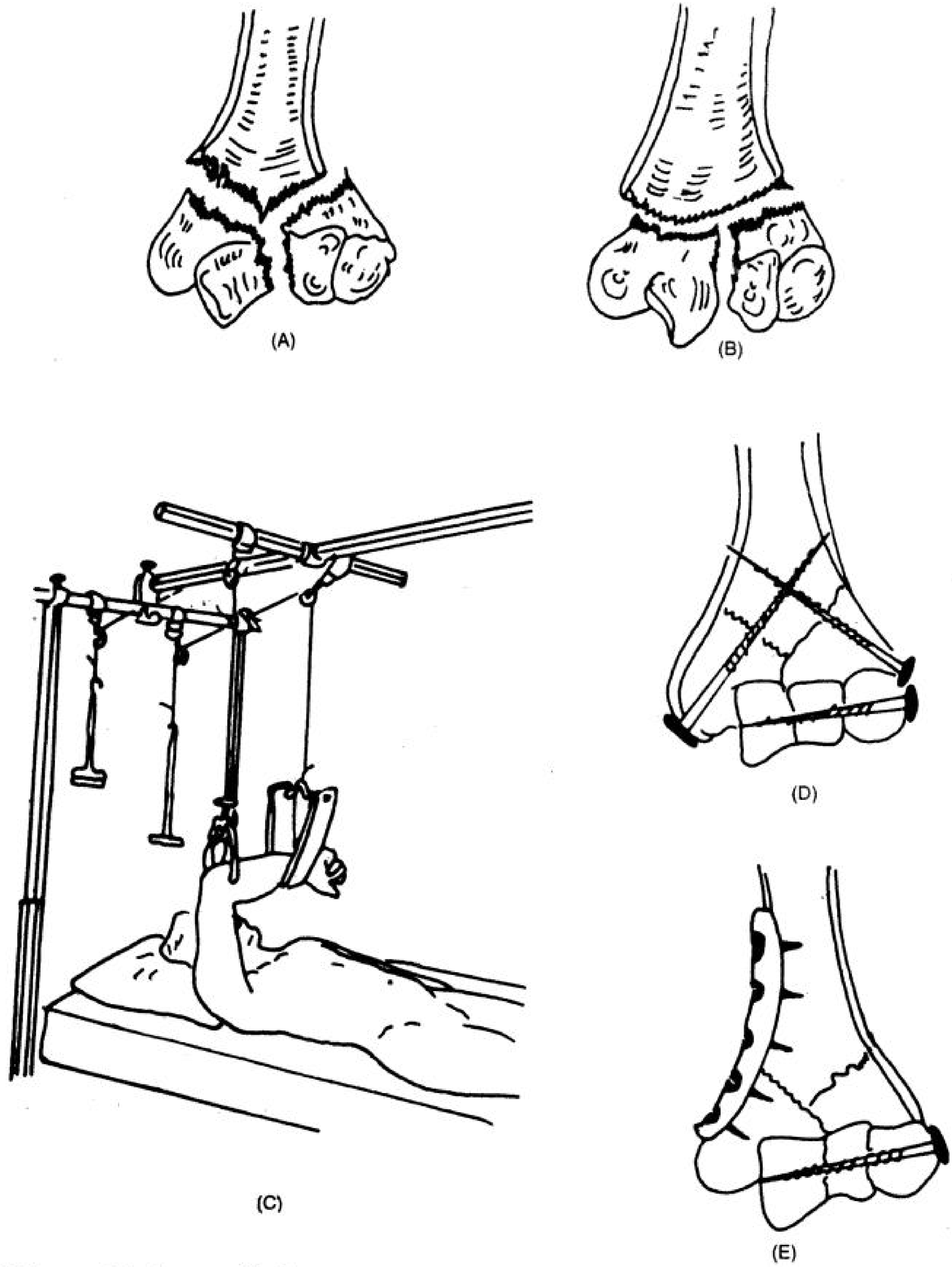

ig. 4.19. Intercondylar fracture of the humerus.
A) Y shaped fracture. **(B)** T shaped fracture. **(C)** Overhead traction immobilisation. **(D)** Internal fixation by screws. **(E)** Internal fixation by plate and screws.

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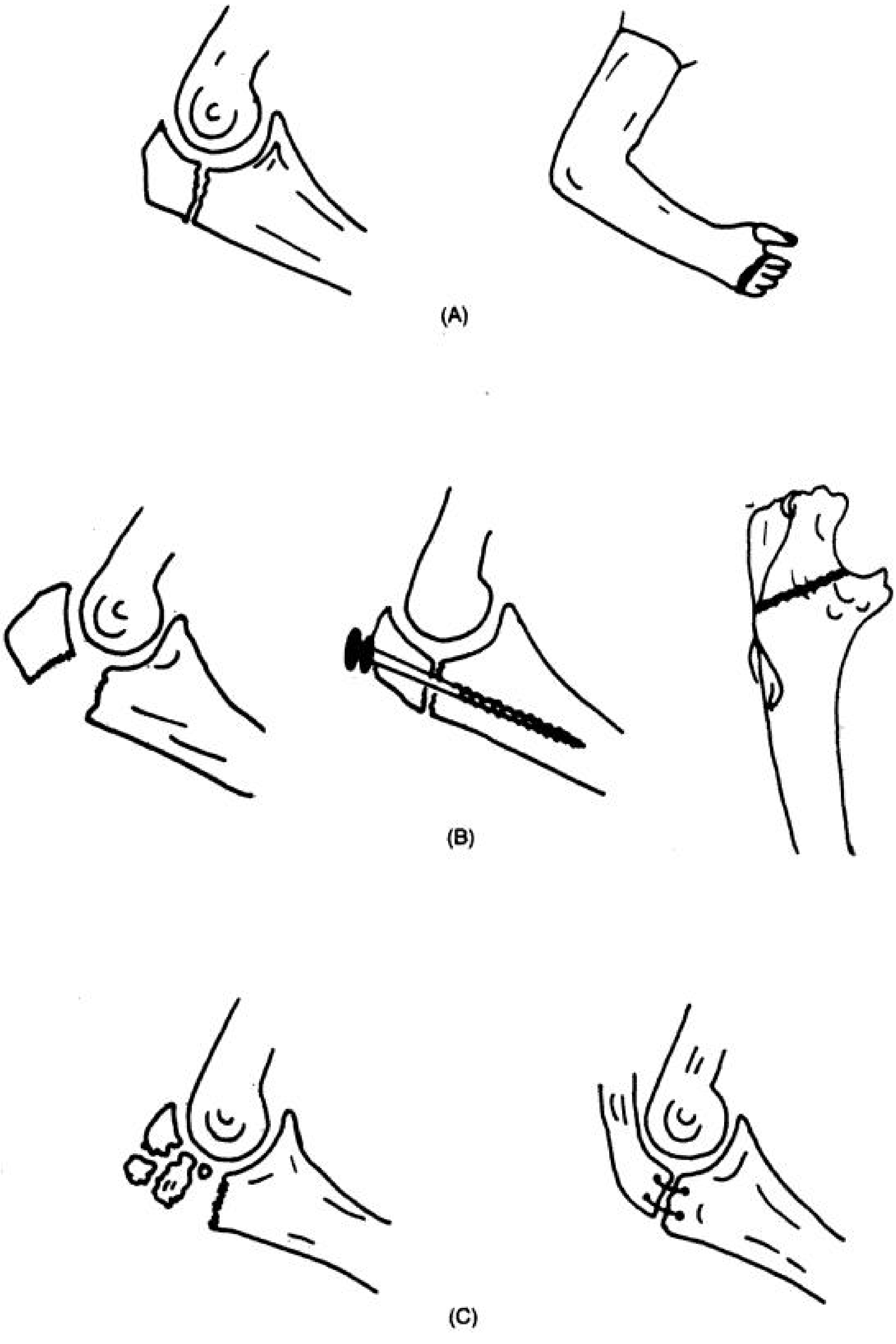

Fig. 4.23. Fracture of the olecranon.
(A) A fracture without displacement – treated by above elbow POP cast. **(B)** Break with separation – treated by screw or tension band wiring. **(C)** Comminuted fracture – treated by excision of the fragments and reattachment of triceps.

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Fig. 4.25. Volkmann's ischaemic contracture (VIC) with typical posture of wrist in flexion, MCP joints in hyperextension and PIP and DIP joints in flexion.

may occur at the ankle and foot and is discussed elsewhere.

This lesion occurs due to temporary occlusion of the arterial circulation to the part.

Signs and symptoms

Within 3 to 4 hours following immobilisation:

1. Severe intractable continuous pain all along the area distal to the site of occlusion. Pain increases in intensity on passive finger extension.

2. The fingers and toes become swollen and discoloured, first pale and then blue, resulting in difficulty in performing movements. Even blisters may appear.

3. Absence of radial pulse.

4. Muscular spasm with hard and woody feeling to touch.

5. Loss of muscle extensibility - giving a feeling of stiffness in the distal joints.

6. Gradual loss of sensory status and motor functions.

If not attended to immediately it may progress to an irreversible typical VIC deformity. The fibrosis of flexor group of muscles leads to flexion deformity at the elbow, wrist, fingers and thumb. The forearm remains in pronation and metacarpo-phalangeal joints in hyperextension. If not noticed even at this stage, increase in the compartmental pressure may cut off the circulation completely leading to gangrene. The median and ulnar nerves may also get involved.

The probable causes are:

(i) Sustained pressure on blood vessels due to tight POP, bandage or splint applied for immobilisation.
(ii) Injury to the brachial artery.
(iii) Latent disease of the vessel.

Preventive measures

1. The most important aspect of prevention is the education of the patient or the parents regarding the expected signs and symptoms of VIC. They must keep a close watch on these and should report to the casualty at the earliest indication. They may themselves remove the cast, bandage or splint, causing pressure, in case they expect delay in reaching the hospital. Ideally, the patient should be properly checked daily for the symptoms of VIC for a week.

2. Thorough examination of the POP splint or bandage to confirm that it is not causing any undue pressure.

3. Check the radial pulse bilaterally, if feasible, to compare and ensure that the radial pulse on the affected side is not weaker as compared to its counterpart.

4. Check the nail bed circulation by applying pressure on the nail beds. The pressure causes whitening of the area pressed but it returns to normal as soon as the pressure is released. It is an alarming sign if it remains white for a longer period indicating that the circulation is slow.

5. Check the motor power and the sensory status of the fingers free from immobilisation.

6. Check the distal free limb joints for the feeling of coldness in comparison to the normal contralateral area.

Treatment (suspected cases)

In case any of these signs appear

1. Immediate removal or discontinuation of pres-

sure causing factors, e.g. splint, POP cast, bandage.

2. Limb elevation and passive as well as active vigorous movements of segments distal and proximal to the affected area.

3. Heat to be applied to the other limbs and the trunk to promote general vasodilation (Adams, 1981).

4. Contrast bath, steam packs, massage and stimulation could be used to augment local circulation and nerve excitation provided the sensory status of the affected area is intact.

Established cases

The prognosis depends upon the degree of permanent damage to the muscle and nerve tissues.

The prognosis is poor if there is total loss of sensation, feeble motor function, stiffness in the joints and fibrosis of the muscles.

However, functionally, useful status can be achieved through constant efforts by the patient and the team of specialised personnel.

The first objective of the management is to stretch the contracted and fibrosed soft tissues on the flexor aspect of the forearm, wrist and hand to the maximum possible extent. This is done by proper stabilisation and carefully graded relaxed passive stretching.

It is equally important to retain the stretch and the elongation of the soft tissues, achieved by relaxed passive stretching, by using a turn-buckle splint.

The therapeutic approach depends upon the type of VIC.

1. Mild type. There is ischemia of the flexor digitorum profundus. It could be managed by exercises and dynamic splinting to maintain finger extension.

2. Moderate type. It involves superficial as well as deep finger flexors, and flexors of the wrist and thumb. If these muscles are still functional, conservative approach of graded splinting and exercises are useful. Muscle lengthening operation may be necessary in non-responding cases.

3. Severe type. Invariably needs surgery as the contractures are progressed beyond the scope of conservative management. However, preoperative passive relaxed stretching and dynamic splinting facilitates surgery.

Serial splinting, as advocated by Sir Robert Jones in three positions or stages, is ideal.

Stage I. The maximum extension is achieved and held at the interphalangeal joints, wrist and MCP joints in full flexion and the fingers are separately splinted.

Fig. 4.26. Corrective dynamic splint for Volkmann's ischaemic contracture.

Stage II. Maintaining extension at the interphalangeal joints, gradual extension is achieved at the metacarpophalangeal joints by a splint extending to the wrist.

Stage III. Maintaining extension at the interphalangeal and metacarpophalangeal joints, graduated extension is achieved at the wrist. Dynamic splint which provides graduated extension at the wrist joint (extending from finger tips to elbow) is incorporated with the previous two splints (Fig. 4.26).

The ultimate aim is to achieve maximum extension at the wrist, which is a functional position. This needs careful fabrication, fitting, use and maintenance of the splint, which is the responsibility of an orthotist and a physiotherapist. The splint has joints at the wrist, metacarpophalangeal and interphalangeal joints that can be easily adjusted at desired angles. For increasing the extensibility of the contracted soft tissues on the flexor aspect, effective adjuncts like massage, ultrasonics and axial traction could be used, besides relaxed passive movements. If the swellling persists, strong voluntary movements with the limb in elevation should be given. As and when the condition improves, exercise programme should be modified to achieve optimal function.

SURGICAL TREATMENT

In severe cases recovery of normal function is impossible. However, the following surgical procedures may be done in selected cases:

(i) Shortening of forearm bones. It is done to overcome the contracture of the flexor group of muscles.

(ii) Muscle sliding operation. The contracted common flexor group of muscles are detached from their origin and are allowed to slide distally. This allows correction of the flexion contractures at the wrist and finger joints.

(iii) Excision of the dead muscles. The necrotic muscle mass is excised and replaced by a healthy muscle obtained from the neighbourhood or from a distant site using microvascular techniques in the latter case.

(iv) Nerve grafting. If the median nerve is damaged beyond repair, nerve grafting may sometimes be helpful.

Physiotherapy management

In all the four surgical procedures the objective of physiotherapy is the re-education of the muscle action. It depends upon the extent of paralysis.

The muscle power, the joint range and the sensory status are assessed preoperatively.

Postoperative management

The most important aspect is to provide a corrective splint, incorporated with immobilisation. This is to maintain the corrected position of the contractures; and assists in movements.

The measures like diapulse, hand elevation and active resistive movements of the related joints are carried out to reduce inflammation and pain.

During mobilisation

The basic therapeutic principles are:

1. Care of the anaesthetic areas,
2. Re-education of the muscle action,
3. Sensory re-education,
4. To improve the functional efficiency and
5. Modifications in the splint to further improve the function.

All these will proceed on the same lines as described for peripheral nerve injuries.

During immobilisation (4-6 weeks)

Routine physiotherapy measures to reduce pain, inflammation and swelling are taken.

During mobilisation

Emphasis is placed on early mobilisation of the elbow joint and strengthening of the elbow and forearm muscles.

Regime of physiotherapy is on the same stages as described for the fractures in the region of the elbow joint.

B. Injury to the peripheral nerves

Median and ulnar nerves may be involved. However, shortening and fibrosis of flexor muscles may lead to ineffectiveness of the muscles supplied by the radial nerve.

If the sensory status is not adversely affected, electrodiagnostic testing should be done to assess the degree of nerve damage. The critical interpretation of these diagnostic procedures forms the basis of the treatment.

Principles of treatment

1. Prevention of contractures

It is achieved best by relaxed passive full range movements which should be self-assisted and taught to be practised slowly with proper proximal stabilisation and low intensity sustained stretching procedures.

Secondly, splints which can maintain constant small stretch should be fabricated. The patient should be taught how to apply and maintain them. Intermittent removal of the splints is necessary.

2. Maintenance of circulation to the denervated muscles

It is achieved by measures like limb elevation, crepe bandage and passive ROM. Thermotherapy and electrical stimulation can be given only if there is no sensory deficit.

3. Strengthening of muscles and movements

There is close interdependant relationship between the conducting power of the peripheral nerve and the strength of the voluntary contraction. Therefore, while planning exercise programme maximum importance needs to be given to this aspect. Meticulously planned and executed strengthening exercises balanced with stretching techniques form most effective aspect of improvement.

4. Concentration of functional movements

Graduated resistive functional movements, as they are performed in the daily routine, need to be stressed. They contribute significantly in improving the strength of the activities and the conducting capacity of the peripheral nerve fibers. In the absence of true recovery such attempted functional movements with correct splints promote the activity by compensatory mechanism. Therefore, care must be taken to encourage such movements only when further chances for the nerve muscle recovery are extremely limited.

C. Malunion

Malunion results in a deformity.

Following conservative management

The deformity is treated conservatively if it is not severe and not causing any pressure on the vital structures like peripheral nerve.

In this situation the job of a physiotherapist is to improve the functional performance, strengthen the muscle power and educate for the better performance of the whole extremity. Functional splint can be given to minimise the effects of deformity.

Following surgical management

The malunited supracondylar fracture of humerus causes either cubitus varus or valgus deformity. The former is more common. This deformity is corrected surgically by performing corrective osteotomy. Postoperatively the limb is immobilised in a POP slab with flexion at the elbow for a period of 4-6 weeks. The elbow is then mobilised.

D. Myositis ossificans (Fig. 4.27)

This is the commonest and yet the most difficult complication of the injuries around the elbow joint.

Fig. 4.27. Myositis ossificans.

Considering the degree of disability it causes, maximum efforts should be made towards its prevention.

Preventive measures

1. Fixation of a fracture in proper alignment.
2. Proper immobilisation of the elbow joint following injury. Discourage early passive mobilisation of the elbow, so that the haematoma around the joint is allowed to get absorbed rather than to dissipate into the surrounding muscles and get ossified.
3. Signs and symptoms like local oedema, tenderness, pain and decrease in mobility should be watched carefully. If any of these is present, rest with total immobilisation is a must for 14 to 21 days.
4. Early vigorous movements, massage and passive movements should be strictly avoided. These are reported to be the causative factors of myositis ossificans.

In suspected cases. Rest with immobilisation has to be continued further. Regular check up of ROM and X-rays is done till the ossification progresses to the 3rd and the final stage of dense shruken mass.

In confirmed cases. Once the progress is arrested, vigorous exercise programme including graduated, sustained but gentle passive stretching could be started to regain maximum possible ROM.

The patient needs to be educated and guided on the process of these exercises to make the home treatment programme effective.

Vigorous active exercises by using aids like roller skates help in improving the mobility in the available ROM, which is required in functions of daily routine.

Myositis ossificans (surgical treatment)

Surgery is rarely indicated in myositis ossificans. Surgical excision of the myositis mass is undertaken only after the radiological evidence of its consolidation. It may take 6-9 months for the myositis mass to consolidate. Since there is a high incidence of recurrence following surgery, the role of surgery is controversial. It is done only if the elbow is ankylosed in a functionally unacceptable position.

Postoperatively the limb is immobilised in a plaster slab for a period of one week, following which movements are started.

Physiotherapy management

The basic objective of physiotherapy is to restore maximal ROM and strength at elbow.

During immobilisation

1. To control pain and inflammation, diapulse can be effective.
2. Resistive full ROM to shoulder and hand.
3. Light isometrics to muscle groups around elbow.

Mobilisation (2-3 weeks)

After removal of the slab, gradual mobilisation to be started.

1. It should be started as an assisted active free movement by using roller skates, sling suspension or hydrotherapy.
2. Carefully monitored relaxed passive movements can be started avoiding passive stretch.
3. Accurate measurement of ROM at regular intervals.
4. Gentle isometrics to the flexors as well as extensors.
5. Gravity assisted elbow flexion and extension to be started on the knee rachet maintaining low intensity long-gentle stretch for further increase in the ROM.
6. Free self-assisted forearm pronation and supination to be initiated by placing forearms on the thighs.
7. It is important to maintain the ROM of flexion by adjusting the angle of the sling.
8. Gentle stretching sessions may be preceded by superficial heating procedures like hydro-packs.

After 3 weeks

If inflammation, swelling as well as pain have reduced, the methods of mobilisation and stress are made progressive. Range of forearm rotation should be full by this time.

Vigorous active free movements are encouraged by using skates. They can be made resistive by putting weight (e.g. sand bag) over the roller skates and performing them slowly.

By 6 weeks good functional range and strength should be regained.

But, on many occasions a stiff or flail elbow may be encountered. The former may be considered for manipulation under general anaesthesia and intensive muscle strengthening procedures for the latter.

SIDE-SWIPE INJURY OF THE ELBOW

This injury results when the flexed elbow, sticking out of a car or bus window, is hit by another passing vehicle. It is often an open injury and consists of fractures of lower end of humerus, upper end of ulna and radius with anterior dislocation of the elbow (Fig. 4.28).

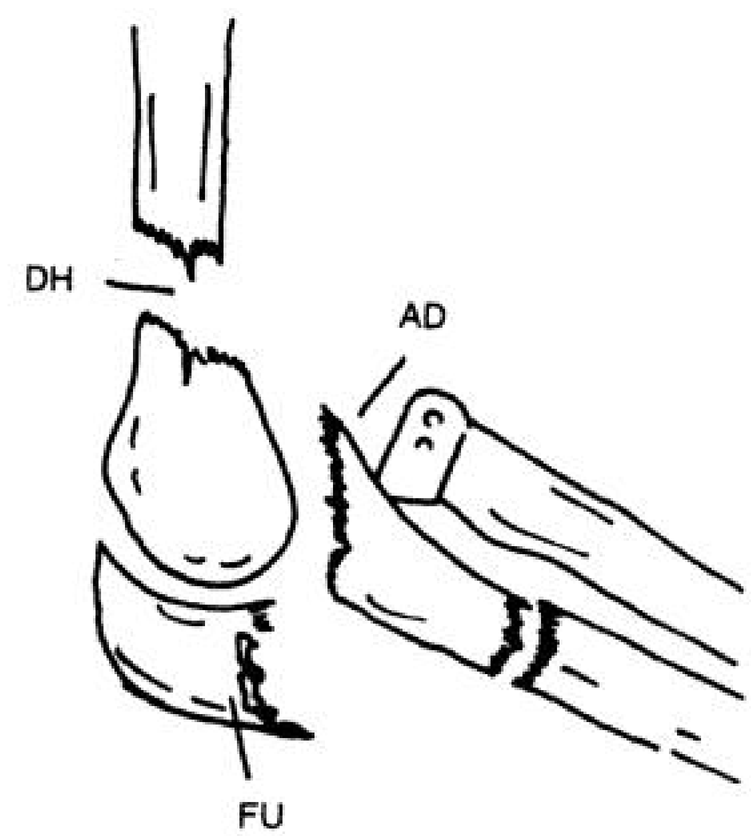

Fig. 4.28. Side swipe injury to the elbow.
DH: Fracture distal end of humerus, FU: Fracture upper end of ulna, AD: Anterior dislocation of elbow.

Treatment

It is a difficult injury to treat. The problems are many: open wound, dislocation of elbow and multiple fractures. Treatment of dislocation gets priority over the treatment of fractures. The modern trend is to immobilise the limb in an external fixator for a period of 6-8 weeks

Results. The results are poor as stiffness invariably results.

Physiotherapy management

Basic objective. To regain maximum functional range movements of elbow and hand.

As the extent of damage and the management of this injury is complex, the results are poor as regards the range of motion.

Physiotherapy treatment is same as for posterior dislocation of elbow. In spite of the poor prognosis, efforts should be made to regain maximum possible range of movements.

Encouragement is given to early functional use of the elbow and forearm rather than repeatedly attempting for the anatomically correct groove of movement.

If the affected limb is non-dominant, return of rotation movements of forearm gives the patient an acceptable functional range as the stability of the elbow is not a problem. Therefore, whenever it is not possible to regain functional range of elbow flexion-extension, efforts are concentrated to improve the range of pronation and supination. Strengthening of the wrist and fingers, shoulder and forearm should be initiated from the initial phase of treatment to provide maximum compensation for the stiff elbow joint.

FRACTURES OF RADIUS AND ULNA
(Fig. 4.29 A–D)

Fractures of the shaft of both the forearm bones (radius and ulna) are seen at all ages. A direct injury results in a transverse fracture which may be an open fracture. An indirect injury, e.g. fall on the outstretched hand, causes oblique or spiral fractures. Fractures in children are usually of green-stick variety.

Treatment

The treatment of these fractures can be conservative or operative.

(a) Conservative treatment

An undisplaced fracture does not need manipulation. For displaced fractures closed manipulation under anaesthesia is carried out. In children, closed reduction alone is often successful. While in adults an attempt is always made to reduce the fracture by closed manipulation. If the reduction is unsatisfactory, open reduction becomes necessary.

After reduction, the limb is immobilised in an above elbow plaster cast with the elbow in flexion. Some surgeons prefer to keep the forearm in supination for the upper 1/3 fractures, in midprone position for mid 1/3 fractures and in full pronation for the lower third fractures. While others prefer to immobilise in mid-prone position only to facilitate the functional performance in the event of stiffness. The plaster is maintained for 3 to 6 weeks in children and 8-10 weeks in adults.

(b) Operative treatment

It is indicated where closed manipulation has failed or a good initial reduction has been lost subsequently in plaster. The bone fragments get displaced because the swelling subsides after some time and the plaster becomes loose.

Operative treatment is also carried out in fresh open fractures. Stabilisation of these fractures by external fixators facilitates wound care.

The commonly used method of internal fixation is by plates and screws (Fig. 4.29F). Another method of internal fixation by intramedullary nails (Fig. 4.29E) and pins is also employed occasionally.

After internal fixation, the limb is immobilised in an above elbow plaster cast for a period of 4-6 weeks, with the elbow in flexion and the forearm in mid-prone position.

Complications

1. Non-union. When the fracture fails to unite, open reduction and internal fixation along with bone grafting is indicated. Postoperatively an above elbow plaster cast is maintained for a period of 6-8 weeks.

2. Malunion. Angulatory deformity of forearm results when the fracture unites in a malposition. It not only results in an ugly deformity but also leads to restriction of rotation of the forearm.

If the angulation/deformity is severe, surgical cor-

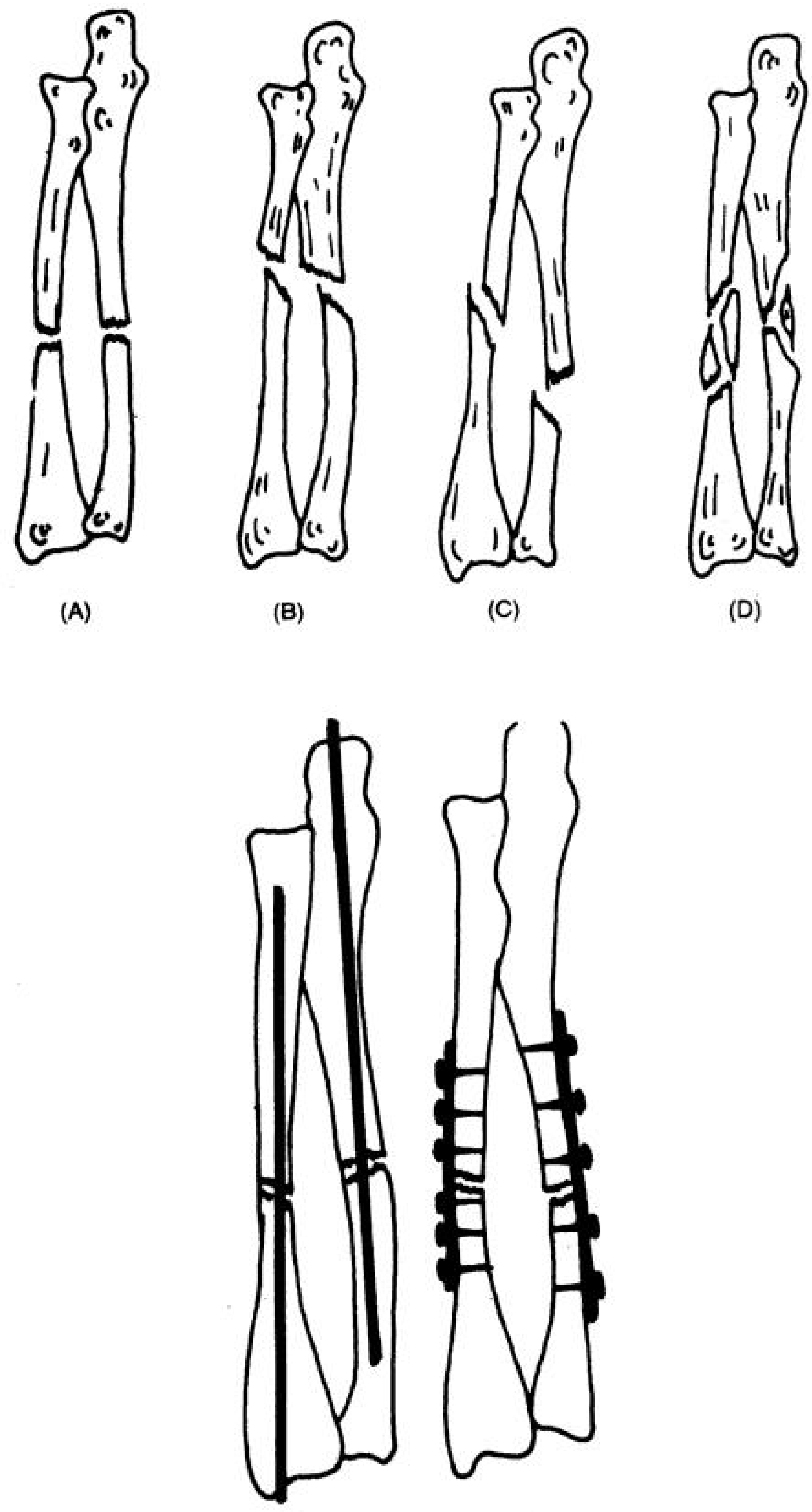

Fig. 4.29. Fractures of both bones of forearm.
(A) Transverse. **(B)** Oblique. **(C)** Spiral. **(D)** Comminuted; treatment by internal fixation. **(E)** Intramedullary nail.
(F) Plates and screws.

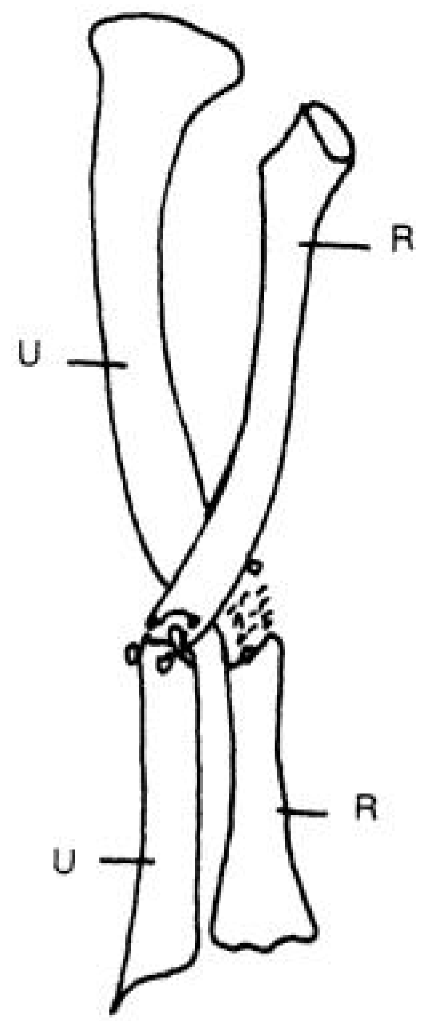

Fig. 4.30. Cross-union of radius and ulna.
Ulna (U) unites with radius (R) when the fracture occurs at the same level in both these bones.

rection of the deformity with internal fixation and bone grafting is undertaken. The period of immobilisation after surgery is 6-8 weeks.

3. Cross union. When the fractures of radius and ulna are at the same level, the chances of cross union, due to fibrous or bony bridging (Fig. 4.30) are high. Cross union causes restriction of pronation and supination of the forearm. In such fractures the forearm is preferably immobilised in mid-prone position. Should cross union occur, the forearm would still be in a functional position.

Physiotherapy management

Fractures treated by conservative approach

During immobilisation (first 3-6 weeks in children and 8-10 weeks in adults)

Initially all the measures to control the process of inflammation are adopted.

As soon as the fracture is reduced and the patient is in a position to do exercises, active full range strong movements should be initiated to the muscles and joints which are not immobilised (e.g. shoulder, fingers and thumb). Shoulder movements to be emphasised to full range, especially in adult patients to avoid secondary stiffness and pain and to improve circulation to the whole limb. At the outset, the physiotherapist must check that a full range of passive flexion at the MP joints is possible and that the plaster is not hindering the terminal range of flexion at these joints. While encouraging and emphasising the movements of digits to improve circulation and edema, the movements should be fast, strong and forceful to dissipate the lymphatic fluid effectively (Basley, 1981). Somehow the tendency is to be gentle and to accept the patient's reluctance.

The patient should be taught to do isometrics for elbow flexors and extensors while the limb is in the cast.

Mobilisation (after 3-6 weeks in children and 8-10 weeks in adults)

Vigorous active relaxed movements of elbow and wrist should be initiated. One has to be careful in initiating and emphasising the movements of pronation and supination. It is carried out as relaxed free movements with the forearm fully supported over the thigh with the patient in sitting position (Fig. 4.14). As the pain becomes less, self-assisted stretching by the contralateral hand should be started (Fig. 4.31).

The patient is made to sit on a stool with his back against a wall. The elbow is kept at 90 degrees with its posterior aspect touching the wall. The active relaxed stretching of pronation and supination are facilitated by holding a wand. Supination and pronation combined with relaxed active elbow flexion and extension respectively facilitates early return of these movements. We have found this method very effective.

Gradual progression may be made to full range resistive pronation and supination.

Children generally get full function within 8 to 10 weeks, while adults require 14-16 weeks and yet may not get full range of rotation. However, functionally adequate range is usually regained.

Fractures treated surgically

In the fractures treated by external fixators or by internal fixation, the period of immobilisation is usually short (4-6 weeks). Moreover, the stability of the fracture is assured. These two factors contribute towards

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Full ROM is regained within 8-12 weeks.

FRACTURE AND DISLOCATION OF FOREARM

There are two types of injuries where fracture of one forearm bone is associated with dislocation of the radio ulnar joint. These injuries are:

1. Monteggia fracture

In this injury fracture of the upper half of ulna is associated with anterior dislocation of the radial head (Fig. 4.32).

Treatment. In children the fracture dislocation is reduced by closed manipulation. Immobilisation is carried out in an above elbow plaster cast with the elbow in flexion and forearm in supination for a period of 4-6 weeks.

In adults, in fresh cases closed manipulation is often successful. Late reported cases may need internal fixation of ulna and excision of the head of radius. The results are not good in the latter.

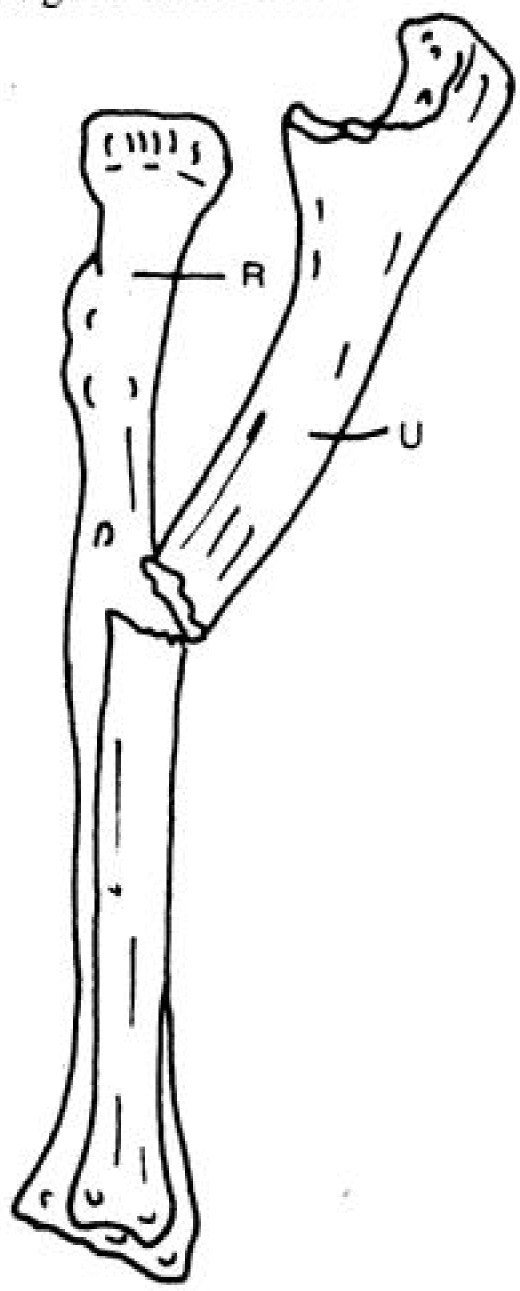

Fig. 4.32. Monteggia fracture.
Fracture of the upper half of ulna (U) with dislocation of the head of radius (R).

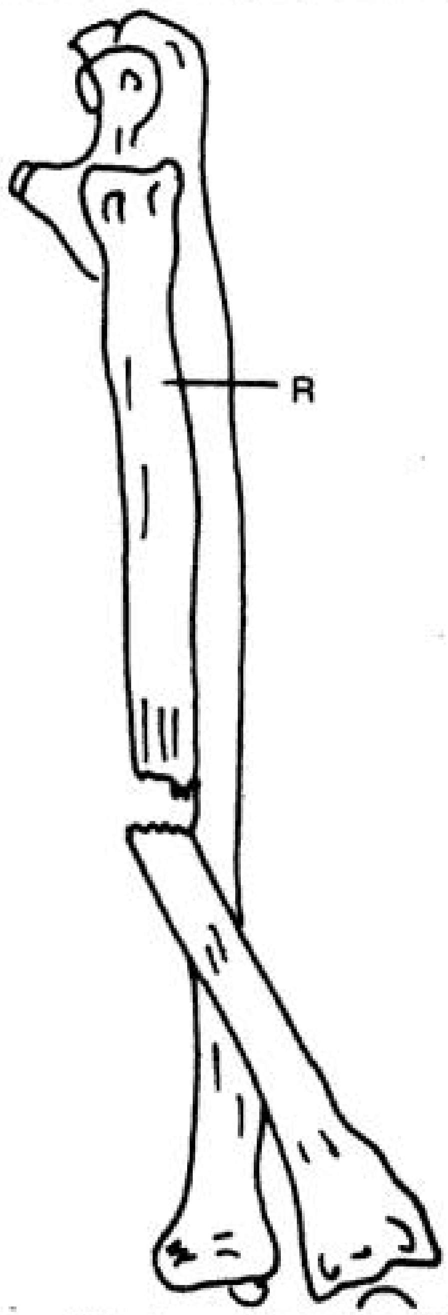

Fig. 4.33. Galeazzi fracture. Fracture of the lower half of radius (R) with dislocation of the inferior radio-ulnar joint.

Physiotherapy management

(a) Treated conservatively. In children the physiotherapy management does not pose any problems and full function is possible in 8-10 weeks with simple guidance on elbow and forearm movements.

In adults, initial measures are taken to control inflammation, pain and swellling. Strong and full range movements, especially to the metacarpophalangeal joints, need to be emphasised.

After removal of the plaster cast vigorous exercise programme for elbow flexion-extension and forearm pronation- supination has to be concentrated and progressed as outlined earlier for the fractures of both bones. The only difference being the persistence of elbow stiffness for a long period due to anterior dislocation of the radial head.

(b) Treated surgically. The physiotherapy management basically follows the same stages as outlined for conservatively treated monteggia fractures.

If reduction of the head of radius is achieved and maintained then the results are good and effectively functional range can be achieved by 8 to 12 weeks. However, in late reported cases even after surgical procedures, the results are unpredicted as regards ROM.

2. Galeazzi fracture

Fracture of lower third of the radial shaft is associated with dislocation of the inferior radio-ulnar joint (Fig. 4.33).

Treatment. Closed reduction of the fracture rarely succeeds or even after a good reduction the fragments get redisplaced after a week or two in the plaster. The treatment of choice, therefore, is open reduction and internal fixation of the fracture. Postoperatively an above elbow plaster cast is given for 4-6 weeks.

Physiotherapy management. It proceeds almost on the same lines as described for monteggia fracture.

It differs from monteggia fracture in that the injury is away from the elbow joint and as such return of the range of elbow joint movement is faster and better. But dislocation of the inferior radio-ulnar joint delays the return of pronation and supination of forearm. Therefore, these movements need special emphasis. Acceptable range of pronation and supination as well as wrist flexion-extension can be achieved by 8-12 weeks in almost all the patients.

COLLES' FRACTURE

Fracture of the lower end of radius within one inch of the distal articular surface of radius is called as Colles' fracture. This fracture occurs at the cortico-cancellous junction of the bone and hence it almost always unites. It is the commonest fracture seen in the middle aged and elderly women following a fall on the outstretched hand with the wrist in an extended position. Amongst the important displacements in this fracture, the distal fragment is displaced and tilted dorsally (Fig. 4.34). The fragment is also deviated radially.

Treatment

Closed manipulation under anaesthesia followed by below elbow plaster cast for 4-6 weeks is the treatment of choice. To maintain proper reduction of the fracture the wrist is immobilised in a plaster in a position of flexion and ulnar deviation.

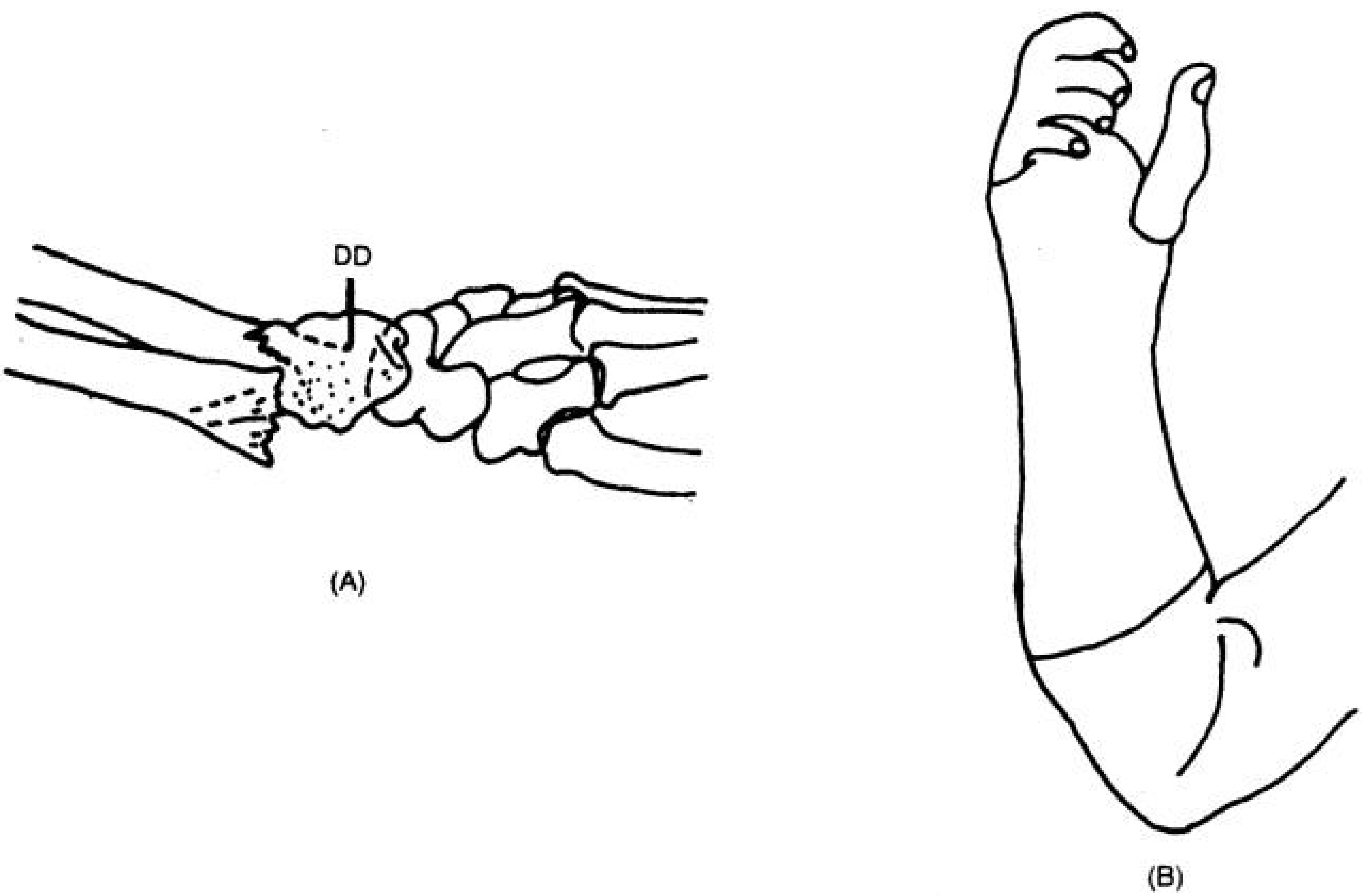

Fig. 4.34. Colles' fracture. **(A)** Extra-articular fracture with common dorsal displacement (DD) of the distal fragment. **(B)** Immobilisation in a below elbow POP cast.

Complications

1. Stiffness. Stiffness of the fingers and shoulder are the most common avoidable complications of Colles' fracture.

2. Malunion. It is quite common in the event of total neglect of the injury or by seeking the advice of unqualified quacks. It may also result if the reduction had been inadequate or had slipped inside the plaster. Severe comminution causes collapse of the multiple bony fragments leading to malunion.

3. Sudecks' osteodystrophy. It is characterised by pain and stiffness in the wrist and fingers, red shiny skin and osteoporosis of the bones of wrist and hand. The main problem is the stiffness of finger joints, pain and oedema of the hand. The treatment consists of maintaining the finger joint mobility despite the pain.

4. Carpal tunnel compression. The median nerve may get compressed in the carpal tunnel following a Colles' fracture. Though rarely, early decompression of the carpal tunnel is indicated for better results.

5. Rupture of the extensor pollicis longus tendon. The tendon of extensor pollicis longus may get ruptured rarely by attrition over the rough area at the site of fracture. The treatment is repair of the tendon or extensor indicis tendon transfer.

6. Non-union. It is extremely rare.

Physiotherapy management

Giving due importance to the high incidence of the injury and also the complications, the management programme needs extra attention and proper guidance.

During immobilisation

After reduction and immobilisation proper guidance is needed to reduce edema by:

(a) Elevation of hand above the elbow, and elbow above the shoulder (Boyes, 1964).

(b) Alons in his monogram advocates the use of electrical stimulation on a sensory excitation level. He proposes that electrical field created in the tissues may trigger the lymphatic system to absorb excessive fluid.

(c) Sorenson (1983) advocates the use of pulsed galvanic stimulation to reduce edema. His technique is to place the negative pole over the edematous area, and the positive pole at a proximal point usually over median or ulnar nerve distribution on the upper arm, to stimulate good muscle pump action.

(d) Jobst (1983) devised intermittent pressure glove to reduce swelling in the exposed fingers and thumb. The pressure should be at a point that is well tolerated, not more than 66-70 mm Hg. This is usually done for 45 minutes to 1 hour.

(e) String wrapping technique to the individual finger as well as to the exposed metacarpal volar pads also helps in reducing edema. Objective circumferential measurements before and after treatment will determine the success of the technique.

(f) Checking the plaster cast to see that it is not hampering the full range of metacarpophalangeal joints of the fingers and thumb.

(g) Full range passive as well as strong forceful active movements of fingers effectively drain the excess lymphatic fluid from digits in the hand (Basely, 1981).

(h) Full excursion of all the movements at the elbow as well as shoulder.

(i) Intermittent use of sling with elbow in at least 70 degrees of flexion, as it maintains elevated position of the hand.

(j) Adjuncts like moist hot pack, infra-red, warm soaks, cryotherapy with ice massage and TENS could also be used.

All these procedures are helpful in improving circulation and decreasing pain and edema. They also alter elasticity of the tissues and viscosity of the synovial fluid. This further helps in preventing joint stiffness besides augmenting the process of bone healing.

On removing plaster (3-6 weeks)

If earlier programme is carried out effectively, the only job now remains is to concentrate on the wrist and forearm movements.

A soothing heat by using hydrocollator pack or paraffin wax bath induces relaxation, improves local circulation and puts wrist and forearm in an ideal situation for exercises.

Wrist mobilisation is initiated with small range of relaxed speedy flexion-extension with forearm in mid

Fig. 4.35. Relaxed free active wrist mobilisation.

prone. The patient is taught to stabilise the forearm just above the wrist joint. This eliminates the force of gravity during flexion and extension at the wrist (Fig. 4.35).

As the wrist is immobilised in ulnar deviation, the movement of radial deviation needs to be emphasised in the initial stages.

To initiate pronation and supination the exercise described on the lap is ideal.

If swelling and pain persist even after a session of exercise, use of an intermittent sling may be necessary.

After 1 week of discontinuing the immobilisation, the exercise regime should be made vigorous to regain further range of motion at the wrist and forearm. Variety of exercises using various aids like wand, etc. can be given. However, a simple but effective regime, which can be done without aids, is as follows:

1. Exercises to improve flexion-extension at the wrist. The patient, sitting with palm over the edge of table, stabilises hand by putting palm of the other hand

(A)

(B)

(C)

Fig. 4.36. **(A)** Self-assisted passive stretching with palm over the edge of a table. **(B)** and **(C)** Self-assisted wrist flexion and extension.

over it. The patient then gradually lowers the forearm downwards for wrist flexion or upwards to improve wrist extension. Initially the relaxed speedy movements are done in a small range and then slow stretch is applied to improve the range further (Fig. 4.36).

2. *Exercise to improve pronation and supination.* Wand or the good hand can be used (as described for fracture of both bones of forearm).

As the range improves, the movements can be made strong by teaching isometric as well as isotonic self-resistive exercises or using weights. Very often passive range exceeds the active range of motion, where adhesions of the tendons or weakness of the muscles is predominant. Former needs measures like ultrasound, friction massage or dynamic stretching splints and the latter needs resistive exercises.

Functional use of the whole upper extremity and especially the forearm, wrist and hand has to be encouraged and progressed right from the initial stage.

The results are good by 8-10 weeks. However, if palmar angulation of the articular surface is not achieved perfectly, there is a bony obstruction to the range of flexion. These patients have limitation of palmar flexion. The patients who are too sensitive to pain and do not allow the terminal stretching of rotation usually have lack of full range of pronation and supination.

In the majority of patients adequate amount of motion and strength are possible. Riggs and Conney (1982) used external fixator on 23 patients and achieved the following average range of motion, ten months after the treatment: 48 degrees of wrist flexion, 47 degrees of wrist extension, 26 degrees of ulnar deviation, 11 degrees of radial deviation, 67 degrees of supination, 62 degrees of pronation and grip strength of 60% of the non-injured hand.

Management of complications

1. Stiffness of fingers and shoulder

This is an avoidable complication if the patient is referred for physiotherapy guidance on the second or third day after plaster application. The best way is to demonstrate to the patient full range movements on the normal side. The patient should then be made to practise them on the fractured side under supervision of the attending physiotherapist.

2. Malunion

As the union has already taken place the physiotherapist can attempt to seek further improvement of the range of motion by using the technique of relaxed sustained stretch.

If it fails, compensatory trick movements by manoeuvring shoulder movement of abduction and adduction to facilitate apparent pronation and supination respectively remain the only alternative.

3. Sudeck's osteodystrophy

When present, physiotherapy is directed to relieve pain, edema and to check further development of stiffness at the wrist, fingers and thumb. Proper positioning of the limb with frequent elevation and a modality like ultrasound or TENS can be used as an adjunct to reduce edema and pain. However, major emphasis has to be on the range of motion by active exercises. Maximum possible use of these joints should be promoted by encouraging functional movements of daily routine.

As the process of recovery is extremely slow in the majority of patients, proper education on the home treatment programme is important. The development of flexion deformities of the fingers should be checked by teaching self-stretching exercises. This is done by teaching the patient to keep the hand on the table with the palmar surface in contact with the top of the table. Then the patient gradually puts the normal hand over the dorsum of the affected hand and exerts gradual pressure. This can be made effective by putting small sand bag to maintain sustained stretch or by using a splint.

Residual flexion deformity of the metacarpophalangeal and interphalangeal joints of fingers may persist even after prolonged physiotherapy. The functional status of hand can be greatly facilitated by early control of pain and the use of hand in day-to-day activities.

In some patients the full functional recovery of the hand may take up to three years.

4. Carpal tunnel syndrome (discussed elsewhere)

5. Rupture of the extensor pollicis longus tendon

Early detection of this complication and surgical repair are essential for obtaining good results.

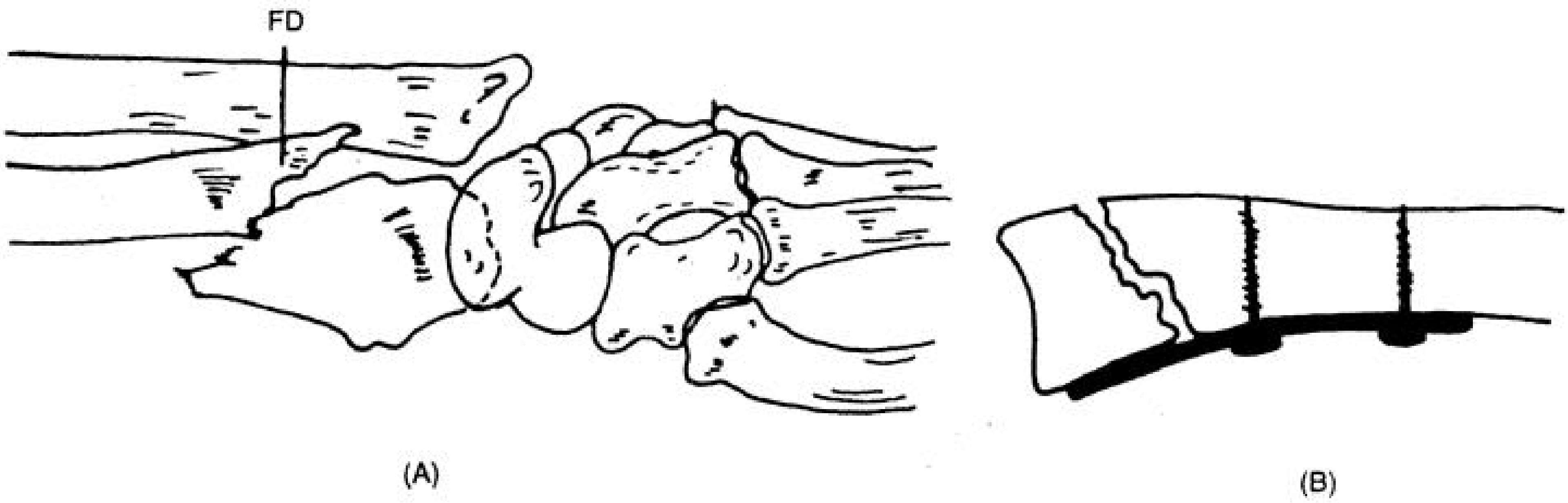

Fig. 4.37. Smith's fracture.
(A) Forward displacement (FD) of the distal fragment. **(B)** Internal fixation with buttress plate and screws.

After surgical repair of the tendon, measures for control of pain and swelling are instituted. The emphasis should be on (i) mobilisation of the interphalangeal joint of the thumb and (ii) re-education of the repaired tendon to effectively flex and extend the thumb at the interphalangeal joint. Graduated self-resistive exercise with proper stabilisation of the thumb proximal to the interphalangeal joint further improves ROM and strength at the interphalangeal joint.

SMITH'S FRACTURE (Fig. 4.37A)

It is a reverse Colles' fracture.

Treatment

Closed manipulation under anaesthesia followed by an above elbow plaster cast for 4-6 weeks with elbow in flexion and forearm in full supination. Open reduction and internal fixation by buttress plate and screws may be necessary if closed reduction fails (Fig. 4.37B).

BARTON'S FRACTURE

It is an intra-articular fracture of the lower end of radius. The fracture line is placed obliquely, separating either a large volar fragment (Volar Barton fracture) or a dorsal fragment (Dorsal Barton fracture) (Fig. 4.38).

Treatment

(i) Closed manipulation under anaesthesia, followed by an above elbow plaster cast for 4-6 weeks.
(ii) Open reduction and internal fixation is indicated if the closed reduction fails or the reduction is lost in the plaster as it is prone to redisplacement.

Physiotherapy management

Physiotherapy for the Smith's fracture and the Barton's fracture on the whole follows the same pattern as described for the Colles' fracture.

FRACTURE OF THE SCAPHOID

Fracture of the scaphoid is the commonest amongst all the carpal bones. It is seen in adults following a fall on the outstretched hand. The bone may be fractured at

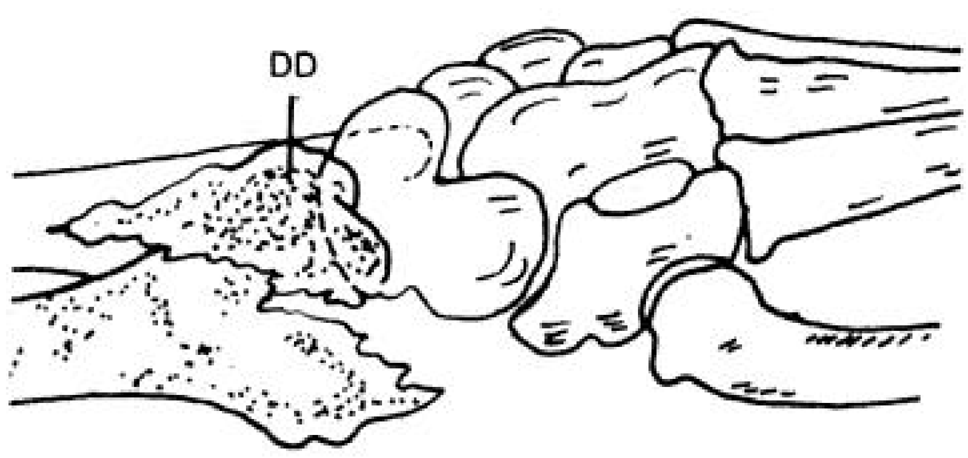

Fig. 4.38. Barton's fracture.
Intra-articular fracture with dorsal displacement of the distal fragment (DD).

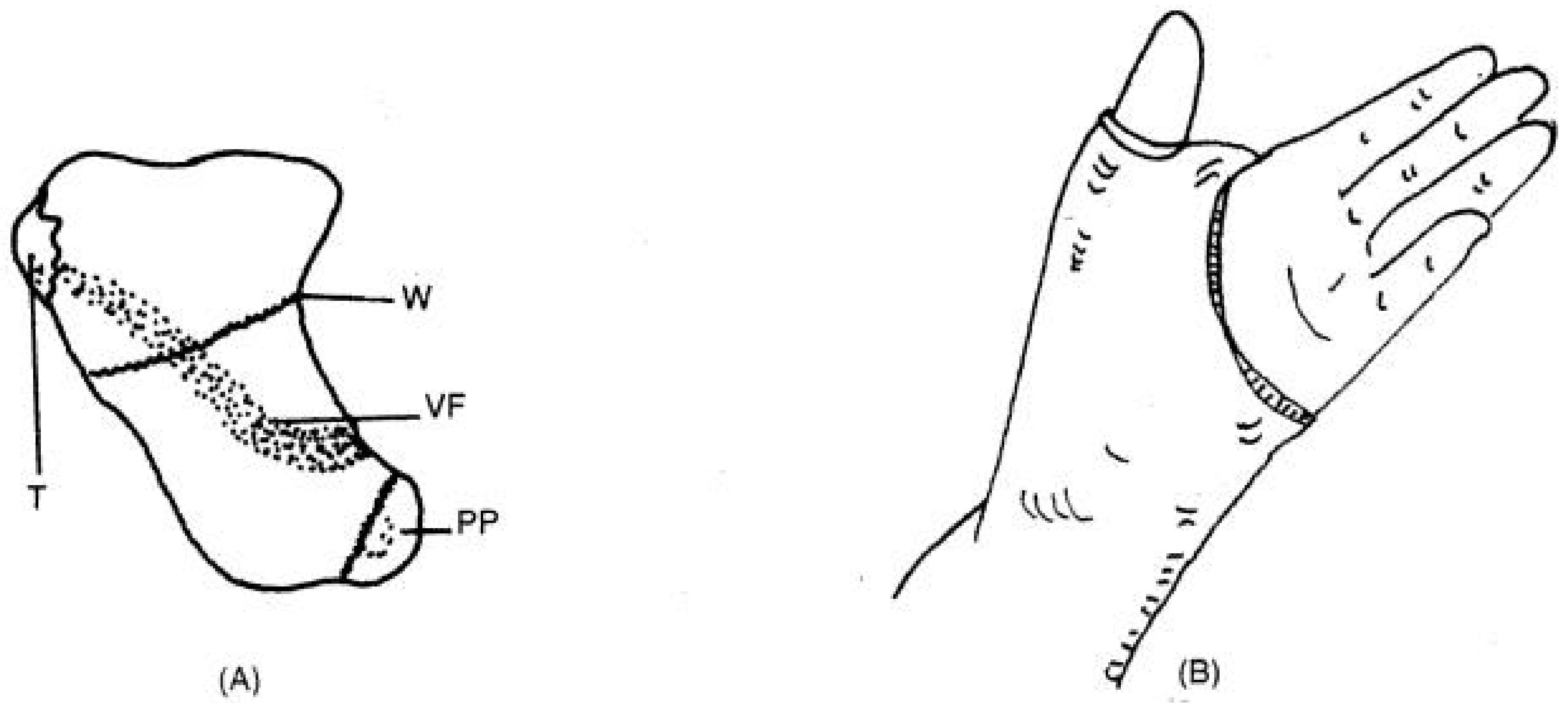

Fig. 4.39. Fracture scaphoid. **(A)** Common sites of fracture. T: Tubercle, W: Waist, PP: Proximal pole, VF: Vascular foramina. **(B)** Immobilisation by a scaphoid POP cast gripping the first metacarpal and the proximal segment of thumb.

any of the three anatomical sites (Fig. 4.39)—the distal pole (the tubercle), the middle (the waist) or the proximal pole. Fracture through the waist is the commonest of the three. Union is generally not a problem in the fractures of the distal pole. The blood supply to the proximal fragment may be cut off in fractures of the waist and the proximal pole. Non-union of the fracture and avascular necrosis of the proximal fragment, therefore, result in the latter variety of fractures of the scaphoid.

Treatment

Manipulation is rarely necessary as the fracture fragments are undisplaced or minimally displaced. A scaphoid plaster cast is applied with the wrist in slight dorsiflexion and radial deviation. The thumb is held away from the palm in "glass holding" position. The thumb is incorporated in the plaster up to the base of the nail while the finger knuckles are kept free (Fig. 4.39B).

In fractures of the distal pole the plaster is maintained for a period of 3 weeks whereas for the fractures of the waist and the proximal pole, the limb is immobilised for a period of 8-12 weeks.

Complications

1. Non-union. Bone grafting is always indicated in cases of established non-union of fracture scaphoid. Internal fixation of the fracture by means of the screw may also be done. Plaster immobilisation is necessary for 2-3 months after bone grafting.

Excision of the proximal fragment of the scaphoid is an alternative method of treating an ununited fracture and it gives good results.

2. *Avascular necrosis.* In the fractures of the waist and the proximal pole of scaphoid the blood supply to the proximal fragment may be cut off resulting in avascular necrosis of the proximal fragment. In such cases excision of the proximal fragment and radial styloid gives good results. The wrist is immobilised for a week after the surgery.

3. *Osteoarthritis of the wrist.* Osteoarthritis of the wrist may develop in later years following avascular necrosis and/or non-union of the fracture scaphoid.

One of the following surgical procedures may be done to relieve pain:

(i) Excision of the proximal fragment and radial styloid.
(ii) Wrist arthrodesis. The limb is immobilised in a below elbow plaster cast for 3 months with the wrist in slight dorsiflexion and the knuckles free.

Physiotherapy management

During the initial period of immobilisation, vigorous movements of the shoulder, elbow, forearm, metcarpophalangeal and interphalangeal joints should be encouraged and checked.

Resistive movements to the fingers and elbow are necessary to augment the circulation at the fracture site.

After removal of the plaster

Fractures of the distal pole of the scaphoid are easy to treat and do not need specific physiotherapy as the period of immobilisation is only 3 weeks.

Fractures at the waist and the proximal pole require longer immobilisation. These fractures are difficult to unite in spite of the longer period of immobilisation, due to the lack of blood supply.

Heavy resistive exercises to the free joints are, therefore, specially important in these fractures.

Immediately after removal of the cast, reduction of pain assumes priority and modalities like ultrasound, TENS, hot pack, etc. may be employed.

Active mobilisation of the thumb should be started immediately. Power grasp should be avoided as it may put extra stress and may increase the pain.

Relaxed passive mobilisation to be initiated and resistance to be added as early as permissible since the stiffness may set in due to the long period of immobilisation.

Protective splint to immobilise the thumb may be necessary if the wrist remains weak (Basley, 1981). Within 1 to 5 weeks following removal of the cast, full and strong movements should return to the wrist (Taleisnic, 1982).

Carefully controlled physiotherapy may succeed in achieving good and strong hand function. In that case, surgical intervention may not be necessary even in the presence of non-union, avascular necrosis or osteoarthritis of the wrist.

Non-invasive pulse electro-magnetic field (PEMF) can be used effectively to deal with non-unions or delayed unions. It modifies the cell behaviour by inducing weak electrical currents. It vascularises and calcifies the fibrocartilage which is replaced with bone. It has been found to be highly successful in 84 percent cases of non-union (Bassett et al., 1982).

When excision of the proximal fragment and radial styloid is performed, acceptable functional results can be achieved with routine physiotherapy in 6 weeks.

In the event of wrist arthrodesis, besides other physiotherapy procedures, special attention is necessary to re-educate and guide the patient about the use of hand with ankylosed wrist joint. ADL training assumes an important role in the management.

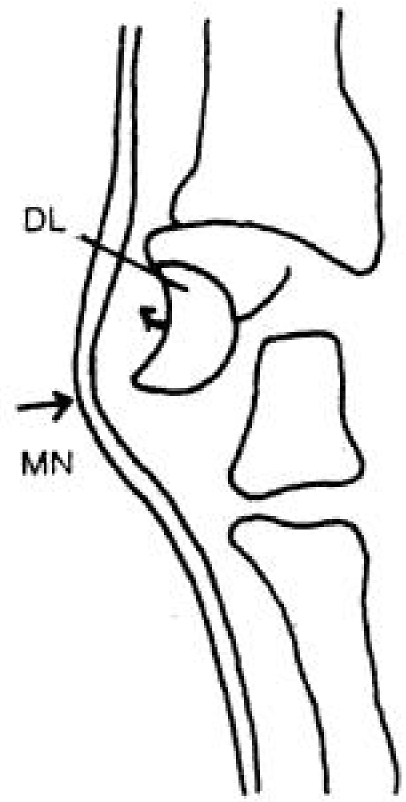

Fig. 4.40. Dislocation of lunate (DL) may cause injury to median nerve (MN).

INJURIES OF THE LUNATE

Fracture of the lunate is oftern missed on X-rays, if not looked for carefully.

The lunate may be fractured through its body, following a fall on the extended hand. Occasionally, there may be dislocation of the lunate from its bed resulting in a rather complicated injury (Fig. 4.40).

Conservative treatment

The fracture of the lunate is immobilised in a below elbow plaster cast for about 3 weeks.

Dislocation of lunate needs reduction under anaesthesia, followed by immobilisation in a below elbow plaster cast for about 3 to 4 weeks.

Surgical treatment

A large variety of treatment procedures have been described, a discussion of which is beyond the scope of this book. However, fusion (arthrodesis) of the wrist is indicated in cases having severe osteoarthritis and instability of the wrist.

Complications

Avascular necrosis of the lunate (Kienbock's disease)

The blood supply to the lunate may occasionally be cut off following an injury (fracture or dislocation) resulting in Kienbock's disease which is characterised by sclerosis and collapse of the lunate.

The patient complains of pain in wrist and instability. Osteoarthritis of wrist may set in after a few years.

Physiotherapy management

(a) In conservatively managed patients

During immobilisation (3-4 weeks)

The period of immobilisation is longer. Therefore all the precautions should be taken to maintain the strength and full ROM of all the uninvolved joints of the fractured limb.

Special efforts to guide positioning of the limb and supervised vigorous and slow stretched finger movements to be carried out as often as possible.

Median nerve paraesthesia due to compression or injury to the median nerve may be encountered occasionally and should be checked repeatedly.

Mobilisation (after 4 weeks)

As there is every possibility of articular and ligamentous damage there is significant limitation and pain at the wrist joint. Reduction of pain and relaxation of the stiff wrist joint needs early attention. Modalities like PWB and HP may be used before initiating mobilisation.

Mobilisation following relaxation should be started in the gravity eliminated position as described for the Colles' fracture.

Progressive resistive exercises should be started using low weight dumbells.

The patient's forearm is placed on a table in a position of supination or pronation with the wrist and hand hanging over the table. He holds dumbell in his hand while the physiotherapist stabilises the forearm just proximal to the wrist joint. The weight of the dumbell and the force of gravity will offer stretch to the wrist joint to improve mobility, whereas active movement with dumbell against gravity will provide strengthening.

Hand functional activities emphasising wrist extension movements play an important role along with strong gripping finger actions.

Generally acceptable results could be achieved within 8 weeks. However, return to heavy labour may take 6 months or longer (Green, 1982).

In surgically managed patients

The line of treatment remains the same, only deep heating modality like ultrasound or friction massage for the surgical scar may be necessary to control pain and adhesions. The pulsed electromagnetic field (PEMF) could be used to a great advantage.

FRACTURE OF METACARPALS (Fig. 4.41A)

Fractures of the metacarpals are caused by direct injuries to the hand or due to fall of heavy object on the hand. Fractures of multiple metacarpals and open fractures (due to machine injuries) are common.

Treatment

Conservative treatment is the treatment of choice for undisplaced or minimally displaced fractures. A below elbow POP slab is given for 3 weeks after which the hand is mobilised. Fracture through the neck with forward tilting needs reduction and immobilisation by aluminium strip in flexion (Fig. 4.41B).

Severely displaced fractures are fixed internally by Kirschner wires (Fig 4.41C1). Postoperatively a below elbow POP slab is maintained for about 10 days before mobilisation is begun. Oblique fracture of the shaft of middle or ring finger needs reduction and internal fixation by a wire (Fig. 4.41C2).

Physiotherapy management

The basic objective is to provide functional painless ROM of the fingers.

During immobilisation (2 to 3 weeks)

1. It is important to control edema of the hand to prevent extensor tendon adhesions and future deformity. Compression dressing, elevation, pulsed galvanic stimulation, massage (milking massage), electrical stimulation on a sensory excitation level and nylon and string wrapping are some of the effective measures.

2. Check the position of the fractured finger frequently for any rotational or angulation deformity, especially in cases of fourth or fifth metacarpal fractures. Protective splint is applied to avoid retraction of the collateral ligaments which may cause extension contracture.

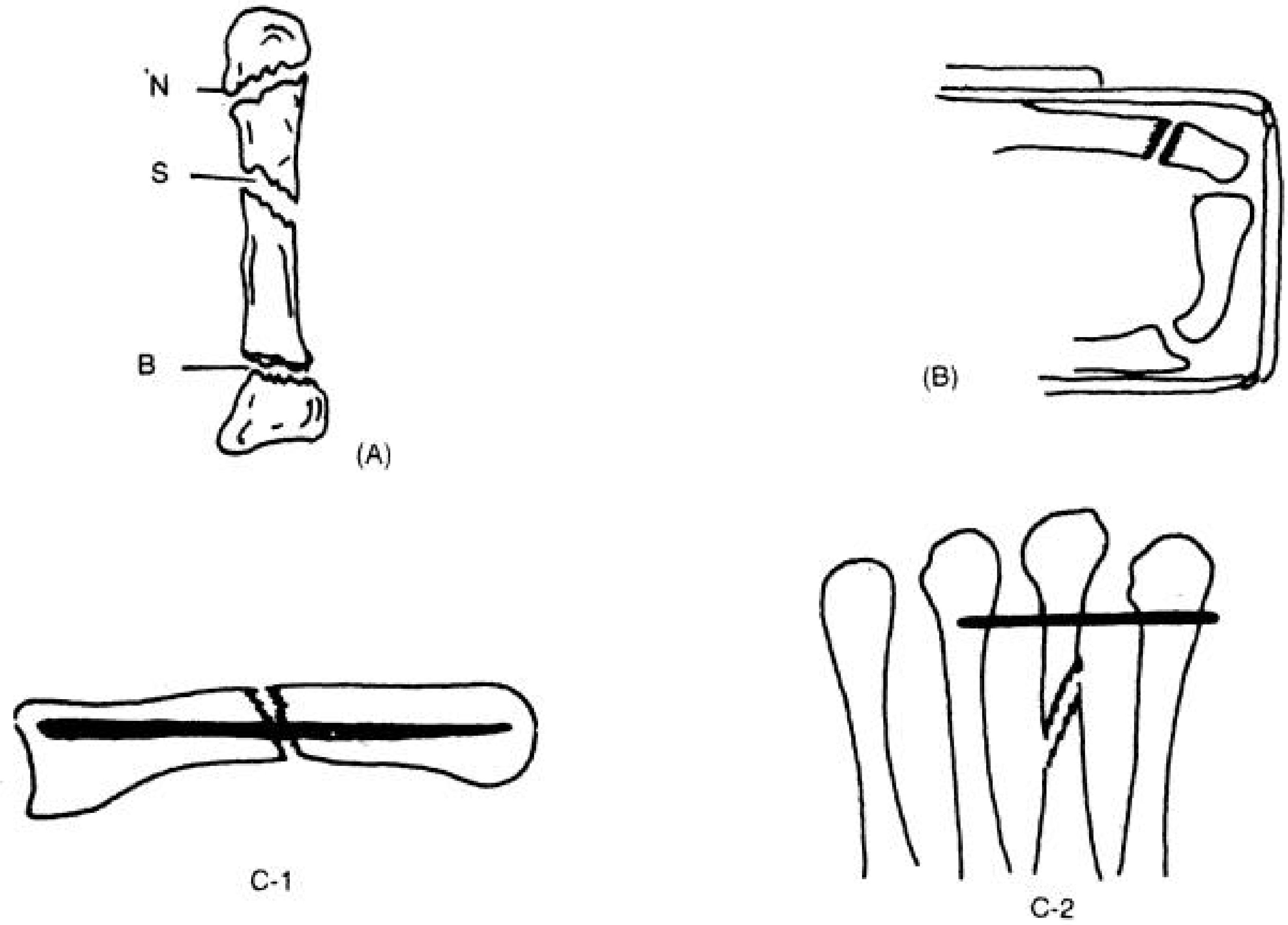

Fig. 4.41. Fracture of metacarpal bone. **(A)** Various sites of fracture. B: Base, S: Shaft, N: Neck. **(B)** Fracture through the neck needs reduction and immobilisation by aluminium strip in flexion. **(C)** Internal fixation by intramedullary wire (C-1) or by a wire through adjacent metacarpals in oblique fractures (C-2).

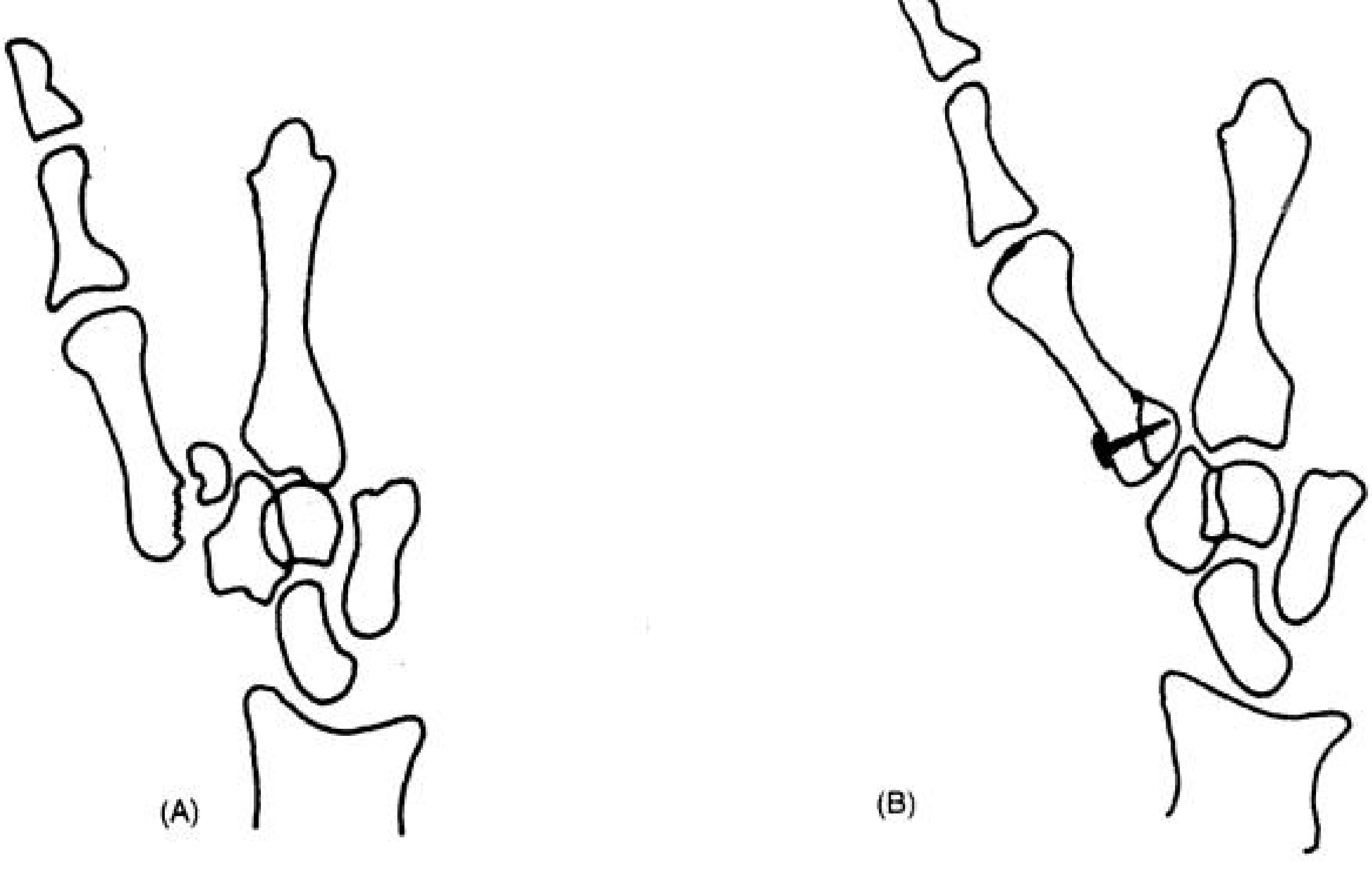

Fig. 4.42. Bennett's fracture dislocation. **(A)** Fracture with dislocation at the base of the thumb. **(B)** Internal fixation by a screw.

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adherence of the flexor and extensor tendons thereby causing functional inadequacy of the hand.

During immobilisation

Routine measures are taken to control edema, inflammation and pain. Improved circulation by vigorous movements and resistive exercises to the joints in the exact groove to the free fingers are important.

Mobilisation

When the fracture is stable mobilisation should be made vigorous by gentle relaxed passive movements in the maximum arc. Well supported active exercises can be given. Static or dynamic splint to prevent or to minimise the deformity as well as to aid scar modulation is necessary.

Continuous and repeated active movements play an important role in facilitating tendon glide and strength.

Exercise programme should be made progressive and functional.

By 3 months good hand function should be regained.

Fracture of the middle phalanx

The basic objective of physiotherapy is to regain full active ROM of the joints proximal and distal to the fractured middle phalanx.

During immobilisation

All the routine measures to control inflammation, pain and swelling are taken.

Irrespective of the method of immobilisation, early measures to initiate mobilisation are extremely important (5-15 days).

Individual joint ROM exercises, passive as well as active, are given by stabilising the phalanx just proximal to joint being exercised. This helps to obtain effective tendon glide by avoiding tendon adherence to the callus.

Mobilisation

After 2 weeks, active flexion-extension exercises are started for the immobilised PIP joint. Care must be taken to avoid terminal range of extension. Dorsal block splint is useful to avoid this (Fig. 4.45). Extension is limited to 30 degrees and 15 degrees during the first and the second week respectively.

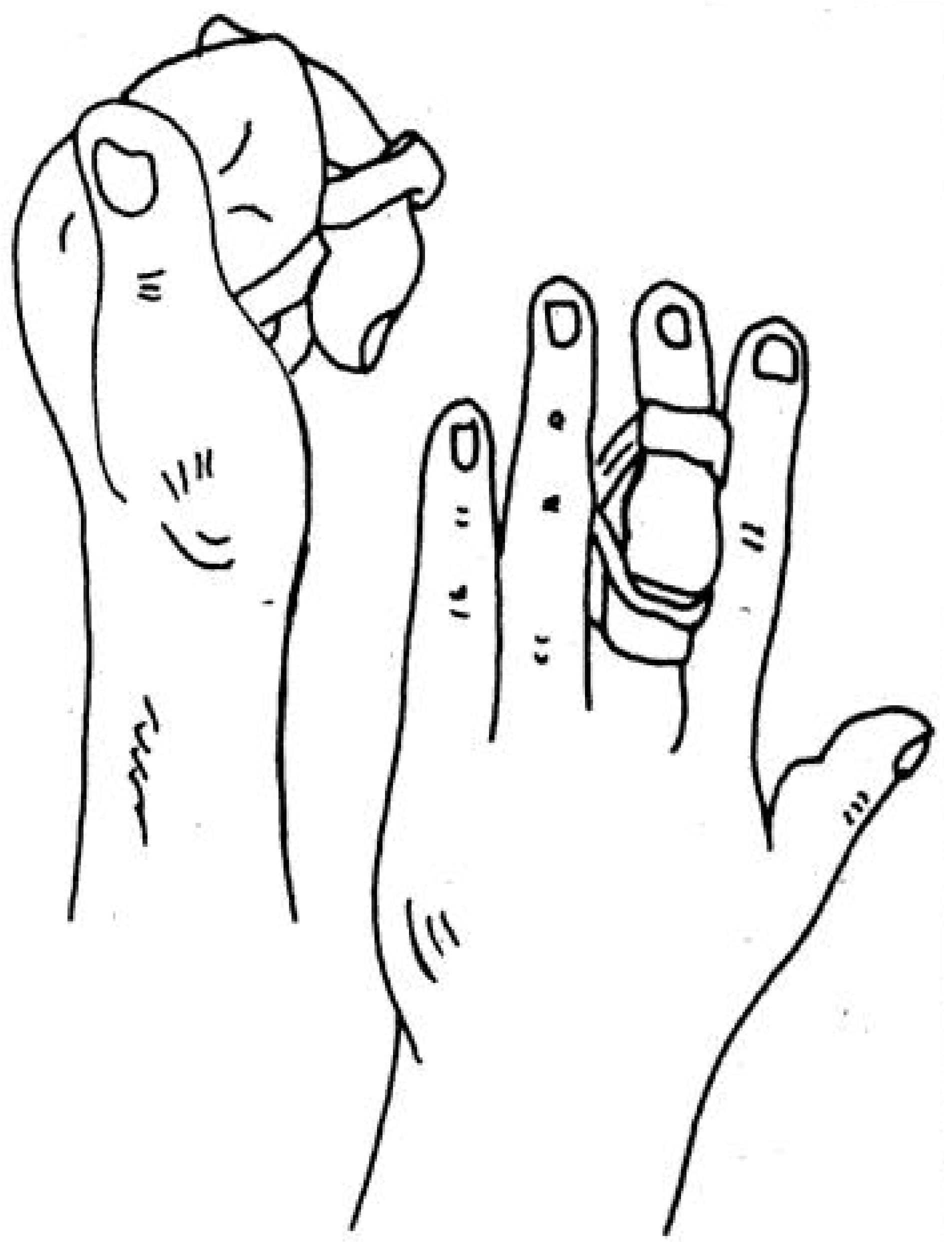

Fig. 4.45. Fracture of the middle phalanx.
Dorsal block splint to limit extension to 30 degrees during the first week, 15 degrees during the second week, allowing full extension by the third week.

After 4 weeks extension can be initiated at the PIP joint and a dynamic extension splint is given to further the extension (Belsole, 1980).

Therapy to be progressed on the same lines to attain full function. However, it may need 6 months to get full active extension at the PIP joint.

MALLET FINGER

The tendon of the extensor digitorum communis sometimes gets avulsed from its insertion to the base of the distal phalanx (Fig. 4.46A). The tendon may be avulsed along with a small piece of bone from the distal phalnx (Fig. 4.46 B). Sudden forced flexion of the distal phalanx is the usual mode of injury.

The patient complains of pain and swelling of the distal phalanx of the finger and is unable to actively extend the finger at the distal interphalangeal joint. However, the finger can be fully extended passively.

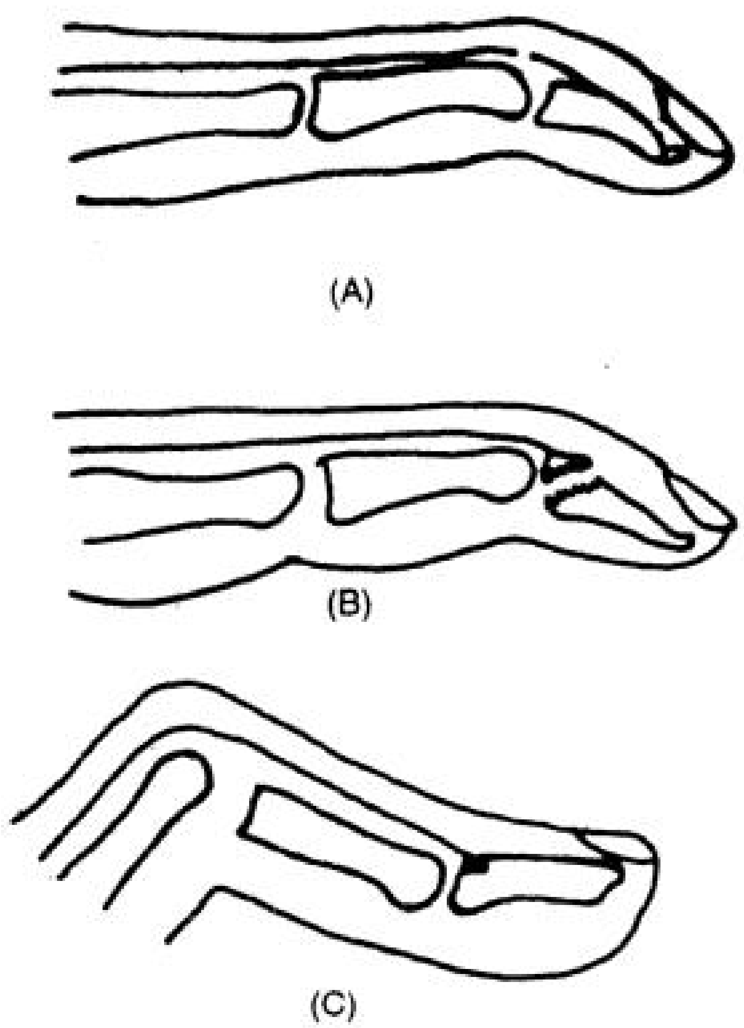

Fig. 4.46. Mallet finger.
(**A**) Rupture of the extensor tendon near insertion. (**B**) Avulsion fracture of the base of distal phalanx. (**C**) Position for splinting.

Treatment

1. Fresh cases are treated by immobilisation in a POP cast or plastic/PVC splints with the proximal interphalangeal joint in 60 degrees of flexion and the distal interphalangeal joint in hyperextension (Fig. 4.46 C). The immobilisation is maintained for 3-4 weeks.

The ruptured tendon is sometimes repaired by surgery. The avulsed bony fragment is fixed to its parent bone by a Kirschner wire. Postoperatively the finger is immobilised in a cast or splint for 3-4 weeks.

2. Late cases are treated by open reduction and repair of the tendon or the avulsed fragment. Rarely, when the pain and deformity persist, arthrodesis of the distal interphalangeal joint in 15 degrees of flexion is performed. The postoperative immobilisation after arthrodesis is generally prolonged, for a period of 8-10 weeks.

Physiotherapy management

The basic aims of physiotherapy are:

1. To regain voluntary extension at the distal interphalangeal joint.
2. Full ROM and strength at the distal interphalangeal joint.

Cases treated by immobilisation/surgical repair

During immobilisation

The patient is encouraged to use hand with a splint or POP cast.

Vigorous early movements are begun to all the fingers and MP and PIP joints of the index finger with the splint protecting the DIP joints. Measures are also taken to control inflammation, edema and pain.

Mobilisation

1. Paraffin wax bath is extremely useful to improve ROM of the distal interphalangeal joint and to facilitate stretching of the injured or repaired tendon.

2. Encourage maximum active movements to the DIP joint with emphasis on flexion. Special attention may be necessary for exercising the extensor digitorum communis.

Extensor lag due to extensor tendon attenuation may be present.

3. Strengthening and re-education of the extensor digitorum communis is achieved by synchronising voluntary exercise efforts with electrical stimulation. Exercises to lumbricals are also important.

Splint is continued till voluntary full extension at the distal IP joint is regained.

Active use of hand with splint and light hand activities without splint are encouraged. Use of splint is gradually waned as the voluntary extension returns.

Full function should return by 3-4 weeks following mobilisation.

Cases treated by arthrodesis

Long period of immobilisation results in pain and stiffness of the PIP joint. Therefore, several sessions of mobilisation in a day are extremely important.

Guidance in the functional use of the hand initially with immobilisation and later following mobilisation is important.

Caution

The patient needs to be warned against performing forced flexion movements like tight grasp, lifting weights, etc. to avoid recurrence.

INJURIES OF THE CERVICAL SPINE

Incidence

Trauma is the commonest cause of injuries to the spine and 30-40 percent of which involve cervical spine. The most vulnerable areas of the vertebral column are lower cervical (C5-C7), mid thoracic (T4-T7) and thoraco-lumbar (T10-T12).

Fractures of the cervical vertebrae are serious injuries, often resulting in paralysis (quadriplegia) or can even be fatal. There can be fracture and/or dislocation of the vertebrae resulting from forced flexion or extension with or without an associated element of rotation.

Flexion injuries (Fig. 4.47)

Most of the flexion injuries (about 75%) occur in the lower cervical spine. There may be a wedge compression fracture of the vertebral body (Fig. 4.47A). Subluxation or dislocation may occur due to disruption of the posterior ligaments (Fig. 4.47 B), the severity of injury depending upon the extent of ligament disruption.

Involuntary forced flexion may result in avulsion fracture of the spinous process of C6, C7 or T1 (Fig. 4.47B) called as "clay-shoveler's" fracture.

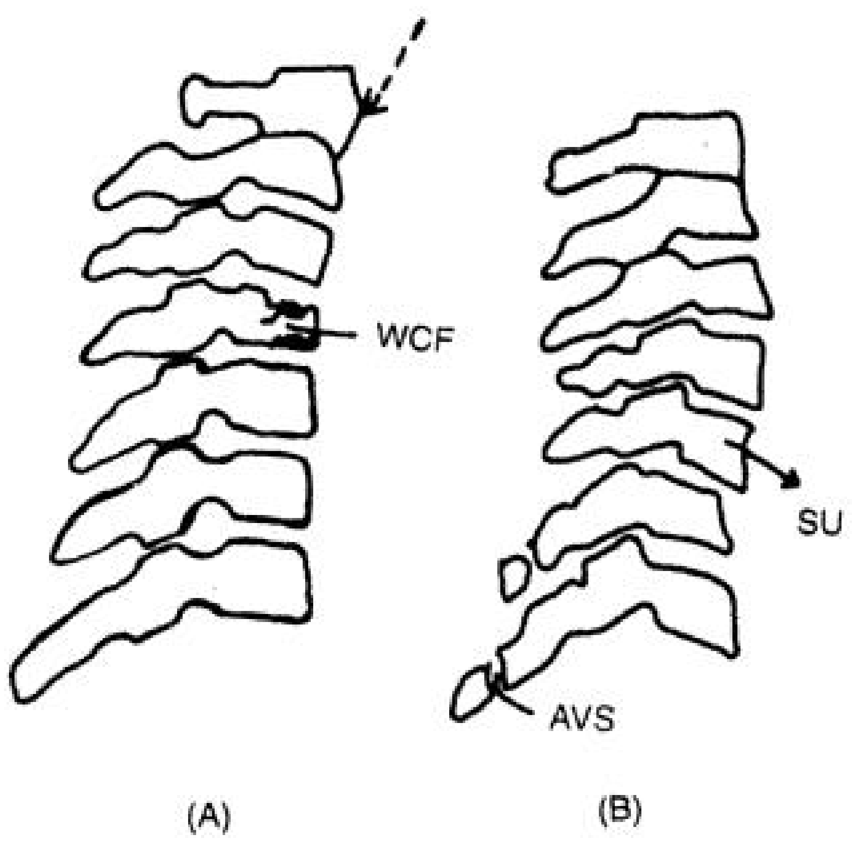

Fig. 4.47. Flexion injuries of the cervical spine.
(A) Wedge compression fracture (WCF).
(B) Subluxation of cervical spine at C5-C6 level (SU), avulsion fracture of spinous process (AVS).

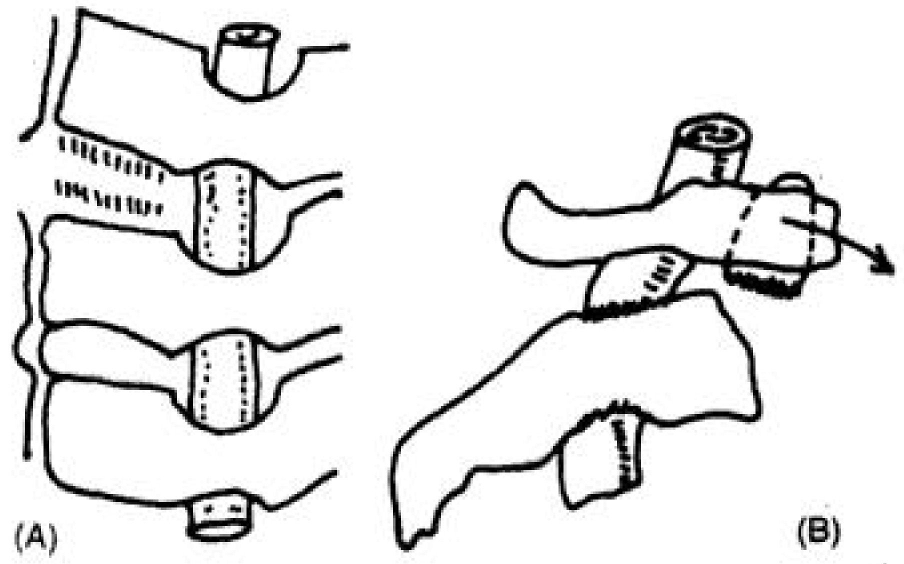

Fig. 4.48. Extension injuries of the cervical spine.
(A) Rupture of the anterior longitudinal ligament.
(B) Fracture of the odontoid process.

A flexion "tear drop" fracture indicates complete disruption of the posterior ligaments and a large triangular fragment of bone avulsed from the anterior aspect of the vertebral body.

Complete disruption of the posterior ligament complex can also cause bilateral facet dislocation, with anterior displacement of the vertebra.

Extension injuries (Fig. 4.48A)

Hyperextension and distraction causes rupture of the anterior longitudinal ligament with posterior dislocation of the vertebra. The dislocation often gets reduced during transportation and handling of the patient, therefore an X-ray taken later in the casualty department may show no bone injury, although the patient has quadriplegia. This injury, therefore, becomes evident on forced extension X-rays of the cervical spine.

Extension "tear drop" fracture results from an hyperextension injury. In this a large triangular fragment of the anterior superior or inferior corner of the vertebral body gets avulsed along with the anterior longitudinal ligament.

Fracture of atlas (C1) vertebra. Extension injury may cause avulsion fracture of the anterior arch or posterior arch of the atlas vertebra. There is, however no complete disruption of the ring and the spinal cord is usually spared.

Fracture axis (C2) vertebra: "Hangman's fracture"

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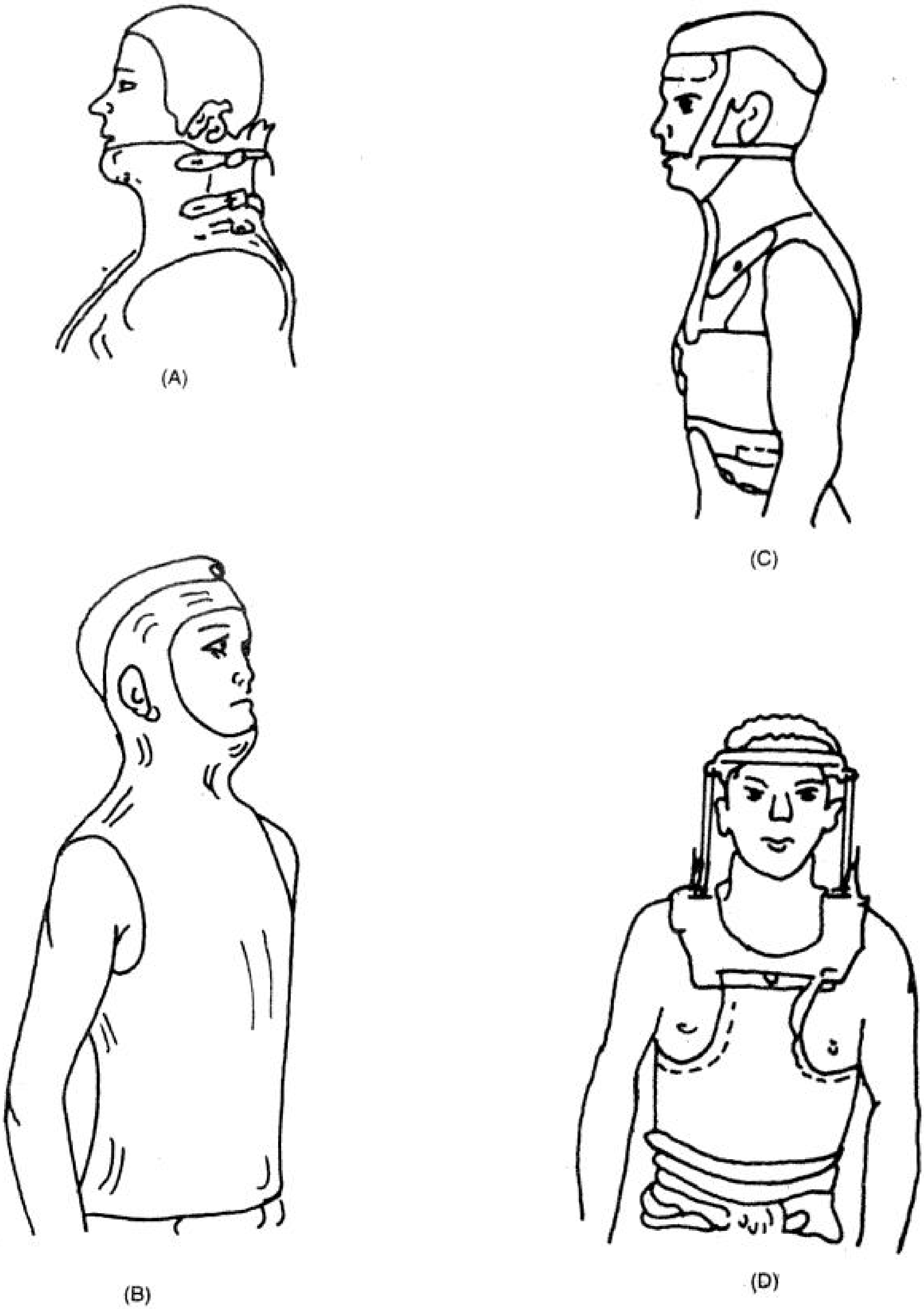

Fig. 4.52. Stable fractures of the cervical spine.
Methods of immobilisation. **(A)** Four-poster cervical collar. **(B)** POP minerva jacket. **(C)** Minerva jacker brace. **(D)** Halo traction brace.

A. Treatment of stable uncomplicated injuries.
B. Treatment of unstable skeletal injuries.
C. Management of paralysis (quardriplegia).

A. Treatment of stable injuries

The stable injuries of the cervical spine, without displacements and paralysis, are treated by immobilisation of the cervical spine by a four-poster cervical collar (Fig. 4.52A), a POP minerva jacket (Fig. 4.52 B) or a minerva jacket brace (Fig. 4.52 C) or a Halo traction brace (Fig. 4.52D). The immobilisation is maintained for a period of 6 to 8 weeks.

B. Treatment of unstable injuries

Unstable fractures of the cervical spine or fracture dislocations are treated by reduction of the fracture and/or dislocation and immobilisation by skeletal traction. The reduction of the fracture and/or dislocation is achieved by heavy skeletal traction given up to 20 pounds (9 kg) through crutchfield tongs (Fig. 4.53) applied in the skull.

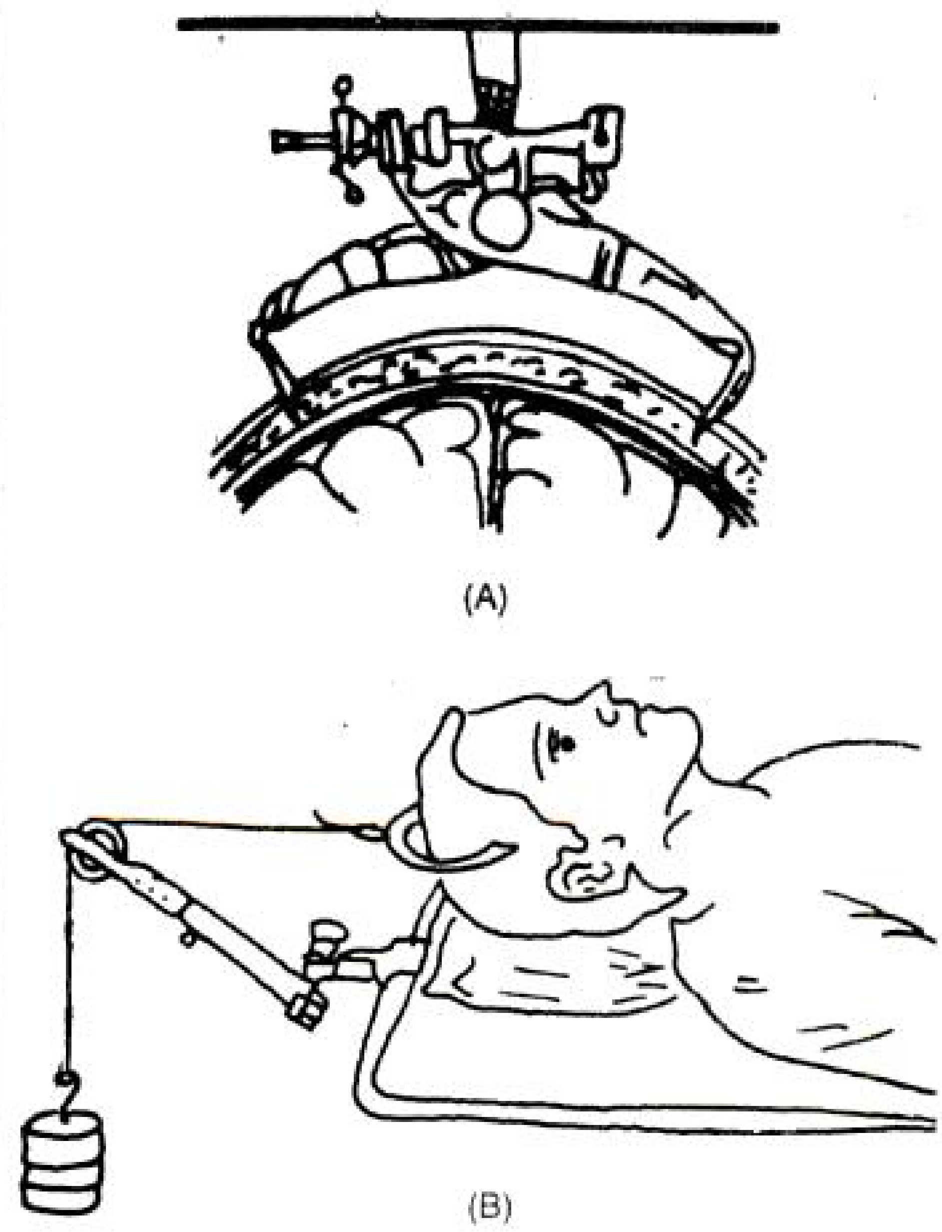

Fig. 4.53. Heavy skeletal traction.
(A) Crutchfield skull tongs. **(B)** Traction in position.

The reduction is confirmed by portable X-rays taken in bed with the traction on. After the reduction is achieved, a light skeletal traction is maintained for a period of 6-8 weeks, after which the neck is supported in a four-poster collar for another or 3-4 months. After reduction of the fracture/dislocation the paralysis may also improve.

Operative treatment

In selected cases the dislocation is reduced by surgical operation and stabilised by spinal instrumentation (Fig. 4.54). The spine is also fused either posteriorly or anteriorly (Fig. 4.55). The neck is supported in a collar for a period of 3 months. However, spinal stabilisation reduces the period of recumbancy and thereby the subsequent complications of the latter.

Physiotherapy management

A. Treatment of stable uncomplicated injuries

The role of physiotherapy in these types of injuries is limited only to continuing general exercises or strengthening of the weak muscles. Ergonomic advice to manage activities without putting strain on the cervical region during immobilisation is important. Graduated neck movements, in smaller range, can be started as soon as the immobilisation is discontinued. Full recovery occurs within 3-4 weeks.

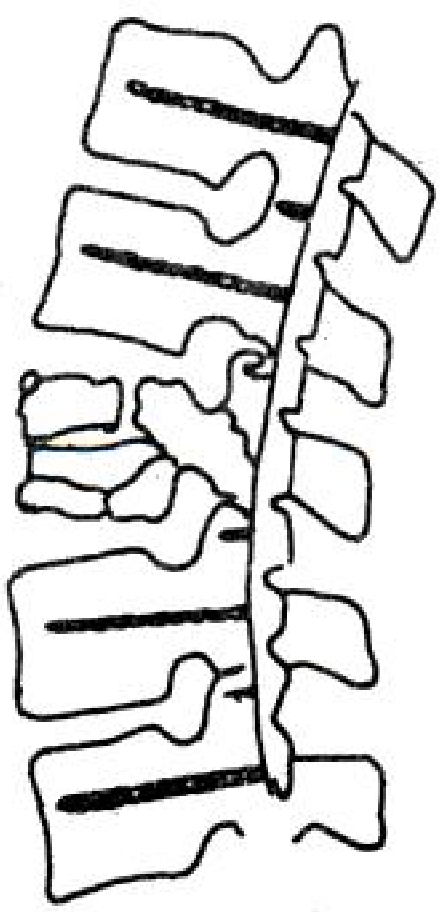

Fig. 4.54. Spinal instrumentation with plate and screws.

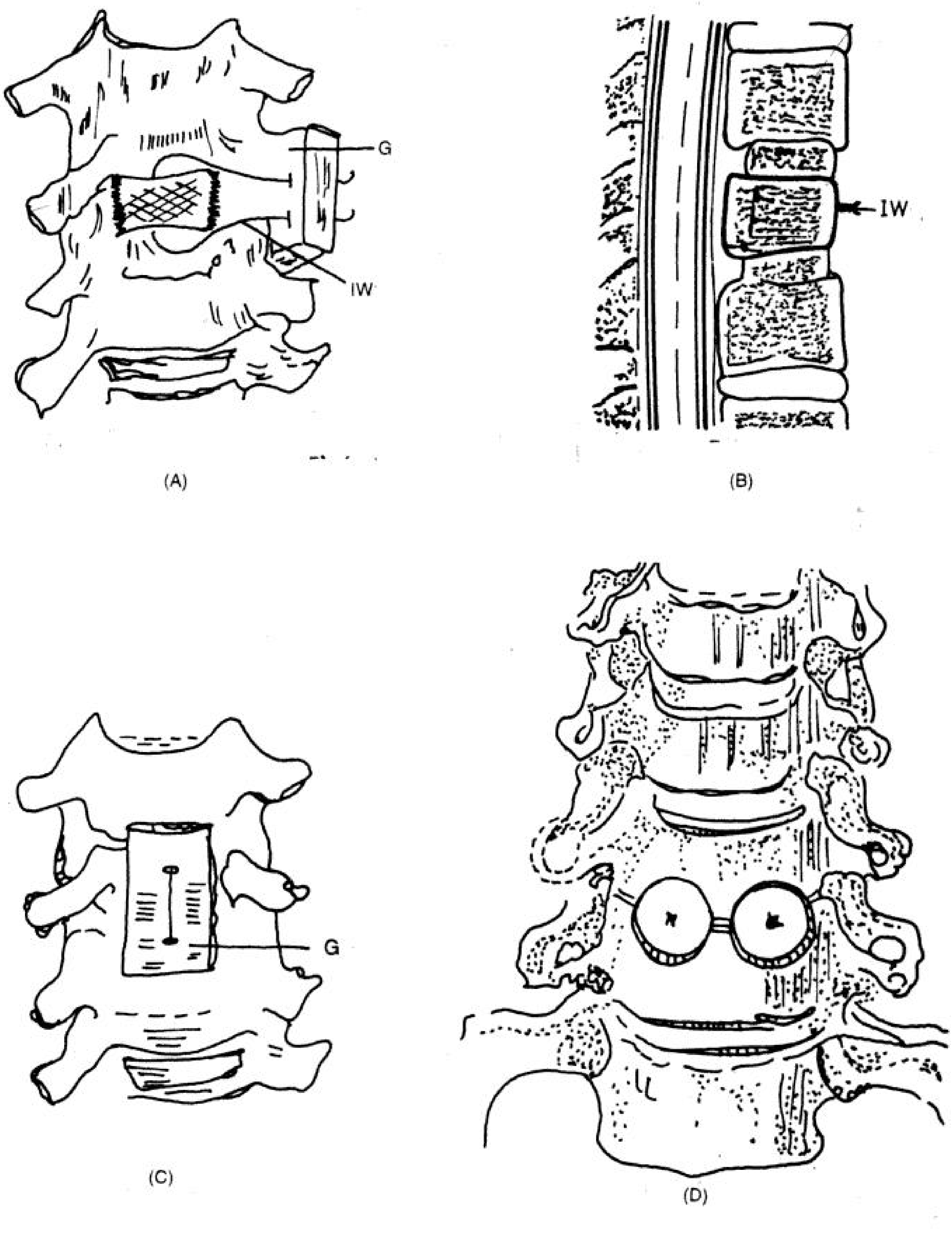

Fig. 4.55. Spinal fusion single interbody block fusion. **(A)** and **(B)** Widening of the spinal defect and graft (G) secured with isthmus wire (IW). **(C)** Graft in place. **(D)** Double–Dowel interbody block fusion.

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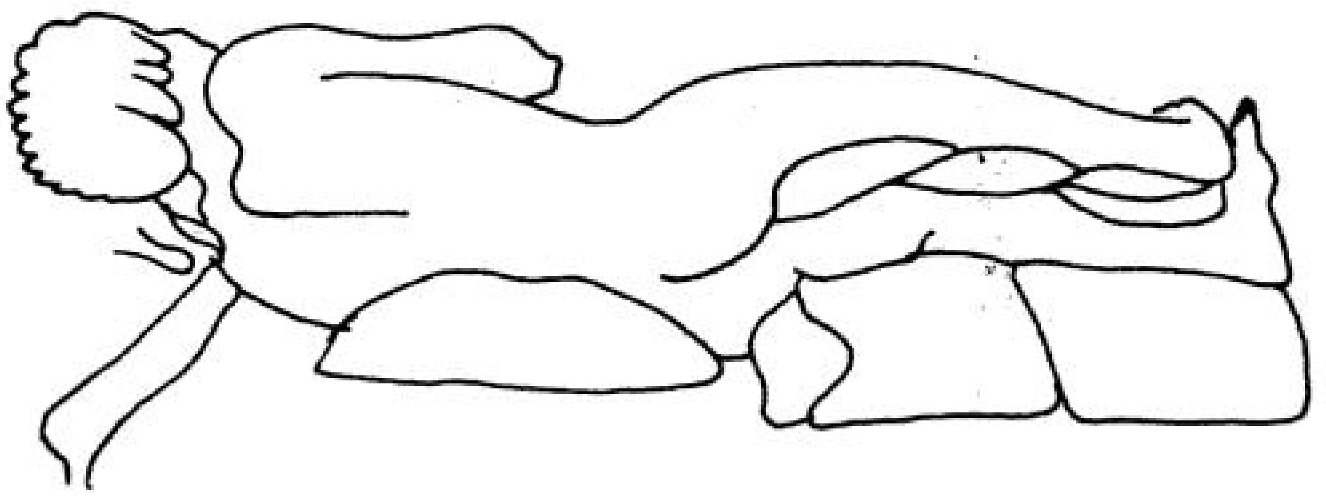


Fig. 4.56. Positioning of the patient in bed to prevent pressure sores (side lying).

which results in contractures which later on organise in the deformity (e.g. equinus deformity due to the neglect of positioning of the ankle and foot). Thus, these susceptible sites should be taken care of by proper positioning, supports and gentle full ROM exercises along with frequent checks.

(c) Maintenance of correct alignment of fracture. Proper positioning of the neck in relation to the body is important to maintain the correct alignment of the fracture. Therefore, this also needs regular checks.

(d) Prevention of heterotrophic ossifications. Excesssive stretching of some of the susceptible joints or the spastic muscles (e.g. at hip, knee, elbow and medial aspect of femur) may result in ectopic ossification, a complication which delays rehabilitation. Overstretching of the joints in the terminal range should be strictly avoided.

(e) Prevention of edema. The loss of vasomotor control and loss of muscle tone, result in stasis and the hands and feet are prone to develop gravitational edema. Therefore, proper positioning of the limbs with elevation and other physiotherapy measures are necessary to reduce edema to the maximum. Persistence of edema may lead to trophic changes, hand stiffness, or even sudeck's osteodystrophy. While maintaining correct positioning of the body, maintenance of paralysed hand in good functional position is important. This is achieved by using short cock up splint, palmar roll and bandage. The wrist is maintained in 45 degrees of extension, MCP joints in 90 degrees of flexion, IP joints in 30 degrees of flexion and thumb in opposition. Keeping MCP joints in full flexion puts stretch on the collateral ligaments preventing the swelling (Cheshire and Rowe, 1970-71). However, regular sessions of relaxed full range passive movements by removing bandage and splint are necessary to avoid tightness.

(f) Autonomic dysreflexia. It occurs as a result of malfunctioning of the body's normal regulating mechanisms for blood pressure and temperature in the lesions above T10 level. It is one of the serious complications and could be life threatening, if not detected and controlled at the initial stage. The signs and symptoms of autonomic dysreflexia are: irregularity in the level of blood pressure which may shoot up suddenly, variation in the skin temperature and colour, excessive sweating above the level of lesion, severe headache and the feeling of congestion. Factors like bladder distension, urinary complications, stool impaction, pressure sores, etc. may produce irritation or discomfort to the body below the level of injury. Autonomic dysreflexia is more commonly seen in the lesions above T5 level, but it can be avoided with early detection and proper measures.

When any of the above-mentioned symptoms is noticed it is necessary to check for the distension of bladder, bowel obstruction due to accumulation of stools, skin irritation or lesion due to tight clothing, appliance or aids, etc.

Adopting sitting or semi-reclining posture and adequate measures to control the respective causative factors are useful to control autonomic dysreflexia (Ozer et al., 1987).

(g) Chronic pain. Receiving and processing of the sensory information from the periphery continues below the level of the lesion. However, it is blocked at that level and cannot be transmitted to the higher centres, resulting in the loss of normal smooth interplay and appropriate action. This malfunctioning of both the reflex centres results in the overexcited response to the stimuli entering the spinal cord. The stimuli are perceived either as inappropriate sensations of pain without any tissue damage or as uncontrolled muscle contractions as spasticity.

The pain could be mechanical (sharp, localised and aggavated by movements), inflammatory (not localised to the site of injury), due to contracture, arthritis, or inflammation of the joints and tendons, or as a phantom sensation of tingling, burning or dull ache, in the back, legs or feet.

The treatment depends upon the clinical evaluation. Combination of treatment like appropriate choice of modality, exercises, medication, psychotherapy are effective. TENS is the treatment of choice.

(h) Prevention of osteoporosis. Immobilisation and prolonged bed rest are associated with atrophy of musculo-skeletal system which alters the mineral mechanism of bone formation resulting in osteoporosis. Osteoporotic bone becomes susceptible for spontaneous fracture even with sudden stretching of the joints. Frequent turning in bed during early stage, passive movements to the paralysed limb, resisted movements to the paretic limbs and early weight bearing like tilt-table standing can prevent the incidence of osteoporosis.

(i) Early identification of paralytic ileus. The presence of abdominal distention with breathing difficulty and nausea are the signs of paralytic ileus. This interferes with respiration and needs immediate medical attention.

B. Weaning phase of the spinal shock

1. A thorough evaluation of the residual neuro-musculo-skeletal deficiencies.
2. Planning and efficiently conducting the therapeutic programme on an individual basis.

When the symptoms of the acute spinal shock recede the cells of the isolated cord recover function. Spasticity sets in with the return of the reflexes. However, when there is longitudinal vascular damage to the cord, or when the cord is injured in longitudinal as well as transverse planes, the flaccidity may persist. In incomplete and bilaterally asymmetrical lesions, there may be return of power in the muscle groups whose segmental innervation is spared.

Physical examination

As this phase is the most important phase of rehabilitation needing vigorous physiotherapy, detailed neuro-musculo-skeletal examination needs to be conducted. This helps to identify the site and the degree of damage to the cord and the prognosis. In fact, this forms the basis of planning the regime of physiotherapy.

Manual muscle testing of various muscle groups is critically done and analysed with reference to the segmental innervation charts (Tables 4.1 and 4.2). The tone of the muscles is assessed through passive ROM, palpation and limb positioning. The evidence of nerve irritation is demonstrated at one level above the actual site. For example, symptoms of lesion at C5 level will be present when actual damage occurs at C6 level. Therefore, spasticity will be present in the deltoid, elbow flexors and forearm supinators when the actual level of the lesion is at C6. The presence of spasticity in a particular muscle group can be identified by typical spastic posture of the arm in bed. Muscle length and joints are carefully examined for the functional requirement of the individual joints as well as the whole limb. Sensory status is examined in detail for pain, touch position sense and superficial and deep reflexes.

Hands and legs are examined for edema. Lack of muscle tone and vasomotor control deficiency greatly enhances edema. Persistence of edema converts collagen deposits into fibrous tissue, resulting in fibrous contractures. The findings of all these tests are correlated with the relative spinal segmental innervation to confirm the lesion.

Therapeutic procedures

Passive movements. Relaxed slow and rhythmic passive movements aid in improving circulation, preventing deformities, reducing edema, educating movement patterns and in reducing spasticity.

Table 4.1. Major segmental innervation of the muscles of the upper limb

<table>
<tr><th>C2</th><th>C3</th><th>C4</th><th>C5</th><th>C6</th><th>C7</th><th>C8</th><th>T1</th></tr>
<tr><td colspan="2">Sternomastoid</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Trapezius</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Levator Scapulae</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Diaphragm</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Deltoid
Rhomboids
Teres minor
Supraspinatus
Infraspinatus</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Biceps, Brachialis</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Brachioradialis
Supinator
Subscapularis,
Teres major,
Coraco-brachialis</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Serratus anterior, Latissimus-dorsi, Extensor carpi radialis-longus</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Pectoralis major</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Pronator teres
Pectoralis minor
Extensor-digitorium
Flexor carpi radialis</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Triceps, Extensor carpi radialis-brevis, Palmaris longus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Flexor carpi ulnaris,
Extensor carpi-ulnaris, Flexor digitorum superficialis and profundus
Extensor indicis
Abductor pollicis-longus and brevis
Opponens pollicis
Flexor pollicis longus, Extensor pollicis longus & brevis</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Adductor pollicis</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Flexor pollicis brevis
Abductor digiti minimi
Opponens digiti minimi
Lumbricals, Interossei.</td></tr>
</table>

Table 4.2. Major segmental innervation of muscles of the lower limb

<table>
<tr><th>L1</th><th>L2</th><th>L3</th><th>L4</th><th>L5</th><th>S1</th><th>S2</th><th>S3</th></tr>
<tr><td>Psoas minor</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Psoas major
Iliacus</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Sartorius</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Hip adductors</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Quadriceps</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Obturator-
externus</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Tensor fascia lata
Tibialis posterior</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Tibialis anterior, Extensor hallucis longus, Extensor-
digitorum longus, Peroneus tertius, Popliteus</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Gluteus medius,
Gluteus minimus</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Quadratus femoris, Semitendinosus
Semimembranosus, Biceps femoris
Peronei</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Obturator internus
Gastrocnemius</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Gluteus maximus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Flexor hallucis-
longus, Flexor-
digitorum-
longus
soleus</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Interossei</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Abductor hallucis
Adductor hallucis,
Lumbricals
Abductor digiti-
minimi</td></tr>
</table>

> **Caution**
>
> Movements should be performed without eliciting muscular spasm. Overstretching of the spastic muscle group should be strictly avoided as it may result in complications like ectopic ossification, rupture of muscle fibers or even spontaneous fractures.

Mobility exercises. The mobility of scapulae, elbow, wrist and fingers with maintenance of the normal length of the muscles passing over more than one joint is of extreme importance in quadriplegics. They are needed to facilitate functional activities, and hence need special emphasis.

Active movement. Movements in the muscle groups with intact innervation should be progressed in grades from assisted active to active resistive modes to hypertrophy of the paretic muscle groups. PNF techniques with precision are extremely useful. However, compensatory mechanisms like tenodesis and other functional controls should always be kept in mind and emphasised more than the usual muscle strengthening procedures (Table 4.3.).

Vasomotor control. The blood vessels in the viscera fail to constrict on assuming vertical posture when the vasomotor control is lost. Adequate compensation can be achieved by the training of the reflex arc by breathing exercises, altering the position in bed and gradually progressing to sitting or standing on the tilt table.

Postural sensibility. Kinesthesia below the level of the lesion results in the loss of perception of movements and the position of the body and the limbs in space. The new postural sense is developed through visual feedback. This is facilitated by the long practice session in front of mirror. This takes a long time and needs tremendous efforts.

Control of edema. Edema can be controlled by elevation of the foot end of the bed, keeping the edematous limb in further elevation, using hand splints with bandage and inflatable plastic splints. Regular relaxed passive movements or speedy isometrics, whenever possible, play an important role in the control of edema.

Control of spasticity. Spasticity greatly obstructs the smooth and coordinated movements and self-care. Therefore it is essential to control it as soon as it sets in. This is done by proper positioning of the limb. Proper positioning in the early phase inhibits the onset of severe spasticity and also influences the pattern of spasticity. Reflex inhibiting postures on mat, standing with correct posture and weight distribution, relaxed controlled passive movements, PNF techniques and carefully monitored cryotherapy are useful.

Re-education of self-care. The attainment of independence in self-care is the ultimate aim of treating these patients, therefore it needs to be initiated right from the earliest stage. The degree of functional independence depends not only on the extent of the spinal cord lesion but also on the physical proportions, e.g height, weight, arm length in relation to the length of the trunk, early adequate management and motivation of patient.

Therapeutic procedures and self-care training are planned by referring to the segmental innervation chart (Tables 4.1, 4.2, 4.4, 4.5), expected joint control as related to the level of the lesion (Table 4.3) and the degree and distribution of spasticity as recorded in the physical examination chart. Mat activities are instrumental in initiating the training of the major self-care re-eduction activities like turning, rolling, sitting from lying, lying from sitting, trunk balance in sitting and balanced transfers. Training for the wheel chair manoeuvres is initiated along with the mat training. The self-care training is greatly facilitated by the intelligent assistance of the surviving muscles, compensatory mechanisms, trick movements and various simple adaptations (Table 4.4) (Fig. 4.57).

Standing and ambulation. Standing, though not practical in high cord lesions, is initiated with assistance for its following advantages:

- It prevents renal complications.
- It reduces spasticity.
- It stimulates circulation.
- It prevents osteoporosis.
- It improves postural sensibility and vasomotor control.
- It provides tremendous psychological influence on the patient.
- Standing and ambulatory capabilities related to the various spinal lesions are elaborated in Table 4.6.

Table 4.3. Guide to functional control of the joints in relation to the segmental levels

Upper Extremity

Joint	*Segmental Level*				
	C5	C6	C7	C8	T1
Shoulder, Elbow	Poor	Fair	Normal		
Wrist		Poor	Fair	Normal	
Hand			Poor	Fair	Normal

Lower Extremity

Joint	*Segmental Level*				
	L2	L3	L4	L5	S1
Hip	Poor	Fair	Fair	Normal	
Knee		Poor	Fair	Normal	
Ankle			Fair	Fair	Normal
Foot			Poor	Fair	Normal

Table 4.4. Expected self-care independence in relation to the segmental level of involvement and the areas of therapeutic emphasis

Segmental Level	*Areas of Therapeutic Emphasis*	*Expected Self-Care Independence*		
		Self-Care	*Aids*	*Transfers*
C_4	Strengthening upper trapezius, sternomastoid, platysma. Use of special respiratory equipment. Using vasomotor control by using neck, shoulders and visio-spatial feedback to learn balance and equilibrium. Tilt-table standing. Wheel chair training.	Typing with special typewriter, turn pages, use of telephone, painting. Power wheel chair, controlled by chin or breath controlled "puff suck" tubes in the mouth.	Mouth stick, dental bite, robotic arms, other electronic aids.	Total dependence.
C_5	Strengthening biceps, trapezius, wrist mobilisation to attain flat palm and elbow locking in hyperextension, this assists body lifting in the absence of triceps. Mobilisation of scapulae and shoulder girdles. Intensive mat work, turning, rolling, sitting up, self-assisted moving of paralysed limbs. Assisted standing in parallel bars. Trunk rotation and flexion through neck and shoulder girdle muscles.	Eat, type, move papers. Manage wheel chair brakes. Push wheel chair on plain surfaces.	Cock up splint for wrist stabilisation. Slot on the palmar surface of splint to hold light gadgets like spoon, etc.	Needs physical assistance.
C_6	Strengthening extensor carpi radialis to facilitate wrist extension to achieve fingersgrasp by tenodesis. Also strengthen supination to further tighten the grip.	Slow writing, eat, drink, wash, shave, brush hair. Sitting from lying and reverse. Dress upper half. Push wheel chair on sloppy ground.	Light leather strap with slot to hold small light objects.	Bed to wheel chair and back with sliding board
C_7	Strengthening triceps, wrist flexors, extensor carpi radialis. Vigorous mat work.	Turn in bed. Independence in dressing. Effective use of hand. Wheeling over uneven ground and small kerbs. Pick up objects from the floor.	Flexor hinge splint to facilitate pincer grip.	Wheel chair to toilet, car and bath.
$C_8 - T_1$	Small hand muscles. Precision training for hands. Removing and putting on braces. Balancing and ambulation training in parallel bars.	Bladder and bowel care. Free wheel chair driving, rear wheel balance.	Orthotic aids for standing.	Chair to floor
$T_2 - T_6$	Gait training in parallel bars (swing-to and four-point)	Independent in self-care and personal hygiene.	Orthotic ambulatory aids.	Independent.
$T_7 - T_{12}$	Gait training on crutches, swing-to on axillary crutches.	Driving. Bladder and bowel functions. Free wheel chair ambulation.	Orthotic and ambulatory aids.	Independent wheel chair to crutches.
$L_1 - L_5$	Gait and ambulation training, All the three gaits on crutches.	Free crutch ambulation with sustained efforts.	Orthotic and ambulatory aids.	Independent
$L_5 - S_2$	Gait training and ambulation.	Can manage freely on elbow crutches or canes.	Orthotic and ambulatory aids.	Independent
$S_2 - S_4$	Total recovery	Total recovery	Total recovery	Total recovery

Table 4.5. Level of lesion and the recovery of function

Level of Lesion	*Initial Stage*	*Following Rehabilitation*
Above C–5	All the functions are severely affected, including breathing	Requires training in the use of special respiratory equipment. Physical dependency for most functions. Some self–propulsion in powered wheel chair may be possible. Devices like environmental control units, robotic arms, other electronic aids to increase independence.
C5	All the functions are impaired	Physical assistance is required in dressing, personal hygiene, transfers and writing. Independent in powered wheel-chair ambulation and eating skills.
C6	All the functions are impaired	Majority need physical assistance for personal hygiene, dressing and transfers. Independence in wheel-chair ambulation, eating and slow writing is possible.
C7, – T1	Personal hygiene, dressing, eating, writing, transfers and ambulation impaired.	Almost all achieve independence in all functions consistent with living alone. Physical assistance may be needed by some.
T3 – T6	Personal hygiene, dressing, transfers, ambulation impaired	Independence in wheel-chair ambulation, personal hygiene, dressing, and transfer is possible.
T7 – T12	Personal hygiene, dressing, transfers, ambulation impaired	Bladder and bowel functions recover totally. Walking only as exercise. Independent in transfers, wheel-chair ambulation, dressing and driving.
L1 – L4	Bladder, bowel and walking impaired	Bladder and bowel functions recover totally. Short distance independent walking can be regained.
L5, S1, S2	Bladder, bowel and walking impaired	Bladder and bowel functions recover totally. Walking with two canes or crutches, may need B.K. orthosis. Long standing difficult.
S–2, 3, 4	Only bladder and bowel functions impaired	Total recovery

Table 4.6. Expected status of standing and ambulation in relation to the segmental level of involvement

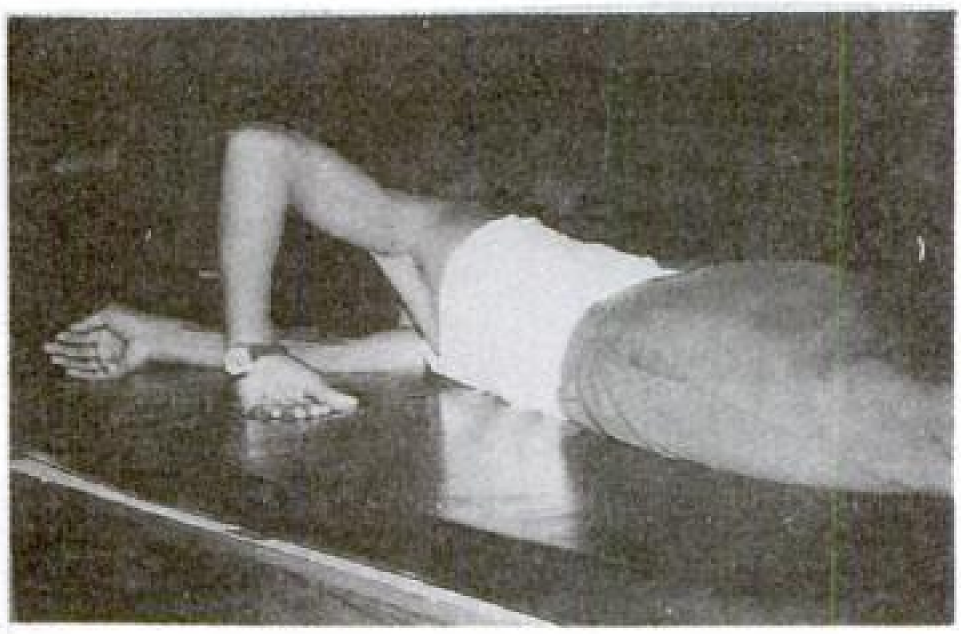
Segmental Level	*Status of Standing and Ambulation*
C4	Only tilt-table standing. Power-driven wheel chair.
C5 – C6	Standing with total assistance with or without orthosis in parallel bars. Wheel-chair ambulation.
C7 – C8	Swing–to gait in parallel bars. Wheel-chair ambulation.
T1— T5	Swing–to and four–point gait in parallel bars. Free ambulation with wheel chair.
T6 – T9	Swing–to on crutches. Stair management on crutches with assistance. Chair to crutches and back.
T10 – L1	All the three "crutch gaits", managing stairs, ramps and kerbs. Crutches to floor and back.
Below L1	Freedom in ambulation either with two canes or crutches. Prolonged standing may remain impaired.

Table 4.7. Guidelines for the expected appliance according to the level of lesion

Level of the Lesion	*Ambulation and the Appliance*
Below T6	Wheel-chair ambulation
T6– T9	Bilateral AK orthosis with attached spinal support
T10 – T12	Bilateral AK orthosis with pelvic band
L1 – L3	Bilateral AK orthosis with pelvic band. Pelvic band can be discarded in due course
L4 – L5	BK orthosis
Below L5	Foot drop assist

(A 1)

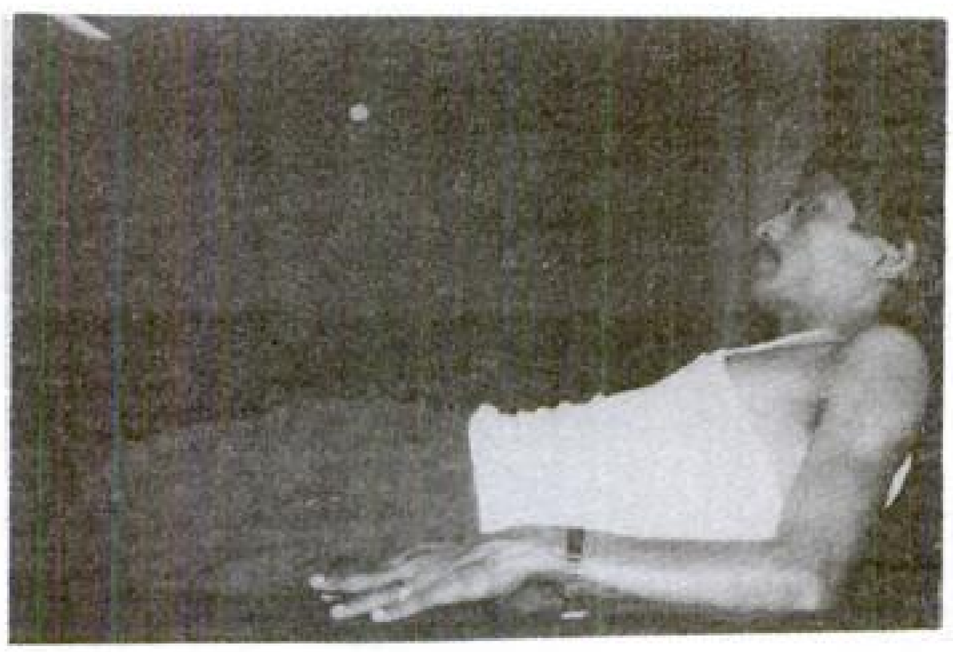
(B 1)



(A 2)

(B 2)

(A 3)



(B 3)

Fig. 4.57. Rolling (**A1 to A3**).

Fig. 4.57. Sitting (**B1 to B5**).

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action can be initiated on stimulation of certain "trigger points". This area is to be identified and tapping is done to set in the reflex for voiding. The quantity of residual urine after involuntary emptying is marginal and hence is not prone to frequent infections. The bladder reconditioning is achieved by reflex voiding of the bladder by clamping the catheter or the suprapubic tube. The catheter or the suprapubic tube is removed when the reflex emptying of the bladder is learnt.

Autonomous neurogenic (non-reflex) bladder

This type of bladder is also known as lower motor neurone or atonic bladder. This develops when the spinal cord lesion is longitudinal or lower motor neurone. Therefore, the bladder now totally depends for its control on the detrusor ganglia, an intrinsic plexus which is situated in the bladder musculature. This type of bladder needs training, and physiotherapy plays an important role in the training. Training of abdominals, diaphragm and pelvic floor muscle contraction and their sustainance increases the intra-abdominal pressure and facilitates bladder emptying. If this is not achieved due to involvement of the abdominals, the bladder can be emptied by teaching the patient to exert manual pressure on the lower abdomen directly over the suprapubic area.

For female patients no satisfactory urine bags are available, therefore pads and rubber pants are the only alternatives. Training methods otherwise are the same as for males. The bladder training programmes need careful monitoring. The bladder should be emptied to the maximum, otherwise the amount of residual urine in this type of bladder is quite large (200-400 cc). It may predispose the bladder to recurrent infections.

The bladder training programme has to be associated with increased amount of fluid intake (at least 2-3 litres a day), regular bladder wash, maintaining the fluid intake and urinary output chart, and closely monitoring the signs and symptoms of bladder infection.

Bowel management

The paralysis of bowel may lead to discomfort due to faecal retention or uncontrolled bowel movements. In case of permanent incontinence the patient needs to be trained on:

1. Attempted evacuation at regular periods;
2. Control of diet and fluid intake–to soften the faecal matter;
3. Use of suppositories;
4. Use of enema and
5. Digital evacuation.

It is important to find out the most suitable method on an individual basis and also regularise it.

Sexual functions

In male paraplegics with a complete lesion, orgasm and erection are difficult; however production of semen, which depends upon the gonadotropic hormones, is not affected. Ejaculation, which is reflex in nature, can occur; thus the power of recreation is not lost. In an incomplete lesion, a great deal of variation occurs. When it returns it does so with the reappearance of reflexes.

In females, menstruation and even pregnancy usually returns within 2 to 3 months even in complete lesions of the cord.

Proper guidance and counselling play an important role in adjusting sexual problems in these patients.

INJURIES OF THE THORACIC AND LUMBAR SPINE

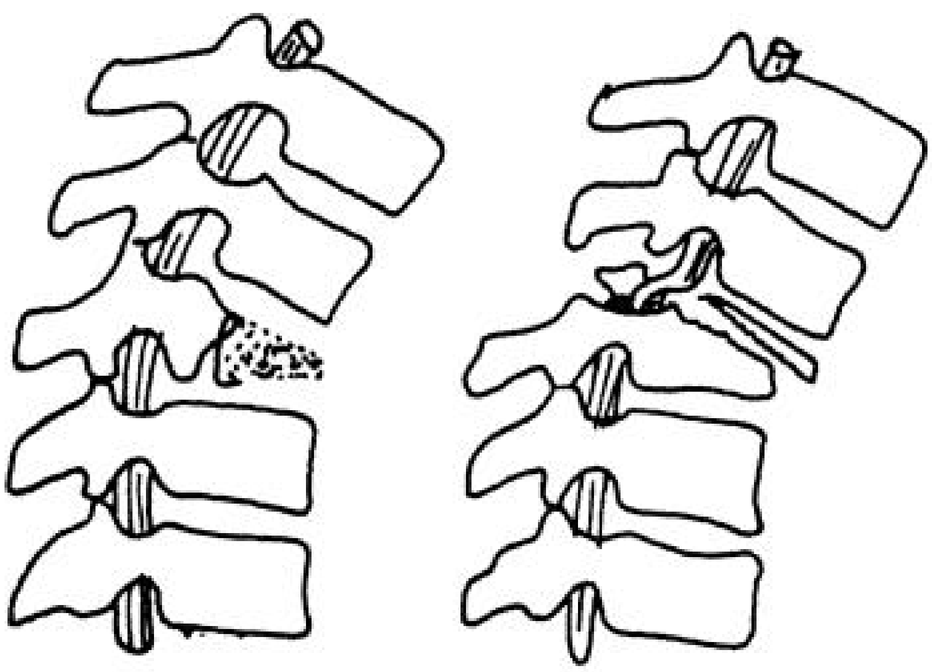
Fractures of the transverse processes and spinous processes

The fractures of the transverse process are seen often, but those of the spinous processes are rare. In these fractures the soft tissue injury around the spine takes priority over the bony injury. The formation of fibrous tissue because of tearing of muscle fibers, rupture of blood vessels, irritation of sensory nerves, and stretching of the areolar tissue leading to pain, muscle spasm, swelling, haematoma are common. Therefore, the treatment is based on the lines of soft tissue injury.

The measures to control inflammation, pain, swelling are necessary. Diapulse, TENS and ultrasound can be used as adjuncts. The patient is advised bed rest.

Early initiation of indirect isometrics through neck or legs as small range active movements may be begun, after 2 weeks.

The rest of the mobilisation, strengthening and back to work programme to be followed on the same lines as for the fractures of the vertebral body.



(A) (B)

Fig. 4.58. Injuries of the thoracic and lumbar spine. **(A)** Stable or uncomplicated wedge compression fracture (intact spinal cord) due to flexion force. **(B)** Complicated or unstable fracture–dislocation due to combined flexion–rotation force producing transaction of the spinal cord.

FRACTURES OF VERTEBRAE

Thoracic spine

In the upper dorsal (thoracic) spine the rib cage offers stability and hence generally compression (wedge) fractures occur (Fig. 4.58A). However, when the injury is severe, a fracture dislocation may occur (Fig. 4.58 B). The spinal cord gets invariably damaged in this type of injuries resulting in paraplegia because of its close fitting to the vertebral canal.

Thoracolumbar spine

Injuries to this region are quite common. There may either be a wedge compression fracture or a fracture dislocation resulting in paraplegia. Since this segment of the spine is more mobile, the displacements of the fractured vertebrae may be marked.

Lumbar spine

Since the spinal cord ends below the lower border of L1 vertebra, fractures below this level usually result in injury to the nerve roots with a resultant incomplete paraplegia. The chances of neurological recovery are quite high in these cases.

Treatment

It can be divided into:

A. Treatment of the skeletal injury.

B. Treatment of the paralysed patient.

A. Treatment of the skeletal injury

The following methods of treatment are employed depending upon the severity and the level of injury.

(i) Bed rest. A stable, uncomplicated fracture of vertebra is treated by simple bed rest on a hard bed for a period of 4 weeks.

(ii) Plaster jacket. A stable fracture, without paraplegia, may also be treated by a plaster jacket for 4 weeks.

(iii) Brace. A spinal brace may be used instead of a plaster jacket.

(iv) Postural reduction. The patients having fracture-dislocation with paraplegia are treated by rest in bed with a pillow placed under the fractured part of the spine. The patient is given a spinal brace after 4-6 weeks and mobilised.

(v) Stabilisation. A patient with fracture-dislocation of spine with paraplegia is nowadays treated by spinal stabilisation. The fractured segment of the spine is opened up by operation, reduced if possible, and fixed internally with two Harrington rods or similar kind of other internal fixation devices. Although neurological recovery is not guaranteed following this operation, particularly in cases where the cord is damaged considerably, the patient can be mobilised early; almost on the second or third day after operation. Early mobilisation eliminates the problems of prolonged recumbancy in a paraplegic patient.

(vi) Laminectomy. In selected cases of fracture spine with paraplegia, the spinal cord may be decompressed by a surgical operation called laminectomy. In this operation the spinous processes and the laminae of the vertebrae are removed, thereby decompressing the cord (Fig. 4.59).

Postoperatively the patient is nursed in bed for 3-4 weeks after which he is given a spinal brace (support) and mobilised.

(vii) Spinal fusion. Rarely, this operation is indicated in the following situations:

– Along with the operation of laminectomy. It is combined with laminectomy by some surgeons, with the idea of giving stability to the spine.

– In the old cases of fracture spine where painful kyphosis results.

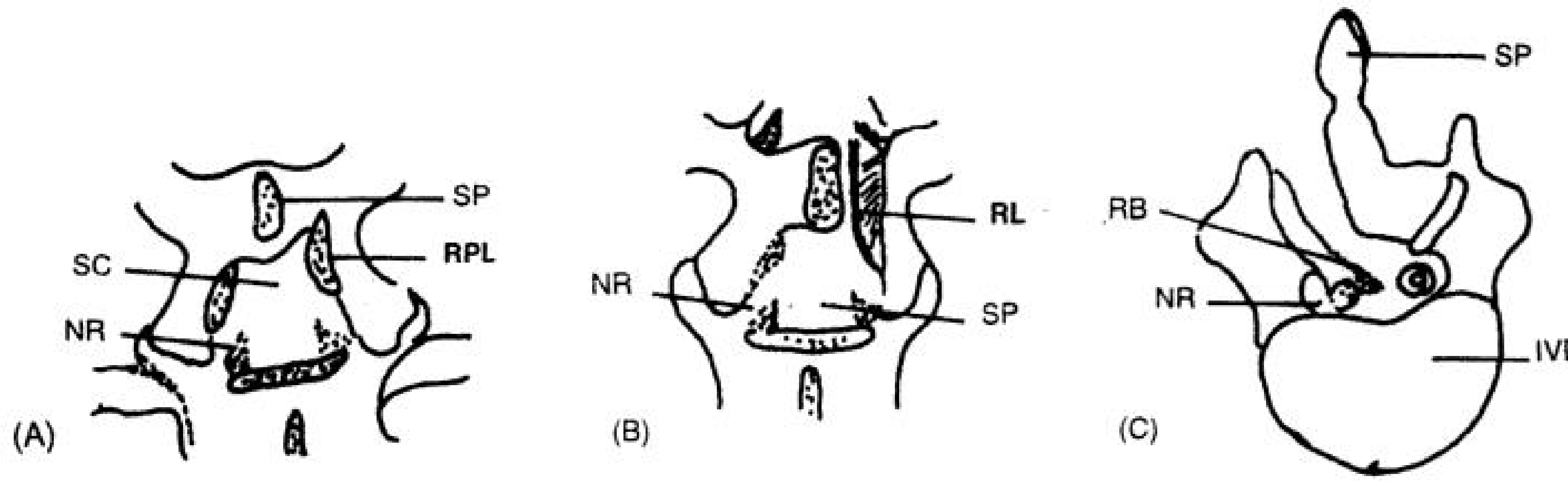


Fig. 4.59. Laminectomy. **(A)** Removal of the portion of lamina (RPL). **(B)** Removal of the entire lamina (RL). **(C)** Removal of bone to relieve stenosis (RB), IVD: Inter-vertebral disc.

CONSERVATIVE TREATMENT

During immobilisation

1. Maintenance of the proper posture of immobilisation.

2. Graduated isometric contractions are given to the spinal extensors and abdominals. If POP jacket has been given, the isometrics can easily be performed by pressing against the plaster. If only positioning is selected as a method of immobilisation, resistive flexion and extension of the neck will induce static contractions in the abdominals and spinal extensors respectively. They are important in preventing atrophy and improving circulation at the site of fracture. Active exercises to the neck as well as hips are useful.

> **Caution**
>
> Exercise like SLR puts excessive compression stress on the lumbar region and hence should be initiated late and with extreme caution.

3. The excursion of thorax is restricted either because of fixed lying or due to the plaster jacket. Early initiation of deep breathing is very important. Maximum expansion of the thorax and its recoiling should be encouraged either against hands or plaster. Vital capacity should be regularly monitored by spirometry.

4. Full ROM, resisted arm and leg movements should be initiated without causing extra fatigue or pain. Slow cycling movement for one leg at a time is ideal if not painful.

Patients treated by POP jacket can be made to sit up and ambulate earlier as it is safe. However, they need training sessions of sitting, getting up, standing, balancing, weight transfers and gait training initially. They should be given functional training on the activities of daily routine work.

Mobilisation

1. Mobilisation should be begun by training correct method of turning in the bed with the knees bent and with adequate arm support.

2. The correct method of sitting up in bed, avoiding undue strain on the fracture site, is taught.

> **Caution**
>
> Flexion and rotational attitudes of the spine in flexion injuries, and hyper-extension in the extension injuries should be strictly avoided.

3. Graded extension exercises with forearm support to be begun for the patients with flexion injury; while graded flexion exercises for the patients with extension injuries.

4. Side flexion of the trunk should be begun with the patient sitting with hands at the back of head, and the physiotherapist stabilises the pelvis.

5. Spinal rotation to be initiated in the same position.

6. All the exercises to be made progressive in ROM, strength and endurance.

7. Progressive ergonomic training for the spinal mechanics during various daily activities is of vital importance.

8. Heavy outdoor activities, games, swimming and cycling can be progressed in stages, to regain the pre-injury status.

SURGICAL TREATMENT

Stabilisation procedures:

Harrington rod instrumentation

This procedure permits early and safe mobilisation as it offers stability to the spine which may be impaired due to the injury to the spine. Therefore, it facilitates early trunk balance in sitting, standing and ambulation promoting rehabilitation.

First two days. Measures to prevent post-surgical complications are necessary.

Third day onwards. Gradual mobilisation is begun; "block rolling" is initiated so that the whole body is turned together as a block. This has to be observed strictly as it prevents rotational torque at the trunk.

It is progressed to supported sitting. Patient can be transferred to tilt table for initial period of standing. This is progressed to standing in parallel bars with adequate orthoses fabricated before surgery. This can be eventually progressed to ambulatory training in phases.

Laminectomy and spinal fusion

After surgery, besides the routine measures to prevent post-surgical complications, efforts are made to elicit voluntary contractions in the paralysed muscles. Possible muscle recovery following decompression should be monitored carefully and adequate therapy is given to strengthen these muscles.

When no muscle recovery is noticed, treatment should progress on the same lines as described for stabilisation procedures. However, if the strength in the muscle groups improves concentrated therapy is given before deciding about the orthosis.

B. Treatment of the paralysed patient (paraplegia)

Basic objective. To provide optimal physical independence within the limits of the disability.

General principles:

1. Prevention of the complications.
2. Maintenance of good morale.
3. Maximal return of self-care and functional status.

The phases of management are:

- Acute phase.
- Rehabilitation phase.

During both the phases the basic mode of physiotherapy in thoraco-lumbar lesions remains the same as described for the cervical lesions including bladder management. The major difference is the better self-care and functional control in the former because of the normal sensory-motor status of the neck, upper extremities and upper trunk in majority of the patients. However, some areas need greater emphasis in the management as listed below:

1. Prevention of deep venous thrombosis

Legs are the common sites of deep venous thrombosis. Regular checking of the legs for swelling and erythema associated with low grade fever is necessary. Movements of the legs should be avoided if signs and symptoms of venous thrombosis are present– to avoid serious complications of embolism.

2. Reduction of spasticity

The presence of severe spasticity greatly influences the achieving of ambulatory efficiency, as such it needs extra-attention right from the initial phase.

Proper positioning of the lower limbs is essential during the acute phase of spinal shock. Careful clinical examination is conducted to identify the pattern and the degree of spasticity and the muscle groups involved. Necessary measures like the reflex inhibiting postures, relaxed passive movements, prolonged stretching, longer periods of standing and walking and hydrotherapy or cryotherapy are taken to reduce spasticity.

3. Prevention of ectopic ossification

The common sites of developing this complication are the lower extremities (e.g. hip joint, medial aspect of femur and knee). Therefore, stretching around these areas should be strictly avoided. Regular checking is done to detect early signs of heterotrophic ossification like spongy feeling of the joint during movements, tenderness, warmth and erythema over these sites.

4. Prevention of tightness and contractures

Common sites to develop tightness and contractures like hip flexion and adduction, knee flexion and ankle plantar flexion need regular monitoring. Adequate measures like proper positioning, splinting and procedures to fully stretch these soft tissues are important.

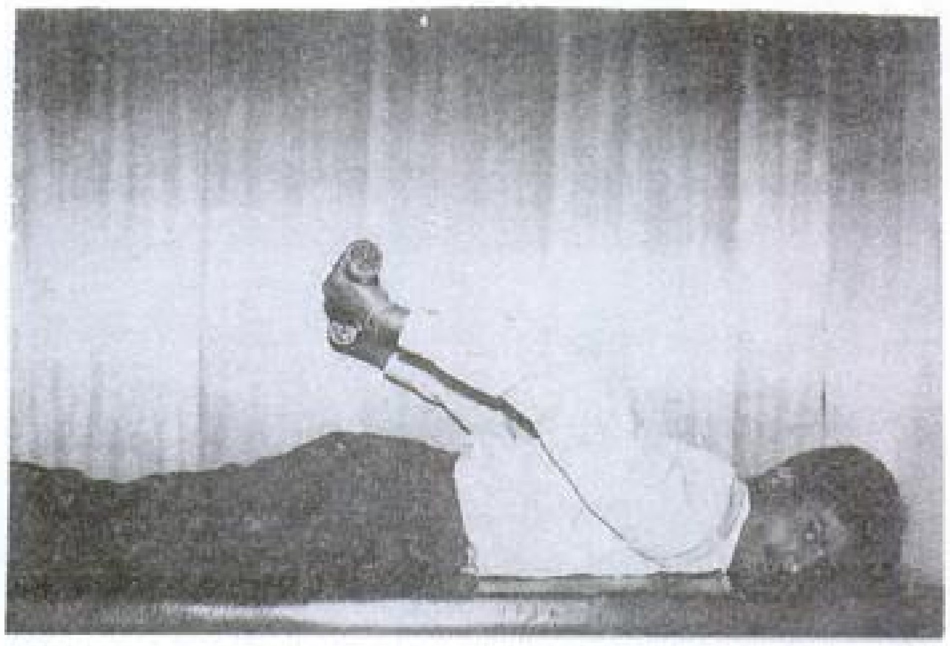


Fig. 4.60. Strengthening exercise for functionally important muscle groups. **(A1)** Latissimus dorsi.

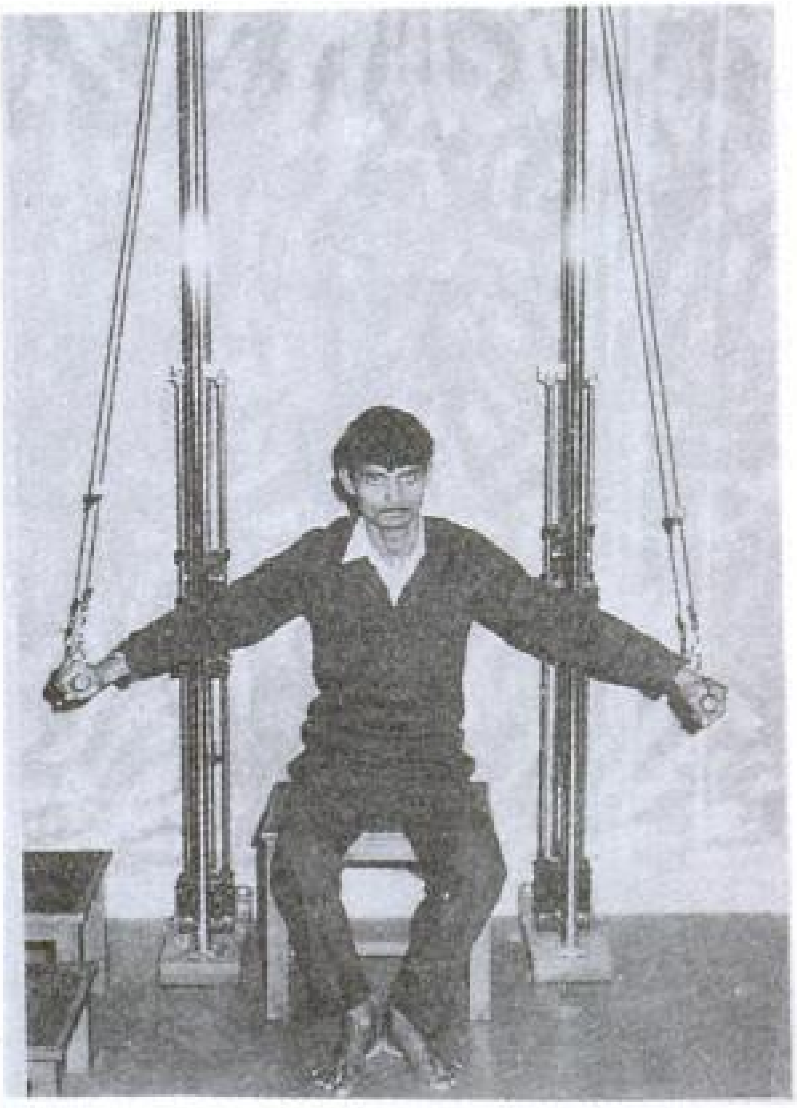


Fig. 4.60. (A2) Latissimus dorsi.

5. Strengthening and re-education of specific muscle groups

Besides hypertrophy of innervated muscle groups, muscle groups which play an important role in the

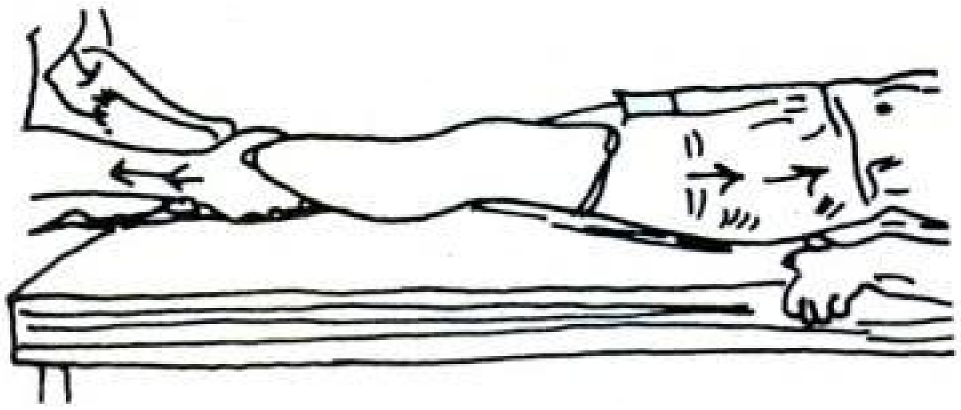


Fig. 4.60. (B) Quadratus lumborum.

maintenance of trunk balance like latissimus dorsi (Fig. 4.60A1 and A2), trapezius, abdominals; muscle groups facilitating crutch walking and transfers like shoulder abductors, depressors, elbow and wrist extensors and finger flexors and quadratus lumborum (Fig. 4.60B) need special attention.

6. Standing–gait and ambulation

Correct methods of standing from wheel chair (Fig. 4.61), standing balance, weight transfers and pelvic tilting are taught in the parallel bars and in front of wall bars (Fig. 4.62).

Gait training is also initiated first in the parallel bars. Basic methodology of gait training like single leg balance, moving hands first, proper placement of the feet, transferring the body weight through feet, and lifting body rather than dragging feet is emphasised. Long and repeated sessions of practice are needed to learn perfect balance, timing, rhythm and coordination of independent controlled walking.

Other ambulatory requirements like turning, side walking and back walking, climbing steps, negotiating slopes and ramps, getting down and up from the floor on to crutches are also practised in lesions between T6 and T10 with good abdominals (Fig. 4.62).

In general, functional walking is not expected in lesions above T6 level. Below this level, gait training and ambulation need adequate appliances and a specific pattern of gait depending upon the level of lesion (Tables 4.6, 4.7).

Gait patterns

The type of gait also depends on the level of the lesion. During the initial phase of training the patient

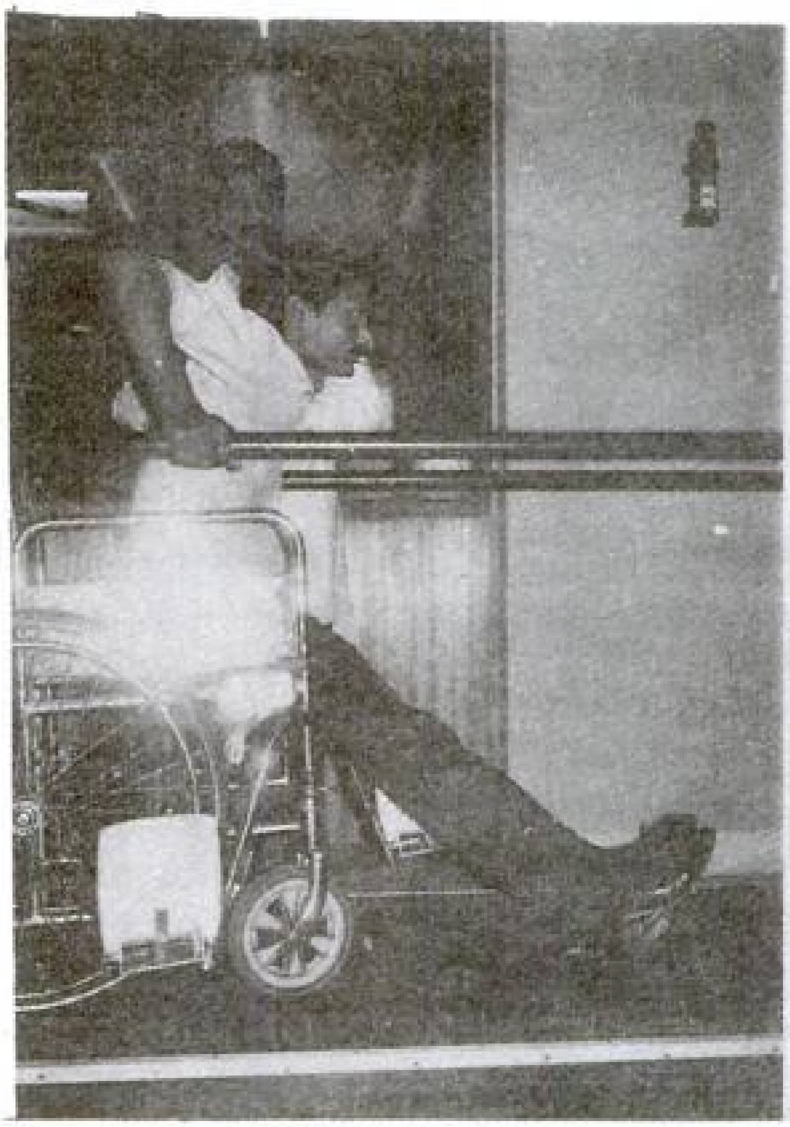


Fig. 4.61 (A)

Fig. 4.61. (B)

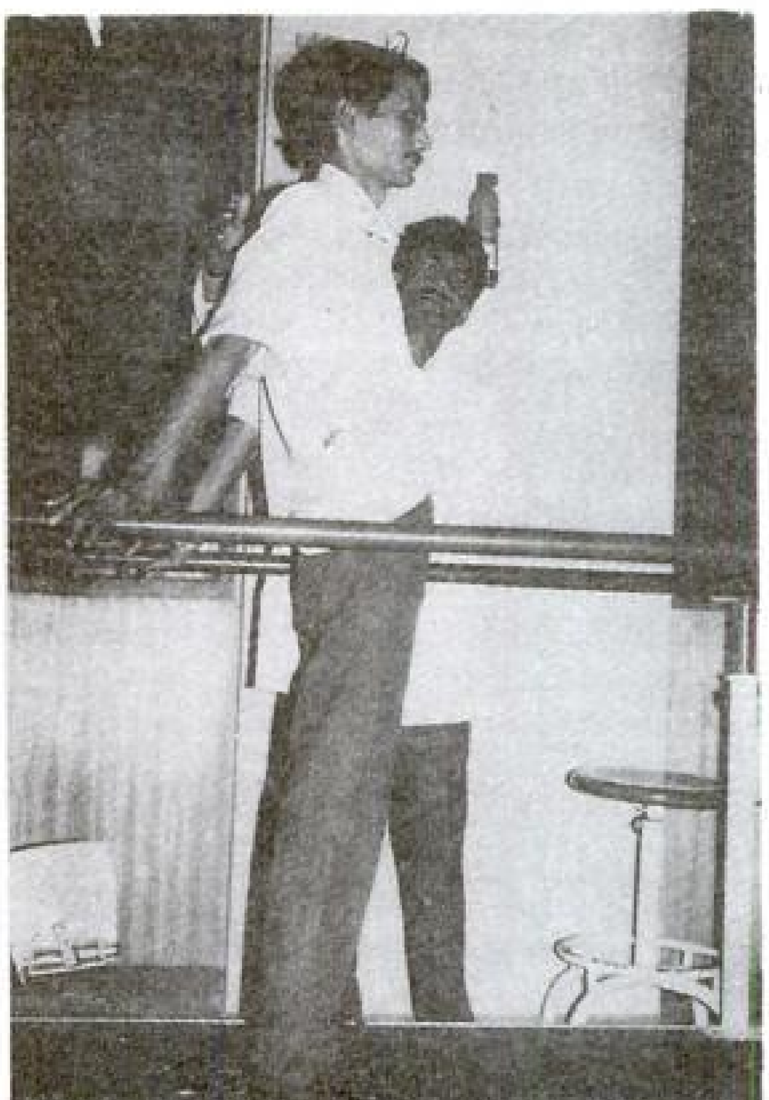


Fig. 4.61. (C)

Fig. 4.61 (A to C) Standing from wheel chair.

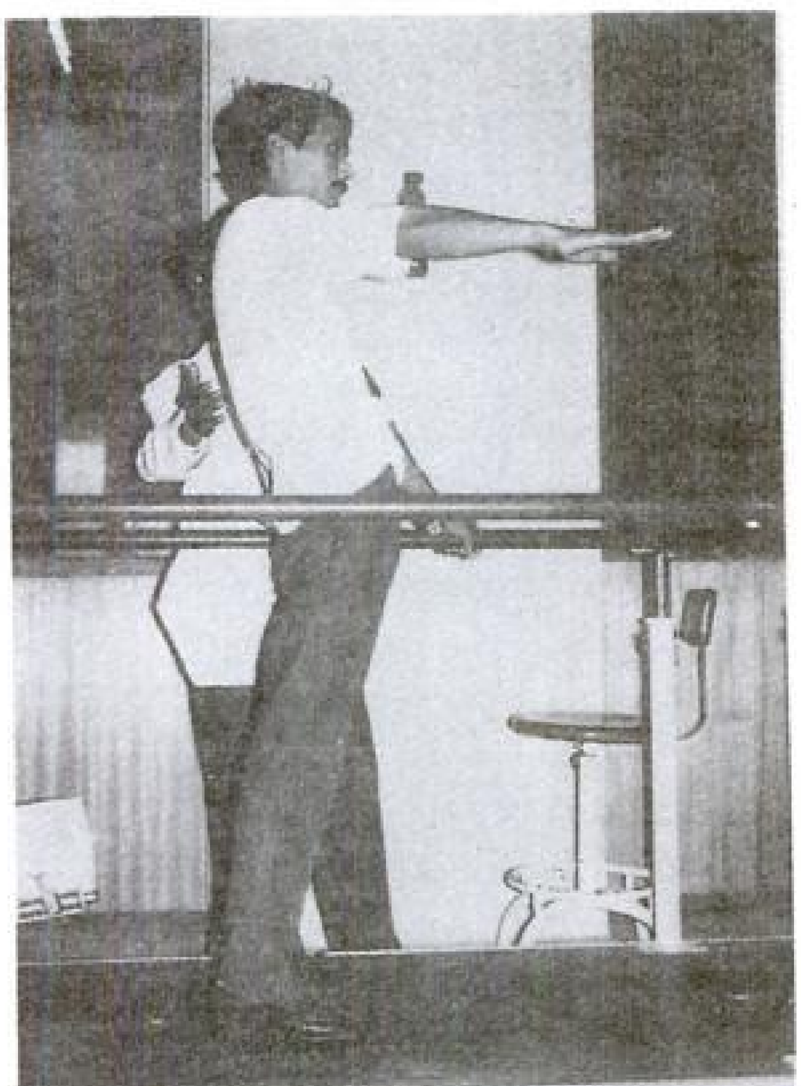


Fig. 4.62. **(A)** Standing balance in parallel bars.

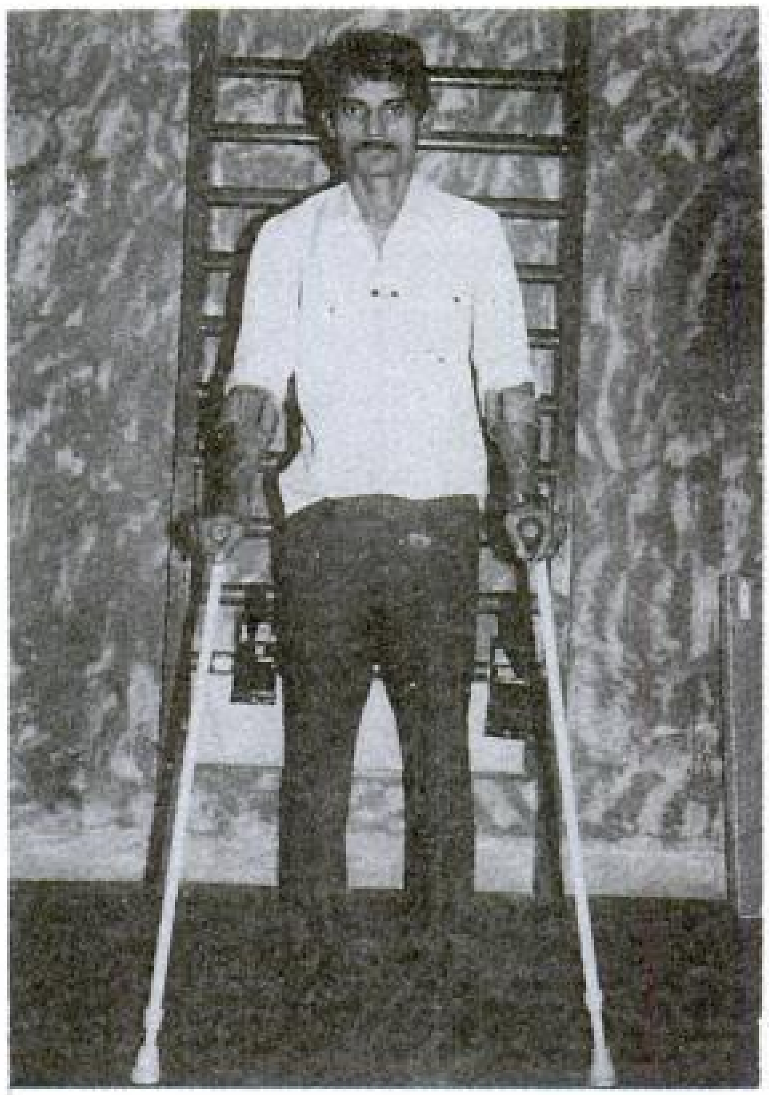


Fig. 4.62. (B) Standing balance on crutches.

Fig. 4.62. (C) Weight transfer.

is first made to walk with the simplest and the safest pattern of gait "shuffle gait". In this gait the patient brings both the arms forward one after the other (later on crutches) and brings both the legs forward simultaneously with toe drag.

The patterns of gait for these patients are :

- Swing-to gait.
- Swing-through gait.
- Four-point gait.

Swing-to gait. This is the safest and simplest type of gait and hence is known as a universal pattern. Therefore, this gait is taught wherever there is marked instability (e.g. patients with level above T10). Bilateral AK orthoses with axillary crutches are necessary, some patients may even need spinal support during the initial stage.

Swing-through gait. This is the fastest and most useful pattern of gait very much acceptable to the patients. This is possible only after a long practice as it requires skilled balance to lift both the feet above the ground and carry them forward beyond the level of crutches.

Four-point gait. This is the slowest of the three, but is more like a normal walk. This gait needs to be included as a therapeutic measure as it improves strength, balance and coordination. It also greatly helps in learning turning in confined spaces. As it needs good balance and dynamic limb control, patients with lesion lower than T12 acquire proficiency in this gait.

7. The appliances

The physiotherapist has to prescribe and check all the appliances needed by a patient. They need to be checked and adjusted while being used (e.g. braces in standing). The limb needs to be checked at the pressure points to the brace during its use.

The patient is also trained to put on and remove the appliances, their correct use as well as their maintenance.

While planning the therapeutic regime, it is absolutely essential to give due importance to vocational planning following rehabilitation. The physical activities expected in the post-rehabilitation phase need to be incorporated in the therapeutic procedures to facilitate vocational tasks.

The goal of the physical, vocational, social and

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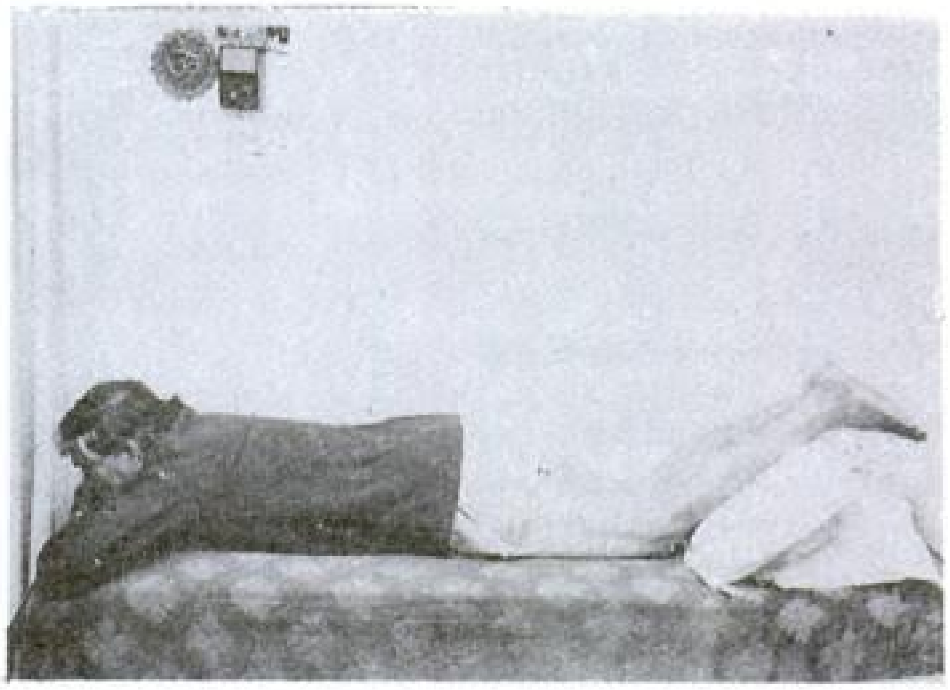

Fig. 4.63. Resting positions for the injured hamstrings.

under the leg (Fig. 4.63) or side lying with the knee in flexion is ideal. This position avoids pressure over the site of injury and relaxes the hamstrings. It is necessary to keep a pillow in between the legs in side lying.

2. Immediate application of ice pack or ice massage is ideal for the control of inflammation.

3. Full range strong ankle and toe movements to be done several times to augment circulation.

4. Diapulse or TENS could be useful adjuncts to hasten the recovery and to control pain.

5. To maintain the hip and knee in flexion, total support of the whole limb without any weight bearing has to be strictly observed.

Mobilisation

(Assisted hip and knee flexion)

1. To avoid the strain of the weight of the limb to the injured muscle, assisted hip-knee flexion should be started with the patient in supine. The patient is guided to flex the hip and knee simultaneously by dragging the resting heel on the bed towards the hip. The ankle should be in dorsiflexion.

2. This should be followed by reversing the process, this time attempting to achieve maximum extension at the hip and knee.

3. A small wedge or a pillow could be placed directly under the knee joint to emphasise isometric quadriceps contractions. Holding the maximum quadriceps contractions at the terminal range of extension is important.

4. Once this becomes painless, sitting with knees at the edge of the bed and knee swinging and if possible hip flexion-extension should be initiated.

5. Progress to resistive exercises for the quadriceps and sartorius, either self-resistive or with suitable weight belt.

6. Gradual weight bearing could be initiated in the parallel bars and progressed to single leg standing and walking.

7. Use of static bicycle to attain smooth coordination is very helpful. Resistance can be applied and increased gradually as it becomes pain free.

Heavy sport activities should not be resumed if the discomfort persists. By 2 months, normal gait and muscle power returns.

A careful watch needs to be kept on the symptoms of increasing pain, stiffness, tight feeling and local tenderness around the hip joint for the suspected myositis.

FRACTURES OF THE PELVIS

The fractures of the pelvis are broadly classified into two types (Fig. 4.64):

A. Isolated fractures of the ilium, pubic rami and sacroiliac subluxation

These are generally stable injuries since the pelvic ring is intact.

Treatment of these injuries consists of bed rest for 2-3 weeks only.

B. Fractures of the pelvis with disruption of the pelvic ring

These fractures occur as a result of direct trauma, e.g. in vehicular accidents or after fall of heavy objects. These are unstable injuries since the pelvic ring is disrupted and one segment of pelvis may get displaced considerably.

These injuries are also associated with complications such as haemorrhage, injury to the pelvic viscera, etc.

Treatment

The patient is treated with heavy skeletal traction to reduce the displacements of the pelvic segments. The traction is maintained for a period of 6 weeks after which the patient is gradually mobilised.

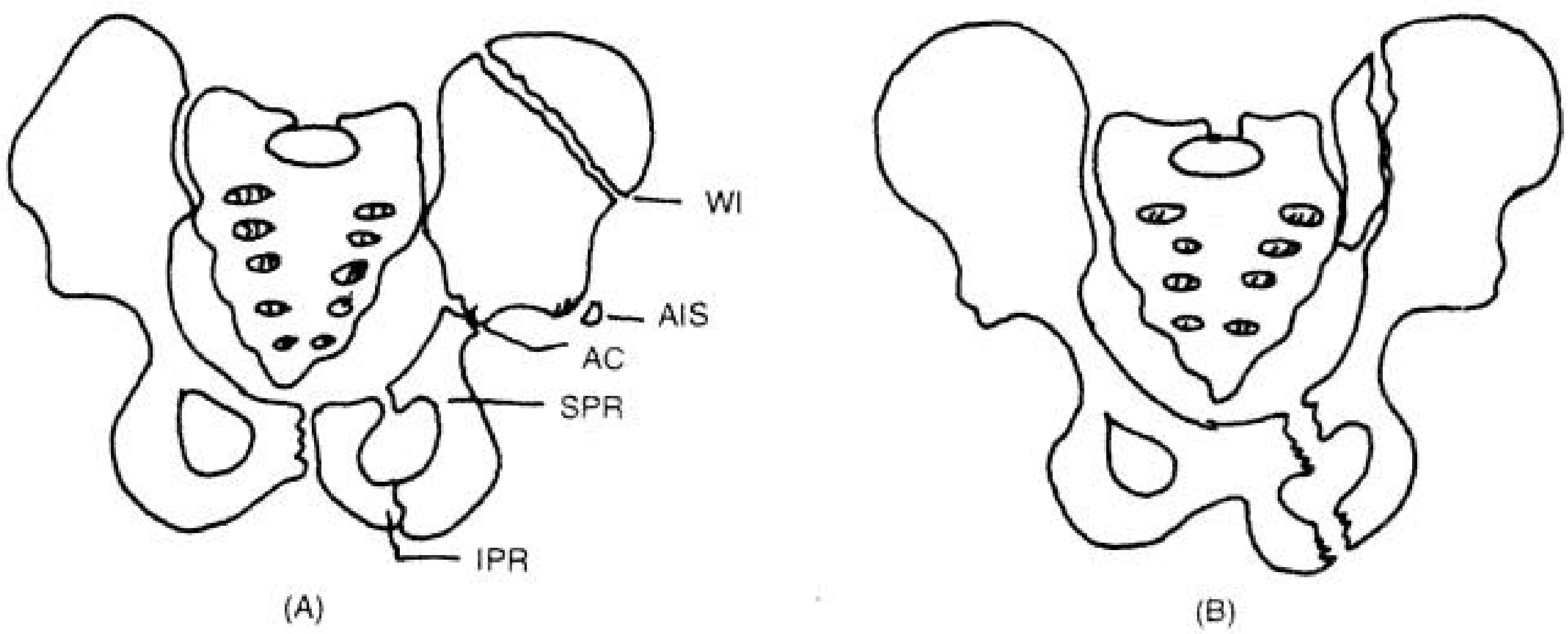

Fig. 4.64. Fractures of pelvis. **(A)** Isolated fractures with intact pelvic ring. SPR: Superior ischio-pubic ramus, IPR: Inferior ischio-pubic ramus, AC: Acetabulum, WI: Wing of ilium, AIS: Anterior inferior spine. **(B)** Displaced fractures with disruption of pelvic ring.

Rarely the fracture may be fixed surgically by plates or an external fixator (Fig. 4.65). The patient can be mobilised 3 weeks after surgery.

Surgical reconstruction for the urethral injuries is taken up later when the patient is mobilised.

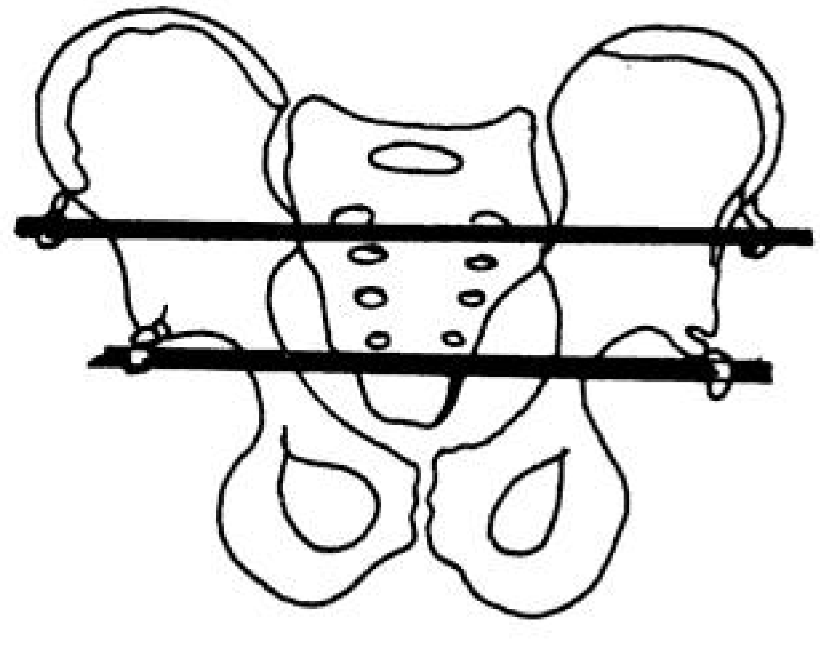

Fig. 4.65. Reduction and maintenance of displaced fracture by external fixator.

Physiotherapy management

A. Isolated fractures of the ilium, pubic rami and the sacroiliac subluxation

These are closed, stable injuries. As such they do not need any specific physiotherapy. During bed rest, strong full range movements of the ankle and toes, isometrics for the quadriceps, hamstrings, glutei and trunk are to be done at regular intervals.

After the period of immobilisation, instructions for gradual weight bearing and ambulation to be given. If the pain persists, appropriate deep heating may be used. The patient should be back to routine activities by 3-4 weeks.

B. Fracture of pelvis with disruption of the pelvic ring

CONSERVATIVE TREATMENT

These injuries are unstable injuries and need heavy skeletal traction for a period of 6 weeks. Therefore, the programme underlined for isolated fractures of ilium, pubic rami and sacroiliac subluxation has to be carried out during immobilisation.

Mobilisation

Initially mobility as well as strengthening exercises should be begun for the lower limbs. Progress to sitting and assisted standing. Weight bearing and walking to be initiated in parallel bars on the second or third day of the mobilisation.

Gait training may be necessary initially. Postural guidance for the functional movements like sitting, gettting up, turning, etc. should be given. Prolonged sessions of prone lying with isolated hip extension may be necessary in the patients who have developed flexor tightness at the hip. The patient should attain full function by 8-10 weeks.

SURGICAL TREATMENT

For the fractures of pelvis treated surgically, the period of immobilisation is short (3 weeks). Therefore, there is an advantage of early mobilisation. But this becomes difficult as the reluctance to do exercises in these patients is more. Firstly, because of the operation and, secondly, because of the external fixator.

The patients need to be encouraged to carry on exercises without worrying for the possible harm due to the external fixator. If the physiotherapist succeeds in gaining patients' confidence in this aspect, early return of function is possible by 4-6 weeks of surgery.

Initial weight bearing and ambulation may be started on a walker or the parallel bars. This should be progressed to the independent ambulation at the earliest.

INJURIES OF THE COCCYX

A fall on the buttocks may cause fracture of the coccyx which may go unnoticed radiologically. The patient has considerable pain which may persist for months. The treatment consists mainly of rest and analgesics.

Physiotherapy management

Persistence of pain for a longer period is known following injuries to the coccyx. These injuries are difficult to treat. Firstly, because of the position of coccyx which is covered by thick fatty and muscular pads of gluteus maximus. Secondly, the area is prone to pressure in sitting. The modalities like ultrasound and TENS may be used for relief of pain. Sitting on a ring cushion and occasional transfer of the body weight over the alternate buttocks should be advised. Sitz bath and strong repeated contractions of gluteus maximus in standing, sitting, prone as well as in supine indirectly improve circulation over the coccygeal area.
Long sitting postures must be avoided. The pain does disappear and there is no functional handicap following this injury.

DISLOCATION OF THE HIP

Dislocation of the hip is of three types:

A. Posterior dislocation (Fig. 4.66A);
B. Anterior dislocation (Fig. 4.66B);
C. Central dislocation (Fig. 4.66C).

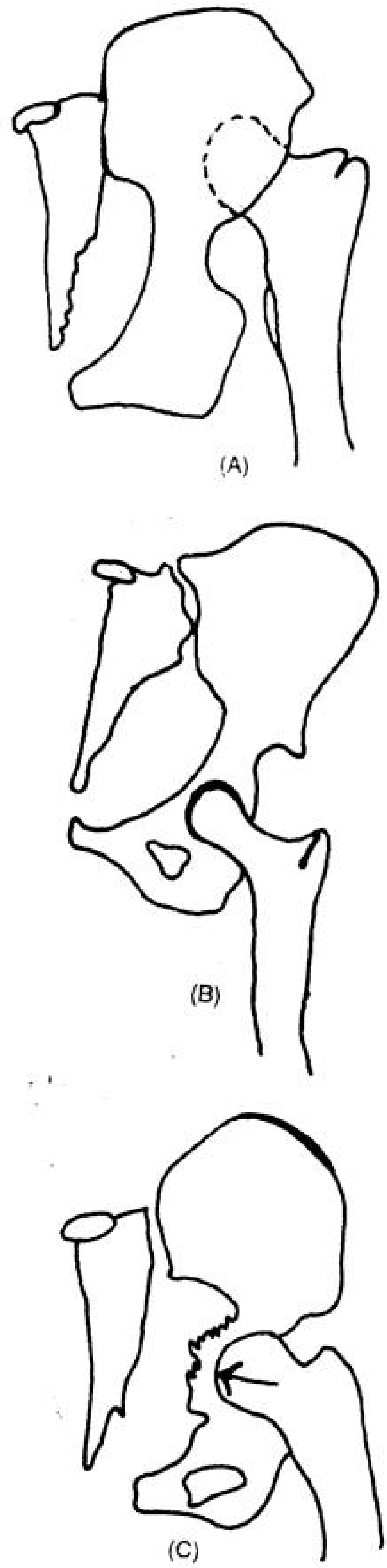

Fig. 4.66. Dislocation of hip joint. **(A)** Posterior. **(B)** Anterior. **(C)** Central.

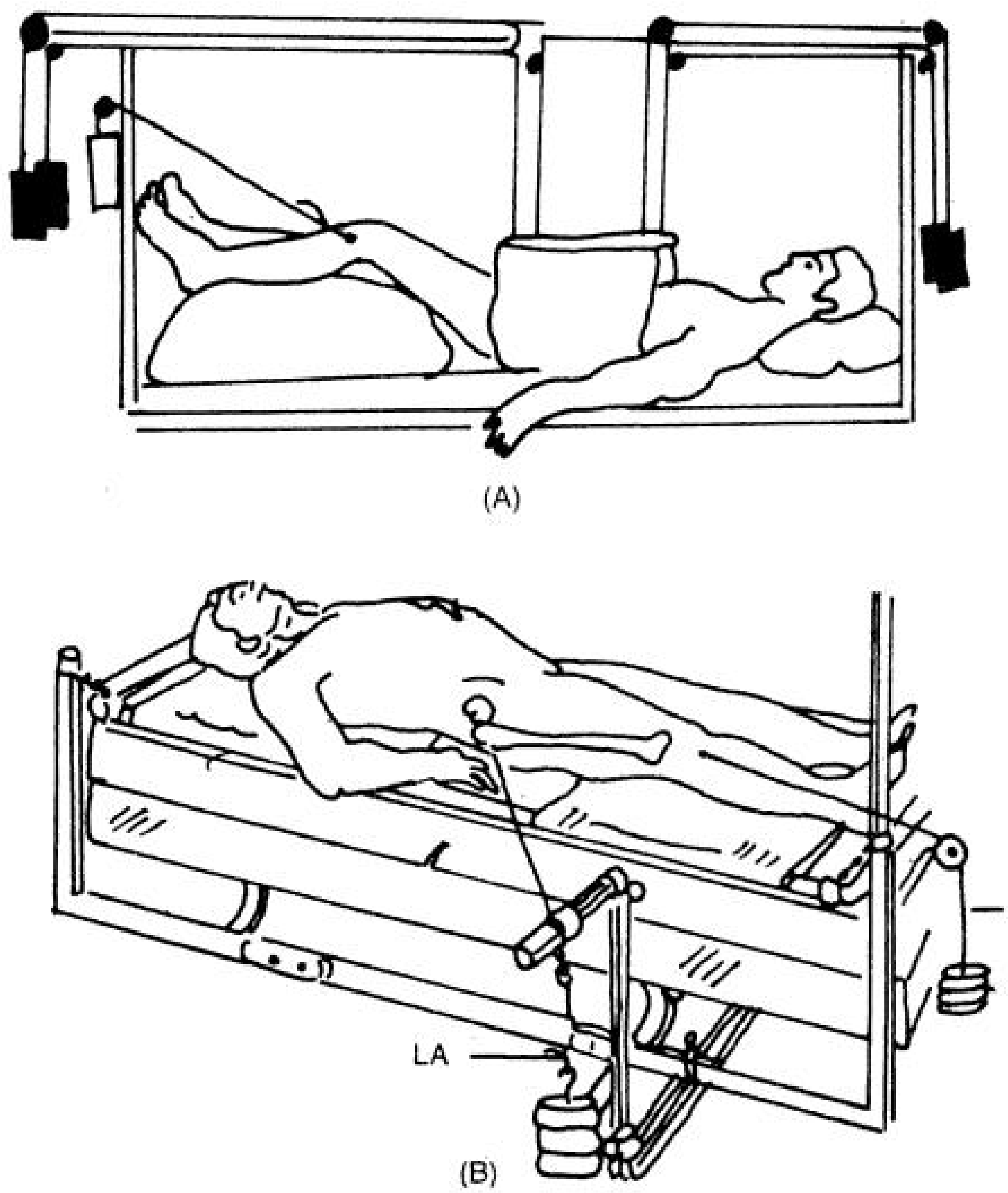

Fig. 4.67. (A) Traction with pelvic compression. **(B)** Two directional skeletal traction.
LO : Longitudinal along the line of leg, LA : Lateral through the greater trochanter.

A. Posterior dislocation

It is the commonest variety amongst three types of dislocations of the hip. It occurs when the adducted and flexed femur is pushed backwards by a violent thrust to the knee, e.g. when the passenger's knee hits against the dashboard of a car. The femoral head is pushed backwards, sometimes fracturing the posterior lip of the acetabulum.

Treatment. The dislocation is reduced under general anaesthesia. In fresh dislocations, closed reduction may be successful; whereas in old dislocations or in cases of associated fractures of the acetabulum, open reduction becomes necessary. A substantially large bony fragment of the acetabulum is fixed internally with the help of screws.

The period of immobilisation, after closed or open reduction, is 6-8 weeks. The limb is immobilised either in a Thomas splint with skin traction or in a POP hip spica. Mobilisation of the hip is started after 6-8 weeks.

B. Anterior dislocation

It is rare and occurs due to road traffic accidents.

Treatment. Manipulative reduction and immobilisation in a hip spica or in Thomas splint for 6-8 weeks.

C. Central dislocation

This type of dislocation results following a fall on the side, or due to road traffic accidents. The floor of the acetabulum is fractured and the head of femur is pushed into the pelvis.

Treatment (Fig. 4.67A,B). The dislocation is reduced by traction with pelvic compression or heavy

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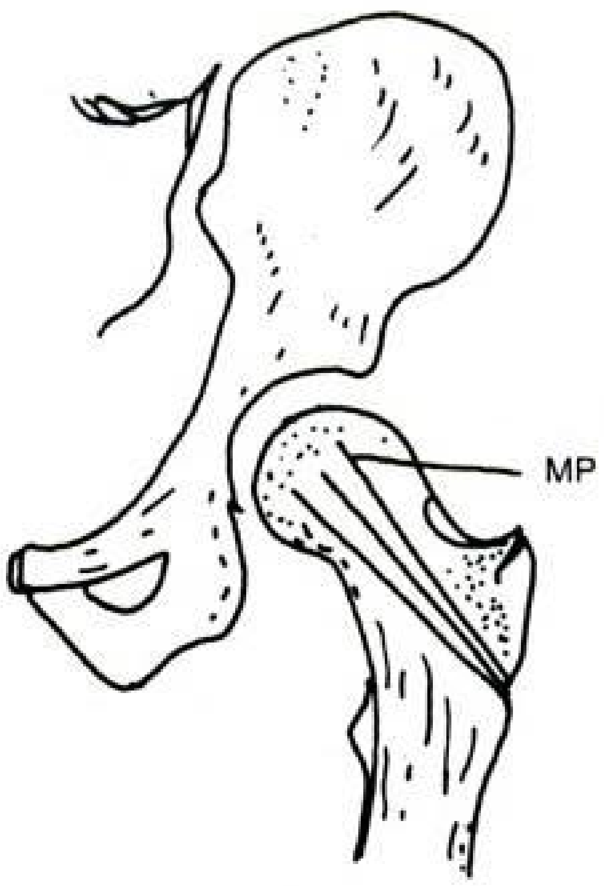


Fig. 4.71. Internal fixation by Moore's pins (MP) or Knowel's pins.

(i) Internal fixation by Knowel's or Moore's pins. The fractures in children are internally fixed with 2-3 Moore's or Knowel's pins (Fig. 4.71). An impacted fracture in adults may also be fixed with these pins to avoid the possibility of displacement occurring at a later date.

(ii) SP Nailing. A fracture in adults is fixed internally with a triflanged Smith Petersen Nail (Fig. 4.72).

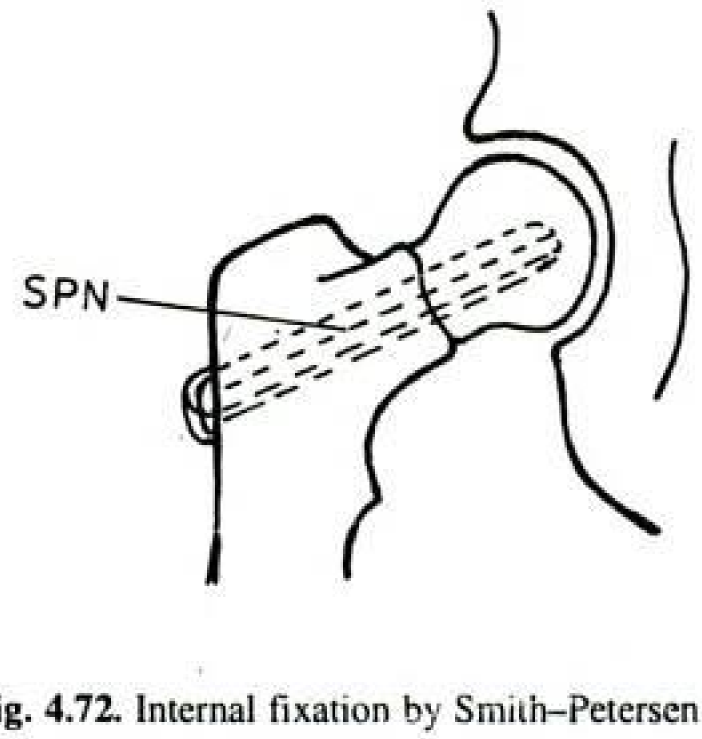


Fig. 4.72. Internal fixation by Smith–Petersen nail (SPN).

Fig. 4.73. Internal fixation by compression AO or dynamic hip screws (DHS).

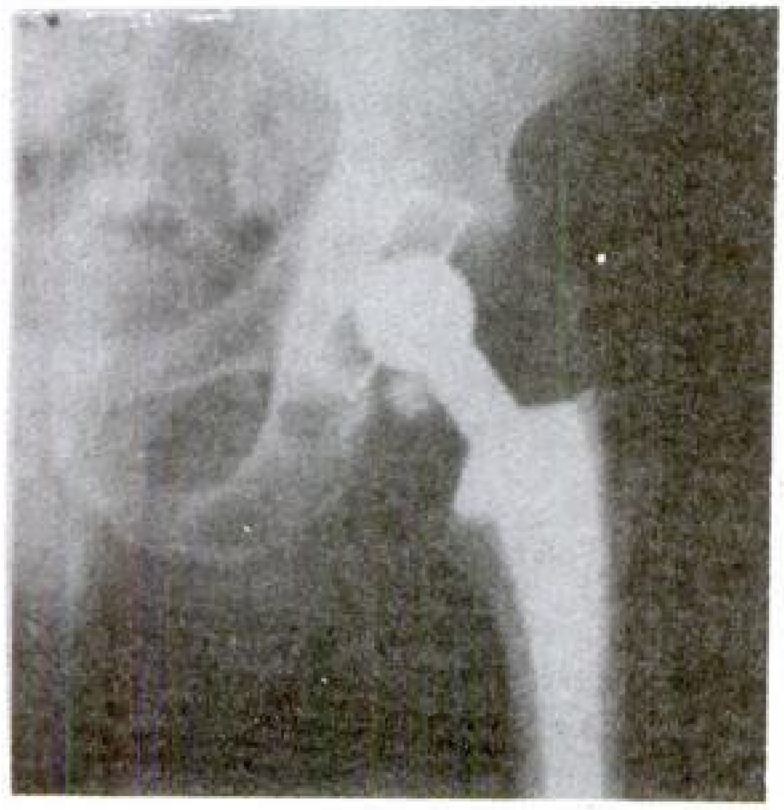
(iii) AO Screws. Nowadays compression AO screws (dynamic hip screws) are used for internal fixation of these fractures. These screws cause compression at the fracture site thereby facilitating the union (Fig. 4.73).

(iv) Replacement arthroplasty of the hip. In patients over 60 years of age replacement arthroplasty of the hip joint is preferred to internal fixation mainly because of two reasons:

(a) The replacement arthroplasty permits early mobilisation and weight bearing. The patient can be made to bear partial weight as early as 2-3 weeks after the surgery.

(b) The incidence of failure after internal fixation (e.g. SP Nailing) of this fracture is quite high even in the best of hands. Avascular necrosis of the head of femur may also occur following this injury. In the event of either of the situations described above a second operation becomes necessary while primary prosthetic replacement of the head obviates these problems.

(A)



(B)

Fig. 4.74. Replacement arthroplasty. **(A)** Hemireplacement athroplasty (only femoral head replaced). **(B)** Total hip joint replacement arthroplasty (THR) (both acetabulum and femoral head replaced).

The replacement arthroplasty is of two types:

(i) Hemireplacement arthroplasty (Fig. 4.74A). This is a commonly performed operation where the head of the femur along with the part of neck proximal to the fracture line is removed and replaced with a metal prosthesis (e.g. Austin Moore or Thompson femoral prosthesis).

(ii) Total hip replacement arthroplasty (Fig. 4.74B). Some surgeons prefer to do a total hip replacement following a fracture neck of femur. In this operation, along with the replacement of the head and neck of femur, the acetabulum is also replaced by an artificial acetabular cup.

Physiotherapy management

Conservative approach

(Fracture treated by skin-traction, skeletal traction and derotational bar)

During immobilisation

As the patients are generally in the age group of 60 years and above the following measures are taken:

1. Adequate chest-physiotherapy to avoid respiratory complications.
2. Repeated checks to assure correct positioning of the fractured limb; with special attention to avoid limb rotation.
3. Resistive movements to the toes and ankle joint of the fractured limb and other body joints.
4. Strong isometrics to the quadriceps hamstrings, hip extensors and abductors. Each static contraction should be strongly held at least for 10 seconds (or 30 counts), to avoid post-immobilisation atrophy and weakness.
5. It is ideal to initiate early knee mobilisation whenever special bed is available (slit-bed).
6. Initiate sitting in bed at the earliest opportunity, maybe with back rest at the beginning.
7. Site of skeletal traction pin should often be inspected for infection/loosening.

Mobilisation

As soon as active mobilisation is allowed, efforts should be concentrated to get maximum possible active ROM of hip and knee.

Weight transfers and brief periods of full weight bearing on the affected leg alone are very important to balance the whole body weight on the affected leg during standing and walking. Guided training is needed to master it. Periods of prone lying, four point kneeling and knee walking are extremely useful as a preweight bearing exercise (Fig. 4.75). This kneel standing should be progressed to knee walking (Fig. 4.76). Strengthening exercises for the glutei and quad-

Fig. 4.75. Graduated weight bearing on the operated hip is facilitated by knee standing and knee walking with hand support.

Fig. 4.76. Total weight bearing on the operated hip is facilitated by knee standing and knee walking without hand support.

riceps should be done by PRE techniques. Passive stretching ROM exercises should be progressed to get full ROM at the hip and knee joints. Supported squatting in front of wall bars and cross-leg sitting with back supported against the wall could be started with guidance and gradual progression.

By 8-12 weeks, the patient should be functionally independent.

Patients treated with hip spica. This method is rarely adopted due to various disavantages. When treated by this method, strong resisted toe-movements, and isometrics inside hip spica are taught and ensured. Sessions of assisted bed side standing to be initiated at the earliest.

During mobilisation the measures and sequence of physiotherapy remains the same as described for treatment by traction and derotational bar.

Patients treated by pseudarthrosis. Patients who are not fit for plaster, traction or surgical methods of treatment are left to pseudarthrosis at the fractured hip.

1. Persisting annoying pain is the typical feature of these patients, therefore basic approach of physiotherapy is directed towards the relief of pain. Pain can be controlled by:

(a) Movements started in combination with TENS.
(b) The patient should be taught accurate methods of transfer and limb positioning during the activities.
(c) Emphasis is laid on repeated sustained isometric contractions to strengthen the functionally important muscle groups.
(d) Isotonic exercises and hasty partial weight bearing should be discouraged, as they produce movements at fracture site leading to non-union.

Gradual weight bearing should be started with adequate support to avoid pain.

As the degree of pain reaches the acceptable level, progressive physiotherapy measures should be adopted to ease ambulation.

Majority of the patients achieve functional independence. However, some may need a walker or two crutches for ambulation, because of persistent pain.

Surgical approach

During immobilisation (first week or 10 days)

The advantage of the fractures treated by internal fixation is early mobilisation of the hip and knee joints. Physiotherapy management of total and hemi-replacement arthroplasties is dealt with in a separate chapter.

1. Deep breathing and coughing manoeuvres to be started immediately to avoid chest complications.

2. Vigorous frequent ankle and toe movements with static quadriceps and hamstrings contractions are im-

portant to avoid thrombophlebitis. Initially as the leg is kept in slightly elevated position to reduce edema, speedy isometrics for the quadriceps and hamstrings are extremely useful.

3. Proper positioning of the limb in bed to be assured with the knee straight or slightly bent and the limb in neutral rotation.

4. Isometrics to the glutei are important and should be emphasised to the maximum. The contractions should be strong enough and held at least for 10 seconds before relaxation. It is important that the contractions should not be too strong to initiate pain.

5. Frequent removal of the pillow under the knee and isometrics for the hip extensors and abductors should be initiated at the earliest possible opportunity.

Pressing the leg down on a soft pillow or mattress is a good method of strong isometric contractions for the extensors of the hip as well as the hamstrings. Isometric exercises for the hip abductors with the leg in neutral position are ideally taught to the attendant holding and resisting the effort of the patient to abduct the limb.

After one week or 10 days

By this time the stitches are removed and considerable healing of the soft tissues has taken place.

Gradual mobilisation of the hip is initiated.

1. Relaxed passive mobilisation should be started by the physiotherapist, totally supporting the weight of the limb.

2. Whenever CPM (Continuous Passive Motion) apparatus is available, it can be used gainfully to initiate relaxed passive hip and knee flexion- extension. The patient is taught to operate it so that maximum possible work for the range of motion is facilitated.

3. Progressive assisted active range of flexion can be achieved by self-assisted dragging of the heel to the hip – "Heel drag" (Fig 4.77).

4. Sitting and transfer with legs hanging over the edge of the bed could be made self-assisted. The patient supports the operated leg by the normal leg.

5. Assisted abduction can be initiated by sling suspension or the patient using the sound leg support underneath the fractured leg.

6. Assisted SLR may be begun as early as possible, in spite of little discomfort.

7. Knee swinging in sitting at the edge of the bed can be made resistive either by self-resistance technique using the normal leg or by graded resisted exercises using weight belts or the De Lorme shoe.

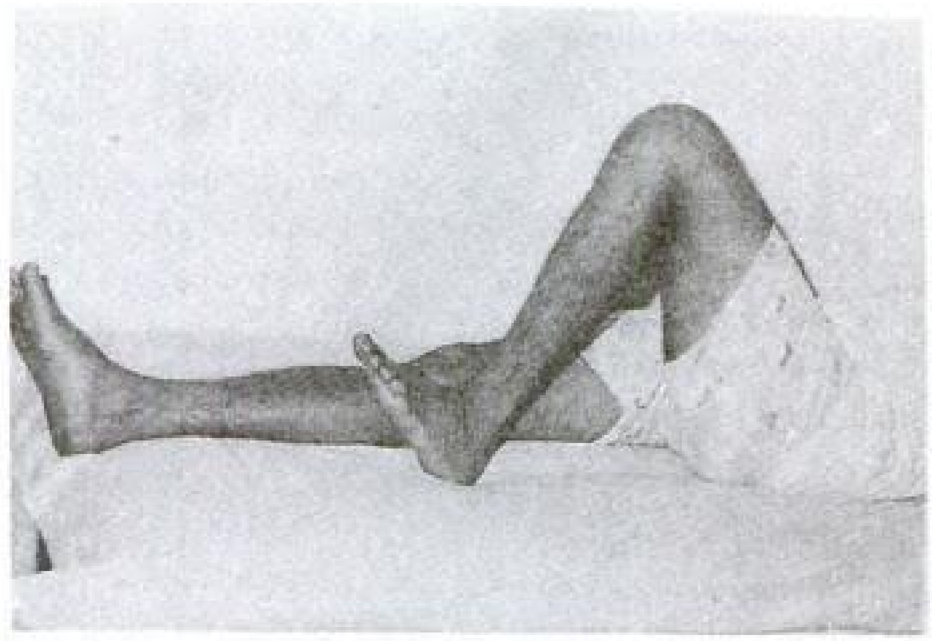


Fig. 4.77. Initiation of hip flexion by self-assisted "Heel-drag".

The other managemental programme should be followed on the same lines as described for the conservative treatment of these fractures. Partial weight bearing can be started after 6-8 weeks, while full weight bearing may be deferred till 12 weeks.

If there are no complications, patients of any age should be functionally independent by 3 to 4 months.

Caution

1. The most important aspect of this period is to regain maximum (near normal) range of hip flexion. Once the fibrous ankylosis is allowed to organise at this stage, regaining the range of flexion becomes impossible at a later stage.

2. All the measures to avoid fixed flexion or abduction deformity at the hip should be strictly observed.

3. If the patient starts complaining of excruciating pain and tenderness around the operated area as well as progressive limitation in the ROM at hip, complications like non-union, loosening of the internal fixation, avascular necrosis or ectopic ossification should be suspected and be reported immediately.

Complications of fracture of the neck of femur

1. Non-union.
2. Avascular necrosis of the femoral head.
3. Osteoarthritis of the hip.

1. Non-union

It is quite common. It may occur in an untreated neglected fracture or following internal fixation. In the former situation the neck gets absorbed and the trochanter may get uprided resulting in considerable shortening of the limb. In a fracture treated by internal fixation, the same complications may be seen. In addition to these, the nail may get loose and back out.

TREATMENT

(a) Mc Murray's displacement osteotomy. In this operation an osteotomy is performed just above the lesser trochanter and the distal fragment is displaced medially (Fig. 4.78). The principle of this operation is to change the line of weight transmission through the upper end of femur. Postoperatively the patient is given a POP hip spica for 6-8 weeks. Some surgeons, however, prefer to fix the osteotomy internally with plate and screws. In that case no plaster is needed and the patient can be mobilised after 2-3 weeks.

(b) Replacement arthroplasty. It is commonly done in elderly patients.

Fig. 4.78. Mc Murray's displacement osteotomy of femur for non-union following fracture of neck of the femur.

(c) Meyer's muscle pedicle bone grafting. When the absorption of the neck is not much and the head of femur is viable, a muscle pedicle bone graft (obtained from the quadratus femoris muscle) with intact blood supply is put over the fracture site and fixed with screws (Fig. 4.79). The fracture in the neck is also fixed internally. Vascularised muscle pedicle bone graft is reported to enhance the process of union (Meyer et al., 1973).

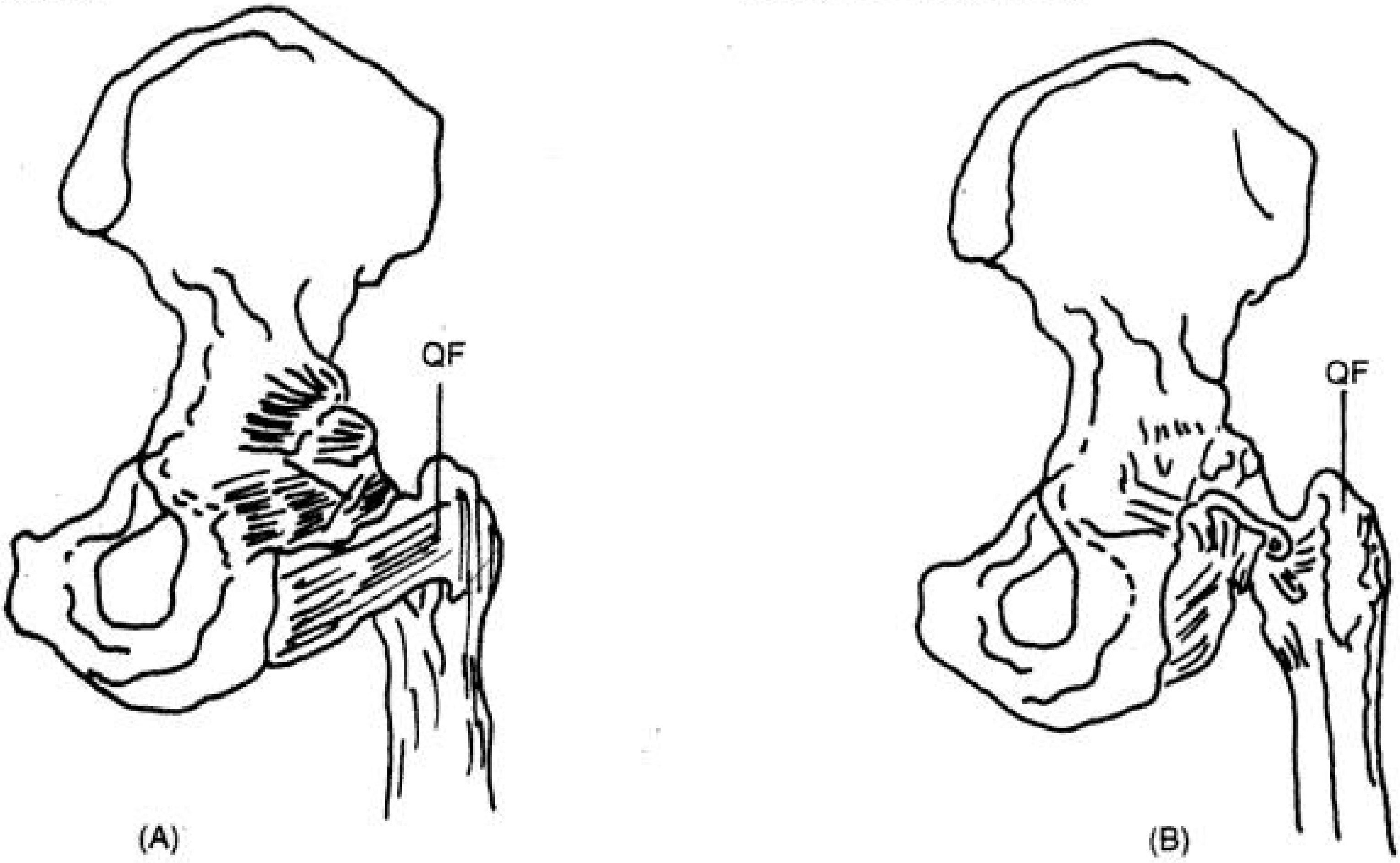


Fig. 4.79. Meyer's muscle pedicle grafting. **(A)** Quadratus femoris (QF) identified. **(B)** Quadratus femoris (QF) fixed into a slot in the neck of femur after internal fixation.

2. Avascular necrosis of the femoral head

It is treated by total hip replacement.

3. Osteoarthritis of the hip

An advanced case of osteoarthritis of the hip may require total hip replacement. Rarely, arthrodesis of the hip joint may be done to relieve pain.

PHYSIOTHERAPY MANAGEMENT

(a) After Mc Murray's osteotomy (during immobilisation, first 6 to 8 weeks). If the hip spica is applied there is not much of a scope for active physiotherapy. However, the following programme should be initiated:

1. Strong and vigorous toe movements.
2. Technique of supported rolling to the side in bed.
3. Isometrics for the hip and knee muscles.
4. Ankle, foot and knee on the normal side needs to be vigorously exercised by hanging the leg over the edge of the bed.

When the osteotomy is fixed internally with plate and screws, mobilisation could be started by 3 weeks. The physiotherapy programme to be followed on the same lines as detailed for the fractures of the neck of femur. The patient regains adequate functional status by 3 months if treated in a hip spica and by 6-8 weeks when treated by osteotomy with internal fixation. Occasional inexplicable weakness of the hip flexors has been noticed by us in patients treated by hip spica. Therefore, active assisted hip flexion needs to be initiated early.

(b) After Meyer's muscle pedicle bone grafting. The physiotherapy management proceeds on the same lines as described for the internal fixation for the fracture of the femoral neck.

(c) After hip replacement and arthrodesis. The physiotherapy management after these procedures is discussed elsewhere.

TROCHANTERIC FRACTURES

A fracture in the region of the greater trochanter (up to the lesser trochanter) is called as trochanteric fracture (Fig. 4.80). A fracture distal to the lesser trochanter (within 2 inches) is called as subtrochanteric fracture of the femur. Trochanteric fracture is also called as extracapsular fracture of neck of the femur since the fracture line is distal to the femoral attachment of the hip joint capsule. However, the term "extracapsular fracture" is confusing and should not be used.

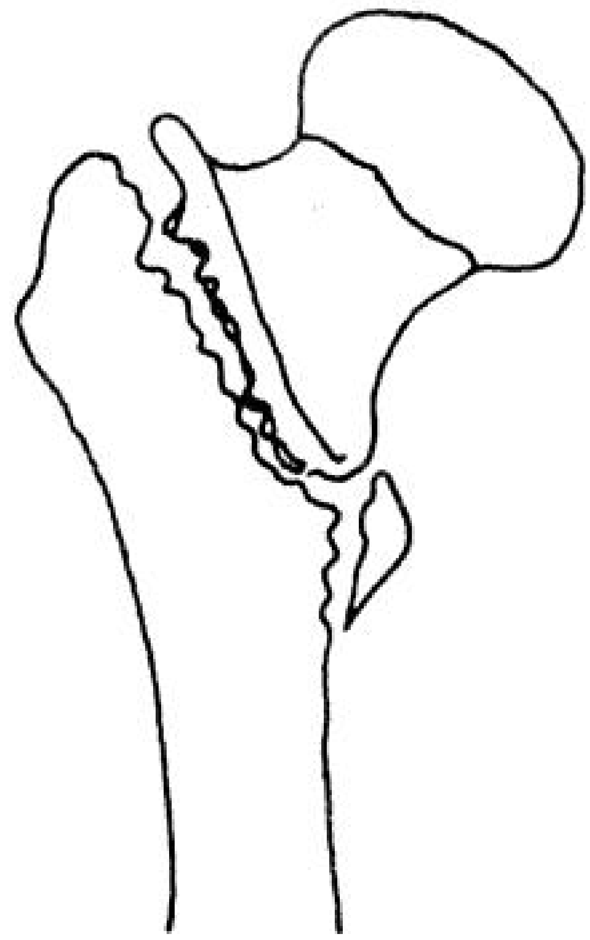


Fig. 4.80. Intertrochanteric fracture.

Trochanteric fractures are common in the elderly patients in whom the bones are osteoporotic and, therefore, trivial trauma like a stumble or a fall can cause this injury. However, this fracture is rare in adults and results following a major trauma. The fracture may be displaced or undisplaced and may be comminuted.

Clinically the limb appears short and markedly externally rotated (much more than is seen in the fracture neck of femur) following injury. The diagnosis is confirmed on X-rays.

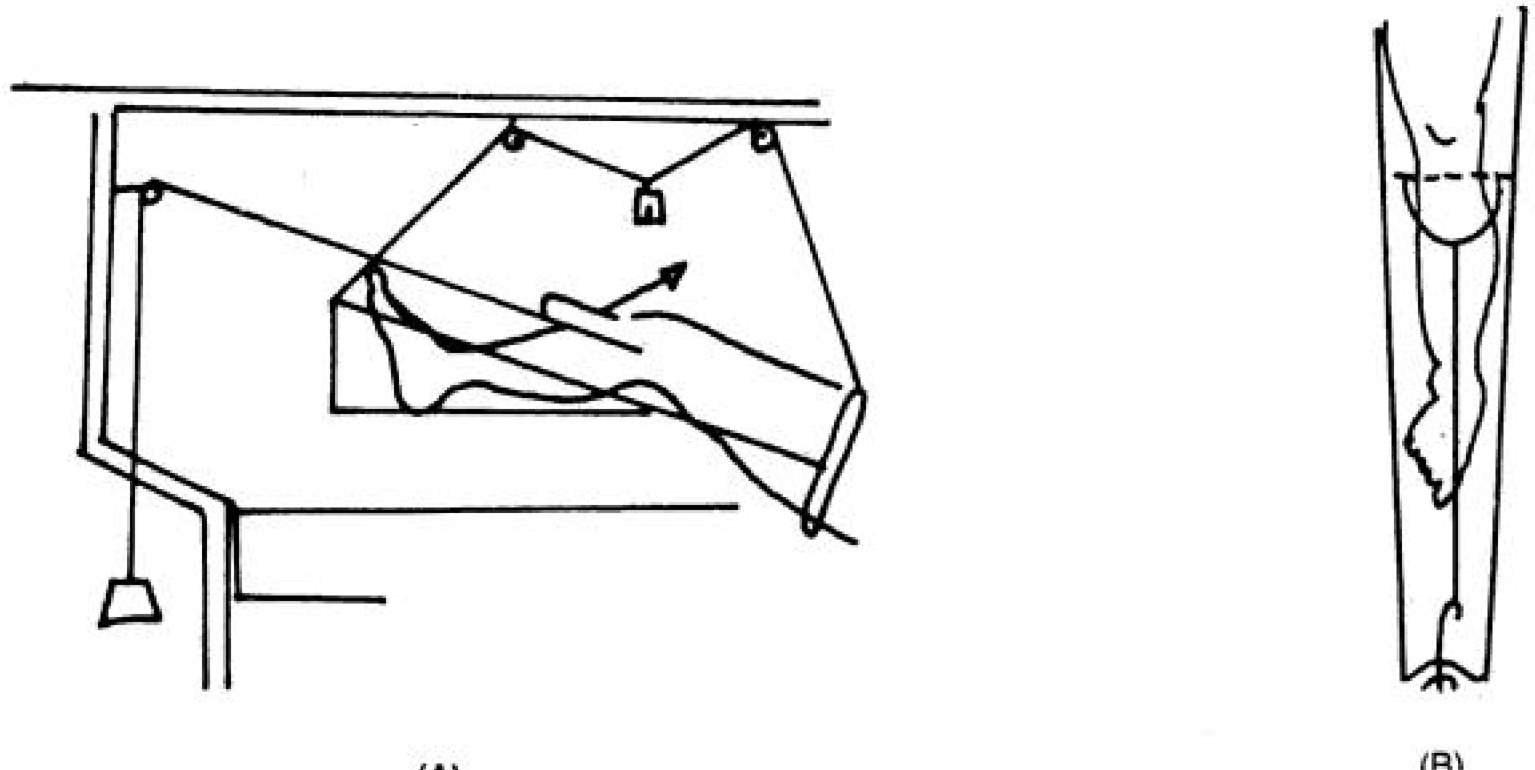
Treatment. The trochanteric fracture generally unites readily as it occurs in the region of cancellous bone. The treatment, therefore, is aimed at maintaining alignment of the fracture fragments either by conservative or operative methods.

1. Conservative treatment

The following methods may be used:

(a) Skin traction,
(b) Skeletal traction,
(c) Plaster of paris hip spica and
(d) Plaster of paris derotation bar.

Skin or skeletal traction (Fig. 4.81) is applied to the leg and maintained for 6-8 weeks. Active mobilisation



(A) (B)

Fig. 4.81. Skeletal traction. **(A)** Continuous traction with balanced suspension using Thomas' splint and Pearson knee flexion attachment and skeletal traction through the tibia or **(B)** fixed traction.

of the hip is then started. However, weight bearing should be started only after 3 to 6 months, depending upon the type of fracture and the evidence of sound radiological union.

Plaster of paris hip spica (Fig. 4.82) is indicated rarely, only in young adults. The plaster spica is given for 6-8 weeks.

In very elderly patients when surgery is contraindicated due to medical problems, occasionally POP boot and bar (derotation bar) is given (Fig. 4.70). It keeps the limb in neutral rotation and thereby prevents any external rotation deformity. It, however, does not reduce the fracture accurately and, therefore, the fracture invariably malunites with shortening and coxa vara. POP boot and bar is also given in an elderly patient with an undisplaced trochanteric fracture.

2. *Operative treatment*

Although most of the patients can be treated by conservative methods, the operative treatment offers the advantage of accurate reduction and early mobilisation, particularly in the elderly patients. The operative treatment thus avoids the complications of prolonged recumbancy.

The fracture is reduced by operation, under X-ray control, and fixed internally by Smith Peterson Nail and plate or Ender's nail (Fig. 4.83). Many other fixation devices are also available today which give better fixation.

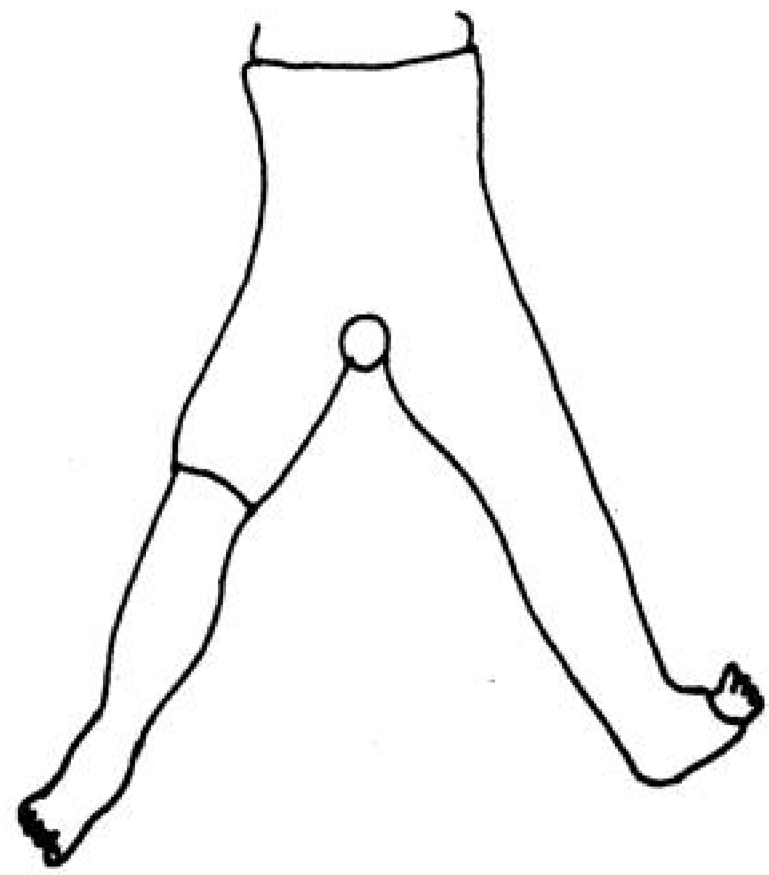


Fig. 4.82. Plaster of paris hip spica.

Postoperatively the patient is given only a dressing (no external immobilisation). The patient can be made to sit up in bed the next day and the hip is mobilised as soon as the pain permits; weight bearing, however is started after about 3 months.

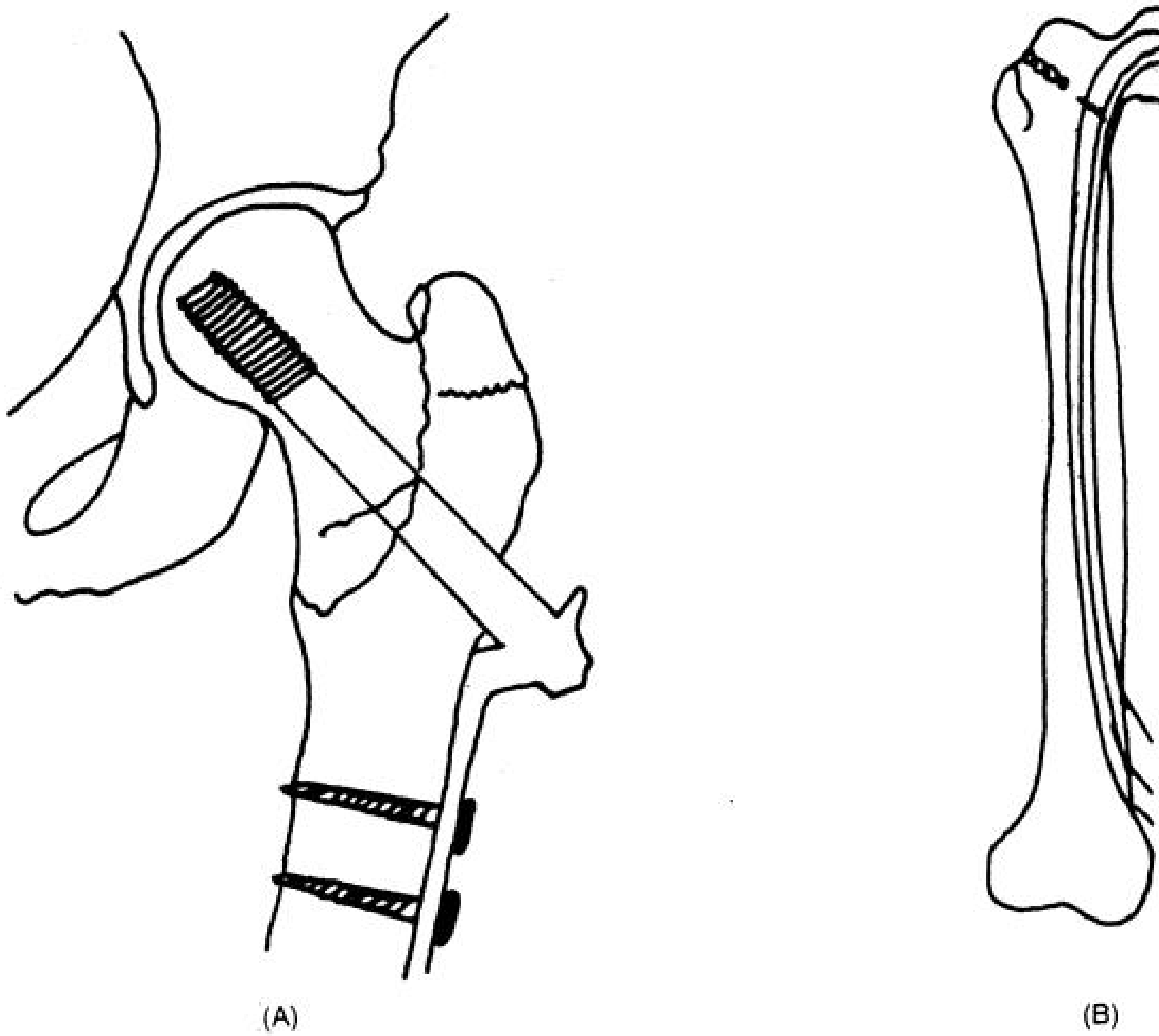


Fig. 4.83. Internal fixation of trochanteric fracture. **(A)** Fixation by Smith Petersen nail and plate. **(B)** Fixation by multiple Ender's nails.

Complications

1. Malunion. Inadequate fixation/immobilisation, implant failure or severe comminution often results in malunion. The fracture malunites in coxa vara which produces shortening and limp.

Treatment. Correction of coxa vara deformity by corrective osteotomy and fixation with SP Nail and plate device.

2. *Non-union* of the trochanteric fractures is extremely rare.

Treatment. Internal fixation with SP Nail and plate with bone grafting.

Physiotherapy management

The physiotherapy management of trochanteric fractures, treated conservatively or surgically, proceeds on same lines as described for fracture of neck of femur.

FRACTURES OF THE SHAFT OF FEMUR

Fractures of the shaft of femur occur at all ages and are caused by severe trauma, except in cases where the bone is destroyed and weakened by disease. Fracture occurring in a diseased bone is called as pathological fracture. It results following a trivial trauma.

In adults generally there is marked displacement of the fragments due to the pull of strong muscles surrounding the femur.

In a case of fracture of the shaft of femur there is generally considerable blood loss from the bone ends and also from the traumatised soft tissues. The patient, therefore, may be in a state of shock when first seen.

Treatment

The immediate treatment includes blood transfusion to combat shock, and temporary splintage of the fracture.

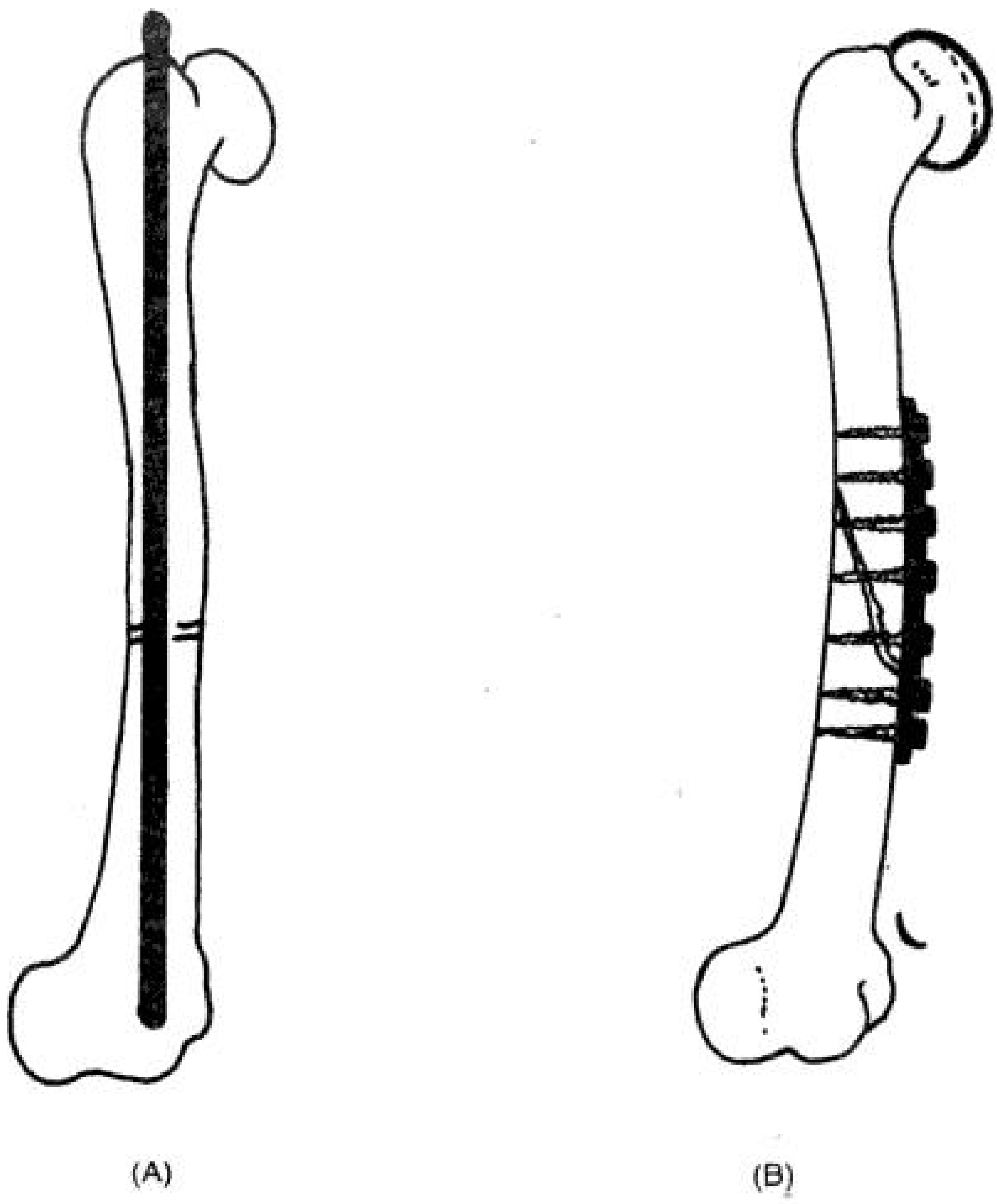


Fig. 4.84. Internal fixation of fracture of the shaft of femur. **(A)** Fixation by Kuntscher's intramedullary nail (K nail). **(B)** Fixation by plate and screws.

Fracture of shaft of femur can be treated by both conservative as well as operative methods.

(a) Conservative treatment

It depends upon the age of the patient:

1. Children under 2 years of age. Fracture of the shaft or femur in children below 2 years of age is treated by Gallow's traction (Fig. 3.6) for 3-4 weeks.

2. Older children. In older children, this fracture can be treated by either of these methods:

Skin traction on pillows.
Skin traction in a Thomas splint and
POP hip spica.

The period of immobilisation is 6-8 weeks.

3. Adults. Fracture of the shaft of femur in adults and elderly patients is treated by skin traction in a Thomas splint or a balanced traction over pulley's. The period of immobilisation is longer, i.e. 12-14 weeks.

(b) Operative treatment

Open reduction and internal fixation of the fracture fragments is generally indicated in adolescent, adult and elderly patients. It is rarely indicated in very young children since in them some amount of angulation and overriding of the bony fragments are acceptable. In young children these deformities get corrected in the process of remodelling of the bone.

Wherever indicated, the femur is internally fixed with Kuntscher's intramedullary nail or plate and screws (Fig. 4.84).

Advantages of operative treatment

- Period of hospitalisation and recumbancy is less.
- Generally no external immobilisation is needed and hence knee mobilisation can be initiated early (after 2 weeks). Although the weight bearing should be started only after the radiological evidence of sound union is obtained, i.e. after 2 to 3 months.

Complications

1. Injury to vessels and nerves. Although rare, a sharp bony fracture fragment can cause injury to the femoral artery and femoral and sciatic nerves. In such a situation it requires urgent repair.

2. Infection. An open fracture is likely to get infected. Infection during surgery can also lead to chronic osteomyelitis of the femur.

3. Delayed union and non-union. If a fracture of the shaft of femur is treated with inadequate immobilisation it can go into delayed union or non-union. Other common causes of non-union include infection and interposition of soft tissues between the fracture fragments.

Delayed or non-union is treated by open reduction, internal fixation and bone grafting.

4. Malunion. Improperly treated fractures can unite in a malposition resulting in shortening and deformity of the limb.

Malunited fracture can be treated by corrective osteotomy. The bone is internally fixed with nail or plate.

5. Knee stiffness. Varying degrees of knee stiffness commonly result after femoral shaft fractures. The possible causes are:

- Prolonged immobilisation of the knee.
- Adhesions of the quadriceps muscle to the bone and callus at the fracture site.
- Intra-articular and periarticular adhesions of the knee joint.

Knee stiffness can be treated by intensive knee mobilisation programmes. Severe degree of knee stiffness can be treated surgically by an operation—quadricesplasty. In this operation lengthening of the quadriceps muscle is carried out. Postoperatively, intensive knee mobilisation is required, initially in a Thomas splint with the Pearson knee attachment.

Physiotherapy management

Early physiotherapy during immobilisation follows the same pattern as described for trochanteric fractures. The skeletal traction here plays an important role as there is likelihood of marked displacement of the fractured ends because of the strong muscular action. In fracture of the upper third of the shaft of femur the proximal fragment is flexed, abducted and externally rotated due to the actions of ilio-psoas, glutei and short

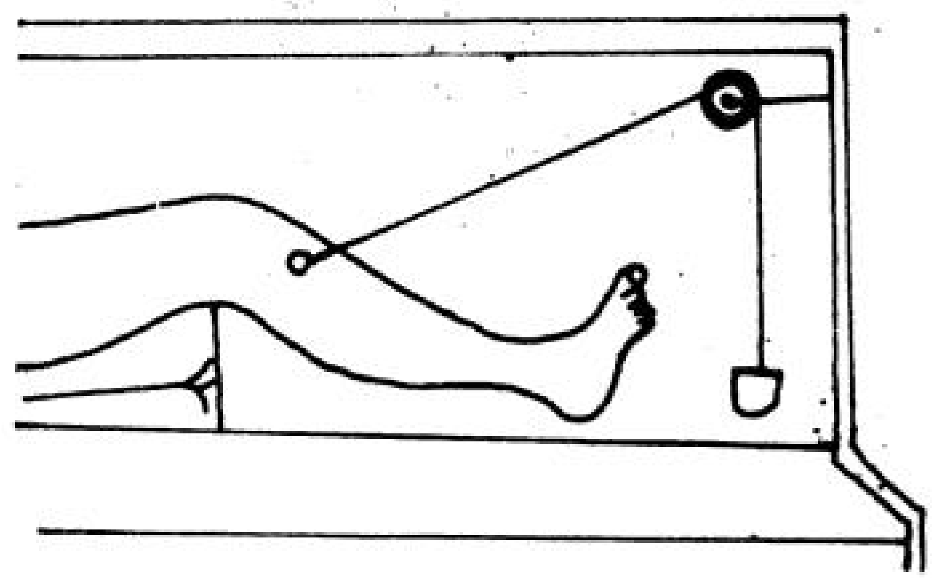


Fig. 4.85. Early knee mobilisation with maintenance of traction, by using a split bed.

hip external rotators respectively; the distal fragment is adducted due to the actions of strong adductors.

In fracture of the mid-shaft region the proximal fragment is flexed by the ilio-psoas and drawn inwards by the adductors. The distal fragment is tilted backwards by the lower part of adductor magnus and is drawn upwards by the hamstrings and rectus femoris.

When the fracture is treated by skeletal traction, as the period of traction extends up to 12 weeks, early knee mobilisation, which is important, can be initiated with traction and split bed (Fig 4.85). Early initiation of isometrics to the quadriceps is essential to gain early control of quadriceps for knee flexion.

When treated by intramedullary nail, mobilisation of the hip and the knee can be initiated early, by 2-3 weeks. Early return of quadriceps strength and control is emphasised to achieve independent SLR by 2-3 weeks when fibrous union is established. Partial weight bearing could be initiated by 6-8 weeks and full weight bearing by 12 weeks.

Rest of the treatment programme is on the same lines as described for the trochanteric fractures treated by internal fixation.

Note

Since these types of fractures are usually associated with extensive soft tissue injury, training isometrics is difficult and painful, but can be made effective by training to simultaneously contract the same muscle groups of both the lower extremities (e.g. bilateral static quadriceps contractions).

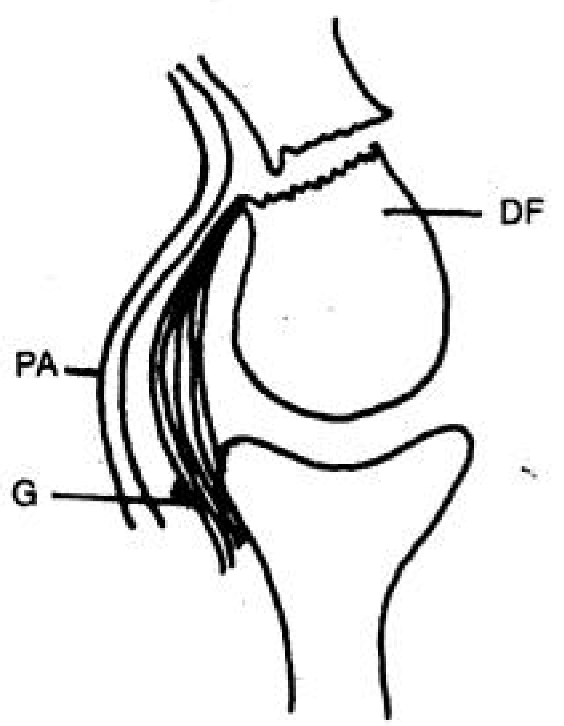


Fig. 4.86. Supracondylar fracture of femur. Gastrocnemius (G) may pull distal fragment (DF) posteriorly and may cause injury to the popliteal artery (PA).

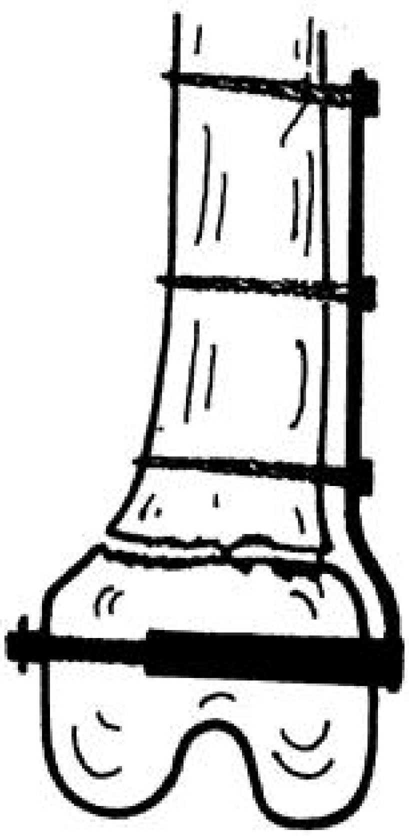


Fig. 4.87. Internal fixation of supracondylar fracture of femur by nail and plate.

SUPRACONDYLAR FRACTURE OF FEMUR

The fracture line is just proximal to the femoral condyles. The distal fragment is pulled backwards by the pull of the gastrocnemius muscle and the sharp edge of the fracture fragment can injure the popliteal artery (Fig. 4.86). The fracture is often comminuted depending upon the severity of the force.

Treatment. This fracture can be treated by conservative as well as operative methods.

(a) Conservative methods

The fracture is reduced under general anesthesia and the limb is immobilised in a Thomas splint. Skeletal traction is applied through the upper end of tibia and the knee is maintained in 30 degrees of flexion. The limb is immobilised for 8 to 12 weeks.

(b) Operative methods

Surgery is indicated in cases where closed reduction fails or injury to popliteal artery necessitates repair. The fracture is reduced by operation and fixed by condylar blade-plate (Fig 4.87). Postoperatively mobilisation can be started after 2 weeks. However, weight bearing is started after about 3 months.

Complications

The complications include malunion, non-union and knee stiffness. The treatmei.t of these complications is the same as that for fracture of shaft of femur. Injury to the popliteal artery is a serious complication encountered in this fracture as already described. Repair of the artery or grafting is indicated urgently in such cases. The fracture is also fixed internally.

INTERCONDYLAR FRACTURE OF FEMUR

It generally occurs as a result of severe trauma. Either single or both condyles may be fractured. When both condyles are fractured the fracture line passes through the condyles resulting in a T or Y shaped fracture (Fig. 4.88). Since it is an intra-articular fracture, it is usually associated with haemarthrosis.

Treatment. It can be treated by conservative or operative methods.

(a) Conservative treatment

The plan of treatment is the same as for supracondylar

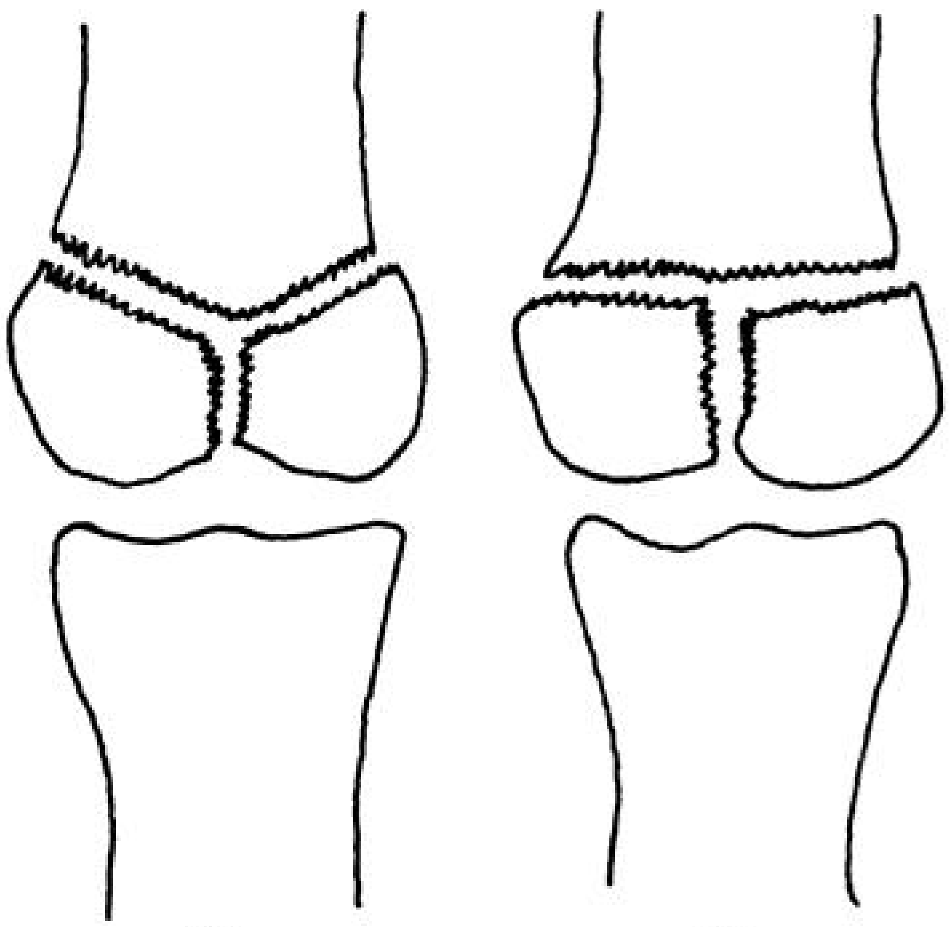


Fig. 4.88. Intercondylar fracture of femur. **(A)** Y shaped fracture. **(B)** T shaped fracture.

fractures of the femur. Skeletal traction is applied through the upper tibia and is maintained for 6-8 weeks. Knee mobilisation is started after 6-8 weeks.

(b) Operative treatment

In all intra-articular fractures, accurate reduction of the fracture, thereby achieving congruity of the articular surfaces, is essential. Therefore, if the fracture is not too comminuted, open reduction and internal fixation of the fracture is indicated. Internal fixation is achieved by multiple screws or Kirschner wires or blade plate. Knee mobilisation is started early, i.e. after 2 weeks only.

Complications

The common complications of this injury are knee stiffness and osteoarthritis of the knee joint.

Physiotherapy management of supracondylar and intercondylar fractures of the femur

The common problems with these injuries are:

(a) Gross effusion of the knee.

(b) Knee stiffness—due to adhesions and involvement of the articular surfaces.

(c) Knee instability—the fracture, especially the comminuted one, may be associated with injuries to the soft tissues including ligaments. Unless the soft tissue repair and bone architecture are properly restored, instability and stiffness of the knee are a common feature.

(d) Reflex inhibition of the quadriceps (extensor lag) due to quadriceps insufficiency.

Right from the initial period, it is absolutely essential to plan appropriate physiotherapy measures to control these four complications. Therapeutic measures are employed to minimise effusion; and acquire early ROM at the knee while maintaining reduction and emphasis on the early and strong isometrics to the quadriceps.

Initially when the fracture is treated with skeletal traction the following programme is instituted:

1. Limb elevation, pressure bandage and isometrics to the quadriceps and glutei.
2. Strong ankle and toe movements.
3. After a week or 10 days gradual knee mobilisation is started. It may be begun as a relaxed passive movement preceded by thermotherapy or cryotherapy. Self-controlled mobilisation by CPM is very effective. Early mobilisation improves and maintains the tone and strength of the quadriceps besides facilitating gliding planes of quadriceps mechanism.
4. Self-assisted relaxed knee swinging, the patient, sitting at the edge of the bed and supporting the operated leg by the good one, is the ideal technique of mobilisation.
5. Non-weight bearing crutch walking should be initiated to make the patient ambulatory.
6. By 4-6 weeks, comfortable ROM of knee flexion beyond 90 degrees should be attained, with minimal effusion and full extension at the knee.
7. All the programmes should be made vigorous to gain further range and the strength.
8. Partial weight bearing is initiated by 9 weeks following surgery and the patient is given proper reeducation in walking.
9. Full weight bearing is permitted by 8-12 weeks. Proper gait training, ambulation and functional training are initiated.
10. Early knee mobilisation and early weight bearing

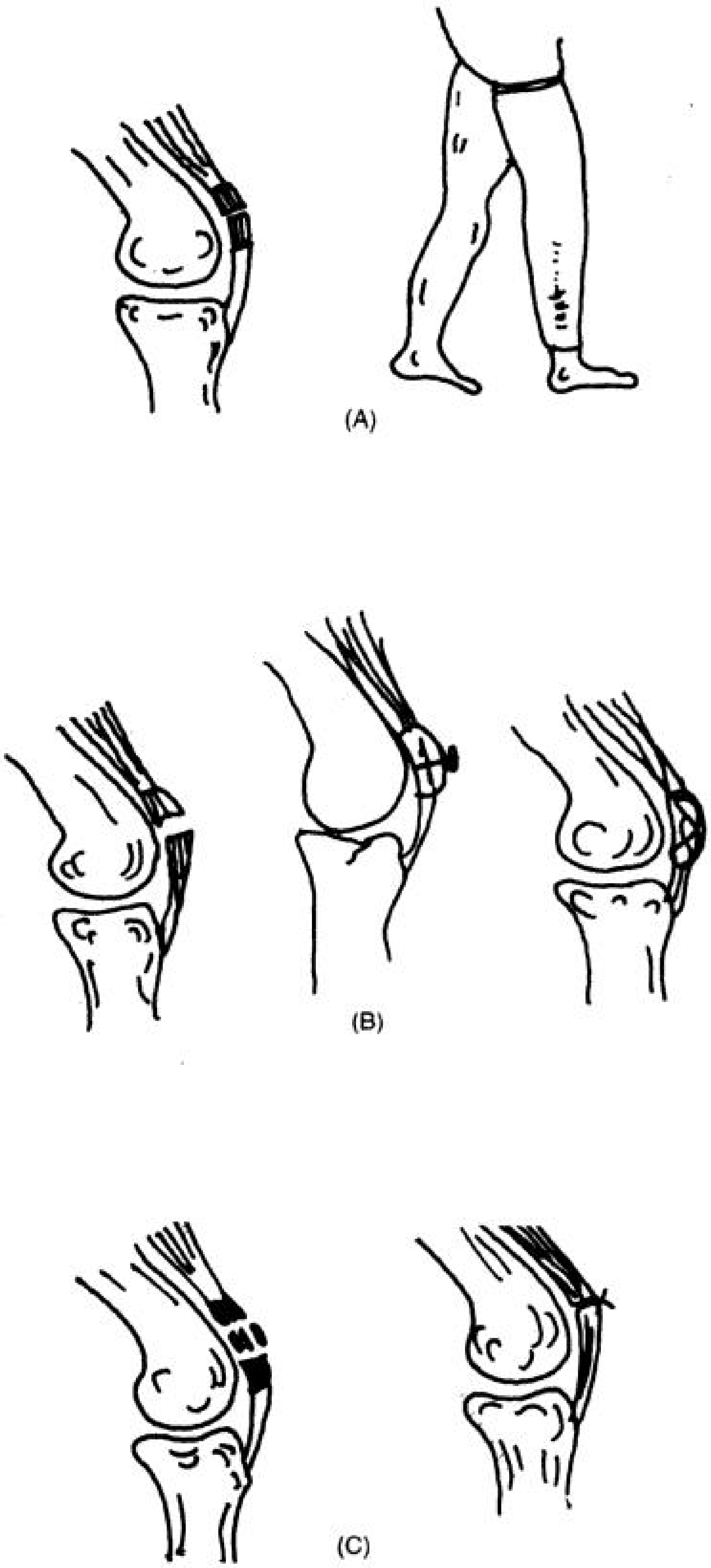


Fig. 4.89. Fracture patella. Various types of fracture patella and its management. **(A)** Stellate or undisplaced fracture treated by walking POP cylinder. **(B)** Clean break of patella with separation of fragments treated by screw fixation or tension band wiring. **(C)** Comminuted fracture treated by excision of patella.

with cast brace has been reported by Borgen and Sprague (1975) for open or closed supracondylar and intercondylar fractures. Cast brace with polycentric hinges is applied between 3-6 weeks (Fig. 3.9). Standing and walking in the parallel bars and knee movements are begun on the next day after applying the brace.

Complications

(a) Ischaemic contracture. Medical and lateral popliteal nerves and vessels may be involved due to compression. Posterior tibial nerve and vessel can also be involved. Therefore, a careful watch is necessary to detect the signs of compression early to prevent ischaemic contractures.

(b) Non-union. In case of non-union, internal fixation is done with Kuntscher's nail or a plate along with bone grafting. Postoperatively the immobilisation is longer and invariably results in a stiff knee unless knee mobilisation is intensified.

FRACTURE OF THE PATELLA (Fig. 4.89)

The patella may be fractured due to (i) a direct injury or (ii) an indirect injury.

(i) A direct injury can cause an undisplaced crack fracture of the patella or a comminuted "stellate" fracture of the patella.

(ii) An indirect injury results in a transverse fracture of the patella with displacement of fragments. This is caused by a forced passive flexion of the knee when the quadriceps muscle is in a state of contraction. The fracture fragments are pulled apart by the pull of the quadriceps muscle. Active extension of the knee, in these fractures, is impossible as the extensor mechanism of the knee is ruptured.

Diagnosis. The patient will have pain and tenderness over the patella in cases of undisplaced fractures of patella; while in displaced fractures there is haemarthrosis and inability to actively extend the knee joint. An X-ray would confirm the type of the fracture.

Treatment. The treatment can be:

(a) Conservative (Fig. 4.89A) or
(b) Operative (Fig. 4.89B,C).

(a) Conservative treatment

An undisplaced fracture (crack or stellate type) is treated by a POP cylinder (Fig. 4.89A), or an above knee POP cast for 4 weeks. It must be remembered that the extensor mechanism should be intact.

(b) Operative treatment

It is always indicated in transverse displaced fractures and rarely in undisplaced fractures where extensor mechanism is torn. The following surgical procedures are commonly employed:

(a) *Internal fixation.* A transverse fracture is fixed internally either by a screw or by tension band wiring (Fig. 4.89B). The extensor mechanism is also repaired. An above knee POP cast is applied for 4 to 6 weeks after which knee mobilisation is started.
(b) *Excision of the patella.* In severely comminuted fractures where internal fixation cannot be done or in elderly patients, who show signs of osteoarthritis, the patella is excised partially or completely (partial or total patellectomy) (Fig. 4.89C) and quadriceps mechanism is repaired. The period of postoperative immobilisation is 5-6 weeks.

Physiotherapy management

The basic principles of physiotherapy:

(a) To reduce effusion, pain and inflammation;
(b) To provide effective quadriceps mechanism and
(c) To regain maximum possible ROM of flexion-extension.

All the efforts are concentrated to get the quadriceps mechanism re-established at the earliest.

(a) Undisplaced fractures

It is usually treated in a plaster cast applied for 3-4 weeks.

1. Static quadriceps contractions are initiated early in the plaster. Similarly, begin with assisted SLR early; though not strong enough to provoke pain. Repetition of SLR and holding it for 10 seconds, the POP slab itself provides good assistance as well as resistance.
2. Weight bearing and crutch walking is started immediately the next day and the patient resumes work in 3-4 days.
3. The POP cylinder cast is removed after 4-6 weeks and knee flexion is initiated as relaxed passive movement or with or without CPM.
4. Knee flexion may be preceded by thermotherapy

or cryotherapy and made vigorous to attain early movement.

5. Correct weight bearing and gait pattern should be re-established to avoid limp.

Full function should be regained by 8-12 weeks.

(b) Displaced fractures

These are usually treated by internal fixation by tension band wiring (TBW) or screw fixation. It is also treated by patellectomy.

Physiotherapy management (TBW treatment)

The basic objective of physiotherapy is to attain mobile and strong knee with emphasis on the return of a strong quadriceps mechanism.

The obvious advantages of this procedures are:

1. The surgical procedure is not as extensive as patellectomy.
2. The patella is retained with its muscular attachments.
3. The period of immobilisation is short.

These factors allow early mobilisation of the knee, which is important to regain strength and mobility.

(a) Preoperative evaluation and education

Due to the presence of pain and haemarthrosis, accurate assessment is not feasible. Therefore, the postoperative regime of physiotherapy should be explained on the normal side.

The physical requirements of the patient's routine and work should be assessed in relation to the knee.

The adjacent joints should be examined to rule out any dysfunction.

(b) Postoperative regime (1 to 10 days)

The limb is immobilised in a posterior plaster cast or in a pressure bandage.

1. The limb encased in a plaster cast should be elevated over pillows. If pressure bandage is applied the pillows should be so arranged that there is no sudden slipping of the limb. Even a slight sudden flexion at the knee should be avoided.
2. Diapulse may be given over the cast or bandage.
3. Vigorous ankle and toe movements and relaxed passive movements to the hip should be given.
4. Direct isometrics to the quadriceps should be deffered to 3-4 days. Indirect isometrics can be initiated by pushing down the whole leg against the mattress or small and soft pillow under the knee or with strong and sustained ankle dorsiflexion.
5. Graduated assisted SLR could be begun by 3-4 days, but it should not be painful.
6. Non-weight bearing crutch walking to be initiated as soon as it is painless.

Mobilisation (10 days onwards)

The stitches are out by 10-14 days. This is the vital period to regain knee ROM as well as strength in the quadriceps and hamstrings. The pain is usually due to the setting in of retro-patellar degenerative changes. Therefore, physiotherapy should be directed to strengthening of the quadriceps and ROM of the knee avoiding undue strain on the repaired extensor mechanism.

1. Mobilisation should be initiated within a small range either by continuous passive motion apparatus (CPM) or as a relaxed passive movement.
2. Strong isometrics to the quadriceps by use of a wedge or self-assisted exercise by using web between the thumb and index finger (Fig. 4.90), repeated every hour, are important.

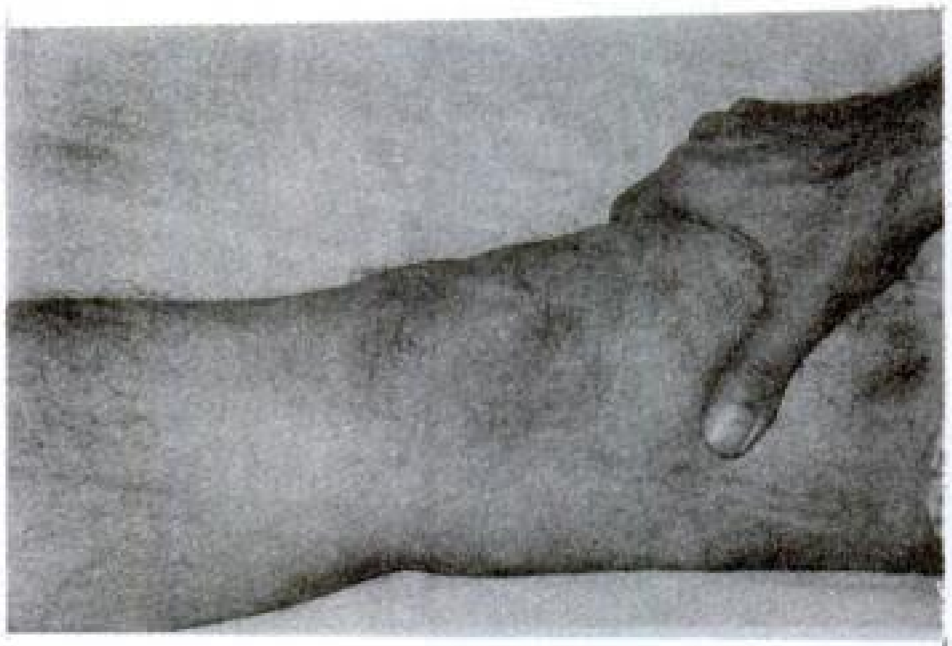


Fig. 4.90. Self-assisted or resisted isometrics to quadriceps by using web between the thumb and index finger.

3. Self-assisted stretching of the knee in the range of flexion as well as terminal extension with knees hanging at the edge of the bed are ideal.
4. Gradual weight bearing to be initiated after 6 weeks, in parallel bars with correct methods of weight transfers and gait. It should be progressed

to a cane. The whole regime of management to be made progressive with PRE and prone kneeling.

The patient must regain adequate knee ROM and muscle power by 6-8 weeks. It takes between 8-12 weeks to gain full ROM. However, mild extensor lag may continue for about 6 months (Dudani and Sancheti, 1981).

(c) Comminuted fracture: treated by patellectomy

FIRST WEEK

1. Strong ankle and foot movements with the leg in elevation are started immediately.
2. The surgical incision and the sutured ligamentum patellae may be painful initially while doing isometrics to the quadriceps. Therefore, mild indirect contractions to the quadriceps should be initiated by putting a soft wedge under the knee. Feeble static contractions to the quadriceps should be ensured. The patients usually use gluteus maximus for the quadriceps. Isometrics to quadriceps at this painful stage are possible only when the patient has had adequate preoperative training.
3. Electrical stimulation could be used as an adjunct to re-educate the quadriceps contractions.
4. Assisted SLR with enough assistance to initiate the lift should be started at the earliest, without much discomfort.

SECOND WEEK

Partial weight bearing gait training to be added making the previous programme or exercise more vigorous.

Mobilisation

1. As the soft tissue healing is adequate to begin gradual mobilisation in a small range in patients treated by bandage, self-assisted small arc passive movements are ideal to initiate mobilisation.
2. Controlled CPM, or relaxed passive movements are extremely effective at this stage.

THIRD WEEK ONWARDS

3. Assisted active movements to be initiated with graduated weight bearing gait training.
4. In the patients treated with posterior splint the splint should be removed intermittently for exercises and reapplied for walking.
5. In the patients treated with POP, non-weight bearing facilitates them to go back to work as the POP cylinder is continued up to 6 weeks.
6. The vigorous exercise programme needs to be given to the patients treated by 6 weeks' immobilisation as the knee joint is considerably stiff and painful.
7. Hydrotherapy is an effective measure to achieve mobility and strength.
8. Progressive resistive exercise (PRE) has to be carried out intensively to strengthen the quadriceps, hamstrings and the ligaments of knee joint.
9. Proper gait training and functional positions are guided.
10. The results are generally good and an adequate range of motion and strength returns by 8-12 weeks after surgery.

Specific observations

Persistence of instability with weakness and atrophy of quadriceps have been observed by West (1962) and Stougard (1970). Kaufer (1971) confirmed the earlier observations of Haxton (1945) and Rene (1954) that following patellectomy efficiency of extensor mechanism was reduced by 30 percent. Thus, the quadriceps has to contract 30 percent more to create the normal torque. This could be the reason for the late recovery, up to 2 years, in a series reported by Lavack et al. (1985). An incidence of reflex inhibition of quadriceps has been reported by Srinivasulu et al. (1986).

All these specific observations following patellectomy reflect an urgency to concentrate maximally on the quadriceps strengthening procedures. Initiating isometrics at the earliest opportunity and regularly monitoring the strength is most essential to strengthen the quadriceps.

Acute Dislocation of the Patella

The patella always dislocates laterally. The injury occurs in a semiflexed knee with the relaxed quadriceps muscle. The patella is forced laterally.

Treatment

The patella may be pushed back into its place easily. However, the reduction may have to be done under general anaesthesia. An above knee POP cast is given

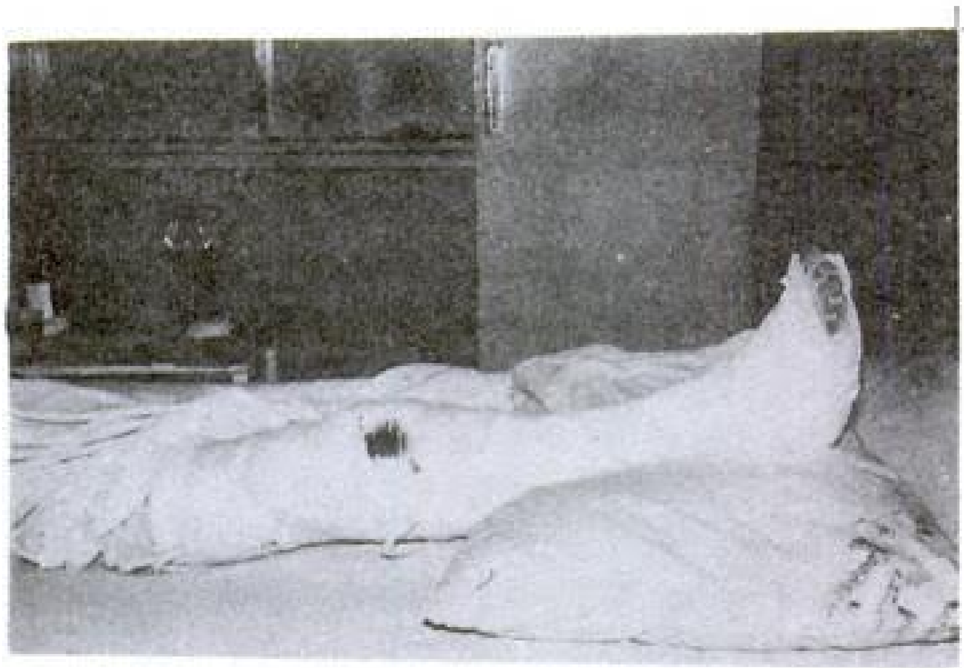


Fig. 4.91. Early initiation of isometrics to quadriceps and gluteus maximus and minimus by pressing pillow downwards.

for 3 to 4 weeks after which the knee is mobilised.

1. Gentle isometrics to the quadriceps are initiated as early as possible. Limb encased in a cast is pressed downwards by placing a pillow under the foot which indirectly initiates static contractions in the quadriceps (Fig. 4.91).
2. SLR by the physiotherapist, fully supporting the weight of the limb, also helps in initiating isometrics to the quadriceps besides improving hip control and strength.
3. PWB crutch walking can be begun as soon as pain is reduced.
4. Vigorous exercise to improve the extensor mechanism and procedures to mobilise the knee are begun on removal of the cast and progressed. Full knee ROM and adequate control of knee mechanics should be regained by 6-8 weeks.

Recurrent Dislocation of the Patella

In recurrent dislocation of the patella, the patient has repeated episodes of dislocation of the patella. The patient is usually asymptomatic between the attacks.

In habitual dislocation of patella, the patella dislocates with every flexion of the knee, but reduces spontaneously as soon as it is extended.

In either type of dislocation, the patella always dislocates to the lateral side. The causes of recurrent dislocation of patella include laxity of the ligaments, weak musculature, poorly developed lateral femoral condyle and small or abnormally placed patella.

Clinical features

Recurrent dislocation of the patella may occur with or without injury. The patella dislocates laterally with severe pain. "Apprehension test" may be positive, which is when the patella is pushed laterally and the knee is flexed, the patient resists this manoeuvre.

Treatment

Surgical operation is the only effective treatment for recurrent dislocation of the patella. The basic principle of surgical operation is realignment of the quadriceps mechanism, so that the patella is prevented from dislocating laterally when the knee is flexed.

The commonly performed operations are as follows:

1. Campbell's operation. In this operation the tight structures on the lateral side of the joint are released and a thin strip of joint capsule on the medial side is mobilised with its base proximally. This strip is then passed under the ligamentum patellae and brought out on the lateral side, and then folded on itself to be stitched back on the medial side (Fig. 4.92A). It pulls the ligamentum patellae on the medial side and prevents its dislocation laterally.

2. Hauser's operation. The ligamentum patellae is detached at its insertion along with a block of bone of the tubercle of tibia. It is then reattached on the medial surface of the tibia, thus changing the line of pull of the ligamentum patellae (Fig. 4.92 B).

3. Patellectomy. In adults having an associated osteoarthritis of patellofemoral compartment the patella is excised and the quadriceps mechanism is repaired changing its alignment more towards the medial side.

Postoperative regime. Postoperatively, an above knee POP cast is given for 4-6 weeks, after which the knee is mobilised.

Physiotherapy following surgery

During immobilisation (4-6 weeks)

1. Strong toe movements and active hip movements to be started as early as possible.
2. On the second postoperative day non-weight bearing crutch walking could be initiated.
3. Indirect isometrics to the quadriceps should be in-

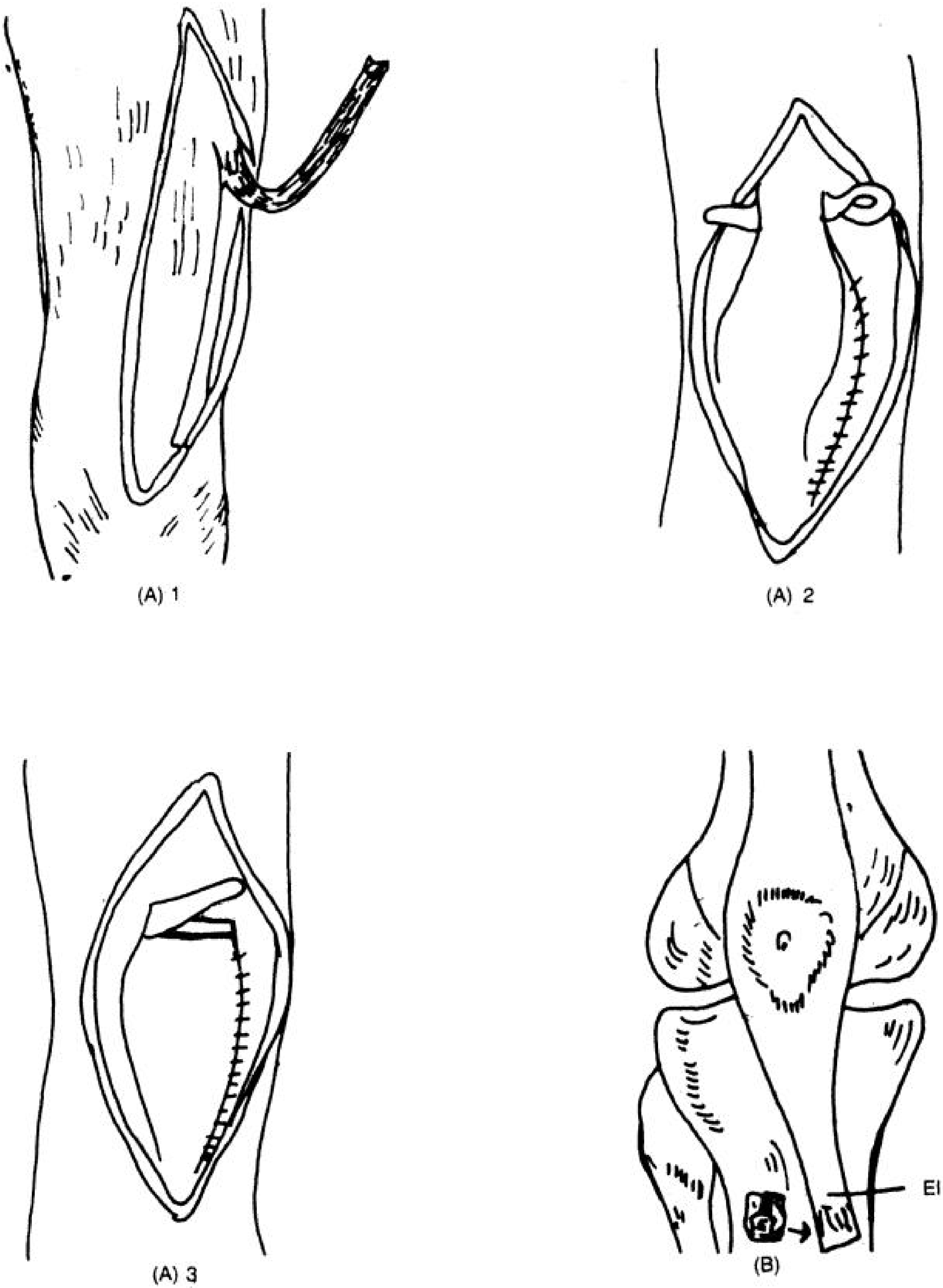


Fig. 4.92. Surgical procedures for recurrent dislocation of patella. **(A)** Campbell's procedure: 1. A strip of capsule is detached. 2. Capsule stitched and the detached strip is pulled through quadriceps tendon on the lateral side. 3. The strip is pulled medially and the end is sutured about the adductor tubercle region. **(B)** Hauser's operation: Release and medial transfer of the entire extensor insertion (EI).

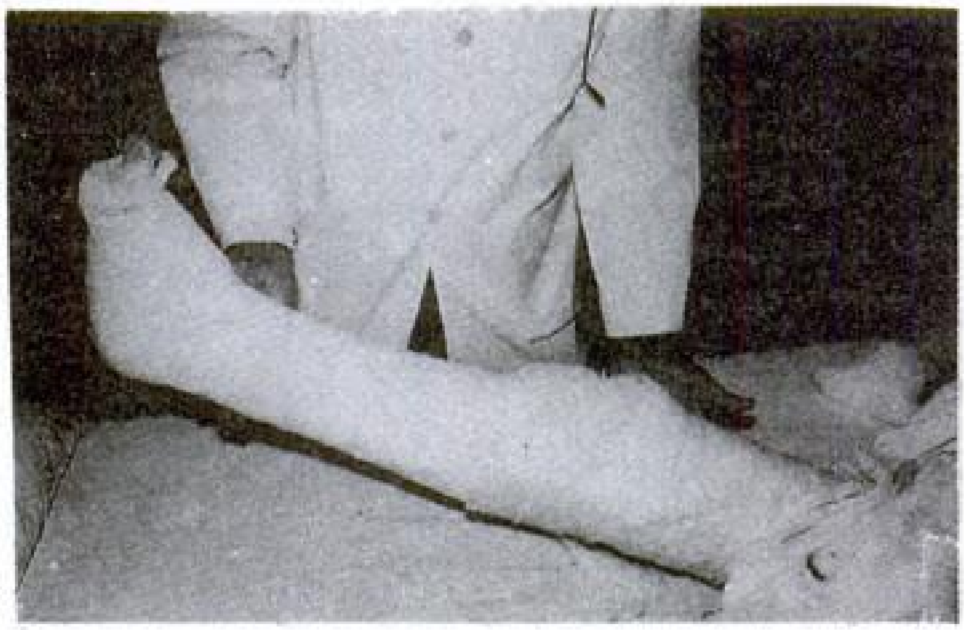


Fig. 4.93. Assisted SLR, assistance is provided by physiotherapist posteriorly just proximal to the ankle joint by one hand, and below knee by the other.

itiated in the form of assisted SLR (Fig. 4.93) or by pushing the leg encased in the cast downwards on the mattress in supine lying. Direct weak isometrics to the quadriceps should be begun inside the cast within the limits of discomfort.

Mobilisation

1. Gradual knee mobilisation is begun in a small range ideally by CPM, relaxed passive movements or as self-assisted (using normal leg) knee swinging.
2. Hydrotherapy in the form of whirpool is extremely useful at this stage.
3. Assisted SLR to be initiated.
4. Self-resistive hamstring exercises and sessions of endurance training in the maximum extension position of the knee to be emphasised.
5. Knee orthosis may be used, as a protective measure for 8-10 weeks while walking, till the patient regains full active extension and 70-90° of flexion.
6. Quadriceps and hamstrings co-contractions could be beneficial in achieving good control of the movements.
7. Isokinetic exercises are valuable means of improving endurance. The exercises should be progressed to resistive exercises.

By 10-12 weeks, body resistive squats may be begun with brief periods of jogging, running and light sports.

The physiotherapy management following patellectomy is described separately.

DISLOCATION OF THE KNEE

It is a rare injury caused by considerable violence. The cruciate and collateral ligament(s) are usually torn.

The dislocation is reduced under general anaesthesia as an emergency. Open reduction may have to be performed, if closed reduction fails. Repair or reconstruction of the torn ligaments may also be required. An above knee POP cast is worn for 12 weeks.

Physiotherapy management

Following closed reduction

Initially the limb is rested on a back splint with knee in 15 degrees of flexion.

1. Ankle and toe movements are checked along with the sensory status to exclude injury to the popliteal nerve.
2. Circulation in the foot is examined to exclude injury to the popliteal artery.
3. Vigorous ankle and toe movements with leg in elevation are given to reduce swelling.
4. When the swelling is subsided, POP cast is applied for 12 weeks.

Following surgical reconstruction
(during immobilisation)

1. Isometrics to the quadriceps, glutei are emphasised right from the first day, besides nos 1, 2 and 3 described above, for closed reduction.
2. Non-weight bearing crutch walking to be begun on the second or third day.
3. Assisted SLR to be begun by one week and progressed to voluntary SLR by the patient.
4. Gradual weight bearing can be initiated with plaster as soon as the patient can perform SLR; and can be progressed to full weight bearing.

Mobilisation

The nature of injury and long period of immobilisation poses two main problems:

1. Stiff and painful knee.
2. Instability of the knee with increased antero-

posterior glide or lateral wobble.

Therefore, extra efforts are needed to concentrate on mobilisation as well as controlled stabilisation of the knee. The maximum range as well as endurance are to be regained at the earliest. It proceeds on the same lines as described for patellectomy. However, manipulation under GA may become necessary to assist further mobilisation when the knee is not yielding to routine exercises.

FRACTURES OF THE TIBIAL CONDYLES

Fractures of the medial or lateral tibial condyles occur as a result of varus or valgus strain respectively. Fracture of the lateral condyle of tibia, also called as "Bumper fracture", is more common and occurs following an injury by the bumper of a car on the lateral aspect of the knee joint (Fig. 4.94 A). These fractures are usually associated with injury to the collateral ligaments on the opposite side. Fractures of the lateral condyles are occasionally comminuted fractures with marked depression of the tibial plateau or compression fracture with fragmentation (Fig. 4.94 B and C).

Following an injury the patient presents with a painful, swollen knee with haemarthrosis of the knee joint.

Treatment

(a) Conservative

Plaster immobilisatin. This method is indicated only in undisplaced fractures. An above knee plaster cast is applied for 3-4 weeks. Knee mobilisation is started after removal of the plaster. Weight bearing, however, is allowed after 3 months.

Traction. This is a simple and commonly employed method of treatment for displaced fractures. A below knee skin traction or skeletal traction through the tibia is given for 3 weeks. After 3 weeks, the knee is mobilised. However, weight bearing is started after the union is consolidated, usually after 3 months. The disadvantage of this method is prolonged immobilisation. However, generally good results, in terms of knee movements, are obtained by this method.

(b) Surgical

Open reduction and internal fixation of this fracture is ideally indicated in grossly displaced and/or fractures where the tibial plateau is depressed due to impact by the lateral femoral condyle. In the latter situation the tibial plateau is elevated and the fracture is fixed by a special type of plate. Bone grafting is also required to support the tibial plateau (Fig. 4.95 A).

Undisplaced fracture can be treated by a long screw (Fig. 95 B). Postoperatively, knee movements can be started after a week but weight bearing is allowed after 3-4 months.

The patient may have some limitation of knee movements in severely displaced and/or comminuted fractures in spite of open reduction and internal fixation.

In grossly displaced or comminuted fractures open reduction with internal fixation is done. Knee mobilisation can be initiated early during second postoperative week. Mobilisation procedures need extra-emphasis and repeated often in spite of discomfort to achieve early functional range of motion. Fractures often result in stiff knee due to severe articular damage.

Physiotherapy management

Undisplaced fractures which are treated by conservative methods do not pose any specific problems.

During immobilisation

- Early initiation of isometrics to the quadriceps and hamstrings is important.
- Vigorous toe movements in POP immobilisation; and ankle and foot movements in the patients treated with traction are repeated often.
- Assisted SLR can be initiated early in the patients treated with plaster immobilisation as soon as it is painfree.
- Non-weight bearing to be initiated on axillary crutches to encourage early ambulation on the third or fourth postoperative day.

Mobilisation

- Knee mobilisation is of vital importance and with correct methods of mobilisation early return of near normal to normal mobility is restored. Suitable electrotherapeutic modality, CPM, relaxed passive movements are instrumental.
- While mobilising, the knee joint should be carefully examined for the possibility of genuvalgum, especially in the fractures of the lateral tibial condyle.

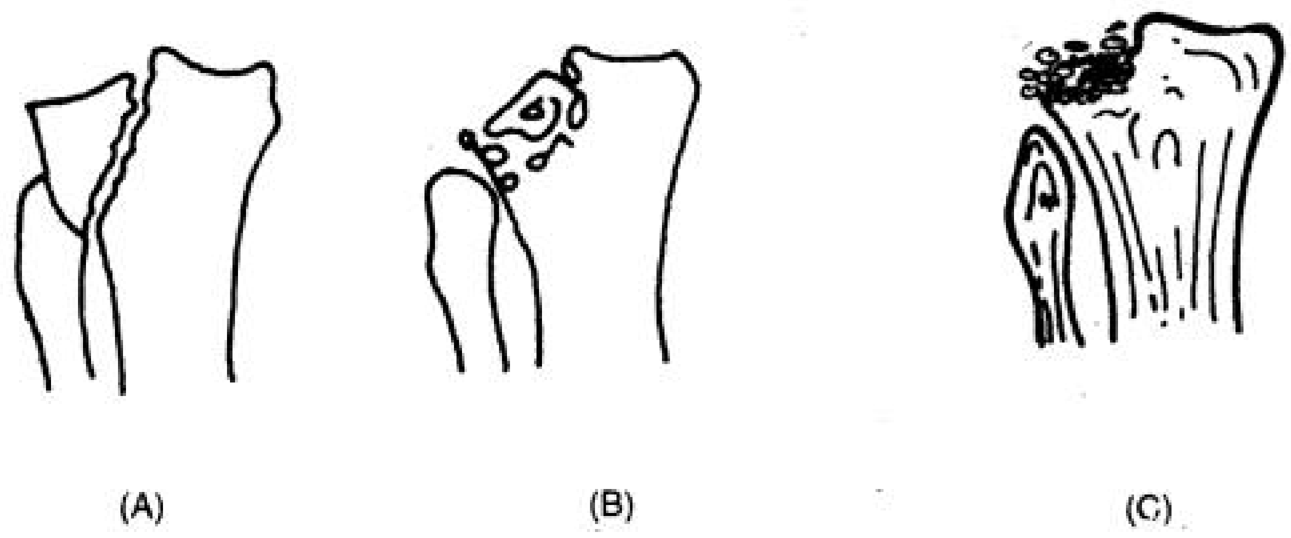


Fig. 4.94. Fractures of the tibial condyle. **(A)** "Bumper fracture", an oblique shearing fracture of the lateral tibial condyle due to valgus stress. **(B)** Depressed plateau fracture without severe fragmentation. **(C)** Compression fracture with fragmentation.

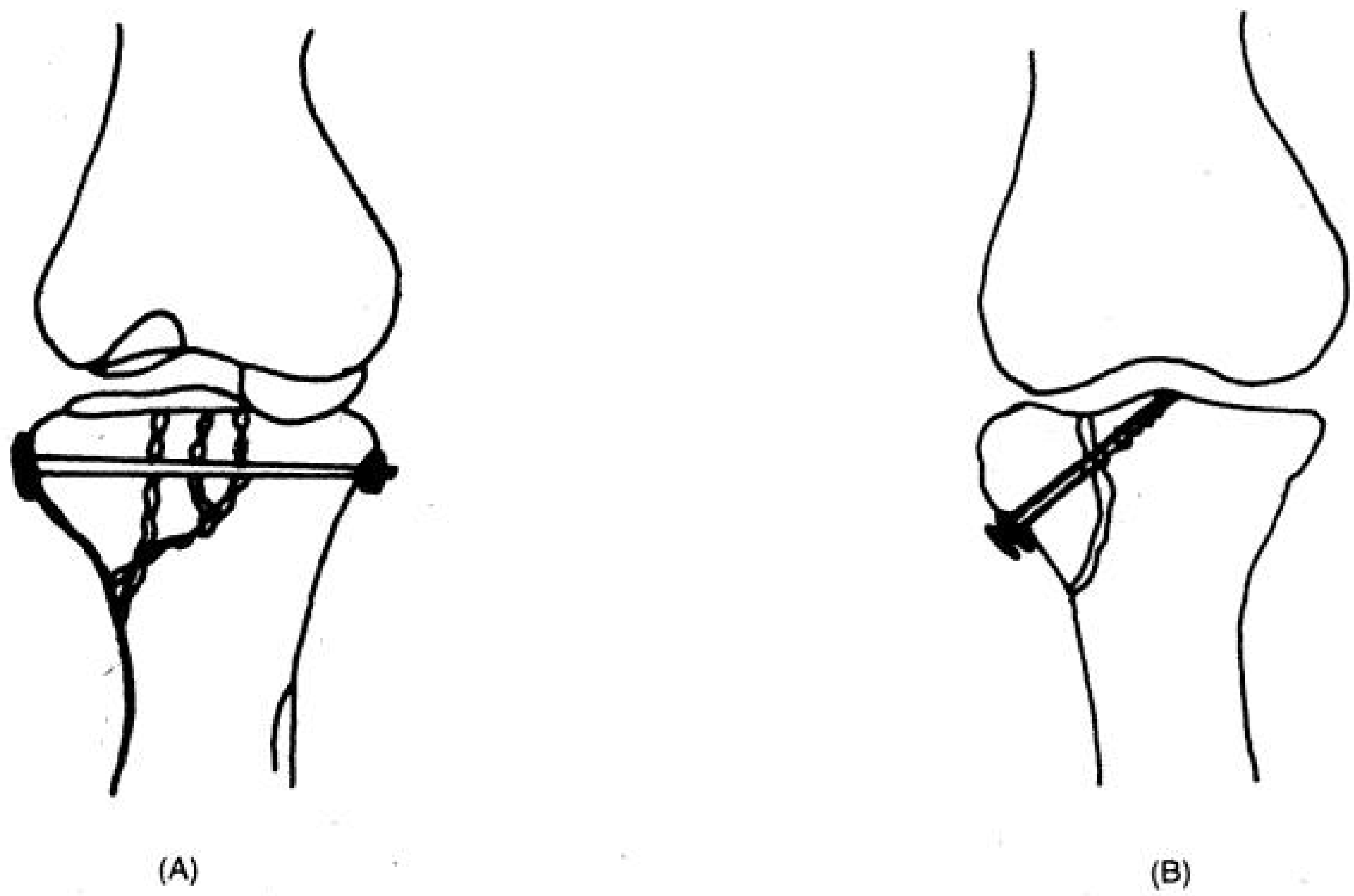


Fig. 4.95. Elevation of tibial plateau and internal fixation. **(A)** By a special screw or **(B)** a short screw.

- Regaining early extension is important to avoid extra-stress leading to osteoarthritic changes and poor gait.
- Strengthening procedures for the quadriceps and hamstrings are equally important. They need special emphasis in view of the expected osteoarthritic changes. The damaged articular surface of the tibial condyle often remain irregular.
- If the union of the fracture is acceptable, graduated partial weight bearing may be started after 10 weeks—from two axillary/elbow crutches and progressed to one crutch, to one cane and no aid, by 12 weeks.
- Other ambulatory activities and gait training should be added. Medial shoe insert or wedge may be necessary in patients with residual genu valgum deformity to relieve compression at the lateral compartment of the knee joint.

INTERCONDYLAR FRACTURES OF TIBIA

A fracture through both the medial and lateral condyles of tibia occurs following a force that pushes femoral condyles on the tibial plateau, e.g. fall from a height. It results in a T or Y shaped fracture through the tibial condyles (Fig. 4.96). It is a rare injury.

Treatment

(a) Conservative

The fracture fragments are reduced under anaesthesia and the limb is immobilised by skeletal traction applied through the lower end of tibia. The traction is maintained for 4-6 weeks and then the knee is mobilised. Full weight bearing is permitted after 3 months.

(b) Operative

Open reduction and internal fixation of the fractured fragments is achieved with the help of screws or special plates. Postoperatively, knee mobilisation is started after a week or 10 days, but weight bearing is allowed after 3-4 months.

Physiotherapy management proceeds on the same lines as described for fractures of the tibial condyles.

FRACTURE OF TIBIA AND FIBULA

(Fig. 4.97, A-D)

(Fractures of both bones of leg)

These are common injuries and result from road traffic accidents. The tibia being a subcutaneous bone, its fractures are often open (compound) fractures.

An angulatory force produces a transverse or short oblique fracture; rotational force produces a spiral fracture and direct blow to the tibia can result in a comminuted fracture.

Treatment

An open wound, which can be extensive, poses a problem in the management of these fractures. However, these injuries can be treated by any of the following methods:

(a) *Plaster.* This is the most commonly used method of treatment. The fracture is manipulated under general anaesthesia and an above knee POP cast is applied. Static quadriceps exercises are begun as soon as the pain permits. Non-weight bearing crutch walking can be started after 2 weeks. Union of the fracture may take 3 to 6 months. Weight bearing is allowed only after the union is consolidated.

(b) *Functional cast bracing.* Relatively stable transverse fractures of tibia may be treated by an above knee POP cast for the initial 3-4 weeks. The plaster is then changed into a patellar tendon bearing plaster (Fig. 4.98). This allows knee mobilisation and early weight bearing.

(c) *Traction.* The severely comminuted fractures can be treated by skeletal traction applied through the lower tibia (Fig. 4.99) or calcaneum. The traction is maintained for 10-12 weeks.

(d) *Operative treatment.* It is indicated when closed reduction fails or the fracture is displaced in the plaster. Open reduction is performed and the fracture is internally fixed by plate and screws, only screws or intramedullay nail (Fig. 4.100 A, B and C). After surgery, knee mobilisation is started after a week or two but weight bearing, however, is allowed after 3 months.

(e) *External fixation.* The tibia is fixed with 2 or 3 pins passed transversely in the tibia on either side of the fracture (Fig. 4.101A, B). It is indicated in severely comminuted fractures and where there is marked soft tissue damage. This method facilitates care of the wound and the patient can walk with the help of crutches (non-weight bearing).

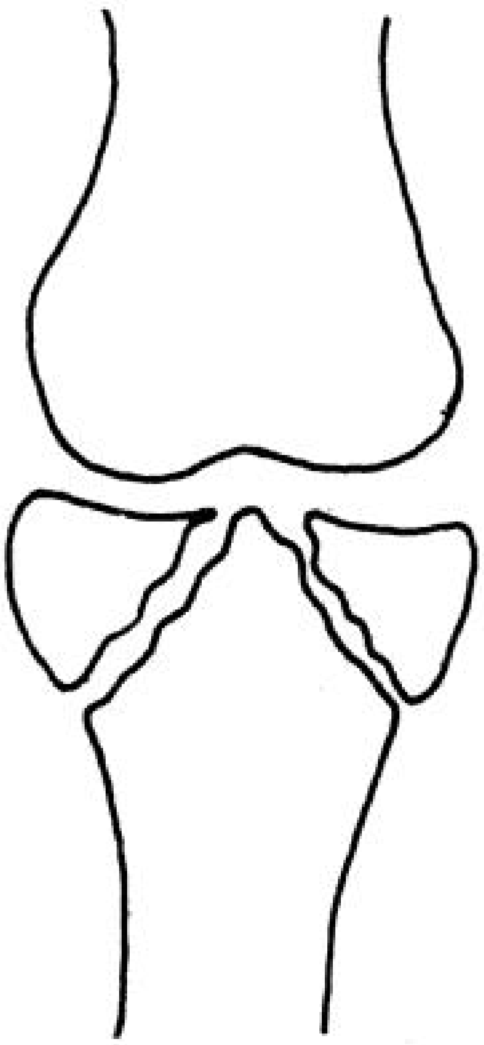


Fig. 4.96. Intercondylar fracture of tibia.

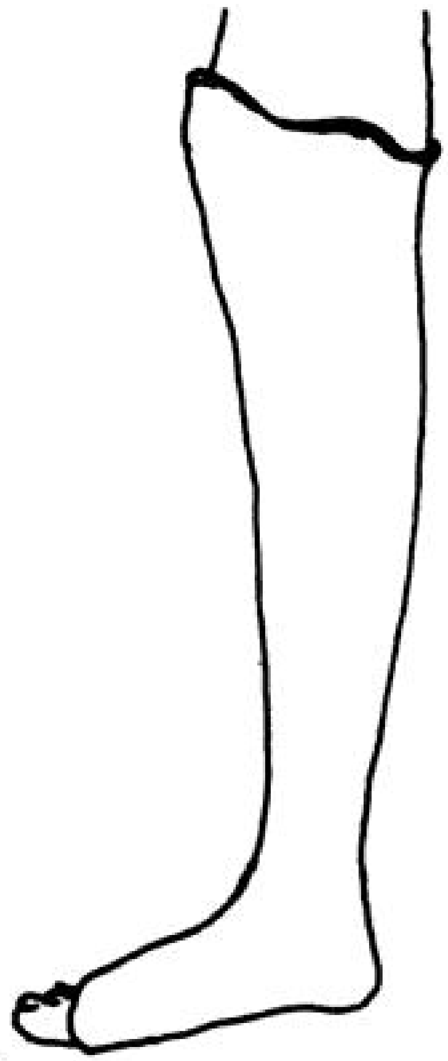


Fig. 4.98. Patellar tendon bearing plaster cast.

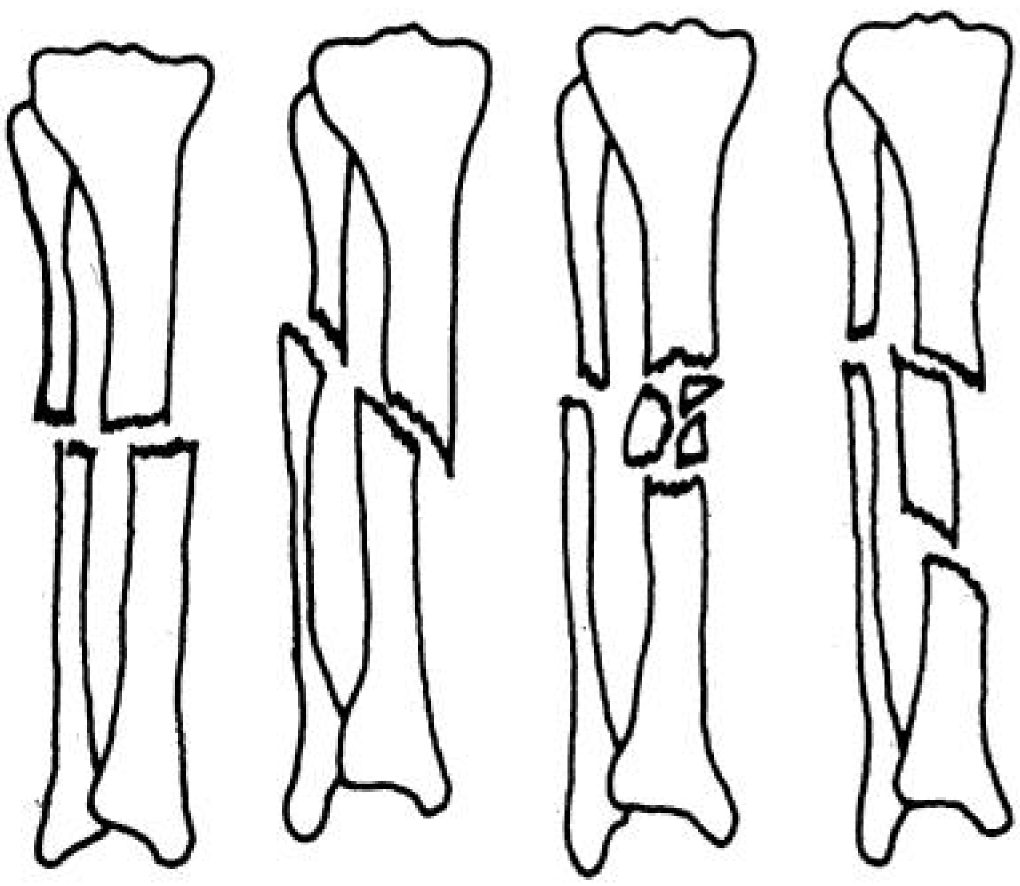


Fig. 4.97. Fracture of tibia and fibula (both bones). **(A)** Transverse. **(B)** Spiral. **(C)** Comminuted. **(D)** Double.

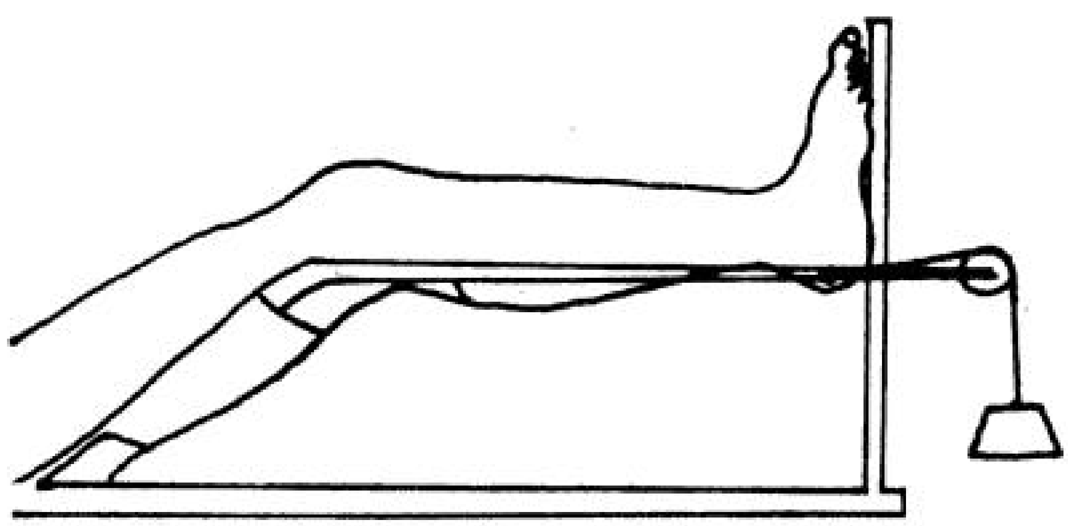


Fig. 4.99. Skeletal traction through calcaneum.

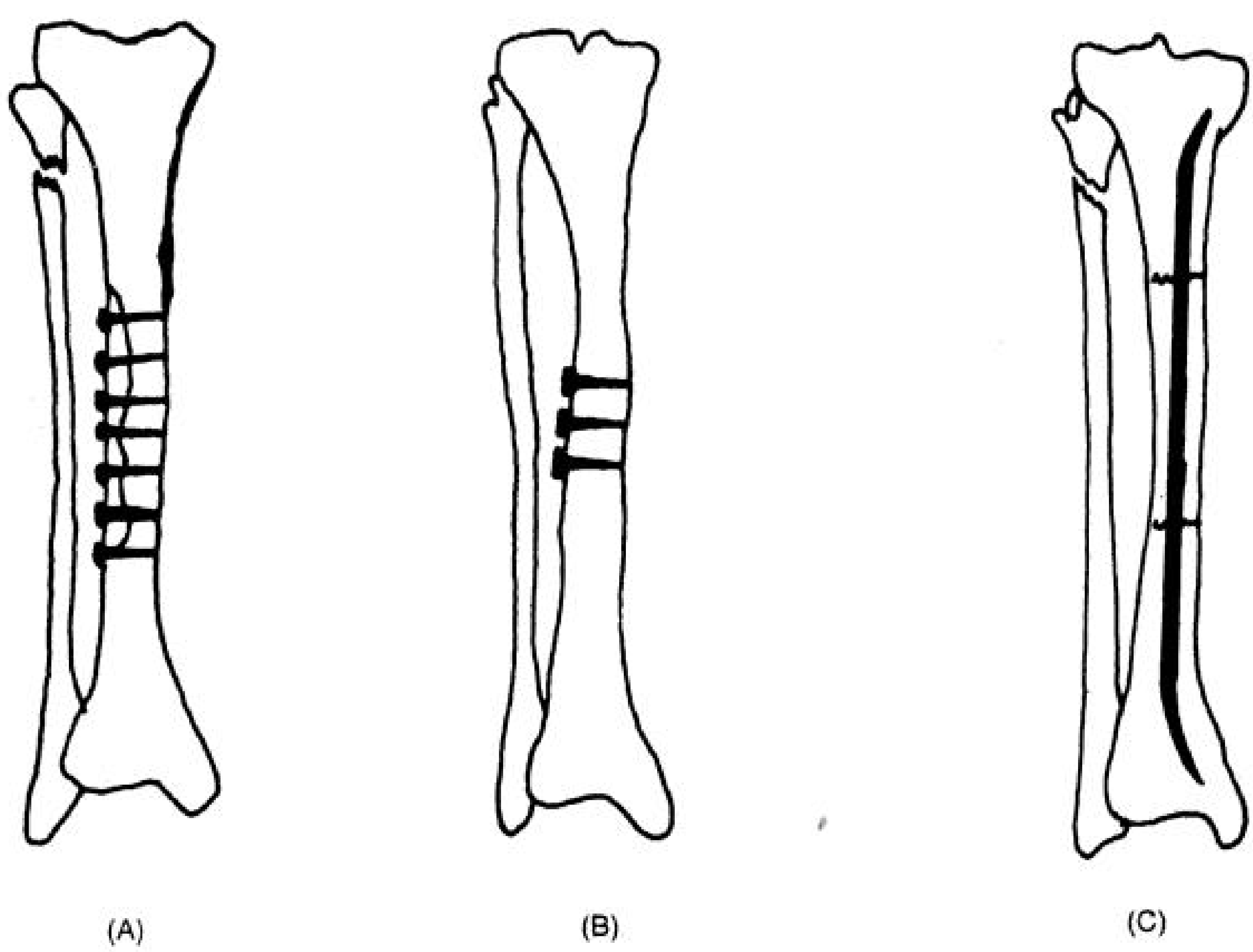


Fig. 4.100. Internal fixation by **(A)** Plate and screws. **(B)** Screws. **(C)** Intramedullary nail.

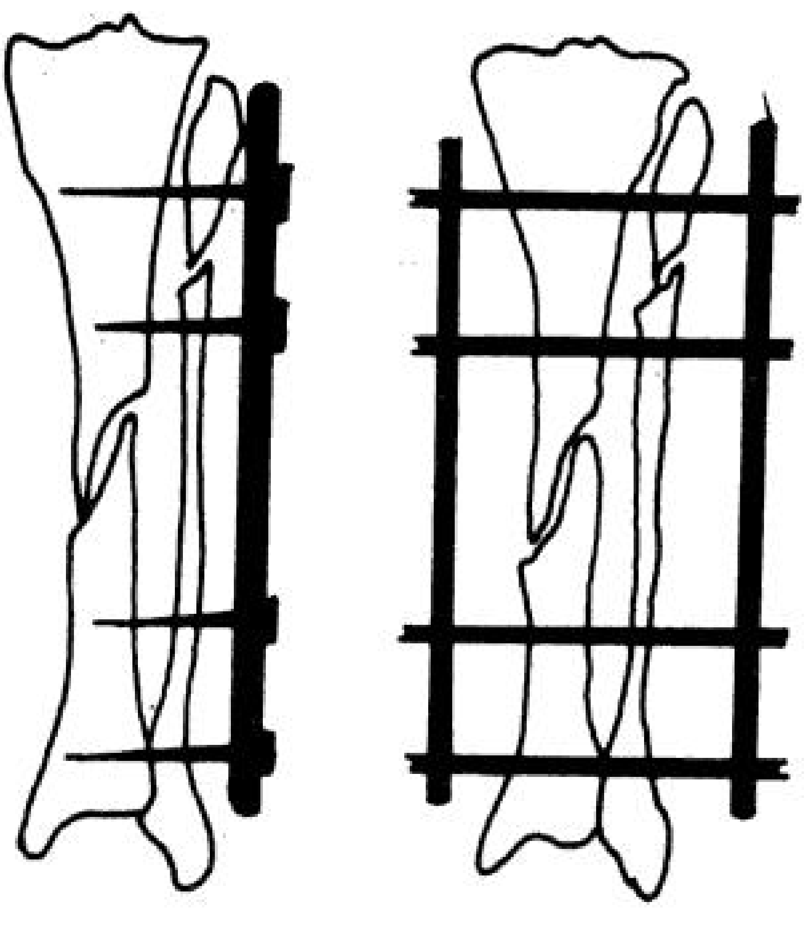


Fig. 4.101. External fixation. **(A)** Single bar with multiple pins. **(B)** Bilateral bar with multiple pins.

Complications

1. *Infection.* As already discussed, open fracture of tibia and fibula are quite common. The bone is likely to get infected and may develop osteomyelitis.
2. *Injury to the vessels.* Popliteal artery may be injured in fractures of the upper third of tibia. The artery needs to be repaired urgently.
3. *Compartmental syndrome.* In a closed fracture, bleeding from the fractured bone ends causes a rise in the pressure in the fascial compartments of leg. This in turn leads to muscle ischaemia. A tight plaster may also have the same effect. Removal of the tight plaster or surgical decompression of the tight compartment is the treatment.
4. *Delayed union and non-union.* Unduly delayed union or failure to unite necessitates bone grafting operation along with internal fixation of the fracture.
5. *Malunion.* It may cause angulatory deformity and/ or shortening of the leg. It may also predispose to osteoarthritis of the knee and/or ankle joints.

Physiotherapy management

(a) Fractures treated by plaster

Immobilisation of the knee, ankle and foot leads to stiffness of these joints and weakness of the muscle groups around them. Strengthening of these muscles takes priority over other measures.

The following measures are adopted:

1. Isometrics to quadriceps, hamstrings.
2. Assisted SLR.
3. Repeated strong and resistive movements to toes.
4. Resisted as well as strong isometrics to the glutei.
5. Knee mobilisation is initiated and made vigorous as soon as pain permits.
6. Vigorous passive stretching exercises are given to regain mobility at the foot and ankle.
7. Non-weight bearing crutch walking to be initiated as soon as leg hanging in standing becomes painless. This will facilitate going back to work and the daily activities (about 2 weeks).
8. Full weight bearing is initiated on the radiological evidence of fracture union (usually 3-6 months).
9. Correct walking and functional guidance.

(b) Fractures treated by traction

Due to the prolonged immobilisation in skeletal traction (usually 10-12 weeks) the chances of the knee becoming stiff are quite high. The isometrics, therefore, need maximum attention. Rest of the programme is same as described for fractures treated by plaster.

(c) Fractures treated by cast bracing

When the stable transverse fractures of tibia are initially treated by POP cast for 4-6 weeks, the physiotherapy programme is same as (a). The above knee POP cast is then replaced by functional patellar tendon bearing plaster; it allows early mobilisation and weight bearing. Therefore, early return to fully active life is facilitated. However, vigorous programmes for the knee mobility, strength and endurance are to be emphasised.

(d) Fractures treated by surgery

Here the knee mobilisation can safely be begun by the end of 2 weeks. This facilitates regaining knee mobility and a strong extensor mechanism.

Partial weight bearing can be initiated by 8 weeks, if not very painful, and full weight bearing by 12 weeks.

(e) Fractures treated by external fixation

These fractures are usually comminuted and associated with extensive soft tissue damage. The wound is watched for infection, etc. Vigorous exercises to the ankle, toes, glutei, quadriceps and the hamstrings play an important role in improving circulation of the whole limb and also the injured area facilitating an early healing.

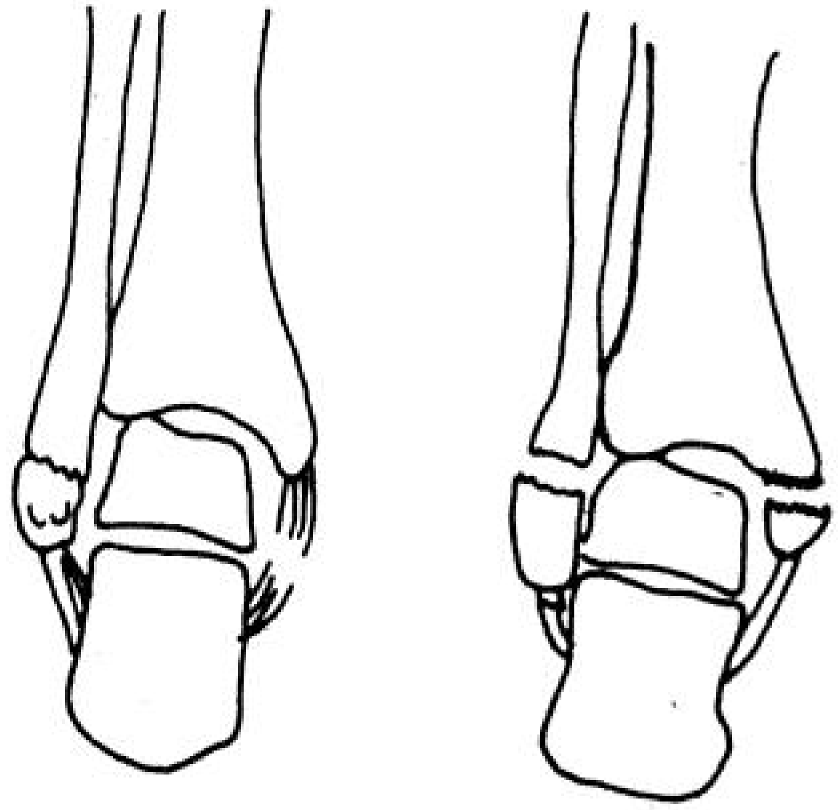
The patient should be given confidence and assistance in early standing and non-weight bearing crutch walking with the leg in external fixator by 2 weeks.

Management of complications

1. *Infection.* Keen observation, wound care and improvement of circulation to the limb are important measures to avoid or reduce infection.
2. *Compartmental syndrome.* Haemorrhage, edema or tight plaster may result in ischaemia leading to fibrosis or even gangrene (like VIC). Therefore, a proper watch is kept on the symptoms of ischaemia like increase of pain, swelling, pallor, absence of distal pulse in the foot and blueness of the toe nails.
3. *Delayed union and non-union.* Fracture of the lower third of tibia is prone for non-union due to poor blood supply to this area. Therefore, in such fractures, the circulation could be improved by vigorous exercises to the adjacent joints.
4. *Malunion.* Improper reduction of the fracture or loss of reduction in plaster could lead to malunion. Detection of the cause and its early correction is necessary. Limb shortening due to overriding is compensated by exact shoe raise to prevent osteoarthritis. Malunion with angulation may need early osteotomy to avoid setting in of osteoarthritis.

FRACTURES AROUND THE ANKLE

Fractures around the ankle are produced by forced adduction or forced abduction of the foot, often associated with an element of rotation or vertical compression.



(A) (B)

Fig. 4.102. Abduction or eversion injuries of the ankle.
(A) Rupture of the medial ligament
(B) Fractures of the medial and lateral malleoli.

Forced abduction force produces rupture of the medial ligament of the ankle or fracture of the medial malleolus or fracture of both malleoli (Fig. 4.102 A, B).

Forced adduction force produces rupture of the lateral ligament or fracture of the lateral malleolus or fracture of both the malleoli (Fig. 4.103 A, B).

When both the malleoli are fractured, it is called as Pott's fracture.

Treatment

The main objective of the treatment is to restore the alignment of the ankle mortice by accurate reduction of the fractures.

The treatment can be conservative or operative.

(a) Conservative treatment

It is the treatment of choice. The fracture is manipulated under general anaesthesia and immobilised in a

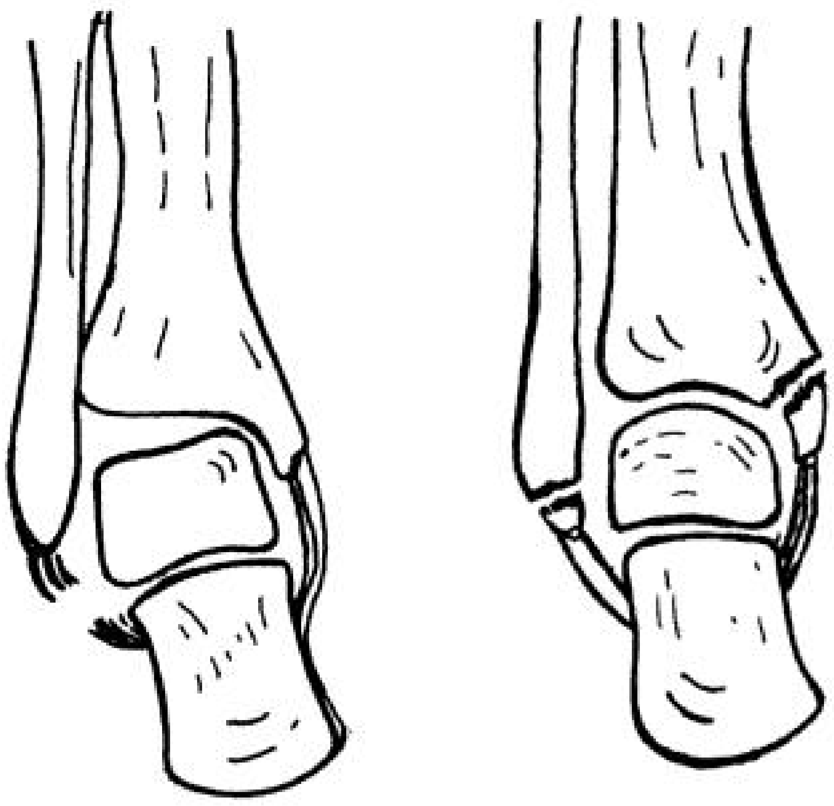


Fig. 4.103. Adduction or inversion injuries of the ankle.
(A) Rupture of lateral ligament.
(B) Fractures of medial and lateral malleoli.

below knee plaster cast for 6-8 weeks. The ankle may be mobilised after 8 weeks; however, weight bearing is allowed only after about 12 weeks.

(b) Operative treatment

Open reduction and internal fixation is indicated where closed reduction has failed or the fracture gets redisplaced in the plaster. The fractures of medial and lateral malleoli are fixed internally by a screw (Fig. 4.104) or tension band wiring.

Complications

1. Malunion. It leads to distortion of ankle mortice and deformity. In later years osteoarthritis may set in.

2. Non-union. It is common with fracture of the medial malleolus. Internal fixation by a screw or tension band wiring with bone grafting is the treatment.

3. Joint stiffness. It results following prolonged immobilisation and oedema. It could be prevented by accurate reduction of the fracture and adequate physiotherapy as early as permissible.

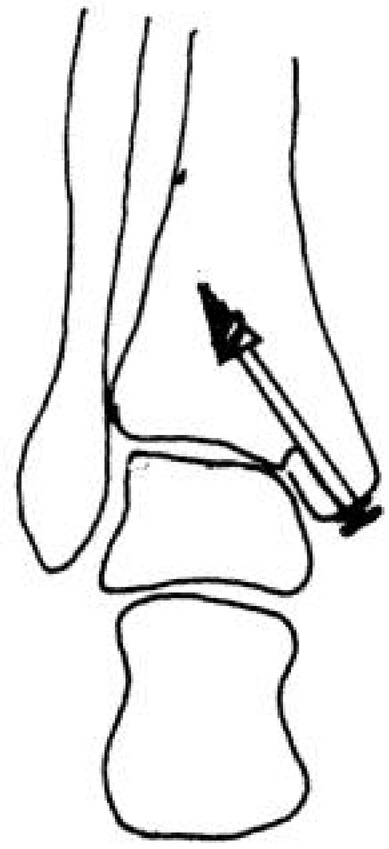


Fig. 4.104. Fixation of the malleolar fracture by screw.

Physiotherapy management

Fractures treated by conservative management

During immobilisation

- Limb elevation
- Strong repeated movements for the toes, knee and the hip.
- Diapulse may be applied over the POP cast.
- Non-weight bearing crutch walking can be initiated on the second or third day.

During mobilisation

1. Early passive mobilisation. Early initiation of relaxed passive range of motion exercises are important. The patient should be made well conversant to practise them often. This can be done best by the patient sitting in a chair with the back supported. The distal portion of the affected leg rests just over the knee on the sound thigh. The ankle and foot, which are free to move, are grasped by the patient using both hands. Full range relaxed passive movements of the ankle and foot can be done effectively (Fig. 4.105).

Relaxed passive movement in the maximum possible range, especially circumduction, causing minor discomfort but not pain are ideal to begin with (Cyriax,

Fig. 4.105. Self-assisted relaxed passive movements of the ankle and foot.

Fig. 4.106 (A)

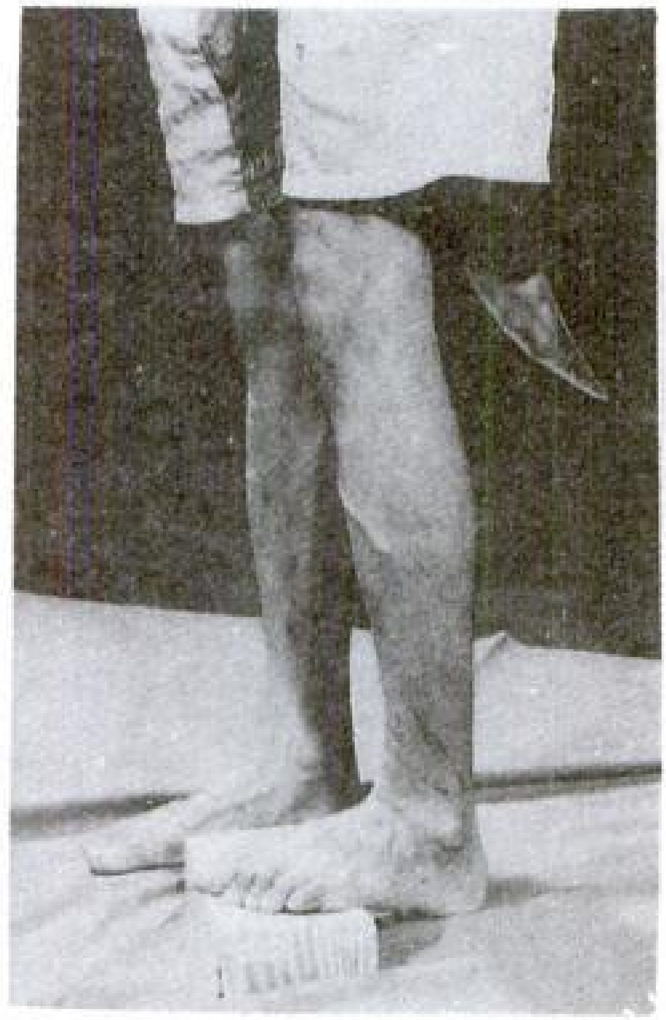


Fig. 4.106 (B)

Fig. 4.106. Self-assisted calf stretching in **(A)** Sitting, **(B)** Standing and **(C)** Step standing.

1978). The passive movement should not be so forcible so as to overstretch the fibrils that are gaining longitudinal attachment within the healing breach; nor should they be so gentle as to fail to disengage those fibrils that are gaining abnormal transverse adherence. Deep friction massage is also useful in preventing the adhesions.

2. *Thermotherapy.* If there is no evidence of edema, thermotherapy is advisable. It increases capillary permeability, promoting the reabsorption of extravasated fluid and the dissolution of the organised haematoma, helping early healing (Griffin, 1978).

3. *Early muscle strengthening.* Exercises to strengthen all the muscles should also be started as early as possible. The technique may be the same as described for early mobilisation, except that the movements are active in this exercise. It can be made self-resistive also, if there is no pain. The movements should be taken to the maximum range, with isometric holding at the end of the range. As the exercises are self-resistive the degree of resistance can be controlled to the level of pain and discomfort.

While strengthening the muscles the patient should be told to concentrate more on the muscles of the anterior and lateral compartments of the leg which are usually weaker as compared to those of the posterior compartment.

Exercising the toe-flexors and intrinsics should not be neglected, to maintain the tone and strength of the foot arches. In fact, active slow circumduction with toes tightly clenched is a simple and more effective exercise.

4. *Stretching exercises* (Fig. 4.106). It is important to stretch the posterior calf muscles. This needs prolonged gradual relaxation of the calf. It can be done by keeping the forefoot on a block or a book and pushing the heel down with the knee straight in standing, or with the knee bent to 90 degrees in sitting; putting a downward pressure over the knee with a block or a book placed under the forefoot. In standing the body weight presses the heel down and stretches the gastrosoleus.

5. *Re-education in weight bearing.* Proper placement of the injured limb, gradual weight bearing and the normal pattern of gait are to be progressed in stages. Weight bearing is started after 12 weeks.

6. *Speedy movements.* Gradual initiation and progress to more vigorous exercises like toe walking, heel walking, spot jogging and single leg hopping.

Fractures treated by open reduction and internal fixation

The period of cast immobilisation after surgery is usually less, about 3-4 weeks. Therefore, mobilisation can be started early. Gentle relaxed passive movements as well as self-assisted procedures followed by thermotherapy should be begun.

The rest of the physiotherapy regime is same as described for the conservative approach. However, SWD, US is contraindicated due to the metallic implants used for internal fixation.

INJURIES OF THE TALUS

Injuries of the talus are rare and result from a fall from a height or forced dorsiflexion injury of the ankle.

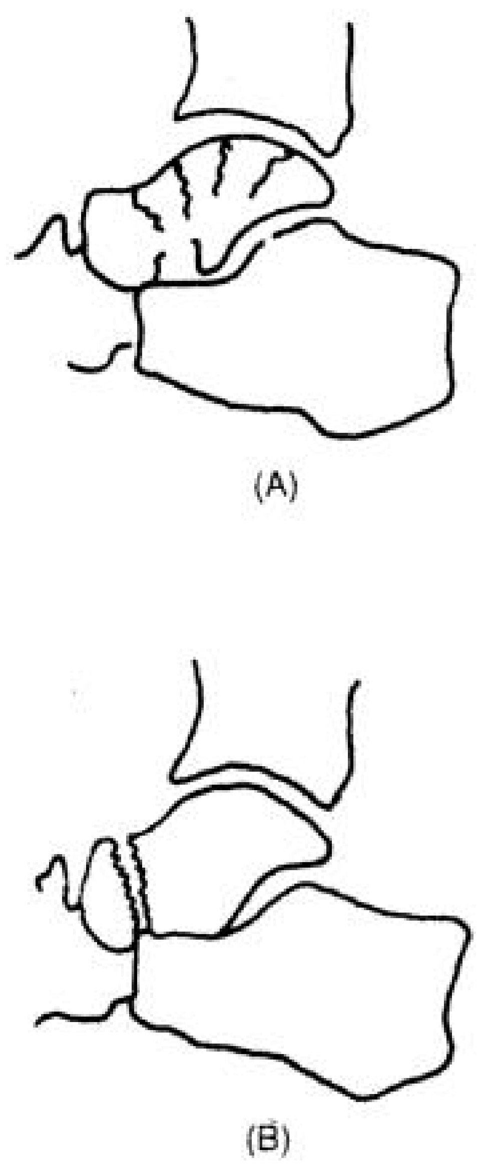


Fig. 4.107. Fracture of talus.
(A) Fracture through body.
(B) Fracture through neck.

The talus may be fractured through its body or neck (Fig. 4.107) or may be dislocated from the ankle mortice without a fracture.

Treatment

(a) Conservative treatment

The fracture or dislocation is manipulated under general anaesthesia and immobilised in a below knee plaster for 6-8 weeks. The ankle is then mobilised; however, weight bearing is allowed only after 3-4 months.

Late neglected cases, where closed reduction cannot succeed, are treated by skeletal traction applied through the calcaneum.

(b) Operative treatment

Open reduction of the fracture or dislocation is indicated where closed reduction fails. The fracture is fixed internally by Kirschner wires (Fig. 4.108).

Postoperatively the limb is immobilised in a below knee plaster for 8-10 weeks.

Complications

Avascular necrosis. Fracture through the neck of talus or dislocation can cut off blood supply to the body of the talus. This subsequently leads to avascular necrosis of the talus. It may cause osteoarthritis in later years which may require ankle arthrodesis.

Physiotherapy management

The physiotherapy programme for the cases treated by conservative as well as surgical methods is the same as described for the abduction and adduction injuries of the ankle.

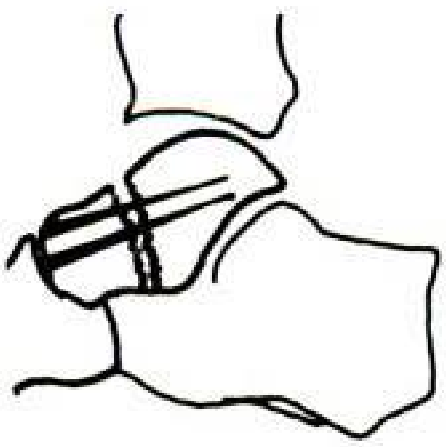


Fig. 4.108. Internal fixation of fracture talus by Kirschner wire.

Fig. 4.109. Floor squatting with the fractured leg forward.

The problem associated with this fracture is the shortening of the tendo-achilles, resulting in limitation of dorsiflexion. It makes floor squatting impossible due to the lack of range of anterior tibial excursion on the foot. Therefore, the patient needs to be taught an alternate method of floor squatting. This method includes the fractured leg to be maintained in forward position so that the pelvis can be lowered down more on the sound limb (Fig. 4.109).

To avoid this, concentrated exercise is necessary to get maximum early dorsiflexion. If the patient regains good range of dorsiflexion, floor squatting can be attained by stabilising the body weight on the sound limb to avoid excessive stretching and pain in the affected foot. As the pain reduces it can be progressed further to near normal floor squatting.

FRACTURE OF THE CALCANEUM

Fracture of the calcaneum results from a fall from a height. The calcaneum is pushed up against the talus and gets crushed.

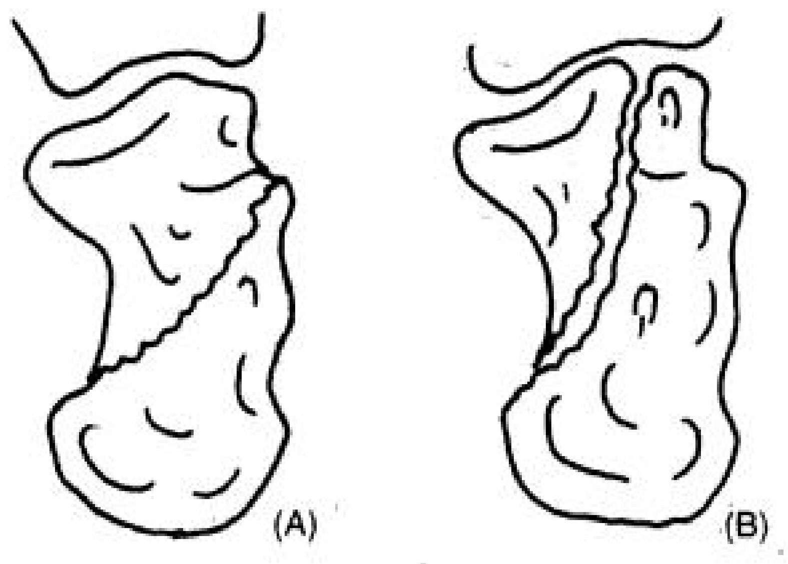


Fig. 4.110. Fracture of calcaneum.
(A) Fracture not involving subtalar joint. **(B)** Fracture involving subtalar joint.

Basically two types of fractures occur:

(a) Fracture of the calcaneum where the subtalar joint is not involved.

(b) Fracture of the calcaneum involving the subtalar joint. Here the fracture line extends into the subtalar joint (Fig. 4.110). Osteoarthritis of the subtalar joint may develop a few years later.

Treatment

In majority of cases the treatment is conservative. A below knee POP cast is applied for 3-4 weeks. Mobilisation of the ankle and gradual weight bearing are then started.

Severely comminuted fractures involving the subtalar joint pose a problem. Closed reduction of such fractures is impossible. Even in such cases the limb is immobilised in a plaster cast for 3 weeks followed by gradual mobilisation. Some surgeons advise primary internal fixation of the fracture or arthrodesis of the subtalar joint in view of the inevitable secondary osteoarthritis of the subtalar joint.

Complications

The following complications are commonly seen mainly due to the inability to accurately reduce the fracture in most of the cases and also due to the type of fracture (whether involving the subtalar joint).

1. Persistent pain in the heel and joint stiffness.
2. Osteoarthritis of the subtalar joint, which may need arthrodesis.

Physiotherapy management

It proceeds on the same lines as described for the adduction and abduction injuries around the ankle. However, the following modifications are necessary to dea with the common problems following this fracture:

1. Persistence of pain while resuming weight bearing. Therefore, partial weight bearing should be deferred to 8 weeks. A cane may be necessary to avoid painful weight bearing for a prolonged period. Appropriate thermotherapy should be given just before standing.

2. Specificity of gait. Both the phases of gait are usually painful. Therefore, initial gait training may need modification to minimise the period of walking cycle at the cost of ideal gait.

3. (a) Subtalar joint stiffness. If not mobilised early it leads to marked limitation of eversion and inversion of foot. Therefore, early mobilisation of these movements is emphasised, especially when the articular surface is fragmented and driven down in the body of calcaneum which itself is crushed.

(b) Limitation of dorsiflexion. Immobilisation leads to limitation of ROM of dorsiflexion, and the related problems, as discussed in the fracture of talus.

FRACTURES OF THE OTHER TARSAL BONES

Fractures of the tarsal bones other than the talus and calcaneum are relatively rare. These fractures do not require manipulation and are treated in a below knee POP cast for 3 weeks.

Physiotherapy treatment

Fractures of the other tarsal bones not associated with crushing injuries do not pose difficulties. Routine measures of physiotherapy are adequate to deal with these type of fractures. Vigorous exercises to the intrinsics should be emphasised right from the initial stages.

FRACTURE OF THE METATARSALS

Fracture of the metatarsal usually occurs due to fall of a heavy object on the foot or in roadside accidents. The base of the fifth metatarsal may be fractured by sudden pull of the peroneus brevis muscle, due to forced inversion and plantar flexion of the foot (Fig. 4.111).

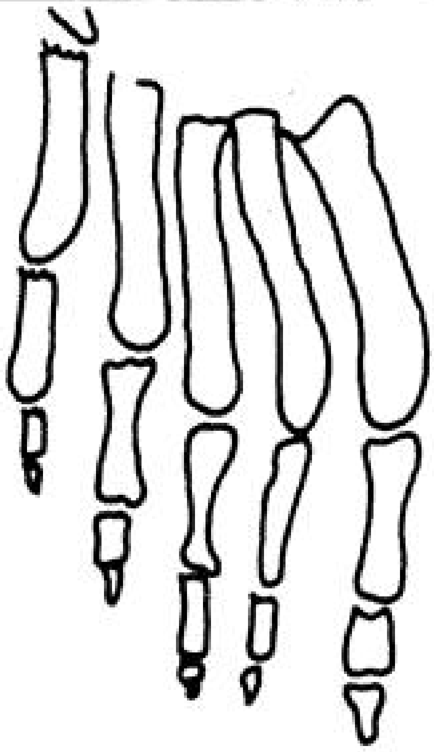
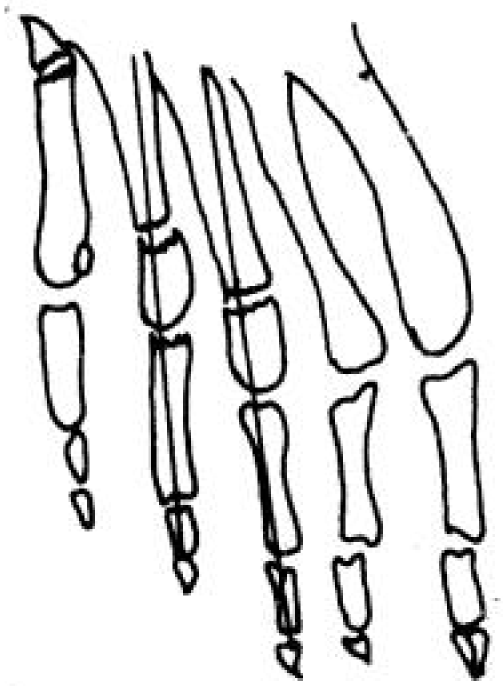


Fig. 4.111. Fracture base of fifth metatarsal.



4.112. Internal fixation by Kirschner wire.

Treatment

(a) Conservative

For undisplaced or minimally displaced fractures, the treatment of choice is conservative. The foot is immobilised in a below knee POP cast for 3-4 weeks. Mobilisation and gradual weight bearing is then started.

(b) Operative

Grossly displaced fractures are fixed internally by Kirshner wires (Fig. 4.112). Postoperatively a below knee POP slab is given for 2-3 weeks after which mobilisation is started. Weight bearing is allowed after 4-6 weeks.

Physiotherapy management

The management of fractures of metatarsal bones proceeds on the same lines as described for the tarsal bones. However, the possibility of damage to the anterior transverse arch of the foot must be remembered. Efforts to get vigorous contractions in the intrinsics at the earliest should not be neglected. During mobilisation faradic foot bath may be necessary to enforce active intrinsic exercises.

Flat foot exercises, proper weight transfers to the foot and gait training may be necessary.

By 5-6 weeks full function should be restored.

FATIGUE OR STRESS FRACTURE OF THE METATARSAL

Prolonged walking in persons not accustomed to it may give rise to a hair line fracture in the metatarsal bone (March fractures). There is no history of trauma; the patient starts feeling pain spontaneously at the site of the fracture on walking with acute tenderness and swelling. The common site of this fracture is the shaft or the neck of second or third metatarsal bone (Fig. 4.113).

Treatment

As the fracture heals spontaneously with abundant callus formation within a week or two usually the treatment is only symptomatic. In certain cases where the pain is severe, immobilisation in a below knee walking plaster for a period of 4 weeks may be necessary. No specific physiotherapy measures are needed to treat these fractures

FRACTURES OF PHALANGES

Satisfactory alignment is preserved even in comminuted fractures of phalanges. Needs no rigid immobilisation, only protection from injury. Soft woolly dressing for 2 weeks followed by active physiotherapy is adequate.

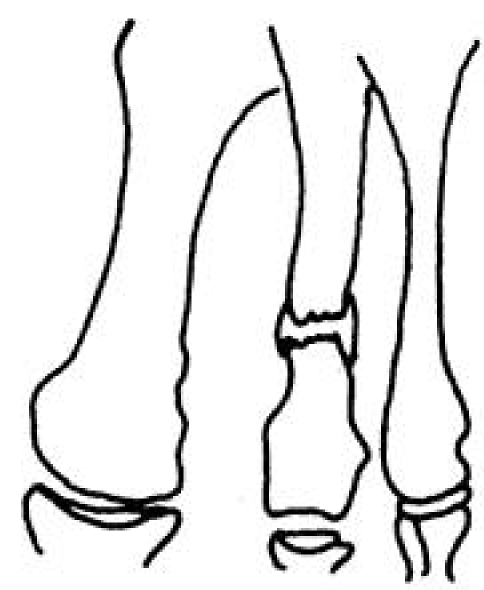


Fig. 4.113. Stress or fatigue fracture of second metatarsal.

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5

nfections of the Bones and Joints

steomyelitis
eriostitis
uberculosis
yogenic arthritis
yogenic osteitis

he common infections of bones and joints are:

1. Osteomyelitis;
2. Periostitis;
3. Skeletal Tuberculosis;
4. Pyogenic Arthritis and
5. Pyogenic Osteitis.

1. OSTEOMYELITIS

fection of the bone by pyogenic organism is called teomyelitis. It may be acute or chronic.

The commonest causative organism is the staphylo- ccus aureus. The other organisms being the staphy- coccus albus, streptococci, pneumococci, E.Coli, etc. ycobacterium tuberculosis may also cause osteo- yelitis, which is discussed separately.

Acute osteomyelitis generally follows a history of ght trauma. It occurs most commonly during the riod of active growth, i.e. between 3 and 16 years of e. The causative organisms spread through the oodstream from the original focus such as tonsils, spiratory tract, intestines, etc. to the bone. Since the fection spreads through bloodstream, this type of osteomyelitis is called haematogenous osteomyelitis.

The long bones of the lower limb are commonly involved, tibia, particularly, being the commonest bone. The upper end of tibia and the lower end of femur are generally involved. The upper end of femur may be involved in infancy.

The initial focus of infection is usually the metaphysis. Abscess is formed and the infection spreads to the medullary cavity of the diaphysis or the shaft. It may spread underneath the periosteum. This results in lifting of the periosteum thereby causing destruction of the bone. Subsequently, the tense abscess ruptures the periosteum and pus comes out through a sinus (Fig. 5.1). If not controlled, it may spread to the other parts of the body.

Acute osteomyelitis, when not treated promptly and adequately, may result in chronic osteomyelitis. Chronic osteomyelitis may also develop in bones following a compound fracture or following surgery.

Another variety of chronic osteomyelitis, i.e. tuberculous osteomyelitis, presents insidiously in the chronic stage only, without presenting in the acute form. It is discussed in the following pages.

In chronic osteomyelitis the dead bone (called sequestrum) becomes surrounded by infected granulation tissue and becomes a chronic source of pus discharge through the already formed sinus.

Reparative new bone is laid down beneath the elevated periosteum. It is called "involucrum". In neglected cases the infection may become chronic resulting in repeated bouts of acute exacerbations, with discharging sinuses and progressive destruction of the affected bone and the surrounding soft tissues.

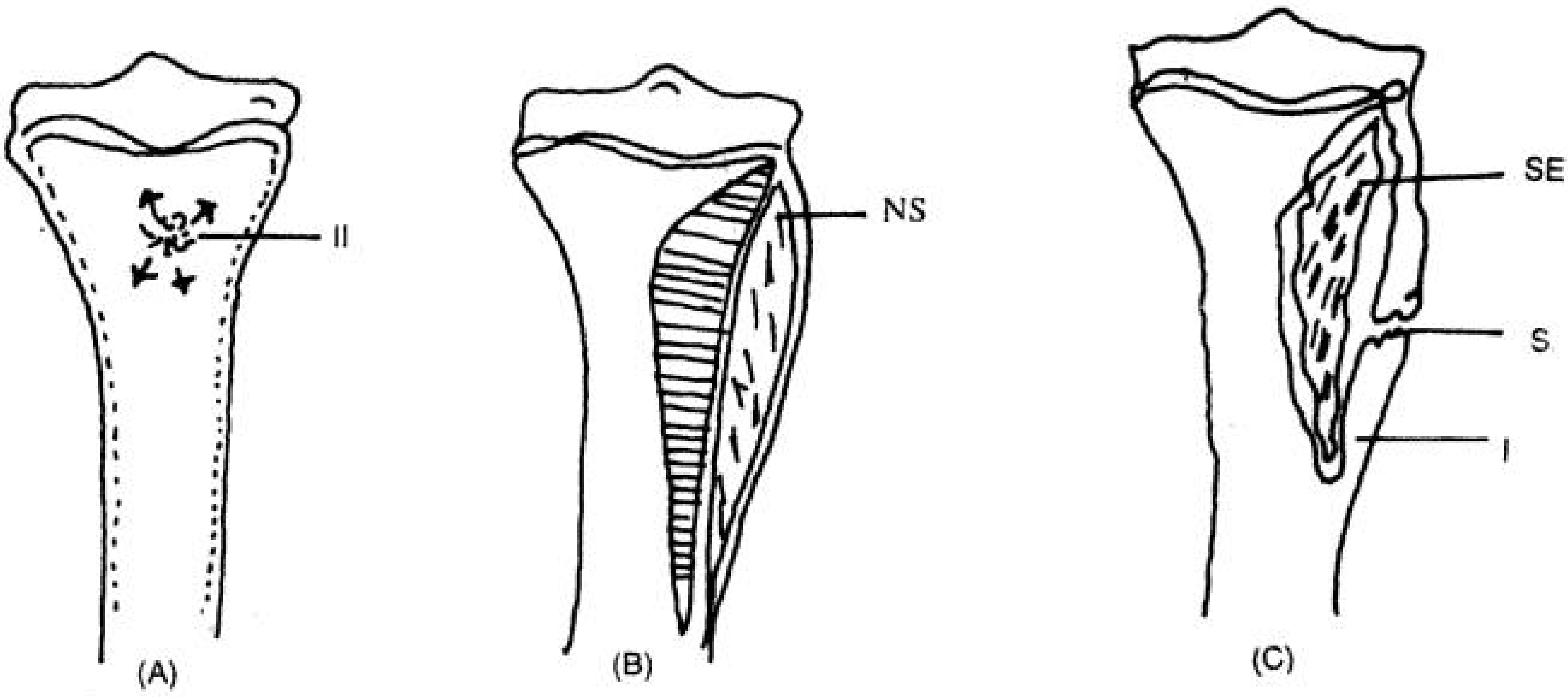


Fig. 5.1. Osteomyelitis stages.
(A) II: Site of initial inflammation. **(B)** NS: Necrotic segment. **C.** SE: Sequestrum, S: Perforating sinus, I: Involucrum.

During the acute stage the following features of acute inflammation are present:

(a) Fever;
(b) Swelling;
(c) Pain and tenderness over the site of inflammation;
(d) Skin appears pale in the initial stage turning to red with raised skin temperature;
(e) Local muscle spasm with inability to move the adjacent joints and
(f) An abscess is formed which may burst, if not drained, leading to sinus formation.

Treatment

Early stage

(a) Antibiotics.
(b) Rest and proper positioning of the limb (area of infection) with a suitable plaster slab with the limb elevated.
(c) Active movements of the other joints to augment circulation.
(d) The abscess, when formed, needs drainage.

Late stage

Uncontrolled infection in the early or acute stage can give rise to a number of complications:

(i) Discharging sinus, sequestrum.
(ii) Pathological fracture.
(iii) Displacement or premature closure of ep physis.
(iv) Joint destruction (if the site of infection i close to a joint)
(v) The involvement of the epiphysis and bon destruction may give rise to limb shortenin or may result in lengthening, if over-growt has occurred due to hyperaemia. This im balance in the bone growth may result in de formities like talipes valgus or varus or clu hand.
(vi) Joint dislocation can also occur when the sit of infection is close to the joint.
(vii) Soft tissue contractures and subsequently los of function may occur.
(viii) Important organs like heart, kidney, live spleen may also get involved.

Sequestrectomy and/or bone grafting may becom necessary.

Sequestrectomy

Removal of the necrotic bone with curettage of th cavity is necessary.

Bone grafting

After a thorough curettage, a cavity in the bone ma be filled with cancellous bone grafts.

hysiotherapy management (late stage)

omplete physical examination with investigations inuding X-rays should be done before the therapy is lanned.

At this late stage of the disease generally the comlications may be present. Physiotherapy will be irected to reduce the influence of these complications nd to provide functional independence. The approach ill depend upon the site, the stage of the disease and e extent of complications.

The routine procedures should include improving e strength, endurance, tone and flexibility of the uscles, the ROM and functional tasks. The specific erapy may need:

- Sustained sessions of soft tissue stretching in the presence of fibrous ankylosis.
- Proper compensatory orthoses in cases of bony ankylosis, limb length disparities and fixed deformities.
- Assistive devices and adaptations may have to be provided to improve limb and body functions.
- Deep friction and/or ultrasonics for an adherent scar.

Caution

Signs of the recurrence of inflammation at the affected site needs to be carefully watched.

2. PERIOSTITIS

eriostitis is an inflammatory condition of the periosum. The bone which is superficial (subcutaneous) is e usual site of such inflammation (e.g. shin bones). he bone gets thickened as a result of direct injury Fig. 5.2).

There is marked tenderness, pain and swelling over e area of inflammation.

reatment

uring the acute stage the treatment consists of rest, nalgesics and anti-inflammatory drugs. An abscess ay need drainage.

hysiotherapy management

leasures should be adopted to reduce the inflammaion and pain. As the joint is generally spared, early recovery is expected. Full range mobility of the adjacent joints should be ensured to avoid stiffness.

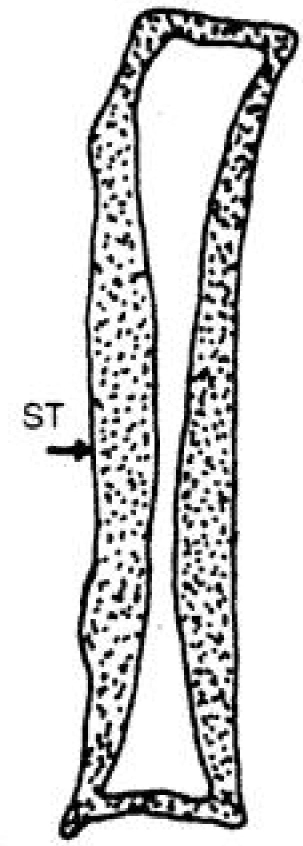


Fig. 5.2. Periostitis.
ST: Diffuse sclerotic thickening of shaft of tibia.

3. SKELETAL TUBERCULOSIS

Tuberculosis is a systemic disease which may affect various organs. Skeletal tuberculosis, i.e. tuberculous infection of the bones and joints, is almost always secondary to an infection elsewhere in the body, usually in the lungs, lymph glands or intestines, etc. Young children and adolescents are commonly affected. Debility, general weakness and unhygienic surroundings could be the predisposing factors. Injury may be a precipitating cause, resulting in small haemorrhages inside the bone. Such haemorrhages cause vascular stasis which favours deposition of the organisms in the injured area.

The causative organism, the tubercle bacillus, enters the body by inhalation, by ingestion or by inoculation. The bacilli multiply after invasion. An inflammatory reaction sets up and eventually a typical tuberculous follicle is formed. There occurs destruction of the bone with pus formation. Later on there is an attempt at fibrosis at the periphery. Tuberculous infection of the bone is seen in vertebrae, phalanges and metacarpals and rarely in long bones. Infection of the synovial membrane occurs in tuberculous arthritis.

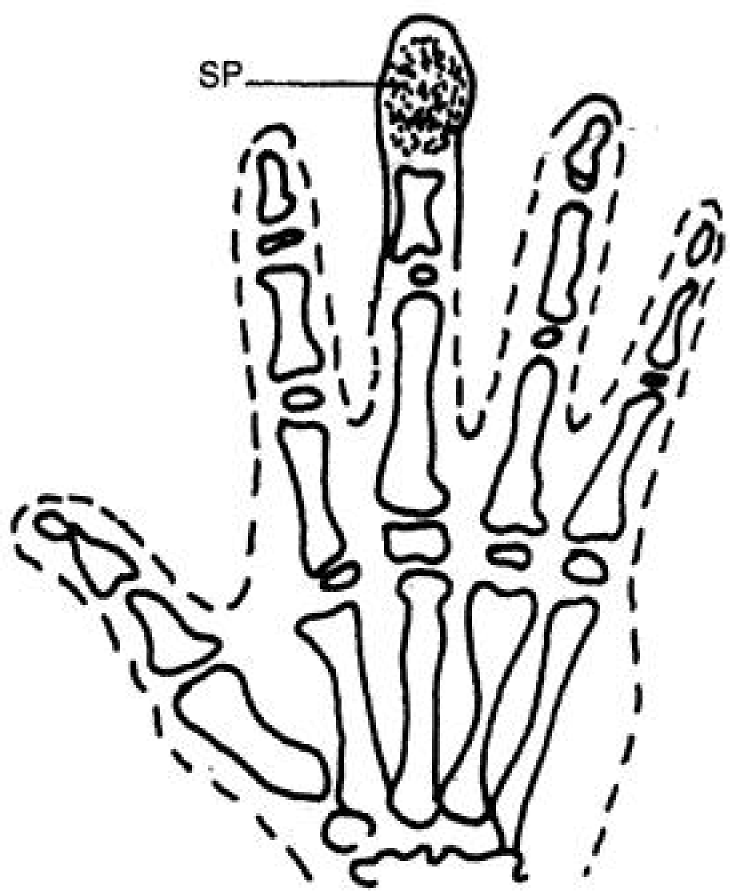


Fig. 5.3. Tuberculosis involving a phalanx.
SP: Spindle shaped appearance of the affected phalanx.

Tuberculous infection of the vertebra is discussed in the chapter on "Spine" in the subsequent pages. In case of tuberculous infections of the metacarpals and phalanges, the affected bones become swollen and spindle shaped (Fig. 5.3). It is commonly seen in children.

Tuberculous arthritis is usually monoarticular but may involve multiple joints occasionally. Hip, knee and elbow joints are commonly involved, whereas wrist and tarsal joints may occasionally be affected.

In the early stage the synovial membrane is affected. A hard, tender swelling develops over the affected joint. Attempted movements of the joints are extremely painful, when the bony ends of the joint are involved. The joint movements are restricted due to muscle-spasm, and involvement of the cartilage. The further progress of the disease may result in the fixed deformity, limb shortening or even dislocation.

If treated early and adequately, there may be good recovery. Delay in treatment may result in fibrous ankylosis, bony ankylosis, joint destruction and even dislocation.

In fibrous ankylosis, the cartilage and the synovial membrane are replaced by fibrous tissue. The bony ankylosis may be due to the knitting of the bony ends following destruction of the cartilage, or ossification may occur in fibrous tissue surrounding the joint.

Dislocation of the joint may occur due to destru tion of the ligaments supporting the joint.

Treatment

Conservative

(a) Bed rest, well balanced nutritious diet.
(b) Drug therapy.
(c) Rest to the affected part in the acute stage. Th may be achieved by traction or splintage or PC cast, in the optimal position of the joint.

Optimal positioning of the affected joint and the lin is of primary importance to avoid deformity and co tractures. The ideal positioning of the individual join should be :

Hip	— Extension, 20-30 degrees of abducti and neutral rotation.
Knee	— Extension.
Ankle	— Dorsiflexion to a right angle.
Shoulder	— Abduction of 40-45 degrees and inte nal rotation.
Elbow	— In flexion near right angle.
Wrist	— In 40-45 degrees of extension.

Surgical

The surgical treatment depends upon the stage and th extent of the disease. However, any one or a combin tion of the following procedures may be indicated in particular case:

(a) Drainage of the abscess;
(b) Excision of the diseased bone and other tissue (debridement), with or without bone grafting;
(c) Joint debridement and
(d) Arthrodesis or arthroplasty of the joint.

Physiotherapy management

Gentle active and passive exercises to the affected joi are started as soon as the pain permits or the diseas activity has subsided. However, the following regim may be followed:

1. Active full ROM of the uninvolved joints to th limit of fatigue.
2. The movements should be begun at the earlie but only after confirming that the disease is quies cent. Early stretching of the joint may set free th encapsulated bacilli leading to flare up of the dis ease.

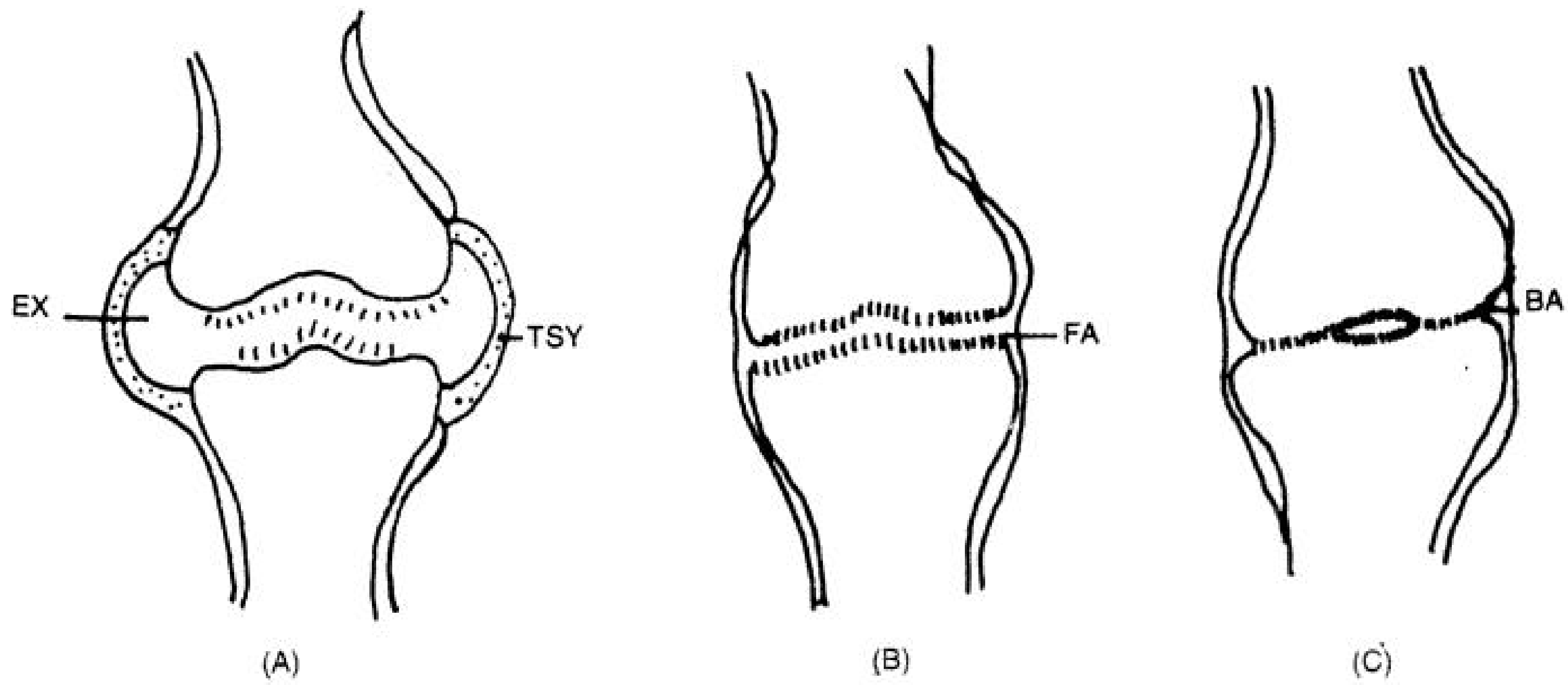


Fig. 5.4. Tuberculous arthritis involving knee.
(A) TSY: Thickened synovial membrane, EX: exudate–turbid fluid or pus. **(B)** FA: Fibrous ankylosis. **(C)** BA: Bony ankylosis.

3. Gradual but definite progress of the therapeutic regime to resisted movements and functional activities be ensured.
4. It may be necessary to provide an assistive aid to facilitate weight bearing and ambulation.

The basic objective of physiotherapy management proceeds on the same lines as described for tuberculosis of spine (Pott's disease) in the chapter on "Spine". Only the emphasis and the managemental procedures vary in accordance with the degree and the site of involvement of the bone and the joint by tubercle bacillus and the therapeutic measures adopted (e.g. conservative or surgical).

4. PYOGENIC ARTHRITIS

Pyogenic infections of the joints, i.e. pyogenic (septic) arthritis, are caused commonly by staphylococci and less commonly by streptococci, pneumococci, gonococci and meningococci, etc. The pyogenic or septic arthritis results from invasion of the organisms into the joint which may occur through any of the following routes:

(a) Spread through bloodstream from a focus of infection elsewhere in the body such as tonsils, teeth, respiratory tract, intestines, etc.
(b) Secondary to osteomyelitis in the adjacent bone, e.g. septic arthritis of the hip following osteomyelitis of the upper end of femur.
(c) Direct implantation of the bacteria into the joint through a punctured wound over the joint, infection from a compound fracture.
(d) Following surgical procedures on the joint such as aspiration, arthrotomy, arthroscopy, etc.

There is inflammation of the synovial membrane with excessive production of joint fluid/pus. The fluid contains a large number of cells, bacteria and fibrin. There occurs destruction of the articular cartilage and the underlying bone. When the joint is distended with pus, pathological dislocation of the joint may occur. The capsule may get perforated and the pus may escape out forming sinuses. If untreated, the joint may get disorganised and end up into fibrous- or bony-ankylosis (Fig. 5.4).

Pyogenic arthritis commonly affects infants and young children. It commences rapidly with high grade fever, swelling and pain in the joint. Movements at the affected joint are not allowed by the child due to pain and muscle spasm.

Aspiration of the joint fluid for analysis and X-rays are the investigations usually undertaken.

Treatment

1. Rest to the joint by traction or splintage.
2. Antibiotic drugs are started at the earliest.
3. Drainage of the pus.
4. Gradual mobilisation of the joint.

5. If the disease is advanced with destruction of the articular cartilage, the joint is immobilised in the optimal position (described earlier) and allowed to ankylose.

Physiotherapy management proceeds on the same lines as described for tuberculosis.

5. PYOGENIC OSTEITIS

Pyogenic osteitis in its early stages resembles spinal tuberculosis. Back pain and stiffness are present. However, at the late stage there are new bone formation at the site of the lesion as against vertebral destruction in tuberculosis.

The bacteriological examination confirms the presence of staphylococcal infection. Rarely infection may be caused by salmonella typhi and other organisms.

Appropriate antibiotic treatment for a long duration is effective.

Physiotherapy measures are to be taken to activate the patient adequately at the earliest. It follows the same pattern as described for other bone infections.

6

Metabolic Bone Diseases

Rickets
Osteomalacia
Hyperparathyroidism
Hypoparathyroidism
Osteoporosis

METABOLIC DISORDERS OF BONE

The following are the common metabolic disorders of the bone:

1. Rickets and osteomalacia;
2. Hyperparathyroidism and hypoparathyroidism; and
3. Osteoporosis.

1. Rickets and Osteomalacia

Calcium and phosphorus metabolism

The physiological activity of the bone plays an important role in the calcium and phosphorus metabolism. Both these mechanisms form the basis of various body functions. The bones form a reservoir with 99 percent of calcium and 90 percent of phosphate in the body. Alterations in the physiological balance of these mechanisms in the bone give rise to the metabolic disorders of bone. Role of calcium ions :

The presence of free calcium ions is necessary for

(a) Coagulation of blood;
(b) Contractions of the cardiac and skeletal muscles;
(c) Functioning of the nerves.

A perfect balance in the calcium metabolism is essential between the absorption of calcium from the gastro-intestinal tract, its excretion by the kidney and its uptake and mobilisation from the bone. Maintenance of blood calcium level is the basis of the perfect functioning of the body systems.

Vitamin D and parathyroid hormone influence the calcium metabolism. Vitamin D is supplied to the body via diet, while some of it is synthesised in the skin by the action of ultra-violet rays on the melanin. Vitamin D absorbs calcium from the intestine. Its deficiency leads to poor absorption of calcium resulting in hypocalcemia. This, in turn, causes deficient mineralisation of the newly formed bone, rendering it weak.

Parathyroid hormone increases the plasma calcium level. It facilitates the absorption of calcium from the intestine, it mobilises calcium from the bone and it also stimulates excretion of phosphate from the kidneys. This results in dropping of the plasma phosphate level and rise in the plasma calcium level.

Rickets

It is common in children ("infantile rickets") while in adults it is termed as osteomalacia.

Vitamin D deficiency results from lack of intake or insufficiency of exposure of the body to sunlight.

The absorption of calcium and phosphate is reduced due to deficiency of Vitamin D. A fall in the level of blood calcium stimulates hypersecretion of parathyroid hormone. This, in turn, mobilises calcium from the bone. This leads to deficient calcium in the bone making them soft and easily malleable to pressure. This causes typical deformities in the weight bearing bones common to "infantile rickets". It also results in formation of osteoid or uncalcified bone matrix. There is an arrest in the activity of the growth plate cartilage resulting in retardation of the ossification bone growth. In osteomalacia decalcification radiologically appears as bands of radio-lucency called as Looser's Zone or Milkman's fracture. Milkman's fracture is pseudo fracture commonly observed at the femoral neck, pubis, upper humerus, scapula and ribs. However, the incidence of pathological fractures is common in this condition.

The common deformities in infantile rickets are:

(a) Pigeon chest – where the thoracic cage is compressed at the sides, and is raised and elongated antero-posteriorly, the sternum being prominent and thrusted forward.
(b) Lower limb – deformities like coxa-vara, genu-varum, genu-valgum, bow-legs or forward bowing of tibia and flat feet occur due to the compressive pressure of the body weight on the soft decalcified bones.
(c) Spine – kyphosis involving both the thoracic and lumber spines may be present which may subsequently lead to lumbar lordosis as the child starts walking.
(d) The "rickety rosary"– bony enlargement occurs at the junction of the ribs with cartilages.
(e) Pelvis – the size of the pelvis may be reduced as well as the overall growth of the child is arrested. All resulting in stunted growth or dwarfism.

Treatment

Administration of high doses of Vitamin D with calcium supplements is the mainstay of the treatment. Mild deformities in the limbs should be treated by the use of splints (mermaid splint). Weight bearing should be avoided till there is definite evidence of calcification in the bones following Vitamin D and calcium therapy. Marked deformities may need surgical correction by corrective osteotomy.

The fractures are treated by adequate immobilisation by POP.

Physiotherapy management

1 Ultra-violet irradiation. Sub-erythemal general exposure of ultra-violet irradition ranging between wave lengths of 3300 Å and 2900 Å is useful.
2. Deep breathing exercises. They are particularly important in improving the general health by increasing the oxygen intake and preventing thoracic deformity.
3. Active exercises progressing to resistive exercises improve circulation to the limb.
4. Prevention of deformities. Wrong postures and weight bearing situations should be avoided to the bones prone to develop deformity.
5. Corrective orthoses are used to prevent further deterioration in the deformity.
6. Appropriate physiotherapy measures should be taken following surgery for correction of deformity or treatment of fractures. Gradually progressive mobilisation and strengthening facilitates early return of function.

The disease, when detected early, can be controlled with administration of Vitamin D and calcium.

Other types of rickets

(a) **Vitamin D resistant rickets.** It is due to the deficiency of blood phosphate (hypophosphataemia). Because of its resistance to Vitamin D normal bone formation needs high doses of Vitamin D.
(b) **Hypophosphatasia.** The calcium deposition in the bone is deficient although its supply is normal. This occurs due to the inherited lack of the enzyme alkaline phosphatase.
(c) **Renal rickets.** Inadequate secretion of phosphorus by the kidney results in fall of phosphate in the blood. This follows malfunctioning of the kidneys. There is an increased secretion of parathyroid hormone which mobilises calcium from the bones, rendering them soft and liable to deformities.

2. Hyperparathyroidism and Hypoparathyroidism

Hyperparathyroidism

Hyperplasia or a tumor of the parathyroid gland could be the causative factor. This hyperplasia results in excessive excretion of phosphate from the kidney. A fall in the blood phosphate level results in the corresponding increase in the blood calcium level. Mobilisation

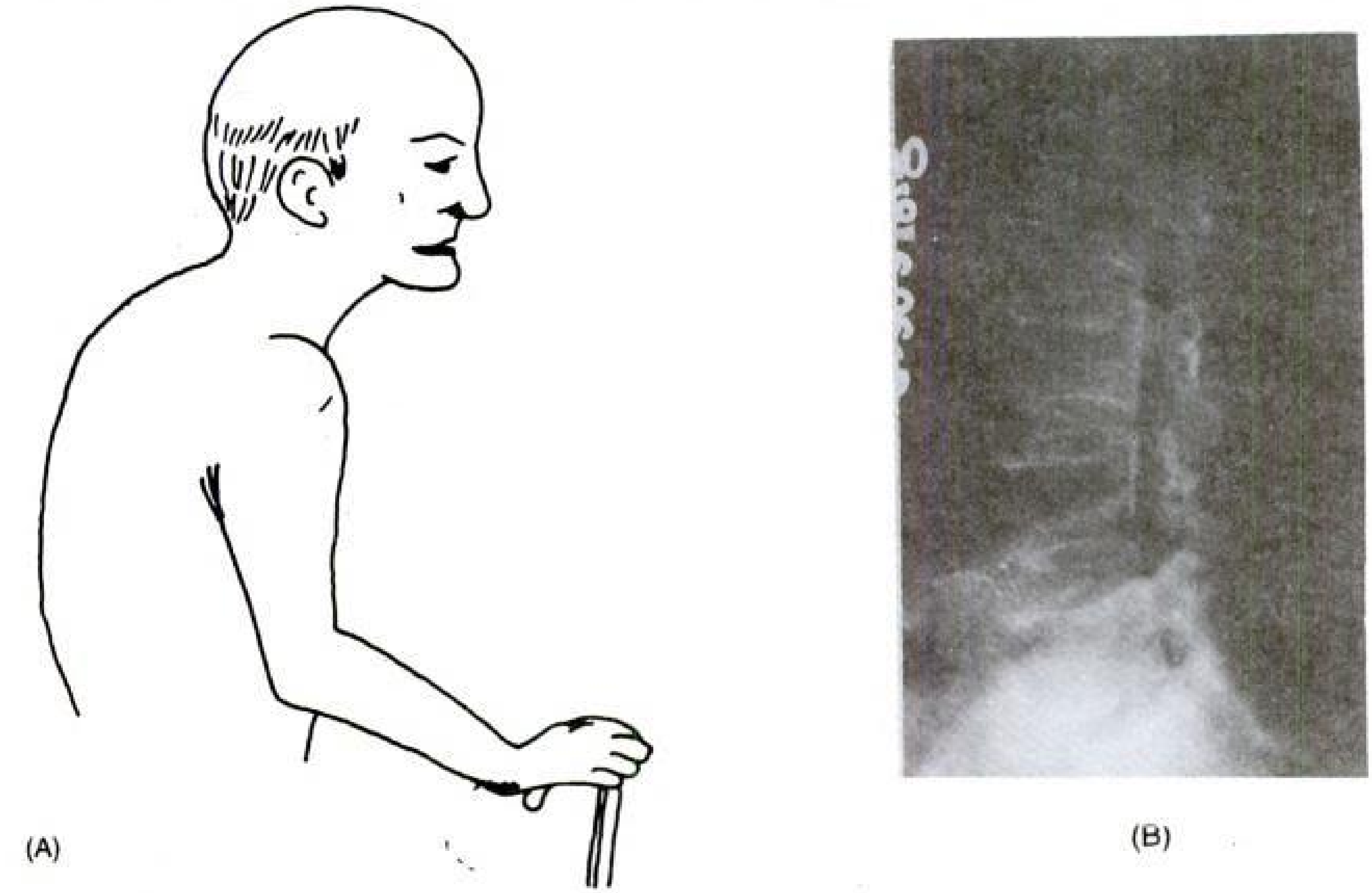


Fig. 6.1. Senile osteoporosis.
(A) Exaggeration of dorsal kyphosis. **(B)** Radiograph (lateral view) of the spine indicating loss of bone density in the bodies of vertebrae with ballooning (saucerization) of the intervertebral spaces.

of calcium from the bones leads to osteoporosis rendering the bones prone to deformities and pathological fractures. Occasionally cysts may be seen in the bones. Formation of kidney stones containing calcium may occur.

Treatment

Removal of the tumor from the glands corrects the metabolic disorder. After this surgery the fractures generally heal spontaneously. They should, however, be immobilised adequately throughout the period of treatment.

Hypoparathyroidism

Removal of parathyroid glands during the surgery of thyroid gland may give rise to hypoparathyroidism. The blood calcium level falls and the patient may have frequent episodes of muscular spasms (tetany).

3. Osteoporosis

In osteoporosis the affected bone becomes soft and brittle due to poor formation of protein matrix.

Osteoporosis may occur as a result of:

1. Immobilisation;
2. Hormonal imbalance;
3. Nutritional deficiency and
4. Miscellaneous causes.

1. Immobilisation

Immobilisation following fractures or bedridden situation results in osteoporosis. The normal stimulus of stress and strain needed for the normal bony structure is deficient. Early mobilisation and stress application can prevent this type of osteoporosis.

2. Hormonal imbalance

Gonadal hormones like estrogens and androgens are needed for the normal process of bone formation. Deficiency of these hormones render bones brittle and weak (osteoporotic) susceptible to fractures. Senile or post-menopausal osteoporosis are the common examples of this type of osteoporosis (Fig. 6.1).

Hypersecretion of adrenocortical hormones like glucocorticosteroids, as in Cushing's syndrome, can also result in osteoporosis. Excessive and prolonged administration of steroids in the treatment of arthritis, certain skin disorders and many other medical conditions lead to this type of osteoporosis with its subsequent complications like pathological fractures and deformities.

The treatment of senile or post-menopausal osteoporosis is generally symptomatic. It includes analgesics and spinal braces. Generalised exercises and activities avoiding undue stresses to the osteoporotic bones should be emphasised.

3. Nutritional deficiency

Generalised malnutrition with deficiency of protein, calcium and phosphorus can also cause osteoporosis.

4. Miscellaneous conditions

Conditions like multiple myeloma and cancer diseases can cause generalised or localised osteoporosis.

7

Bone Tumors

Classification of tumors

Principles of management

TUMORS

Tumor is a swelling due to excessive neoplasia or new growth of a tissue. It may affect any tissue cells in the body.

The tumors are of two types:

1. Benign (Fig. 7.1)
2. Malignant (Fig. 7.2).

The characteristics of both these types of tumors are classified in Table 7.1.

In this chapter, the classification of bone tumors and the basic principles of management are discussed. It is outside the scope of this book to discuss these tumors in detail.

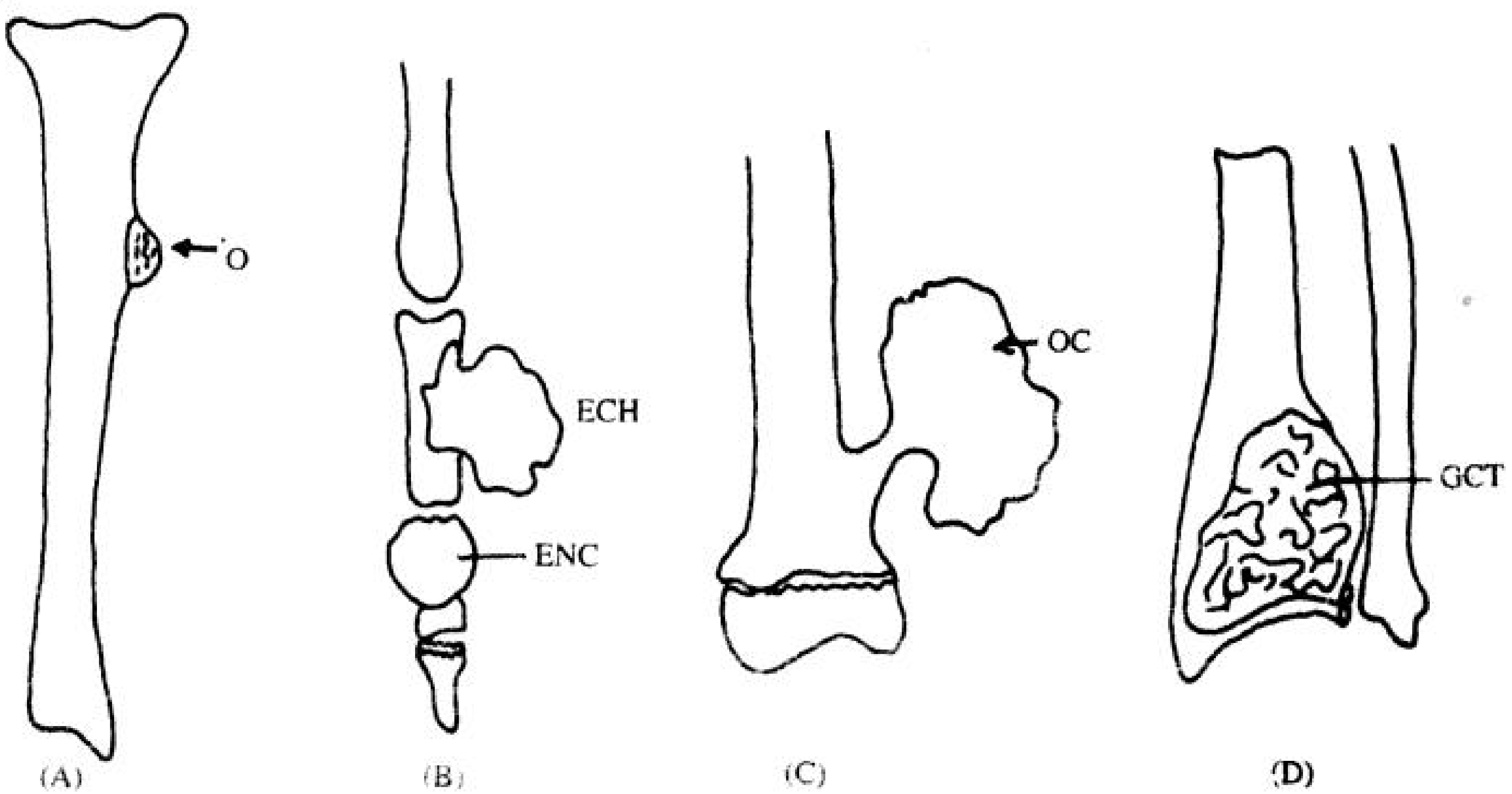


Fig. 7.1. Benign tumors.
(A) Osteoma. **(B)** ECH: Econdroma, ENC: Encondroma. **(C)** OC: Osteo-chondroma. **(D)** GCT: Giant cell tumor.

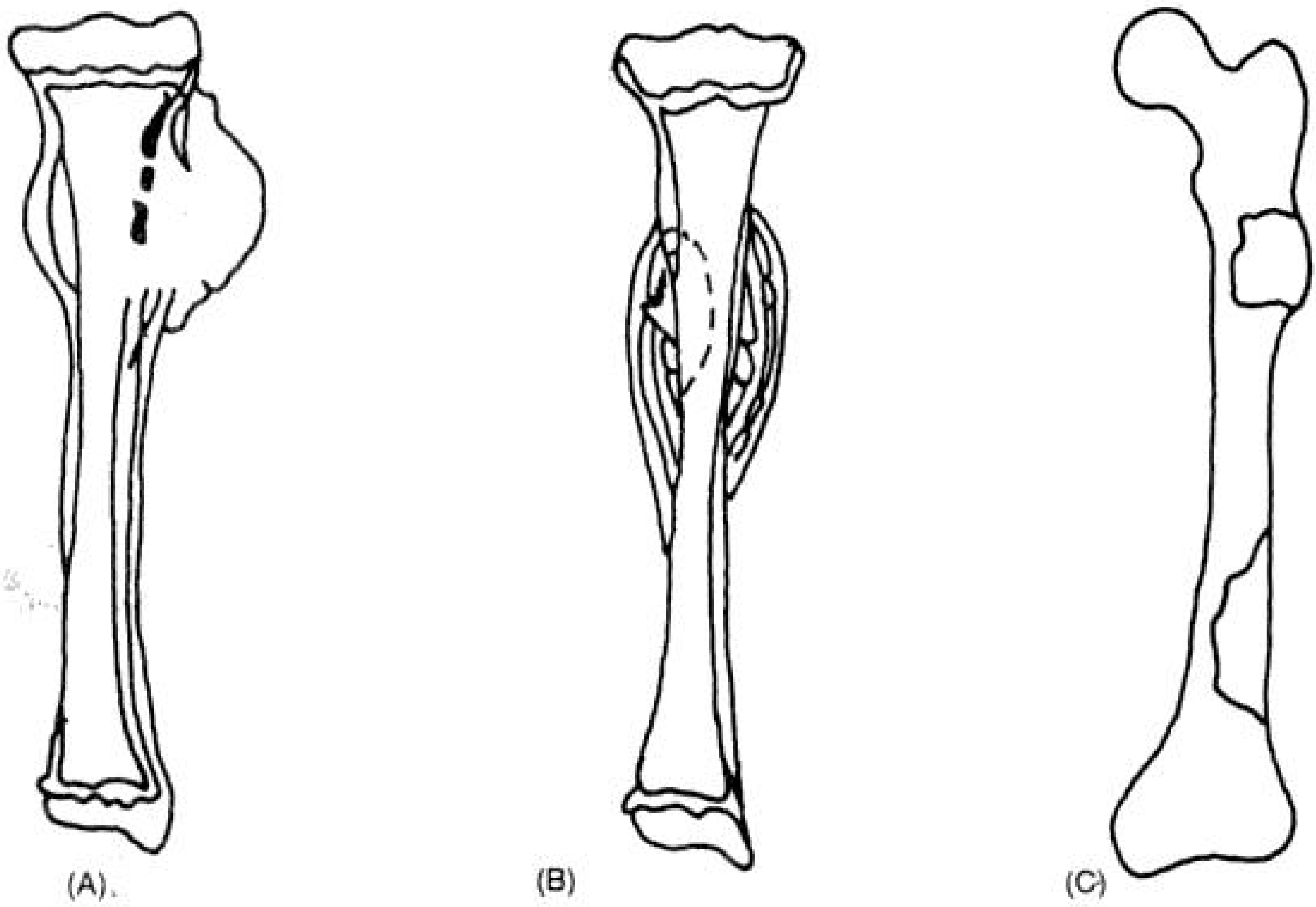


Fig. 7.2. Malignant tumors of bone.
(A) Osteosarcoma. **(B)** Ewing's tumor. **(C)** Metastatic tumors.

Table 7.1. Characteristics of tumors

Benign Tumor	*Malignant Tumor*
Harmless	Harmful and could be fatal
Excessive localised proliferation	Rapid growth with invasion of the surrounding tissue
No recurrence	Recurrence may occur even after treatment
No metastases	Metastases – usually spreading to distant tissues or organs or lymph nodes
Cell nuclei remain unchanged	Abnormal changes occur in the cell nuclei
No anaplasia, i.e. the structure of the newly formed cells similar to the structure of the cells of origin	Anaplasia is present. It fails to produce the tissue structure similar to the cells of origin
Radiological appearance: the tumor edges are clearly defined	Radiological appearance is hazy without a clear outline

Table 7.2. Classification of the tumors of bone and cartilage

Tissue of Origin	*Benign Tumors*	*Malignant Tumors*
Bone	Osteoma, Osteo-blastoma, Osteoid osteoma	Osteosarcoma, Juxtacortical-Osteosarcoma
Cartilage	Osteochondroma Chondroma: (a) enchondroma (b) ecchondroma (c) chondroblastoma	Chondrosarcoma
From non-osseous connective tissues in bone	Lipoma, Neurofibroma Neurolemmoma	Liposarcoma, Reticulo-sarcoma Myeloma, Ewing's tumor
Fibroblastic tissue	Fibroma	Fibrosarcoma
Vascular	Angioma and Aneurysmal– bone cyst	Angiosarcoma
Embroyonic vestigial tissues		Chordoma
Undifferentiated connective tissue tumor		Giant cell tumor

Bone Tumors

Bone tumors could be primary, when they arise from the bone itself, and occur mainly in young adults. They are highly malignant and fatal.

The secondary bone tumors occur as a result of the metastases usually from the carcinoma of breast, kidney, lung, prostate or thyroid.

The classification of the tumors of bone is shown in Tables 7.2 and 7.3.

Table 7.3. WHO classification of bone tumors

Bone forming tumors	Osteoma, osteoblastoma and osteosarcoma
Cartilage forming tumors	Chondra, chondroblastoma and osteosarcoma
Giant-cell tumors	Form group on their own
Marrow tumors	Ewing's tumor and myeloma
Vascular tumors	Haemangioma, glomus tumor and angiosarcoma
Other connective tissue tumors	Lipoma, liposarcoma and fibrosarcoma
Other tumors	Chondroma, adamantinoma, neurilemmoma and neurofibroma
Tumor like lesions	Bone-cysts, fibrous dysplasia and eosinophilic granuloma

Treatment

Benign bone tumors

The benign tumors may overgrow and cause pressure syndromes, e.g. pain, weakness due to interference in muscle action, etc. It may weaken and fracture the affected bone or may even progress to malignancy.

Such benign tumors need surgical treatment like excision or curettage and bone grafting.

Malignant bone tumors

These tumors present as pain and swelling of the affected area.

Local tenderness, warmth over the skin, with visible dilated veins, severe pain and joint stiffness may be present. There is sudden appearance and increase of swelling as the growth of the tumor is rapid. This tumor very often metastasises to lungs.

Primary bone tumors

The diagnosis is confirmed by biopsy. Once the malignancy is confirmed, the treatment is started immediately. The treatment could be either single or a combination of the following :

(i) Surgical excision or amputation;
(ii) Radiotherapy and
(iii) Chemotherapy.

(i) *Surgical excision or amputation.* The treatment specifically depends upon the nature of the involvement. Complete surgical excision of the tumor is the treatment of choice if there are no metastases. If limb salvage is not feasible, amputation of the affected limb is undertaken. When metastases are present, a palliative amputation is done to relieve pain or to prevent bleeding from a fungating tumor. Single metastases, e.g., in lungs, may be excised. As a protective measure radiotherapy may follow amputation even if there are no metastases. In the presence of metastases, usually radiotherapy is the treatment of choice.

(ii) *Radiotherapy.* Radiotherapy helps in the shrinkage of the tumor mass. It many a times offers relief in pain. It is one of the effective measures in reducing the residual mass of tumor either before surgery or in cases where surgery cannot be performed.

(iii) *Chemotherapy.* Chemotherapy is helpful when used in combination with radiotherapy and/or surgery. The drugs (cytotoxic drugs) used in chemotherapy are of various types and are used in combination of 2-4 drugs. The drugs commonly used in the treatment of malignant bone tumors are: cyclophosphamide, adriamycin, vincristine, nitrogen mustard, methotrexate, actinomycin- D, etc.

However, the cytotoxic drugs are extremely toxic and produce marked side-effects in the patients.

Secondary bone tumors

The secondary bone tumors are metastatic deposits from the tumors in the other tissues. The carcinoma of breast, kidney, lung, thyroid and prostate usually metastasise in the bone during or after middle age.
The treatment is as follows:

(i) *Drugs.* Analgesic drugs to control pain. Hormonal drugs in carcinoma of breast and prostate.

(ii) *Radiotherapy.*

(iii) *Surgery.* It involves decompression when the tumor mass compresses upon the spinal cord. Division of the sensory nerves, nerve-roots, or nerve tracts may be necessary to control severe pain. If the tumor fungates, its excision may be necessary. Pathological fractures due to secondary metastases of the long bones may need internal fixation.

Physiotherapy management

The physiotherapy management depends upon the site of tumor and its medical management.

The basic principles of physiotherapy are:

1. To keep up the morale of the patient, especially with a malignant disease.
2. The typical lymph edema which persists longer and is difficult to control needs careful attention from the early stage. Intermittent compression techniques, limb elevation and vigorous movements of the distal components are given.
3. General circulation is maintained but no attempt is made to improve circulation in excess as it may promote cell multiplication. Deep heating modalities like continuous short wave diathermy, ultrasound are strictly contraindicated.
4. The full ROM of the joints and flexibility of the muscle tendon complex is maintained by simple, slow and sustained holding rather than vigorous joint movements.
5. The procedures to improve the strength and the endurance of the muscle groups is taken up at a later stage.
6. Functional use of the affected limb is facilitated at the earliest.

After surgery

The basic aim of physiotherapy is to provide optimal functional efficiency to the operated part to facilitate functional independence. The therapeutic measures cannot be specified as they vary from simple active movements to the use of prosthesis. They have to be adopted as per the therapeutic approach of the management of the tumor.

8

Arthrodesis and Arthroplasty

ARTHRODESIS

With the advent of replacement arthroplasty and other reconstructive surgical procedures, arthrodesis is undertaken selectively only as a salvage procedure.

This procedure involves fusion of a joint which has been damaged/destroyed due to disease/trauma beyond repair or reconstruction with marked instability and severe functional handicap. It is sometimes undertaken to relieve severe pain (e.g. in secondary osteoarthritis) which has failed to respond to conservative therapy. Arthrodesis is also indicated in paralytic conditions (e.g. poliomyelitis) where the muscles are partially or completely paralysed. For example, shoulder arthrodesis for a flail joint. It also becomes necessary after failure of total joint replacement.

The procedure provides remarkable relief of pain and offers maximum stability to the joint, but at the cost of mobility. It is generally performed only at one joint in a limb provided the other joints of the same limb as well as those of the contralateral limb are good.

The operation of arthrodesis is performed in two ways:

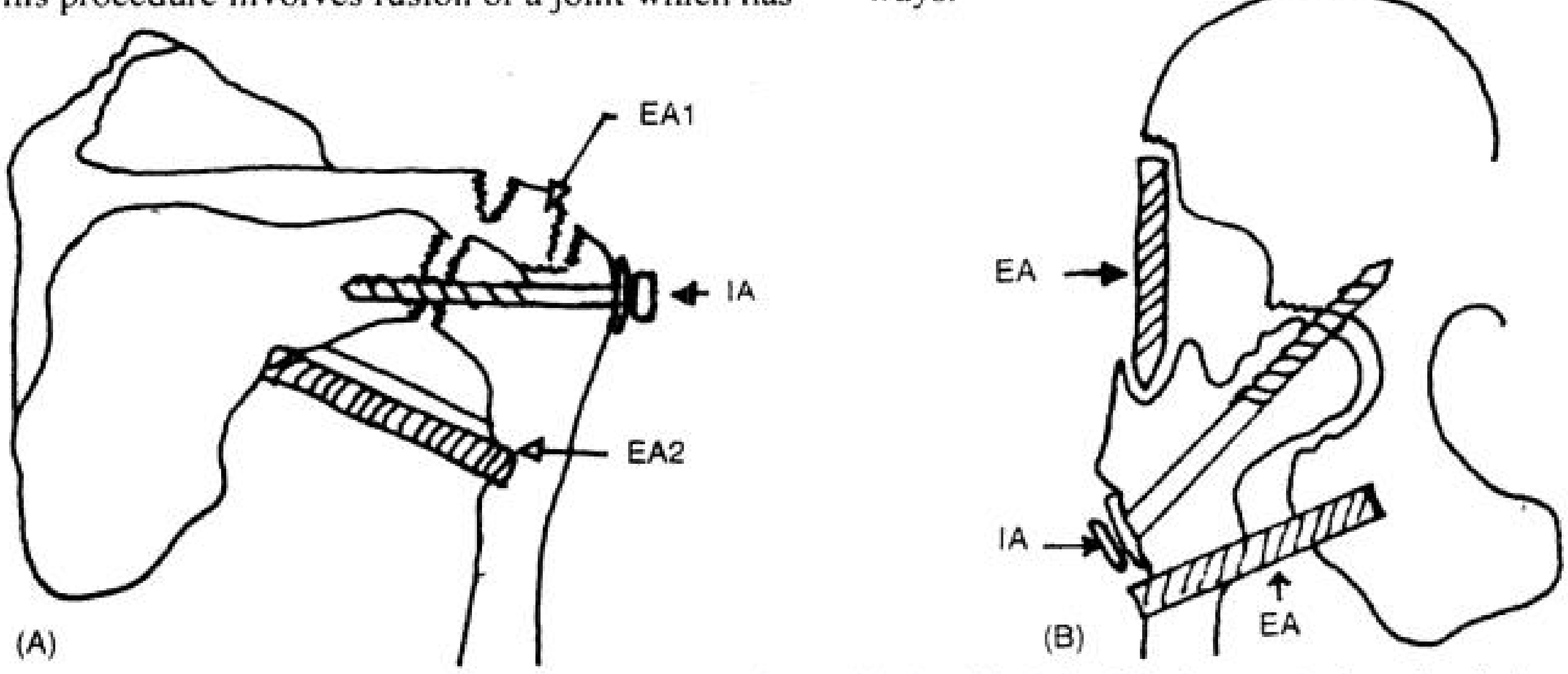


Fig. 8.1. Intra-articular (IA) and extra-articular (EA) arthrodesis. **(A)** Shoulder joint. IA : Intra-articular arthrodesis with fixation, EA1 : Fixation by turning acromion in a slot in the greater tuberosity, EA2 : Fixation with strut graft. **(B)** Hip joint. IA : Intra-articular fixation by nail, EA : Extra-articular fixation with graft.

(i) Intra-articular arthrodesis.
(ii) Extra-articular arthrodesis.

*(i) **Intra-articular arthrodesis***

In this procedure, the articular cartilage is removed from both the opposing bony ends of the joint and the bone ends are cut and shaped to fit in an optimum functional position (Fig. 8.1). The fusion is secured by internal fixation or an external fixation device or by a plaster cast, or by a combination of these methods. This type of arthrodesis is commonly performed in the hip and knee joints for tuberculosis.

*(ii) **Extra-articular arthrodesis***

In extra-articular arthrodesis, the joint surfaces are not denuded of its articular cartilage but the fusion is achieved in the position of optimum function, by a bone graft placed outside but adjacent to the joint (Fig. 8.1). For example, hip and shoulder joints.

The position of arthrodesis for a joint depends upon the functional requirements of the individual. The standardised functional positions of arthrodesis for various joints are as follows:

1. Shoulder. The shoulder joint is arthrodesed, for infective or paralytic conditions, in 40-50 degrees of true abduction, 15-20 degrees of flexion and 25 degrees of medial rotation. This position facilitates the hand to reach the mouth.

2. Elbow. Arthrodesis of the elbow joint is rarely performed. The indication includes destruction of the joint by infection or trauma. When only one joint is affected, it is arthrodesed in a position of 75-90 degrees of flexion, for sedentary jobs; whereas for bilateral arthrodesis one elbow is fused in 110 degrees of flexion to enable the patient to reach the mouth, the other elbow in 65 degree to facilitate toileting, etc.

3. Wrist. Wrist joint fusion is a commonly performed operation for the following conditions: tuberculosis, rheumatoid arthritis, secondary osteoarthritis following fractures of scaphoid and lower end of radius, as a reconstructive procedure for nerve and tendon injuries, Volkmann's ischaemic contracture, poliomyelitis and cerebral palsy.

In unilateral wrist arthrodesis, it is fused in 10-20 degrees extension, whereas for bilateral disease, one wrist is fused in 20 degrees of extension and other in slight flexion.

4. Hand. Arthrodesis of the smaller joints of the hand is indicated when the joint is damaged by injury or disease resulting in pain, deformity or instability.

Fingers. The metacarpophalageal joint is fused in 20-30 degrees of flexion. The proximal interphalangeal joint is arthrodesed in 40-50 degrees of flexion (slightly less in index and middle fingers), while the distal interphalangeal joints are fused in 15-20 degrees of flexion.

Thumb. Instability, pain or deformity due to trauma, burns, contracture, nerve palsy, injury to the collateral ligament or osteoarthritis of carpo-metacarpal joint may require arthrodesis. The interphalangeal joint of the thumb is arthrodesed in 15 degrees of flexion and the metacarpophalangeal joint in 10-20 degrees of flexion. The carpo-metacarpal joint is fixed in 40 degree of palmar abduction and 20° of radial abduction.

5. Hip. The arthrodesis of hip is generally indicated when the articular cartilage is eroded, the joint is destroyed to an extent where a mobile joint cannot be expected. The commonest indication for fusion of the hip is tuberculosis. Arthrodesis should, however, be performed in an adult patient only. The optimum position for arthrodesis of the hip joint is as follows:

Flexion. The flexion actually varies with age, 1 degree of flexion for each year of age up to a maximum of 20 degrees. To facilitate standing, walking and sitting the usual choice of arthrodesis is 15-20 degrees of flexion.

Abduction. The extent of hip abduction depends upon the degree of the limb length disparity as abduction leads to apparent lengthening of the limb. The usual position of arthrodesis is neutral position of abduction and adduction.

Rotation. The hip joint is usually arthrodesed in neutral position of external and internal rotation or in slight external rotation.

6. Knee. The knee joint is arthrodesed, mostly for tuberculosis, either in full extension or in 20 degrees of flexion.

7. Ankle. In men the ankle joint is arthrodesed in neutral position while in women, who wear high heels, in 20-30 degrees of plantar flexion. It is commonly indicated in secondary osteoarthritis following trauma or tuberculosis.

8. Subtalar (talo–calcaneal) joint. It is arthro-

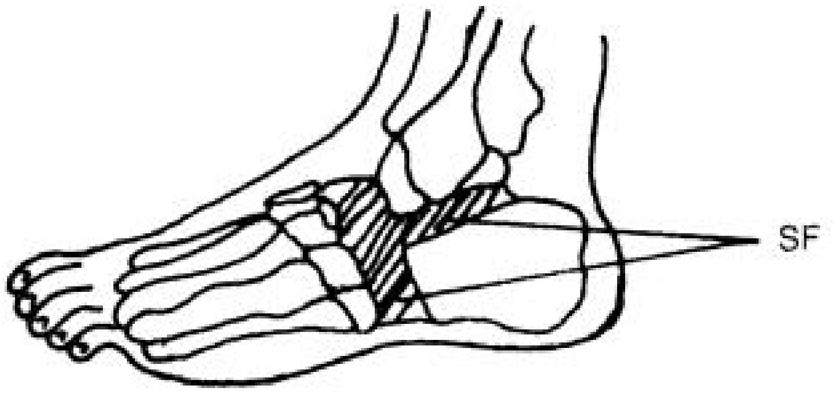


Fig. 8.2. Triple athrodesis (Fusion of talocalcaneal, talonavicular and calcaneo cuboid joints). SF : Extent of excision of the bones at the site of fusion.

desed in neutral position. The talo-calcaneal joint arthrodesis is most commonly performed following comminuted fracture of the calcaneum resulting in severe pain and inability to bear weight. This joint is fused along with talonavicular and calcaneocuboid joints (triple arthrodesis) in deformed/flail foot in poliomyelitis (Fig. 8.2).

9. Great toe. The metatarso-phalangeal joint is arthrodesed in a few degrees of extension and slight valgus (a little more extension for women wearing high heels). It is performed for painful conditions such as hallux rigidus and hallux valgus. The interphalangeal joints are arthrodesed in the neutral position in addition to tendon transfers in poliomyelitis.

10. Rest of the toes. The rest of the toes are arthrodesed in neutral position.

11. Spine. Arthrodesis of the spine is routinely performed for a large number of conditions. The types of spinal fusion are as follows :

(a) Posterior spinal fusion is commonly performed in scoliosis, old healed tuberculosis, in association with disc excision surgery, in fracture dislocations of the cervical spine, etc.

(b) Posterolateral fusion is performed in spondylolisthesis.

(c) Transalar fusion is fusion between the transverse processes of the lower lumbar vertebrae and the ala of the sacrum. It is commonly performed in spondylolisthesis at L 4–5 or L 5—S_1 levels.

(d) Anterior spinal fusion is done in tuberculosis of the spine, spondylolisthesis and in patients who have had laminectomy.

The postoperative regime after all these types of spinal fusion is almost similar. Initially the patient is nursed in bed for a period of 2-3 weeks. After this period the patient is given a spinal support which may be a corset, plaster jacket or a brace (depending upon the disease and the level of fusion) till the fusion consolidates which may take 3-6 months.

Physiotherapy management

The basic objective is to train the patient to functionally use the arthrodesed joint and the limb.

During immobilisation

1. To prevent and/or manage the possible post-operative complications.
2. Maintenance of proper position of the operated joint. The limb should be protected against postures putting strain on joint.
3. Strengthening and ROM exercises for the joints free from immobilisation.
4. Initiating early non-weight bearing ambulation in case of hip, knee and ankle arthrodeses. The functional use is encouraged and initiated early in upper extremity arthrodesis. These approaches of early functional mobilisation need to be emphasised as immobilisation following arthrodesis is often prolonged.

Mobilisation

Whole limb to be exercised in the functional patterns of movements. Ideally it should be incorporated with some objective and competitive tasks. Several repetitions of such sessions are necessary to improve the function in the upper extremity. In the lower-extremity gradual and correct weight bearing, weight transfers and balancing should be initiated with adequate aid.

Functionally important muscle groups and compensatory techniques are to be strengthened.

Guidance and assistance with several sessions a day are needed to achieve functional proficiency.

Optimal function should be regained by 4 weeks following mobilisation.

Physiotherapy following spinal arthrodesis
Covered in Chapter 15, see the section on Scoliosis.

ARTHROPLASTY

Arthroplasty is performed to restore motion in a joint. Ankylosed or damaged joint is reconstructed by replacing it partially or totally with an artificial joint. After an arthroplasty operation, a normal joint can not be expected; however, a satisfactory painfree functional joint can be achieved.

Arthroplasty of the Hip

It may be of two types:

1. Replacement arthroplasty.
2. Excisional arthroplasty.

1. Replacement arthroplasty

Replacement arthroplasty is reconstruction of the joint by replacing the joint partially or totally. It can be

A. Hemireplacement.
B. Total joint replacement.

A. Hemireplacement arthroplasty

In this operation the femoral component of the hip joint is replaced with a metal prosthesis. Two types of prostheses – Austin Moore and Thomson – are commonly used (Fig. 4.74). It can be used with or without cement (methyl-methacrylate). Hemireplacement arthroplasty is indicated in fractures of the femoral neck in the elderly patients.

Postoperatively the patient is nursed in bed in supine position with the limb in abduction to prevent dislocation of the prosthesis. In an elderly, disoriented or uncooperative patient, a below knee skin traction is applied to the operated limb to avoid unwanted movements of the limb. The movements of flexion and adduction are particularly avoided for a period of 4-6 weeks as these movements may precipitate dislocation of the prosthesis. The traction is maintained for about a week after which mobilisation is initiated. While in bed, the patient should be turned frequently to prevent bed sores etc.

Partial weight bearing crutch walking is started after 3 weeks, and full weight bearing is allowed after 4-6 weeks.

B. Total hip replacement (Fig. 4.74)

In this operation, the acetabular as well as the femoral components of the hip joint are replaced. Broadly speaking, there are two types of total hip joint implants:

(i) Cemented hips.
(ii) Non-cemented hips.

(i) In the *cemented hip* the acetabular as well as the femoral components are fixed with the help of bone cement (methyl methacrylate).

(ii) *Non-cemented hips* is a recent development in which bone cement is not used to fix both the components of the hip joint.

Postoperative regime

The patient is nursed in bed in supine position. The movement of flexion and adduction is avoided to prevent dislocation of the hip. In these patients, however, mobilisation is started early in the postoperative period. The patient can be made to stand up as early as on the third postoperative day. Initially crutches and later on a walking stick is used for support.

Physiotherapy management

(Hemireplacement arthroplasty)

Hemireplacement is a common procedure done for fresh and ununited fractures of the femoral neck in the elderly and in avascular necrosis of the femoral head.

The objective of preoperative evaluation and education, as well as postoperative physiotherapy regime follows the same routine as described for THR.

The basic differences:

As the surgical procedure involves the replacement of only the head and neck of the femur the whole programme can be initiated earlier than THR.

The range of flexion of the hip in THR is contraindicated beyond 90 degrees, no such limitation is to be observed with hemireplacement patients. It can be taken to the full range at the earliest to facilitate floor squatting at a later stage. However, excessive adduction with rotation should be avoided, to prevent subluxation or dislocation of the hip.

The programme of exercises to facilitate floor squatting and cross-leg sitting can be started early. The exercises include :

(a) Self-assisted hip flexion in supine lying or in sitting with back supported.
(b) Prone kneeling (Fig. 8.3A).
(c) Knee support squatting against stall bars (Fig. 8.3B).
(d) Back supported, assisted cross-leg sitting (Fig. 8.3C).

Full weight bearing is quite safe by 8 weeks following surgery provided it is well accepted and there are no complications.

The patient should be fully independent functionally by the end of 12 weeks.

Fig. 8.3. Self-assisted early initiation of hip and knee flexion which also promotes weight bearing on the operated leg. **(A)** Prone Kneeling.

Fig. 8.3. (B) Knee support squatting.

Physiotherapy management

(Total hip replacement)

The basic objective is to offer a painless, mobile, stable and functionally acceptable reconstructed hip joint.

Fig. 8.3. (C) Back supported cross-leg sitting.

Physiotherapy programme is broadly divided into

(a) Preoperative and
(b) Postoperative regimes.

(a) Preoperative regime

The objective of the preoperative programme includes 1. Evaluation and 2. Education of the patient.

1. Evaluation. The following parameters are used to evaluate the patient:

(i) Pain;
(ii) Deformity including limb length;
(iii) Range of motion at the hip and related joints;
(iv) Muscle power and muscle atrophy;
(v) Ambulation and gait.

We have used the functional assessment criteria as formulated by Lansky (1967) with slight modifications (Table 8.1). We suggest that rating with numerical scores should be incorporated in each objective test.

2. Preoperative education. It is extremely important to educate the patient on the exact regime of physiotherapy to be followed in the early postoperative period.

Table 8.1. Functional assessment criteria

Ambulatory Aids	
Total assistance (bed ridden)	1
Chair life	2
Two crutches	3
Two sticks	4
One cane (always)	5
One cane (outdoor)	6
No aid	7
Walking Ability	
Bed ridden or a few yards	1
Limited time and distance	2
Limited with one cane	3
Long distance with one cane	4
No aid but limp	5
Normal for age and condition	6
Gait Without Aids	
Can not walk	1
Shuffles with small steps	2
Walks with gross limp	3
Walks with marked limp	4
Walks with slight limp	5
No limp	6
Stair Management	
Unable to do	1
Does with assistance	2
Does independently	3
Toilet Activity	
Needs assistance	1
Manages independently	2
Ability to do Floor Sitting (Cross–Leg Sitting)	
Unable to do	1
Able to do *partially* on plinth with back supported	2
Able to do on high plinth without support	3
Able to do on the floor with considerable support	4
Able to do with some assistance	5
Able to do independently but painful	6
Able to do without discomfort	7
Ability to do Floor Squatting	
Unable to do	1
Able to do *partially* with considerable support	2
Able to do *partially* without assistance	3
Able to do *completely* but with considerable support	4
Able to do, needs some assistance	5
Able to do independently but painful	6
Able to do without any discomfort	7

Functional ambulation requires ability to walk over 100 feet (30.5 metres).

It should be taught on the sound limb for easy grasp. It is also necessary to make sure that the patient has followed these techniques.

Preoperative physiotherapy

1. Deep breathing and coughing to improve vital capacity of the lungs and to be able to get rid of the post-anaesthetic secretions.

2. Strong and sustained isometric contractions to the glutei, quadriceps and the hamstrings to improve strength and endurance.

3. Guidance on ROM and strengthening exercises for both the limbs to avoid stiffness and incoordination.

4. Resistive exercises for the ankle and foot on the affected side and for the weight bearing muscle groups of both the arms, to facilitate early ambulation with walking aids.

5. To teach proper limb positioning of the operated leg in consultation with the surgeon to avoid hip dislocation in the postoperative period. The limb positioning depends upon the surgical approach used.

6. To teach appropriate techniques of transfers, avoiding undue strain on the operated hip.

7. To mentally prepare the patient for the painful active stage ahead.

Postoperative physiotherapy

Broad outlines of the physiotherapy schedule are given in Table 8.2.

FIRST WEEK

1. Chest physiotherapy, especially in the elderly patients, to avoid postoperative chest complications.

2. To prevent pulmonary embolism. Pulmonary embolism following THR is quite common. Evarts & Feil (1971) reported an incidence of venous thrombosis in as much as 53.6 percent of the patients. Massive embolus usually comes from the leg veins and not from the pelvic-veins. Physiotherapy plays an important role in its prevention. Charnley (1968) quoted, "The physiotherapist should forget the operated hip for the first 3-4 days and should be on duty throughout the 24 hours just to avoid this hazard".

(a) Careful watch to detect any local swelling, tenderness, warmth or edema in the leg and foot.

(b) Vigorous resistive/active exercises to the ankle and foot with concentration on the gastrosoleus and the toe flexor groups (elastic crepe bandage may be used to resist active contractions).

(c) The knee should be supported in slight flexion by a knee roll. Hyperextension at the knee should be avoided.

3. Strong and sustained isometric contractions to the gluteus maximus-medius-minimus, quadriceps, dorsiflexors and the toe extensors should be done simultaneously on both the sides. This exercise improves the joint stability (Yoslow et al., 1976).

4. Relaxed passive movements—small range relaxed passive movements for flexion of the operated hip could be initiated. Continuous passive motion (CPM) equipment provides an excellent means of initiating these movements. Isometric programme can be intensified by adding resistance at the terminal range of the available movement.

SECOND WEEK

1. Relaxed passive and assisted/active movements to be progressed so that, by this time assisted hip flexion should be possible up to 90 degrees.

2. To attain further mobility the range of CPM should be progressed. Methods like suspension therapy or using roller skates are excellent.

3. Special attention needs to be given in exercising tensor fascia lata. The ilio-tibial band forms a unit with tensor-fascia-lata and the superficial fibers of gluteus-maximus muscle, giving stability to the hip joint and preventing dislocation.

4. *Turning in bed.* Turning to be initiated on the sound side with a pillow in between the legs (knees) to avoid any possibility of adduction, keeping the knees bent. Bed side independent sitting to be initiated with knees hanging and transferring the weight on both the hip joints.

5. *Standing.* Transfers from bed to wheel chair and to the parallel bars. Brief periods of partial weight bearing (PWB) can be initiated if it is not painful.

THIRD WEEK

Weight bearing. Ambulation with partial weight bearing in parallel bars is safe. Watch gait deviations.

Table 8.2. General outline of physical therapy schedule for total hip replacement (THR)

Day 1:	1. Chest PT. 2. Vigorous toe and ankle movements. 3. Isometrics to quadriceps.
Day 2:	1. Sitting up by gradually raising the back rest. 2. Bed transfers. 3. Standing, walking with partial weight bearing (PWB) or toe down weight bearing (TDWB) with a walker.
Day 3–7:	1. Isometrics to gluteus maximus, medius and minimus. 2. Assisted hip flexion (heel drag) and hip abduction. 3. Initiate prone lying. 4. Thomas stretch. 5. Relaxed passive hip movements.
Week 2:	Active hip flexion, knee extension (bed side sitting or chair sitting with back rest).
Week 3:	PWB walking on crutches with free swinging of the operated leg.
Week 4:	1. Ped-o-cycle or static bicycle (possible free ROM) 2. Stair climbing going up with the GOOD LEG first. Coming down with the OPERATED LEG first. 3. Initiate leg rotation in supine and progress to against gravity and against resistance.
Week 5–6:	Gradually increase hip abduction and rotation in supine and bed side sitting.

AMBULATION AND WEIGHT BEARING SCHEDULE

Cemented prosthesis.

As the stability of prosthesis is achieved within 15 minutes of surgery, WBTT can be started on a walker immediately on th second day.

- Progress to crutch walking and continue crutch walking up to 6 weeks.
- Use a cane for 4–6 months.

Non-cemented prosthesis

PWB or TDWB on walker for 6 weeks.
Progress to crutch walking and continue up to 12 weeks.
Use cane for 4–6 months.

PRECAUTIONS

A. Prevention of hip dislocation

1. Avoid early initiation of hip adduction and rotation
2. Always use pillow between the legs in resting, sitting, while turning in bed or during transfers.
3. Hip flexion ROM to be restricted to 80°

B. Prevention of Trendelenburg limp

1. Initiate isometrics to gluteus medius, minimus and maximus at the earliest.
2. Avoid SLR or hip abduction against gravity as it puts tremendous load on the hip joint.
3. Proper gait training on crutches and cane.
4. Continue cane support till the limp persists.

C. Prevention of hip flexion deformity

1. Initiate Thomas stretch within 2–3 days of surgery
2. Frequent periods of prone lying.

It can be progressed to ambulation with crutches the next day. Initiate walking with reciprocal gait pattern.

The progression in ambulation from walker to elbow crutches, a cane, or independent walking should not be hurried up at the cost of the normal pattern of gait. Therefore, in our patients, we avoid the development of wrong pattern of weight bearing. Instead we concentrate on vigorous strengthening exercises to all the stabilising hip, knee and the ankle muscles. The single leg standing sessions on the operated side alone, knee standing as well as knee walking are useful methods of training. This methodology reduces the degree of apprehension while bearing weight in standing independently and contributes significantly in the stable and good pattern of gait. Beber and Covery (1987) advocated the use of two crutches up to the end of 6 weeks. One crutch up to 8 weeks and progress to ambulating with a cane and continue for 4-6 months. Over emphasis on unsupported ambulation has to be avoided till the patient is stable and acquires acceptable gait. Patients with gluteal lurch or trendelenburg limp must continue to use cane. The quality of gait can be improved further by the techniques of rhythmic-stabilisation and resistive gait as advocated by Knott and Voss (1968).

Caution

The few over enthusiastic patients should be warned against any attempt to overstretch the hip joint to attain floor squatting or cross-leg sitting.

FOURTH WEEK

1. Further progression of all the exercises.
2. Stair climbing to be added. While climbing up the steps the patient should step up with the sound limb. For coming down the steps, step down with the operated leg first.
3. Initiate exercises on pedo-cycle or static bicycle.
4. Initiate external and internal rotation in supine.
5. The patient should be discouraged to adopt positions like long sitting and reaching forward to touch the toes, crossing the knees in sitting, floor squatting and cross leg sitting. These positions may cause hip dislocation due to movements like flexion beyond 90° with adduction and internal rotation.

FIFTH WEEK ONWARDS

Progress all exercises, especially hip external and internal rotation, to achieve strong and functionally stable hip joint. By 12 weeks the patient should be back to the prefracture status. This regime of physiotherapy may need modifications to suit individual requirements. In our experience the results of THR have been good except in cases of ankylosing spondylitis. In ankylosing spondylitis there is a tendency for reankylosis.

2. Excisional (Girdlestone) arthroplasty

Excisional arthroplasty of the hip is indicated in the following conditions:

(a) An advanced case of tuberculosis of the hip where extensive destruction of the femoral head and/or acetabulum has taken place and the joint cannot be salvaged.

(b) Severe osteoarthritis in the elderly where any other reconstructive procedure is contraindicated.

(c) Painful ankylosis of the hip in ankylosing spondylitis.

(d) Rarely, septic arthritis of the hip.

(e) Pyogenic infection of the hip following surgical procedures or fracture neck of femur or total hip replacements.

In this procedure the femoral head and neck are resected down to the base of the trochanter; the superior margin of the acetabulum is also resected to curette out the diseased portion. A gap is thus created between the acetabulum and the trochanter (Fig. 8.4).

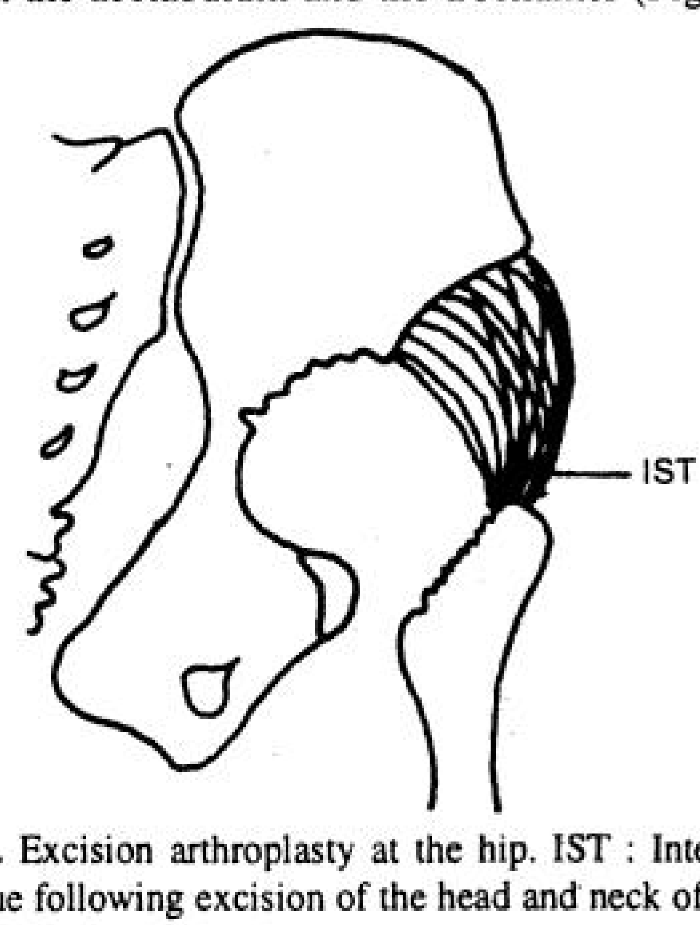


Fig. 8.4. Excision arthroplasty at the hip. IST : Interposed soft tissue following excision of the head and neck of femur.

Postoperative regime

The patient is given skeletal traction through the upper tibia for a period of 5-6 weeks. However, intermittent mobilisation to the knee and hip is started after 4 weeks while in traction. Non-weight bearing crutch walking is started after 6 weeks. Full weight bearing is started after 3-4 months.

After this operation, the patient regains a painless, mobile hip but loses stability at the hip and the length of the limb.

Physiotherapy management

This procedure, also known as excisional arthroplasty, is a salvage procedure. It is indicated in selected cases of tuberculosis and septic arthritis of the hip. The aftermath of surgery poses three main problems:

1. Fairly mobile but unstable hip joint;
2. Marked shortening of the limb and
3. Weakness of the muscles around hip.

The objective of physiotherapy is to provide maximum functional stability to the operated hip.

The physiotherapy programme is divided into two parts:

1. Preoperative evaluation and education and
2. Postoperative therapeutic regime.

1. Preoperative evaluation and education

(a) Considering the longer period of postoperative immobilisation isometric exercises for the glutei, knee extensors and flexors should be started. They need to be repeated for five minutes every hour.

(b) Resisted ankle movements.

(c) The expected outcome of the surgical procedure should be explained to the patient.

2. Postoperative therapeutic regime

FIRST AND SECOND WEEK

Physiotherapy measures:

1. Chest physiotherapy,
2. Prevent pulmonary embolism and thrombosis.
3. Prevent muscle atrophy.
4. Check the position of the limb and the traction.
5. Vigorous isometric exercises to be emphasised as skeletal traction is usually continued for 6 weeks.
6. Resistive exercises to the normal limb and am bulatory muscles of the upper extremities.

THIRD AND FOURTH WEEK

The traction is discontinued intermittently to initiat mobilisation.

1. Small range of relaxed passive movements to b initiated at the hip. Begin with hip-flexion and ex tension. Progress to abduction and rotation.
2. Full range active resistive movements to the kne and ankle.
3. Sitting. Initiate passive hip flexion up to 60° b raising the head end or using a back rest, with th traction on.

FIFTH AND SIXTH WEEK

1. All the earlier therapeutic programmes should b intensified.
2. Suspension therapy can be given to promot mobilisation.
3. Short periods of relaxed passive stretching of hi flexion, extension and abduction movements ar important at this stage to avoid fibrosis.
4. Isometric contractions. The patient should b taught to actively contract gluteus maximus b pushing the limb against the mattress or pillo and sustaining it for 10-15 seconds.

SIXTH WEEK ONWARDS

Traction is removed and the patient is put on vigorou exercises.

1. Non-weight bearing standing. Bedside sitting an short duration standing on the sound limb shoul be started.
2. Intensive stretching. Any limitation of ROM i the hip can be safely stretched to the maximum Supportive modality in thermo-therapy may b used.
3. Continuous stretching. To prevent hip flexion an adduction contractures, gentle sustained tractio may be necessary. The patient should be en couraged to frequent prone lying and to perforr isometrics to the glutei.
4. Strengthening exercises. Gravity resisted hi movements and graded exercises on static bicycl should be started to strengthen the hip muscles.

5. Limb length disparity. Limb length disparity should be accurately measured and compensated. However, there is another school of thought which prefers delay in correction in the limb length by at least 6 months for the fear of progressive upriding of the trochanter, due to weight bearing.
6. Weight bearing. (a) Partial weight bearing crutch walking. It should be initiated in the parallel bars or with the help of double crutch.

(b) Full weight bearing. Total weight bearing should be started 12 weeks after the surgery. Partial compensation for the limb shortening may be provided. Migration of the proximal end of the excised femur is a problem as it disturbs the stabilising abductor mechanism.

Weight bearing may be begun in the parallel bars basically to train weight bearing and balancing on the operated leg alone. Then progressed gradually to single crutch and cane. Cane may remain as a permanent aid, especially for outdoor walking. The patient should be explained to avoid undue weight bearing stresses to prevent further complications such as backache and early osteo-arthritis of the normal hip and knee joints. Stair activities should be started along with ambulation on slope and rough surfaces.

With the help of regular home exercises the patient should be independent by 14-16 weeks.

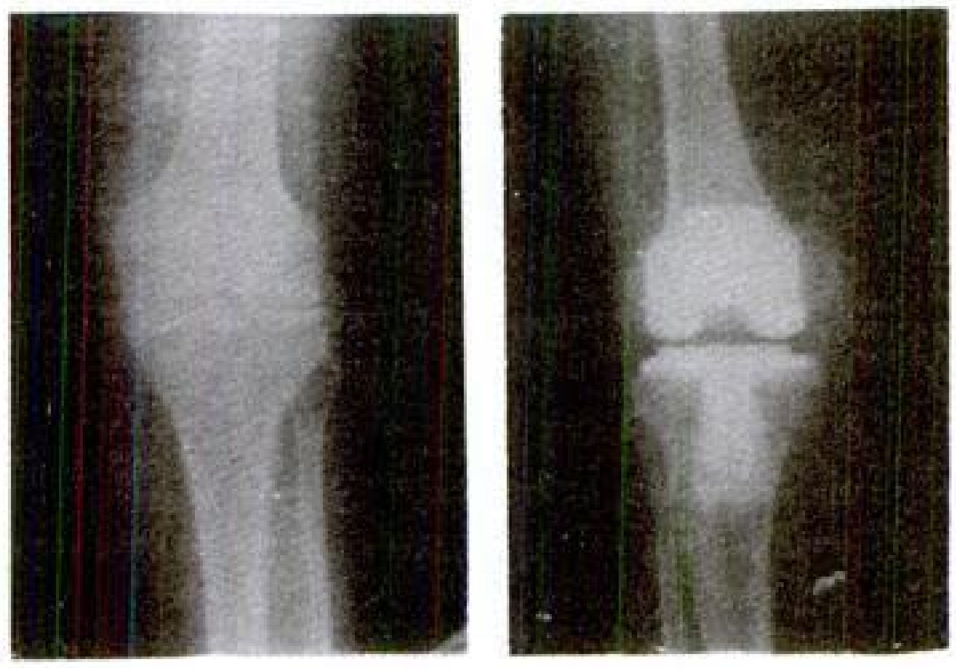
From our experience we feel that the patients with tuberculosis or infective arthritis generally do well as compared to the patients with ankylosing spondylitis (Joshi,1979).

7. Prone-kneeling, cross leg sitting. These can be safely initiated and assisted to gain further range and strength in adopting these positions.

Caution

Postoperatively relaxed passive full range mobilisation should be initiated and taken to the fullest range at the earliest. The movements of hip flexion and abduction with external rotation need to be emphasised in view of the functional postures of floor squatting and tailor-sitting.

Prone lying and hip stretching into extension should be initiated early to avoid flexion deformity at the hip. Flexion deformity complicates efficiency in ambulation and produces excessive strain on the back.



(A) (B)

Fig. 8.5. A.P. view of X-ray showing **(A)** Severe O.A. changes, **(B)** Following total knee arthroplasty.

Total Knee Replacement Arthroplasty

Total knee replacement arthroplasty is indicated when there is unremitting severe pain in the knee with or without deformity. The pain or deformity may be due to osteoarthritis (primary or secondary), rheumatoid arthritis and various other non specific arthritides. It relieves pain, provides mobility and corrects deformity (Fig. 8.5).

The total knee replacement can be:

(a) Unicompartmental;
(b) Bicompartmental and
(c) Tricompartmental.

(a) Unicompartmental arthroplasty. The articular surfaces of femur and tibia of either the medial or the lateral compartment of the knee are replaced by an implant. The other compartment of the knee joint is left intact. This type is obviously indicated for disease pertaining to one compartment only, e.g. osteoarthritis. This procedure, however, has almost become obsolete due to its long-term poor results.

(b) Bicompartmental arthroplasty. In bicompartmental arthroplasty, the articular surface of tibia and femur of both medial and lateral compartments of the knee joints are replaced by an implant. The third compartment, i.e. the patellofemoral joint, is however left intact. Bicompartmental knee arthroplasty has also been discarded due to its high failure rate.

(c) Tricompartmental arthroplasty. The articular surfaces of the lower femur, upper tibia and the patella are replaced by prostheses. Tricompartmental arthroplasty is the most commonly performed arthroplasty today. The prosthesis consists of a tibial component, a metal femoral component and a HMWPE (High Molecular Weight Poly Ethylene) button for the articular surface of the patella.

Postoperatively the knee is mobilised after about 4-5 days.

Physiotherapy management

The principal aim of the physiotherapy is to offer maximum static as well as dynamic stability to the knee.

Severe pain, instability of the joint or deformity which cannot be corrected by osteotomy are the chief indications for total knee arthroplasty.

Preoperative assessment

A thorough assessment is done prior to the surgery, and the postoperative regime of physiotherapy is explained to the patient.

(a) Pain. The degree, site and the positions aggravating/relieving the pain are recorded.

(b) Deformity. The degree of deformity is measured in weight bearing as well as non-weight bearing positions. The degree of deformity is recorded when the whole body weight is borne over the affected knee alone, maybe with some support if required.

(c) ROM. Accurate measurements of the active as well as passive ROM at the knee are recorded. Patellar mobility is also checked and graded. Ligamentous stability around the knee is evaluated.

(d) Strength and endurance. Strength and endurance of the quadriceps, hamstrings and glutei are evaluated.

The quality of quadriceps contractions need to be assessed in particular.

(e) Effusion and atrophy. The area and extent of effusion as well as the muscle atrophy (especially of quadriceps) are documented.

(f) The other related joints, i.e. hip, ankle and foot are assessed for their alignments, ROM and strength.

(g) Complete gait analysis, status of ambulation and functional competence are documented.

(h) Physical requirements of the patient's working situation are reviewed.

Preoperative training

It includes the following:

(i) Explain to the patient the total postoperative regime and his responsibility. Biomechanics of the movements at the knee to be explained on the normal knee (if possible) and the importance of regaining early ROM at the knee is emphasised.

(ii) Educate the patient on the measures taken for prevention of edema, deep venous thrombosis and chest complications.

(iii) Training of isometrics (speedy as well as sustained) to quadriceps, hamstrings and glutei.

(iv) Self-assisted passive mobilisation, relaxed free movements, and assisted active and resistive exercises are taught on the sound limb.

(v) Techniques of self-assisted mobilisation and strengthening are explained.

Postoperative regime (Table 8.3)

FIRST WEEK

- Appropriate chest physiotherapy.
- Limb positioning to avoid rotation and to encourage knee extension. Ideally, the heel resting on a pillow and pressing the pillow will encourage static quadriceps and gluteus maximum contractions along with extension stretch to knee.
- Gentle isometrics to the quadriceps could be begun. It should be progressed to rhythmic speedy quadriceps contractions and relaxations which will promote patellar excursion and reduce edema.
- Sustained isometrics to quadriceps, reinforced by simultaneous strong dorsiflexion of the ankle, are ideal. Slow isometrics should follow the rule of "tens" i.e., holding maximum contractions for 10 seconds, to be done 10 times in each session and each exercise session to be done 10 times a day.
- Isometrics to hamstrings, glutei and hip abductors should also be included.
- Supported SLR could be initiated with simultaneous isometrics to quadriceps and ankle in maximum dorsiflexion.
- Bed transfers, standing or even well assisted ambulation (even with the POP on) with walker could be attempted by 3rd or 4th postoperative day. For cemented prosthesis weight bearing to

Table 8.3 General outline of physical therapy schedule for total knee replacement (TKR)

Day 1

1. Chest PT.
2. Vigorous toe and ankle movements.
3. Maintain the limb in extension (with POP on or with heel or lower leg resting on a pillow).
4. Static glutei by pressing the pillow below the heel.
5. Gentle isometrics to quadriceps.

Day 2–3

1. Transfers in bed.
2. Gentle patellar mobilisation.
3. Rapid isometrics to quadriceps (speedy and with 10 sec. hold).
4. Assisted SLR.
5. Stand and ambulate with POP on and walker (WBTT for cemented and TDWB or PWB for non-cemented).

Day 4–5–6

1. Transfers in chair.
2. Self-assisted passive knee flexion:
   (a) Heel drag in supine.
   (b) Bed side sitting, relaxed knee movements with the help of sound leg (in unilateral TKR).
   (c) Sitting with feet planted on the ground, lift and push forward by raising trunk on arms
3. CPM 5° – 10° daily (1 cycle per minute).

Range of knee flexion MUST NOT EXCEED 40° because transcutaneous O_2 tension of the skin near the incision decreases significantly after 40° of flexion.

4. Begin active or active assisted exercises, if the wound is clean and dry.
5. Bed side active knee flexion – extension (self-assisted, if necessary).
6. Ambulation without POP (can do three SLR without POP).

Day 7–10

1. Work up towards 90° knee flexion by 10–14 days.
2. Hamstrings strengthening
3. Assisted step and stairs

Day 11–3 weeks Progress all exercises.

Week 4–6

1. Work up towards knee flexion 110° – 115°.
2. Quadriceps dips and steps up.
3. Stationary bicycle.
4. TWB with cane.

The patient should be made to hold this position with active effort. By this time pronation-supination should be near normal.

If the condition of the skin and the surgical incision are healthy, paraffin-wax bath preceding mobilisation and stretching manoeuvres provides excellent relaxation for the above-mentioned procedures.

Progressive strengthening exercises for the biceps brachii against graded weights can be given by holding wand and weight in sitting. For the triceps the position should be prone lying with the shoulder in abduction and forearm hanging over the edge of plinth.

Functional use of the hand in activities like eating, lifting and placing light objects, combing hair, shaving, buttoning, dressing and scratching the back should be encouraged, maybe with little assistance. These natural movement patterns are effective means of treatment.

Judicious planning and executing the regime of exercises can result in a functionally useful elbow within 8 to 12 weeks of surgery.

Observations

1. Excessive surgical excision of the joint can result in an unstable elbow. The relative lengthening of the common flexor and extensor groups renders great mechanical disadvantage to the effective action of these muscles. Therefore, it results in an unstable and weak elbow joint where flexion and extension more or less remain only a passive entity. In these patients a brace with an elbow hinge provides a mechanical advantage to facilitate muscle action, and strengthening. In case of a weak elbow the brace can be locked at a desired angle for functional use.

2. Surgery in a long-standing ankylosis may give a partially mobile but weak elbow joint. This may be due to the marked disuse atrophy of the muscles.

2. *Interpositional (fascial) arthroplasty*

In this procedure the lower end of the humerus and the upper end of ulna are excised. The exposed ends of both these bones are covered by fascia lata strip.

The postoperative management including physiotherapy is similar to that of the excisional arthroplasty.

3. *Implant (total joint replacement) arthroplasty*

Total replacement of the elbow joint is not a commonly performed procedure yet. It is undertaken only when there is massive destruction of the joint due to rheumatoid arthritis, post-traumatic arthritis, etc., and as a reconstructive procedure after tumor resection.

In total replacement arthroplasty of the elbow the joint is replaced by metal or plastic hinge prosthesis (Fig. 8.8B).

This procedure succeeds in providing adequate stability and mobility to the joint to a limited extent, allowing light sedentary functions.

Physiotherapy management

Preoperative assessment

It consists of evaluation of:

1. Range of motion, passive as well as active.
2. Muscle power and endurance of the flexors, extensors, pronators and the supinator groups.
3. The degree of deformity.
4. Sensory status of the arm, forearm, wrist and hand.
5. Integrity and functional efficiency of the shoulder, wrist and hand.

Preoperative training

1. In view of the expected postoperative weaknes , vigorous exercise regime is taught to improve the strength and endurance of the elbow flexors, extensors and forearm rotators. The programme of training should be initiated on the normal/better limb.
2. To improve the overall functional efficiency of the extremity as a whole, free and strong range of movements should be achieved at the related joints. This will facilitate function in the presence of moderately stiff and weak elbow joint.

Postoperative phase

DURING IMMOBILISATION (first week)

Limb is immobilised in elevation with pressure bandage and a posterior plaster shell. The physiotherapy is aimed at :

1. Reduction of inflammation;

image
not
available

Table 8.4. Physiotherapy schedule for total wrist arthroplasty

First week

Hand splinted in slight radial deviation to counter ulnar deviation forces. Repeated movements to shoulder, elbow and fingers to be done.

Second week to fifth week

Relaxed passive and active assisted wrist movements avoiding ulnar deviation, should be initiated and progressed.

Selective strengthening of wrist extensors, to strengthen the grip.

Dynamic splint should replace the static hand splint.

Sixth and seventh week

Initiate full range passive movements without ulnar or radial deviation.

Concentrate to strengthen all the hand grips as well as the coordinated movements of hand in relation to shoulder, elbow and forearm.

Caution

No lifting of heavy weight of more than 5 lbs in future. No heavy pulling or pushing using operated hand. Body weight stretch like putting body weight on arms are contraindicated.

- Active as well as passive range of motion.
- Muscle power and endurance of the wrist flexors and extensors.
- Grip and pinch strength measurement by dynamometer.
- ROM and strength of the other joints of the extremity.

Preoperative training

It is basically directed to

- Strengthen the flexor and extensor muscle groups at the wrist. These muscles are usually weak because of the distortion of the joint. They are at a great mechanical disadvantage to act effectively. Strengthening procedures are taught with correct stabilisation of both the segments (distal part of the forearm and proximal portion of hand). Isometrics are extremely valuable. Isotonic in a limited painfree ROM should be auto-resisted and in the correct groove of the movement.
- Stiffness or weakness at any other related joints of the extremity should be treated to increase the strength and freedom of the movements to the maximum.
- Teaching of postoperative physiotherapy regime.

Postoperative regime

The wrist and the hand are fixed with dressing and plaster splint. The arm is kept in elevation.

- Careful check of the immobilisation is done.
- Status of circulation, sensation and any nerve compression symptoms are checked.
- Early initiation of finger, shoulder and elbow movements supporting the operated arm is taught to the patient. These self-assisted movements should be performed in maximum possible range.

Mobilisation

When the cast is removed, wrist mobilisation and strengthening techniques should be initiated and progressed gradually.

- Relaxed passive wrist flexion and extension is initiated in the gravity eliminated position with full support and secured stabilisation (on the same lines as for elbow).
- Active and active assisted movements to be made intensive. Functionally important position of wrist extension needs extra emphasis.
- Functional activities (self-assisted) to be initiated and progressed at the earliest.

- Functionally useful, painless wrist joint should be regained by 4- 6 weeks.

Arthroplasty of the Hand

Arthroplasty of the joints of the hand is indicated in painful stiff joints and/or in case of deformity preventing hand function, due to rheumatoid arthritis or degenerative and traumatic conditions.

Types of arthroplasty

1. Excisional (resection) arthroplasty

Resection arthroplasty of the PIP joints of the finger is rarely indicated in cases of infective arthritis. In this operation the head of the proximal phalanx is excised, the wound is closed and the finger is given traction through the distal phalanx (Fig.8.13A) for about 6 weeks. The patient may regain some degree of useful movements at the PIP joint but usually has instability at the joint.

2. Implant arthroplasty

Implant arthroplasty is indicated commonly in PIP and MP joints, and occasionally for the DIP joints. Swanson (1972) and Niebauer (1971) developed silicon rubber prostheses in the 1960s; the Niebauer prosthesis is based on the hinge concept, while the Swanson prosthesis is basically a spacer designed to improve the stability of resection arthroplasty. The articular surfaces of the two adjoining bones of a particular joint of the finger are excised and the stems of the finger joint prosthesis are fixed into the medullary canals of the two bones (Fig. 8.12). Small silastic joints are used as implants with elastometric silicon implants. Excellent remodelling of the bone with formation of cortical bony shell and thickening of the metaphysis of the metacarpals and phalanges has been reported by Swanson in a long-term study (Swanson et al., 1982). Postoperatively the joint is mobilised after a week or 10 days.

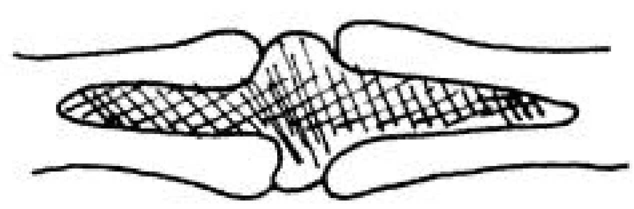


Fig. 8.12. Hand – implant arthroplasty.

Physiotherapy management

Aim. Return of painfree maximal function of the hand.

Preoperative assessment

- Evaluation of the active and passive ROM of the concerned joint.
- Evaluation of strength and endurance of the related muscle groups.
- Evaluation of strength of hand and pincer grip by dynamometer.
- Evaluation of degree of pain and its character.
- Overall functional evaluation of the whole limb and in relation to the activities of daily living.
- Education on the postoperative regime.

1. Excisional or resection arthroplasty

Postoperative regime

- To check the alignment of the traction and the circulation to the finger.
- Prevention of inflammation and its complications.
- Active resistive movements to the joints free of immobilisation.

  Instability at the resected joint is the major drawback of this surgical procedure. Therefore, maxium emphasis is on various strengthening procedures to the flexor and extensor groups. As soon as traction is discontinued graduated mobilisation is given to the MCP, PIP and DIP joints.

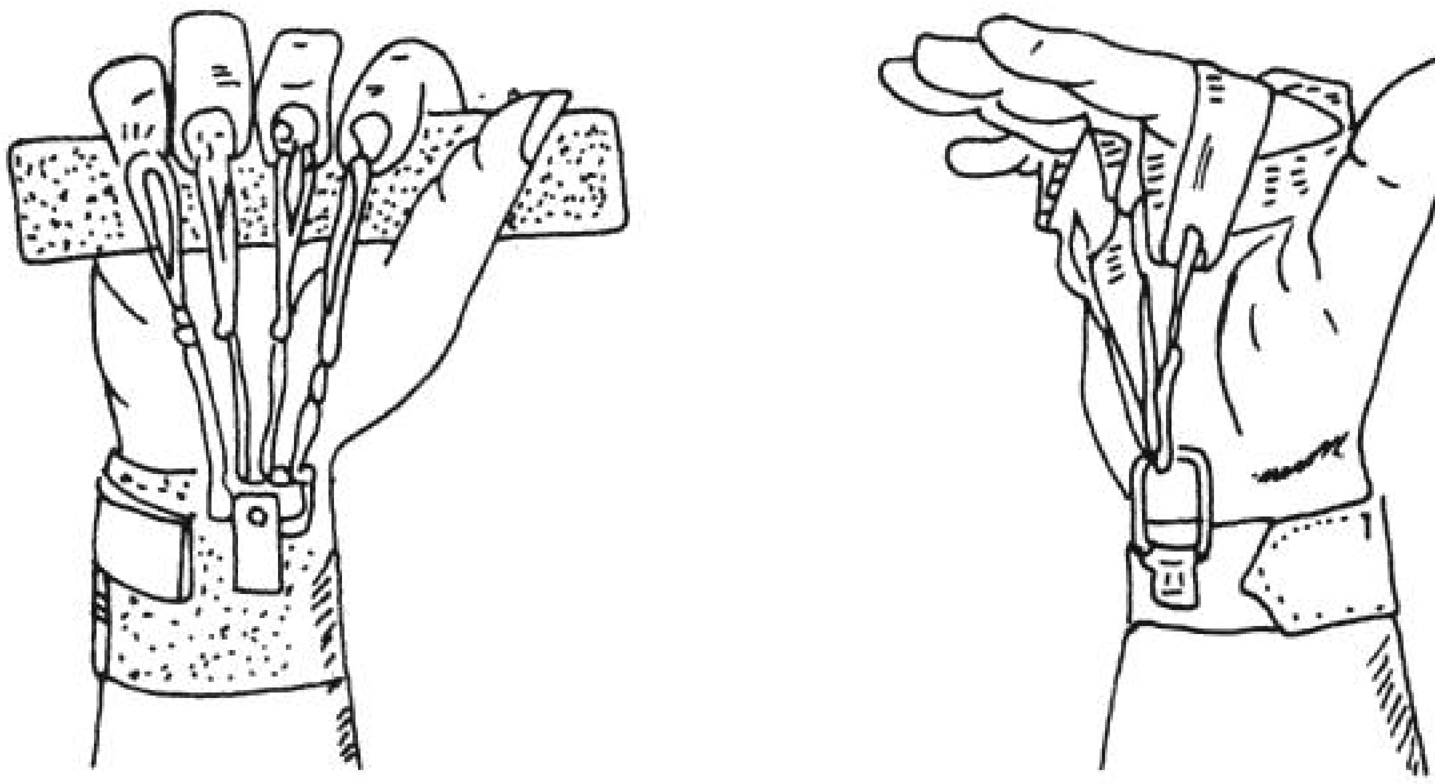
  Isometric and isotonic exercises for both flexor and extensor muscle groups are concentrated at the PID and DIP joints.
- Active use of hand is encouraged. A splint may be necessary to stabilise the MCP joint.
- Resistive exercises should be initiated as early as possible to regain full function.

2. Implant arthroplasty

Early postoperative regime is the same as described for resection arthroplasty. A dynamic splint holding the MCP joints in maximum corrected position and offering resistance to flexion can also be applied (Fig. 8.13B).

Postoperative regime

After surgery the hand is supported in a pressure dress-



(A) (B)

Fig. 8.13. **(A)** Resection arthroplasty splint with traction through the distal phalanx. **(B)** Implant arthroplasty. Splint holding MCP joints in maximum corrected position.

ing with elevation.

1. Controlling inflammation.
2. Full arc movements to the shoulder and elbow help improve circulation to the operated area.
3. Finger tips and thumb to be checked for the status of circulation.

Mobilisation

Controlled mobilisation by dynamic flexion assist splint plays an important role in the return of function following implant arthroplasty. The methods of mobilisation fall into three types as advocated by three eminent hand surgeons.

(a) Madden (1977) advocates the use of dorsal splint stabilising the wrist in 15-20 degrees of extension. It has adjustable transverse bar to secure rubber band and loop for each finger. This splint is applied as soon as the swelling is reduced. He recommends early initiation of the passive movements with prolonged use of the dynamic splint.

(b) Wynn Parry (1981) prefers plaster cast for a long duration till healing of the extensor expansion is complete up to 3 weeks. MCP flexion is limited to 30 degrees but full flexion-extension is allowed at the interphalangeal joints. After 3 weeks, exercise programme is gradually progressed from relaxed passive movements to resisted movements to the MCP joints.

(c) Swanson regime. As soon as swelling of the hand is reduced, protective movements are initiated on the third or fifth postoperative day. Dynamic splint with rubber outrigger is positioned accurately to prevent ulnar deviation, and allows 70 degrees of flexion at the MCP joints. Maintenance of flexion in 70 degrees is of vital importance during the period of 3 weeks. The brace needs to be continued in the event of extensor lag, tendency for ulnar deviation or flexion contracture.

ADL using the affected hand is encouraged along with other progressive procedures of improving strength, ROM and endurance. Periodical monitoring of grip and pinch strength is done to assure improvement.

Fully functional hand should be restored within 3 months of surgery.

Arthroplasty of the PIP Joints

As this operation does not involve tendon reconstruction, active physiotherapy can begin early.

1. A splint is applied to maintain neutral position of the PIP joint.
2. Active flexion can be begun as early as 3-5 days postoperatively.
3. Adequate measures should be adopted to evaluate and treat extensor lag, which is a common feature following this operation.
4. Proper watch should also be kept on the development of an angular deformity. Strapping of the aluminium splint to the appropriate side of the finger may be necessary to control the angular deformity.

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PNF techniques, PRE and strong endurance exercises to the specific muscle groups are needed to facilitate effective body functions with the prosthesis. The muscle groups to be concentrated are:

(a) Disarticulation of the arm. Shoulder elevators, depressors, protractors and retractors. Mobility exercise to the neck and trunk are also important.

(b) Above elbow amputation. Flexors, abductors, and extensors of the shoulder. Scapular elevators and retractors on the normal side.

(c) Below elbow amputation. Elbow flexors, extensors, pronators and supinators of the forearm with mobilisation of the trunk.

(d) Hip disarticulation. Pelvic rotators and elevators.

(e) Above knee amputation. Hip extensors, abductors, flexors and shoulder girdle muscles.

(f) Below knee amputation. Knee extensors and flexors, hip abductors and extensors.

(g) Syme's amputation. Same as in below knee amputation

ROM exercises

Full ROM exercises are regularly given to the joint to proximal to the stump and also to other joints susceptible to develop contractures. Longer periods of prone lying should be encouraged.

PROSTHESIS

Temporary prosthesis

A light weight, mechanically simple temporary prosthesis (rocker pylon) is given to assess the potentials of the patient and to encourage early standing (Fig. 9.2). It can be fitted following stitch removal within 2 weeks. The patient is given training in balancing and standing in the parallel bars.

Final prosthesis

A final prosthesis is prescribed after critically assessing the performance of the patient with the temporary prosthesis.

Basic features of a prosthesis (Fig. 9.5)

1. Socket. It provides weight bearing and receptive areas for the stump.

2. Suspension. It holds the prosthesis to the stump.

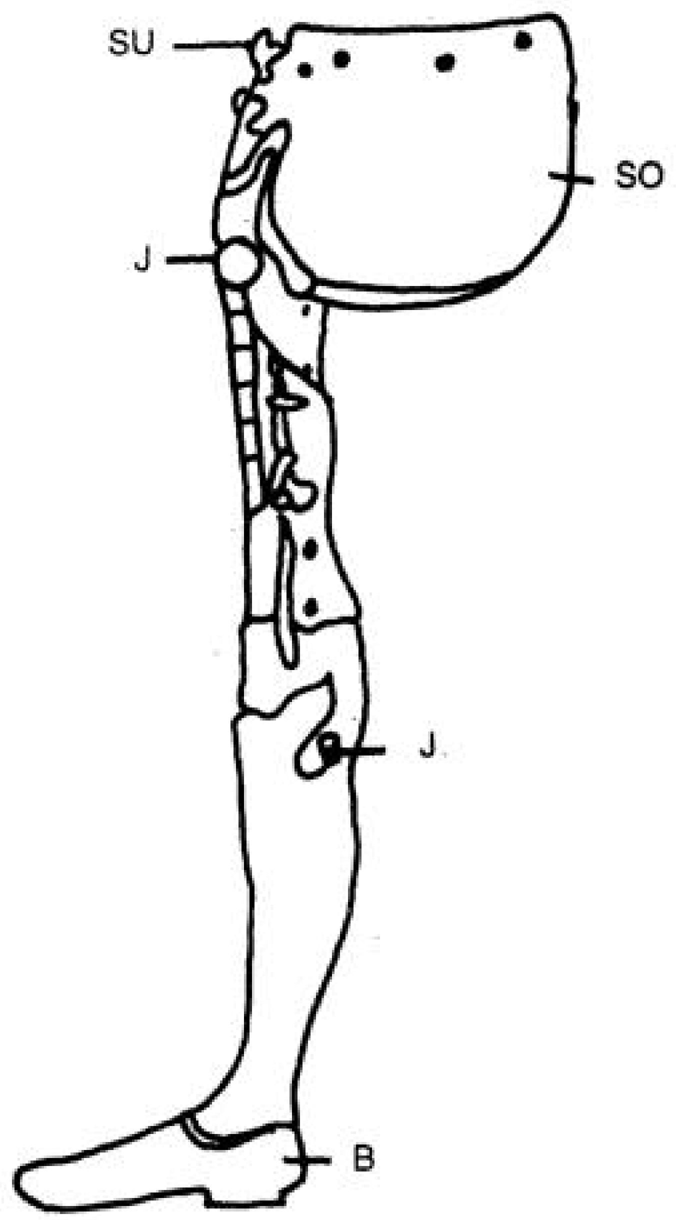

Fig. 9.5. Hip disarticulation prosthesis and its basic features. So : Socket, SU : Suspension, J : Joint, B : Base.

3. Joints. The joints which are amputated are replaced by artificial mechanical joints.

4. Base. It provides contact with the floor.

Methods of fabrication of prosthesis

1. Conventional or exoskeletal prosthesis: The strong outside shell supports the body weight of the patient.

2. Modular assembly prosthesis (MAP) or endoskeletal prosthesis: Here the patient's weight is supported by a metal tube with soft cosmetic covering. The present trend is to provide a light weight endoskeletal prosthesis with one piece cosmetic covering.

The mechanical joints are constructed according to the functional demands of the amputated joints, giving the necessary mobility as well as stability. Locking mechanism can be automatic, semi-automatic or manually operated. The joint can be free or with a restricted arc of motion or it can be one with constant friction.

Material used for prosthesis

Metal. Steel and other alloys are used for the hip and knee mechanisms and duraluminium for the socket and the outer shell.

Leather. Soft leather is used for suspension straps while hardened leather (block leather) is used for sockets and thigh corsets.

Plastics. Thermoplastic materials like polypropylene are used for the socket. For the inner lining of the sockets, plastic foam is used to support the distal tissues of stump and the cosmetic covering of prosthesis.

Wood. It is preferred as a socket material and for prosthetic feet in the tropical climate.

Prescription of the prosthesis

The type of prosthesis to be prescribed depends on various factors like:

1. Age of the patient
2. General physique of the patient
3. Length of the stump
4. Status of circulation to the stump, e.g. a suction socket should not be prescribed for a patient with insufficient limb circulation.
5. The strength, ROM, stability and mobility of the related body segments.
6. The requirements of job and daily living.

A. Prosthesis for Lower Limbs Amputations

Depending upon the level of amputation there are seven types of prosthetic designs for the lower extremity amputations:

1. Hemipelvectomy amputation;
2. Hip disarticulation;
3. Above knee amputation;
4. Through knee amputation;
5. Below knee amputation;
6. Syme's amputation and
7. Partial foot amputation.

Designs of fabrications vary with level of amputation.

1. Hemipelvectomy

In this operation half of the pelvis and complete lower limb is removed.

2. Hip disarticulation (Fig. 9.5)

In this the pelvis is intact but whole of the lower limb is removed from the acetabulum.

The prosthetic design:

Socket. Totally embracing socket is given which encloses both the iliac crests. In case of hemipelvectomy the weight bearing area is ischial tuberosity and buttock of the other side, while for hip disarticulation, the weight bearing area is ischium and the buttock of the amputated side.

Suspension. Through the total tissue contact with locking over the iliac crests. Additional shoulder suspension may be necessary.

Hip mechanism. It could be either of the following:

(a) Standard hip joint which locks automatically in extension.

(b) Canadian tilting mechanism which is fitted anteriorly on the socket. It locks anteriorly on the socket. It locks automatically when the patient stands. At the same time it allows 20 degrees of hip flexion during the swing phase of gait.

Knee. The knee joint is constructed in slight hyperextention to offer stability during the stance phase. This allows the ground reaction force to pass anterior to the knee joint. Knee lock could be hand-operated, semi-automatic, or with constant friction device.

Feet. Ideally SACH (Solid Ankle Cushion Heel) foot is given to offer maximum stability during floor contact (Fig. 9.6).

3. Above knee amputation

The prosthetic design:

Socket. Quadrilateral H-type socket, in which most of the body weight is transmitted through the ischial seat and the posterior brim of the socket.

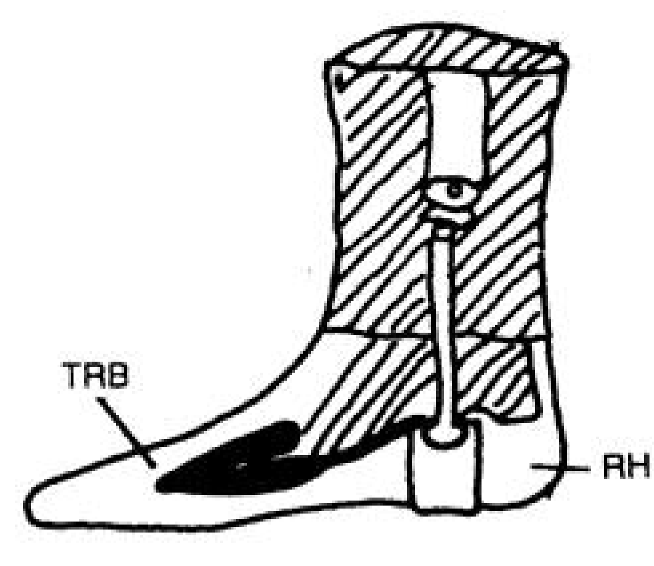

Fig. 9.6. Solid ankle cushion heel (SACH) foot.
TRB : Toe (rubber) bumper, RH : Rubber heel wedge.

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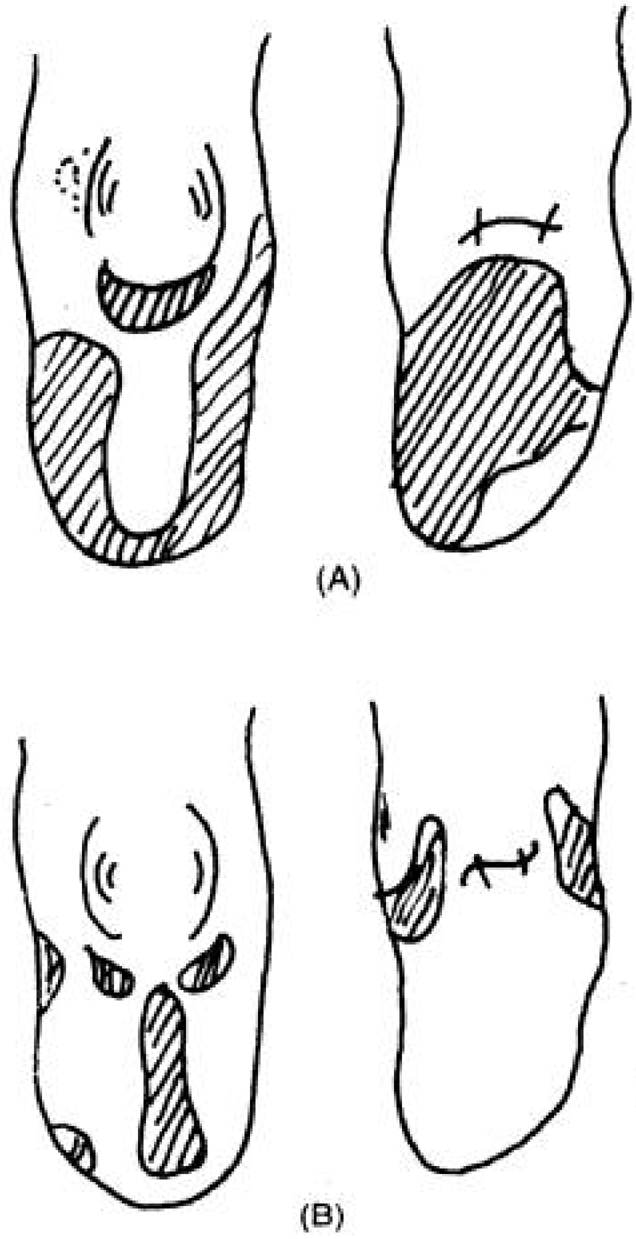

Fig. 9.10. Critical areas on the anterior and posterior aspects of below knee stump. **(A)** Pressure tolerant areas or weight bearing areas. **(B)** Pressure sensitive areas or weight relieving areas.

and lateral insertion of hamstrings (Fig. 9.10).

Suspension. Elastic stocking suspension and supra-condylar cuff.

Feet. Either uniaxial, multiaxial or SACH can be used.

Almost all the patients can be made ambulatory with a normal or near normal gait. The younger patients can manage all the activities including running and sports without any aid (Brouwer et al., 1989).

*6. **Syme's amputation*** (Fig. 9.11)

(i) Plastic syme prosthesis. A hard plastic outer socket is lined by pelite liner with medial or posterior access panel. The foot could be uniaxial or SACH.

(ii) Three strip syme posterior steel socket is fully articulated to the foot. The socket is anteriorly connected by two side steels and an inverted Y shaped

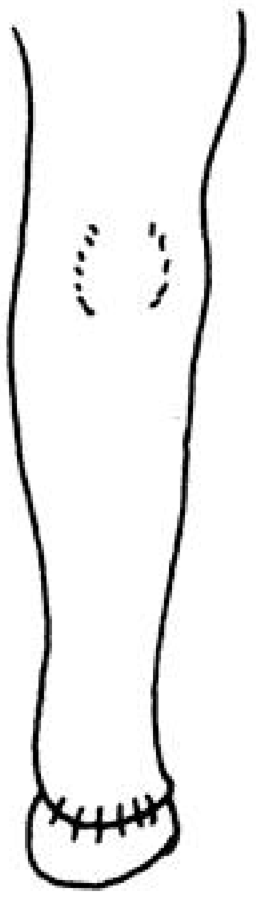

Fig. 9.11. Syme's amputation.

front steel parts. The sockets is made of leather with an access opening posteriorly.

(iii) Enclosed metal syme. There is a leather liner with a posterior flap opening fitting inside the metal socket. The uniaxial foot is used.

(iv) Tongue and bolt syme. A leather socket with front open and two side steels connect the socket to the foot piece.

These patients need no support and can manage all activities freely including sports.

*7. **Partial foot amputation***

1. A simple shoe filler made of leather, covered with ortholene, is fitted in the shoe.

2. A short leather ankle corset is attached to the wooden foot worn inside the shoe. The design of the prosthesis depends upon the individual stump and thus several designs can be fabricated.

The patients achieve total freedom of ambulation and all the activities.

Prostheses for bilateral amputations

Bilateral amputees pose problems in balancing and equilibrium because of the total loss of proprioceptive feedback from the walking surface. They invariably need temporary short prosthesis which brings down the centre of gravity to ease the learning process.

Table 9.1. Gait deviations with the PTB prosthesis and the possible causes

Deviation	*Amputee Cause*	*Prosthetic Cause*
During Stance:		
Excessive knee flexion	1. Flexion deformity at Hip/knee 2. Pain	1. Excessive dorsiflexion 2. Ill-fitting socket 3. Faulty cuff suspension 4. Stiff plantar flexion bumper
Insufficient flexion or hyperextension	1. Weak vastus medialis 2. Unstable knee 3. Stump discomfort 4 Patient habituated to corset prosthesis	1. Excessive foot plantar flexion 2. Hard plantar flexion bumper 3. Incorrectly aligned socket
Trunk lateral bending	1. Painful stump 2. Lack of balance 3. Weakness of hip abductors	1. Short prosthesis 2. Socket in adduction 3. Too lateral foot setting
Foot rotation	1. Pain 2. Unstable knee joint 3. Weak hip muscles	1. Hard plantar flexion 2. Ill-fitting socket 3. Poor suspension
During Swing:		
Delayed knee flexion	1. Limitation of pelvic and hip movements 2. Stiff knee 3. After having used AK/BK prosthesis	1. Inadequate suspension

Standing and partial weight bearing (about 8-9 kg) can be instituted as early as the next day of surgery. Full weight bearing is permitted by 6 weeks when the tissues are healed well and are ready to take the body weight.

Advantages of instant prosthesis

1. Initiation of standing and partial weight bearing ambulation from the next day of surgery minimises the following problems:

(a) Stump edema.
(b) The complications of prolonged prosthetic period.
(c) Unstable non-weight bearing crutch walking.
(d) Contracture and deformities.
(e) The regime of strengthening and ROM exercise is minimised.
(f) Rigid cast socket coupled with pylon promotes conditioning of the stump.
(g) Prevents or provides relief in the phantom lim sensation.
(h) The patient is discharged early with either a tem porary or a permanent prosthesis.
(i) The patient quickly picks up a stable and goo pattern of gait.

2. The most important advantage of the surgical pro cedure is that it reduces the neurologic silence belov the level of amputation. The significant part of th feed-in mechanism is preserved which quickly estab lishes communication with the proximal parts. Re-es tablishing the proprioception and feedback by contac with the floor, substantiated with visual and auditor feedback, alerts the appropriate muscles for the norma synchronised actions. It re-establishes the signalin system. It promotes stabilisation, weight transfer an early ambulation.

Although this procedure was not reported to be suc cessful by many centres in UK due to problems of poc

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vascularity and healing, Stovlov et al. (1971) thought it to be ideal in patients without vascular disease.

Re-education of the upper extremity amputee

The basic responsibility of the physiotherapist in the re-education of an upper extremity amputee is to train the patient for the functional activities.

The training aspect has the following objectives:

1. To increase the mobility of the related adjacent body parts so that some compensation can be achieved for the absence of the true limb.
2. To strengthen the muscles directly involved in activating the prosthesis.
3. To increase the endurance of these muscle groups to sustain the motion of the prosthetic joint whenever necessary.
4. To prevent the soft tissue contractures in certain muscle groups like shoulder adductors, and rotators and elbow flexors.

STANDARD BASIC AREAS

(a) Above elbow (AE) amputee

Mobility to be concentrated to the scapulohumeral and scapulothoracic motions along with the neck and trunk.

Strength and endurance of the flexors, extensors and adductors of the shoulder. Powerful arm flexion is needed for producing strong flexion at the prosthetic elbow while extension is needed for controlling the locking mechanism of the prosthetic elbow joint.

(b) Below elbow (BE) amputee

For the forearm and wrist amputees the mobility of the shoulder girdle, shoulder joint and elbow needs to be improved but more emphasis should be placed on the forearm. Although prosthesis can not perform pronation and supination it can have a device to lock the forearm in the necessary functional position.

Strengthening and endurance exercises should be planned for the shoulder complex, elbow as well as forearm. All these play a key role in the prosthesis.

Training of the prosthesis controls. Four basic body controls are necessary to operate the upper extremity prosthesis (Aylesworth, 1952).

1. In the beginning the patient is trained to perform one basic movement, e.g. true shoulder flexion without the movement occurring at the shoulder girdle (arm flexion control motion). This is the major control for the above elbow amputee. When proficiency is attained in performing one basic body motion, then coordiation of the individual motions can be taught for the operation of prosthesis. Manually operated accessories like wrist flexion unit are not operated by a control system and can be taught to be pre-positioned or fixed (Fletcher, 1954).

2. Below elbow single control system. Patients with forearm amputation or wrist disarticulation use below elbow single control system to operate the prosthesis. For example, the patient is first trained to flex the elbow to 90 degrees and then flex the shoulder till the terminal device becomes operational (Taylor, 1955).

3. Above elbow dual control system. Patients with above elbow or through elbow amputation use the dual control system. Here the arm flexion control motion is used to teach the following two prosthetic operations:

(a) With the prosthetic elbow unlocked, flexion at the shoulder produces flexion at the elbow of the prosthesis.
(b) With prosthetic elbow locked, flexion at the shoulder operates the terminal device. To begin with combined operation of elbow flexion by flexing the shoulder; and locking the elbow by protraction of the shoulder is taught. When this is achieved, the amputee is trained to operate the terminal device.

4. Above elbow triple control system. Standard above elbow amputee is trained by a triple control system. The amputee is first trained to control elbow flexion and elbow lock as mentioned in the dual control system. Elbow flexion is produced by the arm flexion control motion, locking of the elbow is achieved by arm extension control motion. Operation of the terminal device is achieved by controlled shrugging motion on the normal side. Practice makes it possible to coordinate all these movements together.

Besides these, guidance is also necessary to use this prosthetic hand for various other activities of daily life.

Complications

1. Phantom pain. It is a common complication where the patient feels pain in the amputated part of the limb. It is due to the persistence of nerve impulses caused by local anoxia, neuroma, or atherosclerois.

10

Lesions of the Brachial Plexus and Peripheral Nerves

Signs, symptoms, classification, evaluation and treatment of:

- **Erb's palsy**
- **Klumpke's paralysis**
- **Peripheral nerve injuries**

LESIONS OF BRACHIAL PLEXUS

Disability of the arm due to lesions of the brachial plexus is one of the common problems. The lesions (Fig. 10.1) may occur due to :

1. Trauma and traction injuries;
2. Pressure during prolonged unconsciousness;
3. Post radiation fibrosis;
4. Tumor and
5. Following surgery (removal) of cervical rib.

Basically the lesions are of two types (Fig. 10.2):

1. Pre-ganglionic lesion. Where the nerve root is avulsed out of the spinal cord. This type has a poor prognosis.

2. Post-ganglionic lesion. These are of two types:

(a) Lesion in continuity–the nerve root and its sheath are intact and hence recovery is spontaneous.

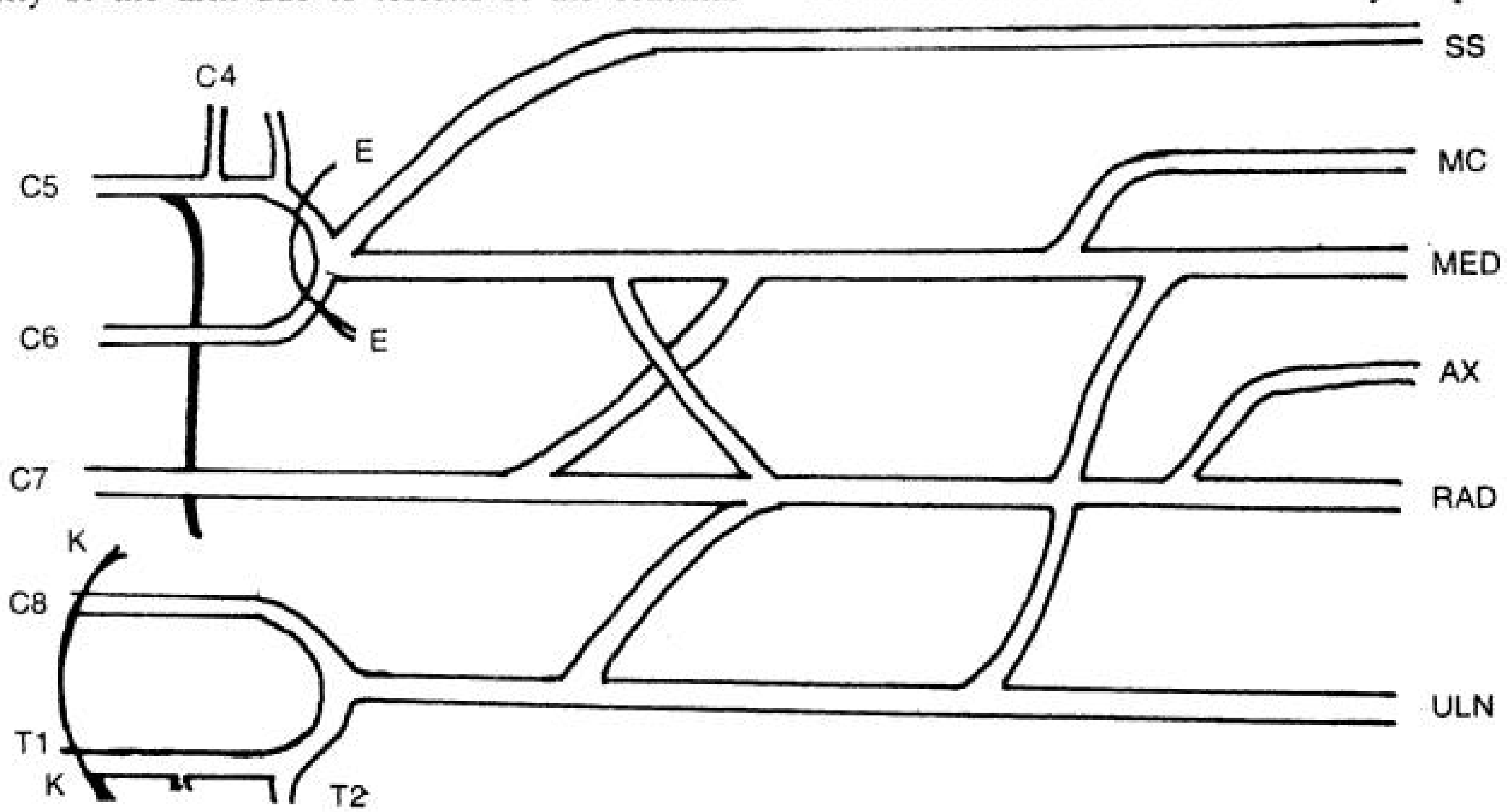

Fig. 10.1. Brachial plexus. SS : Suprascapular, MED : Median, MC : Musculo cutaneous, RAD : Radial, AX : Axillary, E : Erb's palsy (lesion involving C5-C6 roots), K: Klumpke's palsy (lesion involving C8-T1 roots), ULN: Ulnar.

the availability of proximal axons for grafting.

Examination of passive range of motion

The passive range of motion (ROM) of all the joints of upper limb should be done to assess any sign of soft tissue tightness. Soft tissue contractures may be present in patients with severe lesions with flail arms. Common sites of contractures are:

1. Shoulder. Elevation, abduction and external rotation;
2. Elbow-extension and supination;
3. Wrist-Palmar flexion and extension;
4. Metacarpophalangeal joints flexion, and
5. Interphalangeal joints-extension.

In addition, reduction of the thumb web space, shortening of the long flexor tendons with loss of full extension of digits and wrist in extension may be present. Any sign of tightness, which precedes the contracture, must be carefully examined to avoid contractures. Also examine for subluxation of the shoulder joint. Proper guidance to fully stretch these movements to the full range of motion is necessary. Shoulder needs more emphasis on abduction and external rotation as brachial plexus cannot be exposed for surgical intervention without full external rotation at the shoulder joint.

Examination of sensibility

Sensibility evaluation for light touch, pinprick and proprioception is documented on the body chart. It can provide definite guidance in the diagnosis of the lesion.

Evaluation of vascular status

It can be done by palpation of pulses (either radial or carotid). If necessary, angiography can provide further information.

Vasomotor changes like dry and cold skin, or the presence of edema indicates significant nerve injury.

Manual muscle testing

Manual muscle testing (MMT), though time consuming, still remains the most vital part of evaluation.

1. MMT as applied to plexus injury, however, needs a thorough knowledge of the anatomical inter-relationship of various muscle groups and their innervation. The specific muscle action, atrophy and deformity should be detected. The common trick movements, e.g., winging of the scapula without the lesion of spinal accessory nerve, should be looked for. This muscle is innervated by C5, C6 and C7 branches which come off immediately after the nerve roots exit from the intervertebral foramina. Injury to them could be because of root avulsion.

If the serratus anterior is intact, and the supraspinatus and infraspinatus are paralysed, the lesion could be infra-ganglionic in the region of Erb's point where C5 - C6 join to form the upper trunk.

If the serratus anterior is intact with paralysis of the deltoid and the biceps, the lesion could be more distal in the terminal branches of the plexus.

Radiological examination

Radiological examination is done basically to rule out fractures. Fractures of transverse process may result in avulsion of the corresponding nerve root, because of the attachment of the deep cervical fascia between cervical nerve roots and vertebral transverse processes (Sunderland, 1978). Widely displaced fracture of the clavicle or scapula can produce traction injury.

Electro-diagnostic tests

As the electrical changes are parallel to the pathophysiology of denervation or to the loss of axonal continuity, they provide significant information:

1. To confirm denervation, and
2. To diagnose the nature of lesion, whether it is preganglionic (avulsion) or post-ganglionic.

Electromyography

The following investigations should be conducted 4 weeks after injury:

1. Electromyography (EMG) of the limb and the shoulder girdle muscles;
2. Motor and sensory nerve conduction velocity.
3. Somatosensory evoked potentials and the "F" responses.

EMG. The muscle, which is innervated normally, does not exhibit spontanous electrical activity at rest. Therefore, the presence of small fibrillation potentials or the large potentials called sharp positive waves at rest, when the muscle is examined with needle electrode, indicate Wallerian degeneration.

4. Self-assisted and guided functional movements and
5. Relaxed passive movements, active assisted movements, progressed to resisted exercises. It provides the necessary strength and endurance to the transplanted muscle.

ERB'S PALSY

It is the lesion of the 5th cervical root. It occurs as a result of birth injury due to traction between the child's head and shoulder. The principal strain falls on the upper root (C5) of brachial plexus. Often the force may be excessive enough to involve the root below (C6) (Fig. 10.1).

Injury to the 5th cervical root alone results in weakness or the loss of:

1. Shoulder: abduction and external rotation,
2. Elbow: flexion, and
3. Forearm: supination.

This occurs due to the involvement of deltoid, rhomboids, supraspinatus, infraspinatus and teres minor at the shoulder complex; biceps and brachialis at the elbow and supinators at the forearm.

Involvement of the 6th cervical root results in the loss of wrist extension (radial side) due to the involvement of extensor carpi radialis longus and brevis.

The involvement of these muscle groups results in the typical posture of "waiter's or policeman's tip" position to the involved limb (Fig. 10.3). The arm loosely hangs by the side of the trunk internally rotated with elbow in extension.

Anaesthesia may be present over the outer border of the arm and forearm; on both anterior as well as posterior aspects. When the 6th nerve root is involved anaesthesia extends medially and also involves the thumb.

Treatment

To avoid soft tissue contracture, abduction splint (aeroplane splint) may be given. This maintains the shoulder in abduction and external rotation, elbow in 90 degrees flexion, forearm in supination and wrist in a few degrees of extension.

However, this splint is too cumbersome for a child during sleep and therefore the mother is taught to keep the child's arm in this position by using small sand bags.

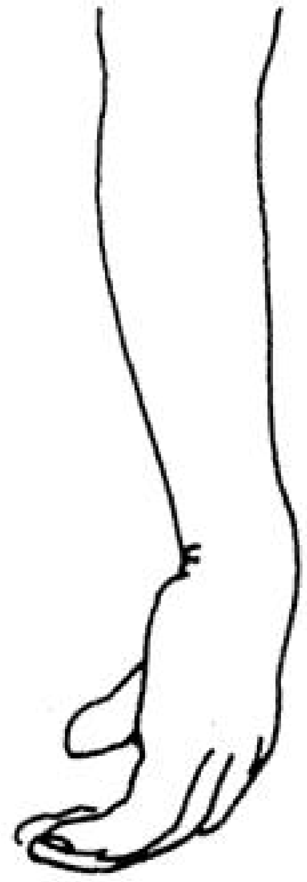

Fig. 10.3. Erb's palsy (lesion involving C5-6 nerve roots) : the typical arm posture of "waiter's or policeman's tip". This posture is due to the paralysis of shoulder abductors and external rotators, elbow flexors, and forearm supinators. The arm hangs by the side of the trunk in internal rotation with elbow in extension.

Passive full range movements to prevent the contractures are taught to the mother.

The involved muscles are activated by assisted active movements by using sensory stimulus. Bilaterally symmetrical PNF patterns may be included to achieve irradiation from the normal contralateral limb; or from the surviving strong muscles of the affected limb.

In the later life, a similar condition may occur as a result of violent injury to the brachial plexus. The clinical picture depends upon the degree of involvement of the brachial plexus. The plan of treatment is similar to that of the Erb's palsy. However, as the patient is able to follow the instructions the therapeutic procedures can be more precise like:

- Involved individual muscles groups can be exercised and re-educated.
- Electrical stimulation can be used as an adjunct.
- Trick movement for functional achievements can be taught effectively (e.g. substitution by the long head of biceps brachii and brachioradialis with flexors to achieve shoulder abduction and elbow flexion respectively).

Conservative treatment is successful only in children with mild involvement or in adults with incomplete severance of the nerve roots.

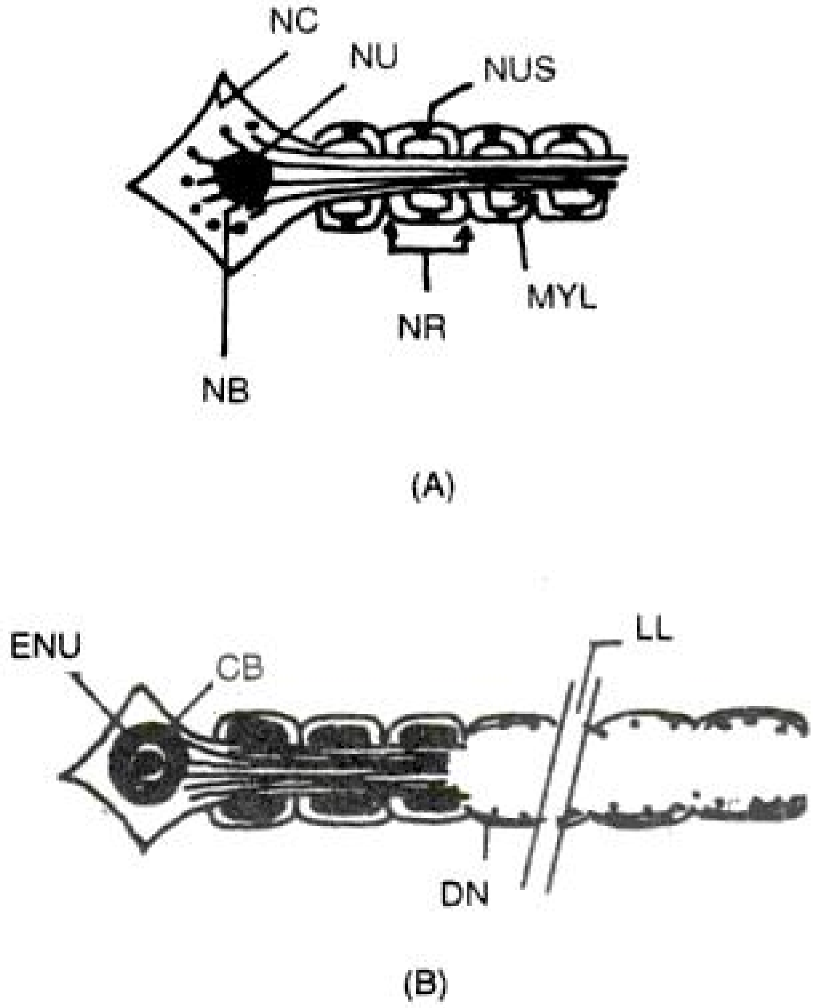

Fig. 10.5. (A) Structure of nerve fibre. NC : Nerve cell, NU, Nucleus, NB : Nissl bodies and nerve fibrils arising from them, MYL : Myelin sheath, NUS : Nucleus of schwann cell, NR : Node of Ranvier. **(B)** Wallerian degeneration following axonotmesis or neurotmesis. LL : Level of lesion, ENU : Enlarged nucleus, CB : Cell body empty of Nissl bodies, DN: Degeneration of neurofibrils to the nearest node of Ranvier.

is no Wallerian degeneration and it recovers rapidly within 3 to 6 weeks.

2. Axonotmesis. An interruption of the axons and their tubes, epineurium, perineurium and endoneurium remain intact and guide the regenerating axons to their appropriate peripheral connections. Recovery takes place within 6 months.

3. Neurotmesis. Nerve is either completely severed or disorganised to an extent that spontaneous regeneration is impossible. There is complete disruption of not only the neural elements but also the fibrous elements (Fig.10.5). The chances of natural recovery are remote.

Sunderland's classification

Sunderland (1978) classfied nerve injuries into five degrees.

First degree injury. A transient syndrome–nerve edema causing motor paralysis with little sensory or autonomic involvement.

Second and third degree injuries. As per Seddon's classification they correspond to axonotmesis. There is complete motor, sensory and autonomic dysfunction. However, some of Sunderland's third degree lesions are irreversible which can clinically be compared to neurotmesis.

Fourth degree injury. There is neuroma-in-continuity with no axons crossing the area of injury.

Fifth degree injury. The nerve is not in continuity as in neurotmesis.

However, the nerve injuries do not rigidly follow the grades of these classifications. A single nerve injury may include neuropraxia, axonotmesis and neurotmesis simultaneously. Approximately 95 percent of the upper extremity fractures are associated with nerve injuries (Goodall, 1956). Radial nerve injury is commonly seen in fractures of the shaft of humerus. Median and ulnar nerves are involved in the distal third fractures of humerus. Incidence of nerve involvement resulting from fractures is as follows:

Radial nerve in about 60 percent, ulnar nerve in 18 percent, median nerve in 6 percent and common peroneal nerve is involved in 15 percent of the cases (Goodall, 1956; Gardjian and Smathers, 1945; Lewis, 1922).

An incidence of nerve injuries is higher in dislocations and stretch injuries rather than in fractures. Nerve injury sustained following dislocation is less likely to recover as compared to that following a fracture (Omer, 1982). In closed fractures, the nerve injury is usually neuropraxia, and shows better recovery than in open fractures.

Lacerations are usually neurotmesis lesions and may need exploration and repair.

Complete physical examination of peripheral nerve function at the time of injury is the best baseline for management.

Electrodiagnostic studies should be initiated after 3 to 4 weeks and repeated periodically to evaluate the course of clinical recovery.

Exploration should be done after 3-4 months if no recovery occurs.

Motor and sensory deficiencies in injuries of the peripheral nerves in upper extremity

1. Radial

Motor–extension of wrist and fingers.
Sensory–thumb-web, dorsum of thumb and index finger (Fig. 10.6A).

Median nerve

1. Infraclavicular median nerve entrapment: Anomalous muscles, vascular pressures and fascia in the infraclavicular area of pectoralis minor can compress median nerve with coracoid processes in the loose hyperabducted shoulder joint. Arm abduction at shoulder which produces excessive tension on the median nerve may produce symptoms of median nerve compression.

2. Supracondylar process: Anomalous bone spur at the supracondylar process 3-5 cm above the medial epicondyle can cause median nerve symptoms when precipitated by injury (Spinner, 1980).

3. Pronator syndrome: Compression of the nerve in the cubital fossa, under the lacertus fibrosus and as the nerve enters between the two heads of pronator teres gives rise to weakness in the intrinsic and the extrinsic muscles supplied by the median nerve. Early management is done by limiting the activity. Splint, rest and drugs are given to reduce the pain. Surgical release of the nerve may be necessary (Jewett, 1980) if there is no favourable response.

4. Anterior interosseous syndrome: The anterior interosseous nerve arising from the posterior surface of the median nerve in the cubital fossa may be compressed. It supplies flexor digitorum profundus to the index finger, flexor pollicis longus and the pronator quadratus. Its compression produces classical "pinch sign" with inability to flex the terminal IP joints of index finger and thumb (Kiloh and Nevin, 1952). Initial management is conservative. If it fails to improve by 3-6 months, surgery may be necessary (Spinner, 1980).

Carpal tunnel syndrome (Fig. 10.8)

The carpal canal at the wrist joint is a cramped space, crowded with nine flexor tendons and the median nerve. Any tension in this canal, e.g. flexor tenosynovitis, amyloid deposits, malunited radial fracture or carpal dislocation can compress the median nerve.

Burning, aching, tingling sensation in the hand and wrist are present at night. It is relieved by shaking or massaging the wrist. Radiation of pain and paresthesia may be present proximally, as far as the shoulder. Occasionally weakness and stiffness of wrist and hand may be present. According to Crymble (1968), weak-

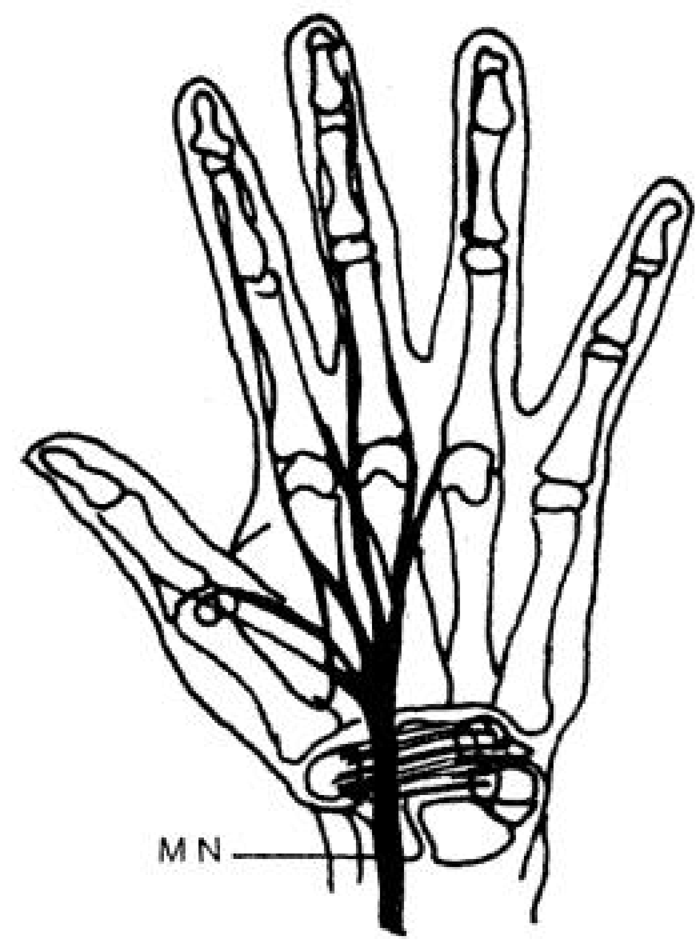

Fig. 10.8. Carpal tunnel syndrome, entrapment of median nerve (MN) in the carpal tunnel (CT).

ness of abductor and opponens pollicis with atrophy of the lateral part of thenar eminence may be present. Pain and paraesthesia on the palmar aspect of thumb, index, middle and ring fingers may radiate to forearm.

Confirmatory tests

The symptoms can be reproduced by the following tests:

1. Phalen's test (1966). It is done by performing acute volar wrist flexion for a minute.

2. Modified Phalen's test. Forceful flexion of the thumb and fingers with the wrist in flexion (Smith et al., 1977).

3. Reverse Phalen's manoeuvre. Recently, a reverse Phalen's manoeuvre has been reported as an added diagnostic test in CTS (Werner et al., 1994). This test involves holding wrist and fingers in extension for one minute; maintenance of extension position was found to increase hydrostatic pressure in the carpal canal significantly as compared to the traditional Phalen's test or modified Phalen's test. This manoeuvre also resulted in the prolongation of the sensory revoked response.

4. Tinel's sign (Moldover 1978). The tourniquet is inflated for one minute or the median nerve is per-

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tures, synovial proliferation in rheumatoid arthritis, or soft tissue tumors are the precipitating factors (Morris, 1974; Licher and Jacobson, 1975; Sjostrand et al., 1980).

Superficial radial nerve entrapment

Pain and altered sensibility in the dorsal thumb web area: a tight cast is the common cause, even tight watch band or hand cuffs may give rise to these symptoms (Braidwood, 1975; Dorfman and Jaepram, 1958). Surgical release of the radial nerve in the elbow is indicated when the conservative therapy fails.

Axillary nerve

The axillary nerve may be compressed as it passes through the quadrilateral space. It supplies the deltoid muscle and sensations over the lateral aspect of the shoulder.

There may be shoulder pain radiating distally to the arm. Symptoms may be elicited by moving the shoulder into abduction or external rotation.

Treatment is conservative but exploration may become necessary.

Other unusual entrapment neuropathies may include suprascapular nerve (Solheim and Roaas, 1978), the musculo-cutaneous nerve and the intercostal nerves (Wood, 1978). These should be kept in mind in the differential diagnosis of shoulder pain.

Lower extremity nerve compression syndromes

1. Lateral femoral cutaneous nerve (meralgia paraesthetica)

Lateral cutaneous nerve of the thigh is a sensory nerve derived from L2 and L3 nerve roots. It enters the proximal thigh through an opening formed by inguinal ligament and the anterior superior iliac spine.

It causes burning and altered sensations over the anterior and lateral aspects of the thigh. Even friction of the skin due to clothes initiates the symptoms. This could be because of tight belts, garments or mechanical trauma to the nerve due to improper retraction during hip or lower abdominal surgery.

Conservative treatment including steroid injections are effective in resolving the symptoms.

2. Sciatic nerve compression

Mechanical compression of the nerve by hip dislocation or heavy retraction during hip surgery.

Femoral nerve is rarely involved following bleeding in the retroperitoneal space and anterior thigh in hemophiliacs (Zarranz and Salissachs, 1979).

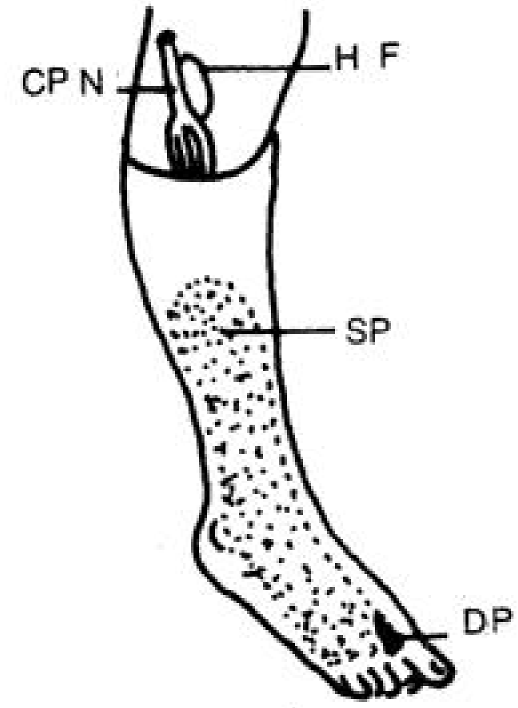

Fig. 10.9. Common peroneal nerve compression.
CPN: Common peroneal nerve, HF: Head of fibula, SP : Superficial peroneal involvement, DP : Deep peroneal involvement.

3. Common peroneal nerve (Fig.10.9)

This is the most commonly involved nerve in the lower extremity. Its involvement results in foot drop and loss of sensation over the dorsum of the foot. The commonest site of compression is its subcutaneous disposition at the fibular neck. Sitting cross-legged, sleeping on the side on a hard surface, wrongly placed calf-cuff in an orthosis, tight casts or a cast applied with knee in hyperextension can cause the compression. Ganglia of the proximal tibiofibular ligament may also cause compression (Nakano et al., 1978).

4. Posterior tibial nerve

Tarsal tunnel syndrome (Edwards et al., 1969)

The posterior tibial nerve may be trapped at the medial aspect of the ankle. Pain and burning over the plantar surface of the foot is common. The nerve gets trapped between the tendons of flexor digitorum longus and flexor hallucis longus. The nerve at this level may be

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Essentials of Orthopaedics and Applied Physiotherapy

Orthopaedic physiotherapy is one of the major specialties of the art and the science of physiotherapy. It plays a vital role in the rehabilitation of the physically handicapped. There are a large number of books on orthopaedics and physiotherapy, but they all deal with these subjects as a separate entity. There is not even a single book that provides the overall picture of the total therapeutic management. This book, the first of its kind, fills the gap.

Salient Features

- It studies the essentials of orthopaedics and applied physiotherapy with an interspecialty therapeutic approach.
- Most of the chapters start with a treatise on relevant applied anatomy, clinical features, diagnosis and comprehensive orthopaedic and physiotherapy management of all the common orthopaedic conditions including fractures and dislocations.
- A large number of diagrams and photographs have been used to describe the various aspects of diagnosis and treatment of particular condition.
- Some of the latest research works have been included in the References, which appear at the end of each chapter, for further reading on the subject.
- Interesting chapters on Sports Medicine and Yoga have been included.

The book will be useful not only to the students of medicine and physiotherapy, practising physiotherapists but also to the orthopaedic surgeons, physiotherapists and others engaged in the rehabilitation of the physically handicapped.

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