Rehabilitation surgery for deformities due to poliomyelitis

Techniques for the district hospital

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Preface

This handbook is part of a series produced by the World Health Organization on the surgical care of patients at small hospitals that are subject to constraints on resources and where doctors have limited access to specialist services. It describes surgical procedures that can facilitate rehabilitation of selected patients with deformities due to poliomyelitis. The procedures described are those that can be undertaken by the non-specialist medical officer who, nevertheless, has experience, gained under supervision, of all the relevant techniques. Procedures that involve bones require more training and experience; although descriptions of some such techniques are included here, they should be performed at the district hospital only by doctors with wide experience or under the immediate supervision of a specialist. These procedures are marked with an asterisk in the text.

Physical therapy is an essential part of the management of these patients, especially before and after surgery. The physiotherapist and the surgical team must therefore work together to provide the patient with the best possible rehabilitation. This work at the district hospital depends greatly on regular supervision and technical support by specialists at regional or central hospitals.

The handbook has been prepared in collaboration with the following organizations:

Handicap International
Health Volunteers Overseas
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International Society of Orthopaedic Surgery and Traumatology
International Federation of Red Cross and Red Crescent Societies
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Introduction

Poliomyelitis is a major problem in most developing countries and is one of the main causes of locomotor disability. The disability resulting from paralysis is greatly aggravated by deformities which frequently develop, especially in the lower limbs. Patients with severe deformities of both limbs cannot stand or walk, and this greatly restricts their daily living and social activities.

The correction of deformities, using simple surgical procedures, can significantly facilitate rehabilitation and improve the physical independence of polio victims. According to recent estimates, the number of people in need of such surgery in developing countries is in the region of one million. However, rehabilitation surgery is not available to the majority of disabled people in these countries. There are few special institutions, and they cannot cope with the magnitude of the problem.

One solution would be to make essential rehabilitation surgery services available at the district hospital. Such services, however, cannot work effectively in isolation. They must have close links with community rehabilitation activities, within the framework of the district health services. It is evident that only selected surgical procedures are feasible at this level. Reasonably experienced district hospital doctors should be able to carry out such basic procedures provided that they have had practical training in essential rehabilitation surgery.

This guide has been prepared both for training purposes and as an *aide mémoire*. It is aimed at doctors providing surgical services in district hospitals. The procedures described have been deliberately limited to those that are feasible at this level and can meet the needs of the majority of people with disabilities due to poliomyelitis. These are, therefore, mainly corrective and stabilizing procedures on the lower limbs.

The surgical techniques described fall into two groups: first, simple but essential procedures that can be carried out by a general duty doctor with some experience, in an average district hospital; second, procedures that require more experience and better than average facilities. However, operations in the second group (marked with an asterisk in the text) might also need to be performed at district hospitals.

As rehabilitation surgery is not life-saving, patients who require treatment involving more complicated techniques should be referred to specialized centres. It is important that the district hospital doctor is fully aware of the level of service the hospital can offer.

In rehabilitation surgery, just as in general surgery, additional skills such as a basic understanding of underlying pathology, practical competence in clinical evaluation, and sound judgement in selecting patients for surgery are important.

The procedures described here are intended to be carried out as part of a comprehensive rehabilitation programme for those with limb disabilities resulting from polio. Neither physical therapy nor surgery alone can bring full benefit to many patients with such disabilities. A coherent system of prevention, kinesitherapy, surgery and bracing, integrated with general health services at all levels, is needed. Particular emphasis must be placed on services at community and district levels.

POLIOMYELITIS AND THE FUNDAMENTALS OF REHABILITATION SURGERY

1
Basic information on poliomyelitis

General remarks

Poliomyelitis is an acute infectious disease caused by a group of neurotrophic viruses (types I, II and II). The poliomyelitis virus has a special affinity for the anterior horn cells of the spinal cord and for certain motor nuclei of the brain stem. The affected cells undergo necrosis and the muscles that they supply become paralysed.

Poliomyelitis, once an epidemic disease, has been practically eradicated in industrialized countries, as a result of the development and widespread use of an effective prophylactic vaccine. Unfortunately, in most developing countries the incidence of poliomyelitis is still very high, mainly among children. Even though there is currently an intensified immunization campaign against poliomyelitis aimed at eradicating the disease by the end of this century, there will still be people with deformities requiring rehabilitation, including surgery, for many years to come.

Clinical forms

Paralytic poliomyelitis occurs in three clinical forms: spinal, bulbar and bulbo-spinal. Spinal paralysis is due to affection of the anterior horn cells of the spinal cord and may involve limb and trunk muscles. Bulbar paralysis, which has a high mortality rate, results when motor cells in the brain stem are affected, and causes difficulties with swallowing, respiration and speech. Bulbo-spinal paralysis is a combination of both of the above.

This guide deals only with sequelae of the spinal forms of paralysis.

Clinical course

In its natural course, the disease has three major stages: the acute illness, lasting 1–3 weeks, followed by the recovery stage, extending over 6–12 months, and finally the chronic or residual stage.

Acute illness

The acute illness is further subdivided into minor and major.

The minor illness is characterized by nonspecific symptoms similar to those of many other infections, such as fever, general malaise, headache, generalized aches and pains, nausea and vomiting. After 1–3 days the patient may temporarily improve and then become sick again.

The major illness in its *pre-paralytic stage* is marked by the same symptoms as the minor illness, but in a more severe form, and by the appearance of additional and more specific signs and symptoms. These include neck and back stiffness, and pain and tenderness of muscles accompanied by muscle spasms which can last for a long time. After 1–2 days, the *paralytic stage* sets in, becoming fully developed during the following 1–2 days. The paralysis is of a flaccid type with no sensory loss. The limbs and trunk muscles become paralysed in varying combinations and to varying degrees. General symptoms and muscles usually begin to improve from about the second week after the onset of the illness. During the third week the general and local symptoms subside. There is some clinical evidence to suggest that muscles that are exercised during the acute stage of the disease are more prone to paralysis. It is therefore prudent to insist on complete bedrest during this period and to ensure proper positioning of the limbs, to alleviate muscle spasm and pain.

Recovery stage

Muscles begin to recover power and function directly after the acute illness. Between 3 and 6 weeks after the onset of the disease, the final outcome (prognosis) can be determined. Muscles that show neither movement nor strength at 6 weeks will remain totally paralysed; muscles with a little movement or strength will improve but remain weaker than normal; muscles that can be moved by the patient (who is usually a child) will acquire increasing strength.

Muscle recovery is quick during the first 6 months after the illness and much slower from then on. By the end of the first year, muscle recovery is practically complete.

Rehabilitation training should be instituted from the beginning of the recovery stage, to promote muscle recovery, general fitness and mobility, and to prevent muscle contracture. Management comprises muscle exercises, positioning, gait training, bracing and practice in daily living activities. In young children, the rehabilitation process also includes the stimulation of normal motor development, e.g., rolling, sitting, crawling, standing.

Residual stage

Any residual muscle paralysis at the end of the first year after the onset of disease may be regarded as permanent disability. However, the functional capacity and general performance of the patient can be greatly improved by proper training. This is true even for children with severe paralysis. If proper rehabilitation procedures are used, most children will not require rehabilitative surgery. However, if fixed deformities develop (i.e., deformities of joints resulting from contracture of muscles and tendons), surgery may be used at the residual stage to help the rehabilitation of paralysed persons. The earlier surgery is performed the better, since deformities become more severe and fixed with time. Nevertheless, corrective surgery can be useful even late in the residual stage, particularly for children.

2 Sequelae of poliomyelitis

Paralysis

Flaccid paralysis of muscles without loss of sensation is a direct sequela of poliomyelitis. The paralysis of the affected muscles may be mild, moderate, or severe. Within the same limb, some muscles may be unimpaired, while others display various degrees of paralysis. Paralysis affects the lower limbs in the majority (80–90%) of children. In some of these children, the trunk muscles may also be involved, while in a few the upper limbs are affected too. In a large proportion of children there is paralysis of only one leg.

Functional consequences of paralysis

The functional consequences of paralysis depend on the parts of the body affected, and on the extent and degree of paralysis. In general they are:

- impairment or loss of specific movement, e.g., loss of active extension of the knee in the case of paralysis of the quadriceps muscle;
- impairment of stability of a joint, e.g., involuntary "knifing in" of the hip in the case of paralysis of the gluteus maximus muscle, causing the person to fall down during walking;
- impairment of general motor performance, e.g., locomotion and self-care;
- development of deformities, e.g., contractures of the joints and axial deviations of the limb such as valgus, varus and recurvatum deviations.

Deformities

Deformities of the limbs and trunk, and in particular of the lower limbs, develop in most children who do not receive adequate treatment from the onset of the disease. Many deformities could be avoided, or kept to a minimum, by the application of proper secondary prevention at the acute and recovery stages. Muscle contractures will limit or block joint movements, and can result in axial deviations of the limb (e.g., valgus deformity of the knee).

Some deformities, such as flexion–abduction contracture of the hip, may arise early in the acute stage of the disease. Because of pain and muscle spasm, the child assumes a posture in which the muscle is contracted, which, in the absence of treatment, becomes fixed (Fig. 1A).

Other deformities develop at later stages of the disease. These are mainly caused by:

- Muscle imbalance. When antagonist muscles, e.g., flexors and extensors of the knee, are affected unequally, one group pulls more than the other. For example, partially weak flexors of the knee will pull more than paralysed quadriceps, leading to flexion contracture of the joint.

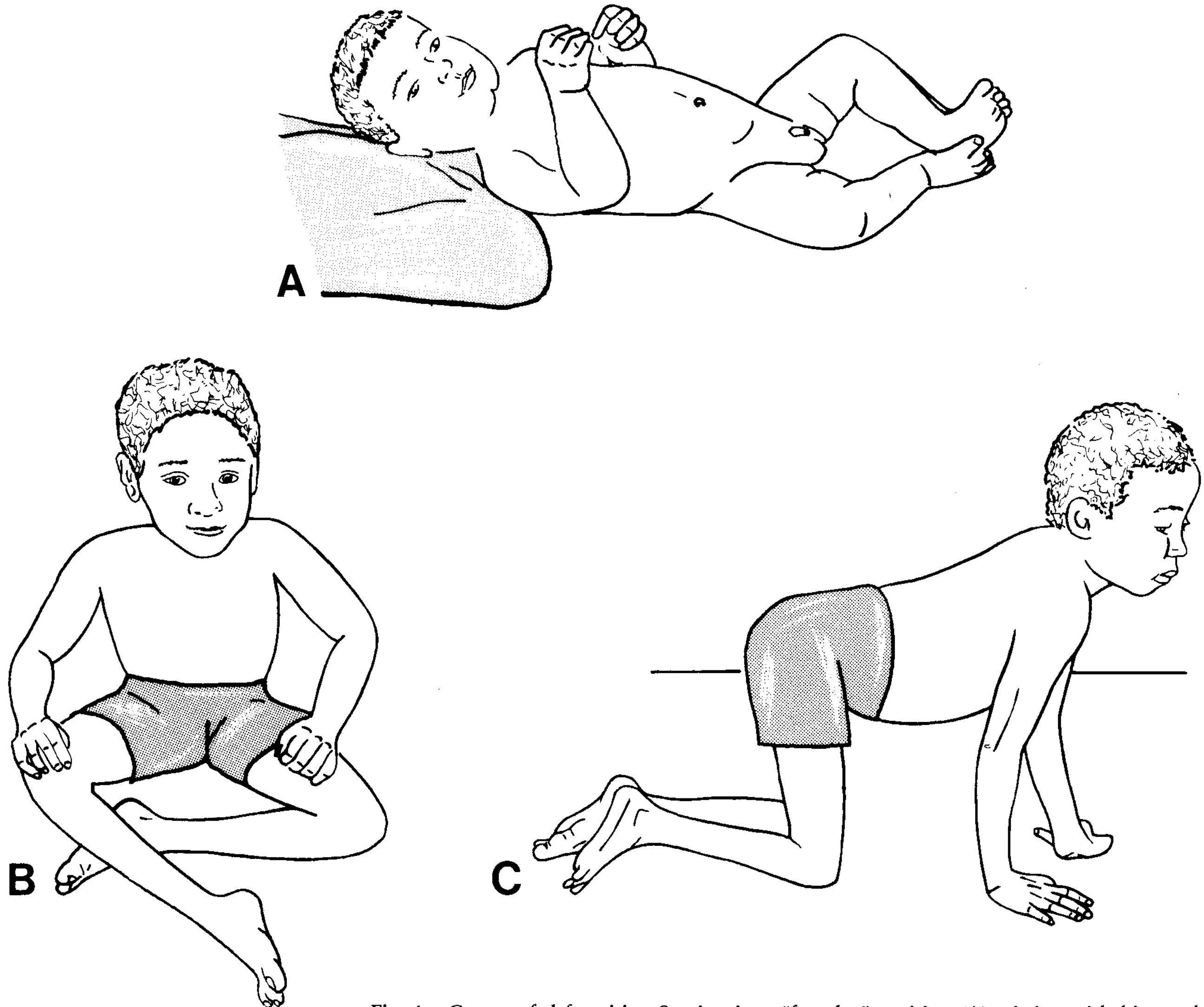


Fig. 1. Causes of deformities. Staying in a "frog-leg" position (A); sitting with hips and knees bent (B); crawling on hands and knees (C).

- Gravity acting on the affected part of the body. This can, for example, result in drop foot. External weights, such as blankets pressing on the foot, can lead to equinus deformity. Bending backwards of the knee (genu recurvatum) or bending sideways (genu valgum or genu varum) can be due to the weight of the body itself acting on an unstable knee.
- Maintaining an unfavourable position for a long time. Sitting all day with flexed hips and knees leads to flexion contracture of these joints (Fig. 1B); crawling or moving in a crouched position on hands and bent knees also leads to fixed knee and hip contractures (Fig. 1C).

Distribution of deformities

Deformities occur most frequently in the lower limbs, but the trunk and upper extremities may also be involved. Any joint can be affected, most often the hip, knee and foot, alone or in combination. Further descriptions of deformities of the lower extremities are given in the relevant chapters on specific surgical procedures.

Functional consequences

Deformities seriously aggravate the consequences of paralysis. Their harmful effect is especially apparent in locomotion. For instance, a person may be able to walk upright, even if the quadriceps or gluteus maximus muscle is paralysed, provided that the joints are straight. Flexion contracture of the knee or hip makes erect walking impossible.

3
Evaluation of the patient before surgery

Careful evaluation of the patient before surgery is essential for setting up an adequate programme of treatment and rehabilitation. In addition to a routine history-taking and examination, evaluation should include: muscle-testing to determine the extent of paralysis; identification of deformities and determination of their impact on functional performance; functional assessment (stance, locomotion, self-care, physical independence); and overall assessment of the patient.

The decision as to whether the patient qualifies for surgery and, if so, what procedures would be appropriate, must be based on the information thus gained.

Muscle-testing

Muscle-testing provides information on the degree of paralysis of a particular muscle or muscle group. For practical purposes it is sufficient to use a simplified method of Lovett's manual testing, which distinguishes six grades of muscle power, ranging from grade 0 (no power, complete paralysis of the muscle) to grade 5 (normal, full power). The details are as follows (Fig. 2):

- 0 — no contraction of the muscle, which is completely paralysed.
- 1 — a flicker of contraction, which can be felt when the muscle is touched, but which does not bring about any movement at all.
- 2 — sufficient muscle contraction to move the joint, but only when the effect of gravity is eliminated (e.g., in water, in a sling, on a slippery horizontal surface). A grade 2 muscle may also be able to move the joint a little against gravity.
- 3 — sufficient contraction of the muscle to move the joint against gravity (e.g., the quadriceps muscle straightens the knee completely when the person is sitting).
- 4 — sufficient muscle strength to move the joint against gravity and some resistance (e.g., the knee can be straightened with some load attached to the leg, or against the resistance of the examiner's hand).
- 5 — normal, full muscle power.

Testing of all individual muscles of the limbs and trunk requires special training. However, techniques for testing major muscles or groups of muscles of the lower limb can be easily learned. Hip extensors, quadriceps, gastrocnemius and foot extensors are the most frequently paralysed muscles; together with trunk muscles, they are the most important for upright position and gait.

The testing scheme described below refers only to the major muscle groups

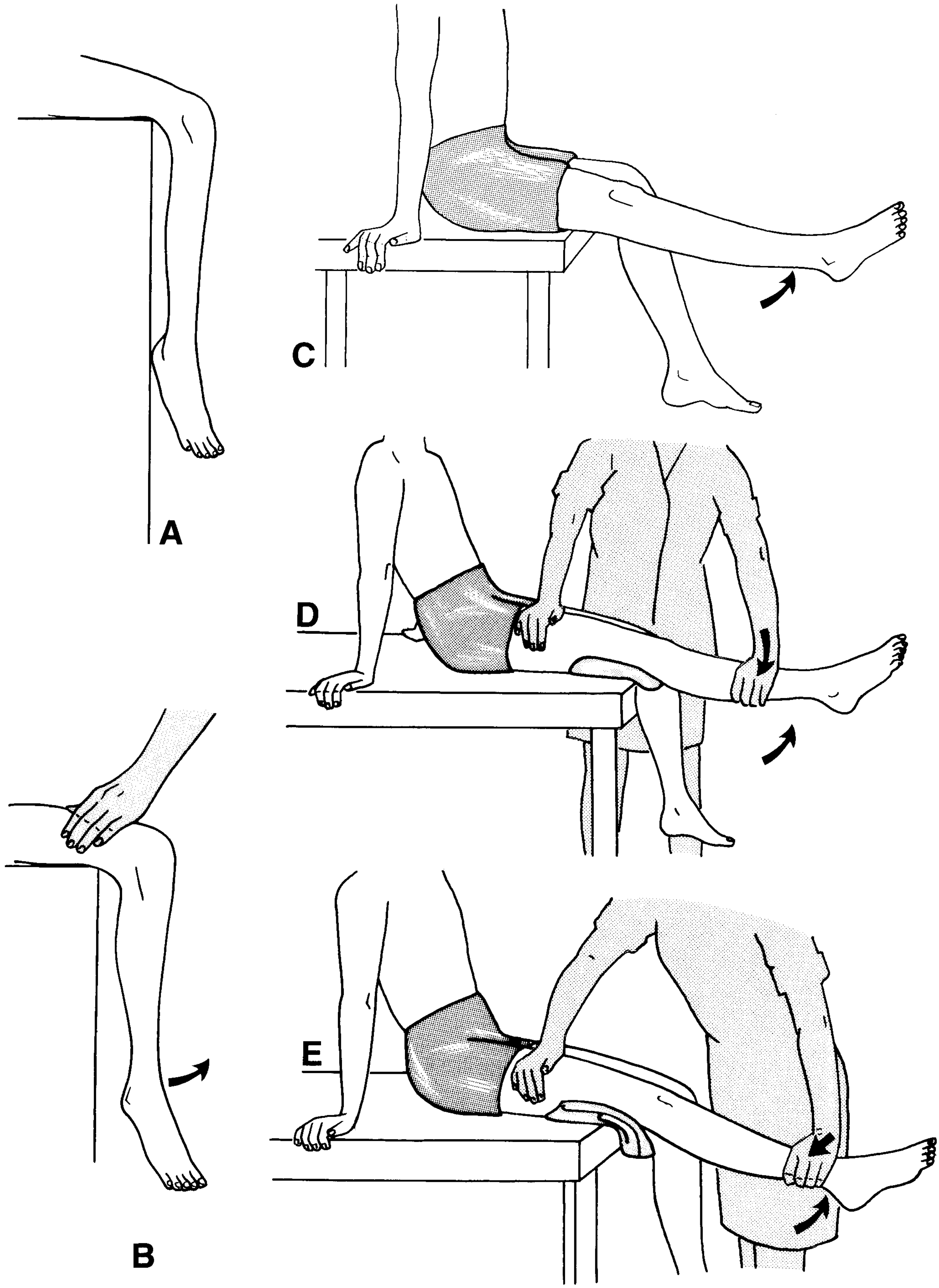


Fig. 2. Grades of muscle strength. Grade 0, no contraction of the muscle (A); grade 1 or 2, flicker or slight contraction, no movement or slight movement (B); grade 3, full movement against gravity (C); grade 4, full movement against additional resistance (D); grade 5, full power in the muscle (E).

of practical importance for posture and walking, and which are important for the prevention and treatment of deformities of the lower extremity.

Testing lower limb muscles

Hip muscles

Extensors

The gluteus maximus muscle, lying posterior to the hip joint, is a prime mover in the extension of the hip joint, and a key muscle for erect stance and gait. Bilateral paralysis of hip extensors makes erect walking very difficult or impossible, especially in the presence of severe flexion contractures. However, patients with paralysed hip extensors can walk with the aid of crutches or other supports provided that there are no excessive flexion contractures.

Testing technique. Place the patient in a prone position. Ask the patient to raise the limb. Ability to raise the leg above the horizontal indicates that the muscle is fairly good with power of at least 3 (Fig. 3A). If the leg can be raised against resistance (e.g., the examiner's hand pushing down), muscle power is 4 or 5 (Fig. 3B). If the patient cannot raise the limb, the muscle is paralysed or severely weakened (grades 0, 1 and 2).

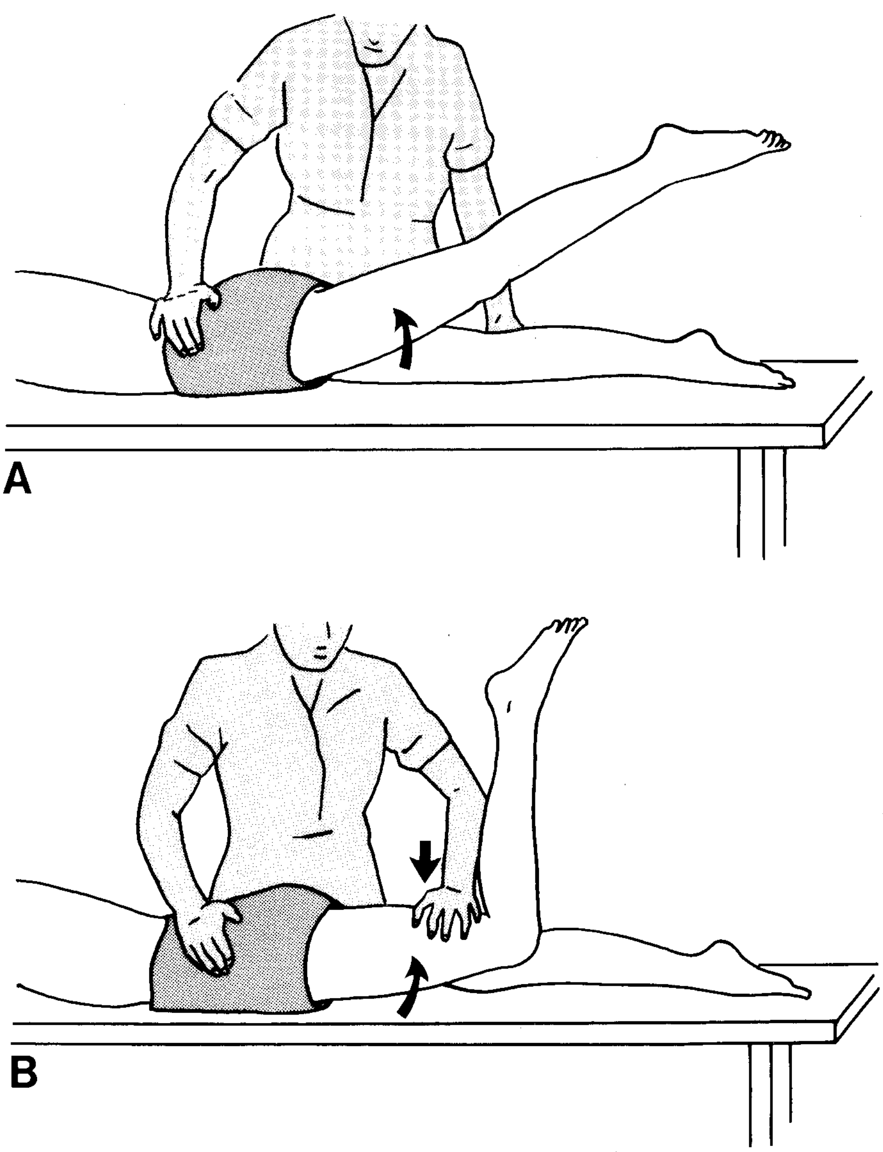


Fig. 3. Testing hip extensors. Lifting the leg straight (A); lifting the leg against resistance with the knee bent (B).

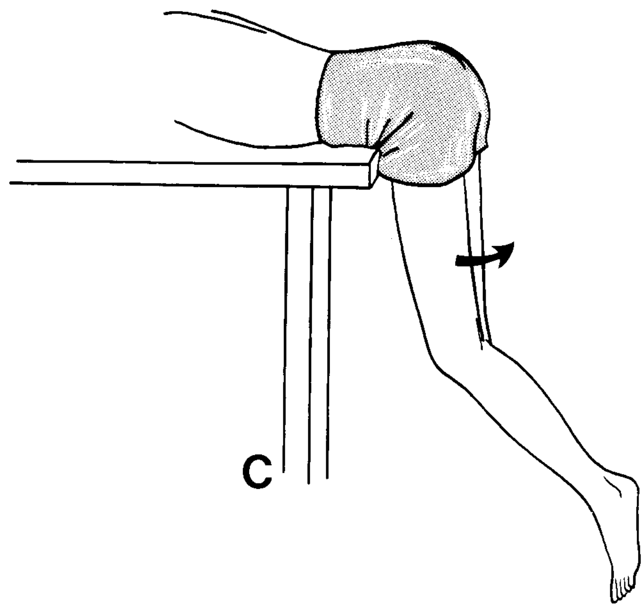


Fig. 3 Testing hip extensors (*continued*)**. Lifting the leg hanging over the edge of the table (C).**

An alternative testing technique can be used with a person who has marked hip flexion contracture. Place the person prone with the thighs hanging over the edge of the couch. Ask the person to raise the leg, first with the knee bent, then straight (Fig. 3C). Watch that the person does not roll his[1] body forward to extend the hip passively against the couch.

Flexors

The iliopsoas muscle, in front of the hip joint, is the principal hip flexor. It is assisted by other muscles such as the sartorius, rectus femoris, and tensor fasciae latae. Shortening of these muscles results in flexion contracture of the hip.

Testing technique (Fig. 4A). Seat the patient on a chair or table. Ask him to lift up his thigh and assess the muscle power as he does so. The person should not lean backwards from the trunk.

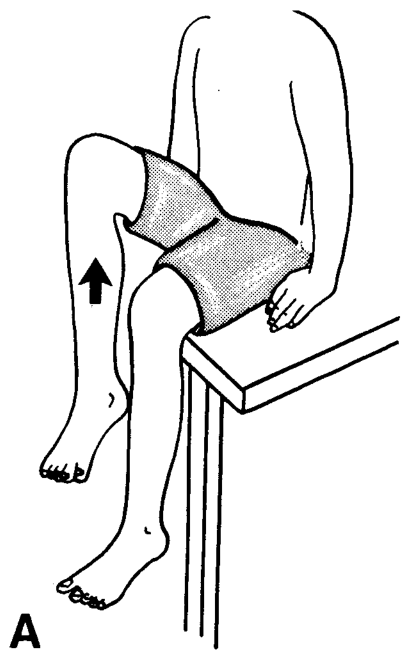


Fig. 4. Testing hip muscles. Hip flexors (A).

[1] For the sake of convenience, the masculine gender has been used throughout this manual for pronouns referring to the patient.

Abductors

The gluteus medius, gluteus minimus, and tensor fasciae latae muscles are the main abductors of the hip. They lie on the lateral aspect of the hip providing lateral stability of the joint. Shortening of these muscles contributes to the development of abduction contracture of the hip.

Testing technique (Fig. 4B). Place the patient in the lateral position, the pelvis held steady and the hip extended. Ask the patient to raise the top leg, first with the knee flexed, and then with the knee extended.

Adductors

The adductors are a powerful group of muscles on the medial aspect of the thigh whose paralysis can contribute to the development of abduction contracture of the hip. The adductor muscles are very seldom contracted and shortened in poliomyelitis.

Testing technique (Fig. 4C). Ask the patient to lie supine with legs abducted, and then to bring the legs together. This test is not done against gravity, because it is too difficult to position the person for this purpose.

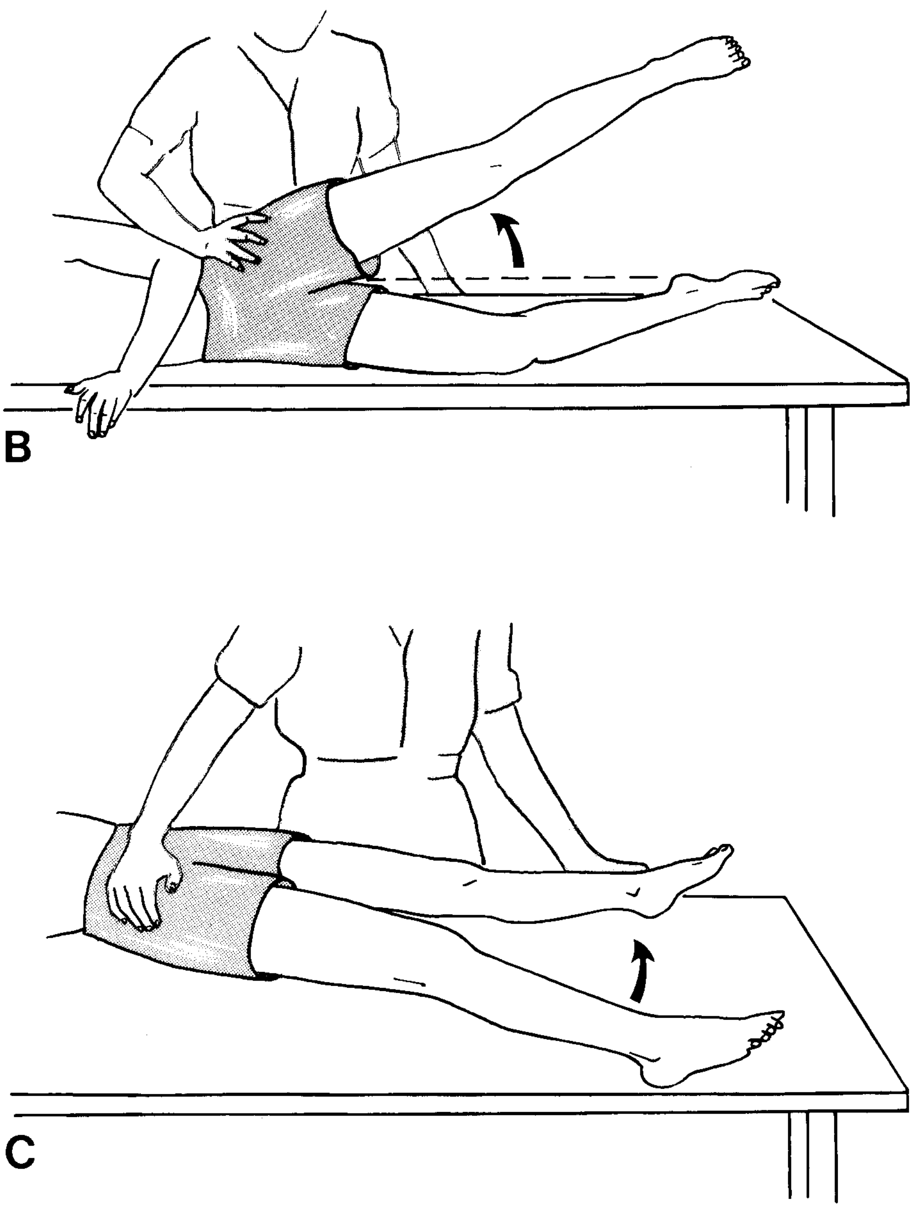


Fig. 4. Testing hip muscles (*continued*). Hip abductors (B); hip adductors (C).

Knee

Extensor

The quadriceps, a powerful muscle, is located on the anterior (including anteromedian and anterolateral) aspect of the thigh. It is the only extensor of the knee joint, and the chief stabilizer of the knee for standing and walking. Its paralysis seriously impairs walking and contributes to flexion contracture of the knee.

Testing technique (Fig. 5A). Place the patient supine on a couch with his legs over the edge, and ask him to straighten the knee. Make sure that the patient does not move his body backwards to extend the knee against the edge of the couch.

Flexors

The hamstrings (the biceps femoris, semimembranosus and semitendinosus), lying on the posterior aspect of the thigh, are the main flexors of the knee and assist in hip extension. The hamstrings also contribute to lower limb stability during walking. Their paralysis can lead to development of genu recurvatum. Shortening of these muscles results in flexion contracture of the knee.

Testing technique (Fig. 5B). Lay the patient prone on the table and ask him to bend his knee.

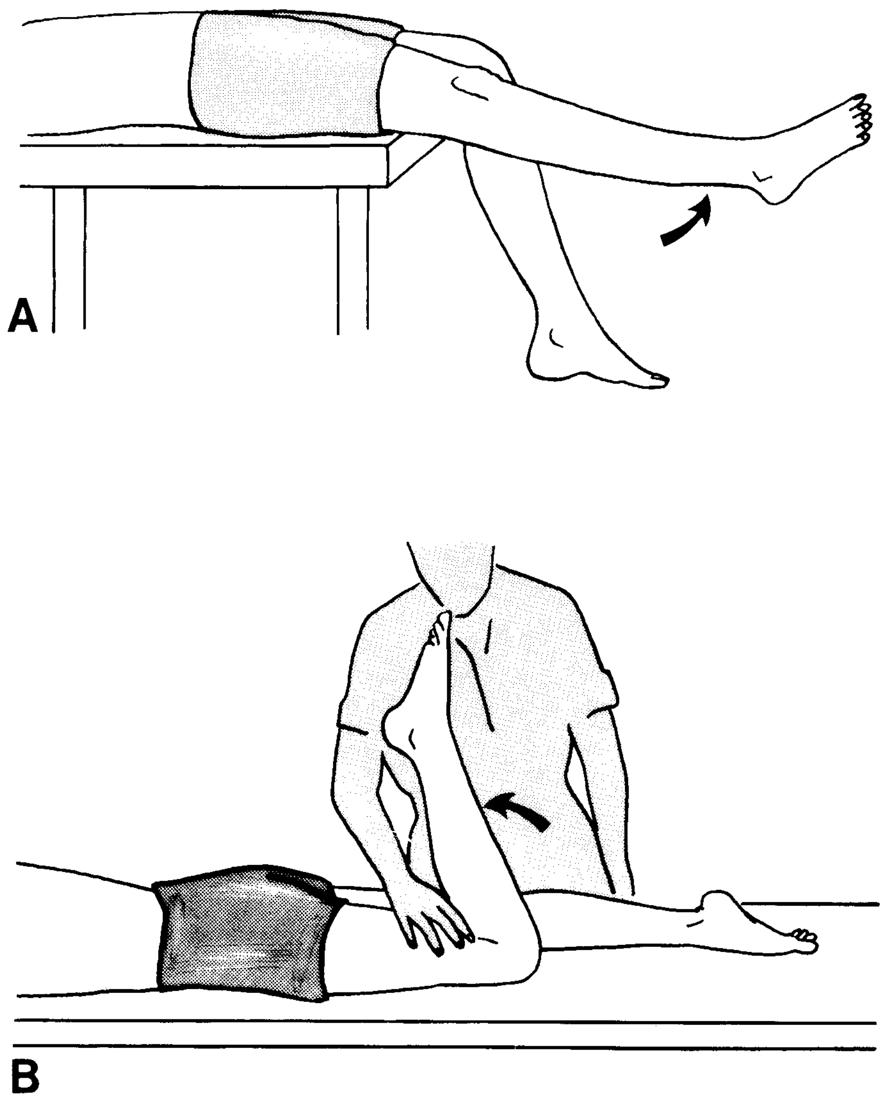


Fig. 5. Testing knee muscles. Knee extensors (A); knee flexors (hamstrings) (B).

Ankle and foot muscles

Ankle dorsiflexors

The ankle dorsiflexors are a group of muscles lying on the anterior aspect of the leg below the knee, comprising the anterior tibial and the long extensors of the toes. Paralysis of these muscles leads to drop foot, with the foot dragging on the ground during walking. If uncorrected, paralysis of the dorsiflexors ultimately results in fixed equinus deformity of the foot.

Testing technique (Fig. 6A). Ask the seated patient to bend the foot up.

Ankle plantar flexors

The triceps surae muscle is a prime ankle plantar flexor. This powerful calf muscle lying on the posterior aspect of the lower leg is assisted in plantar flexion by the long flexors of the toes, the peroneal muscles and the posterior tibial muscle. The main function of the plantar flexors is to "push-off" the foot from the ground when walking.

Testing technique (Fig. 6B). Ask the patient to stand on the toes of one leg only. The patient will be able to do so only if the triceps surae muscle is normal or in good condition (i.e., grade 5 or 4).

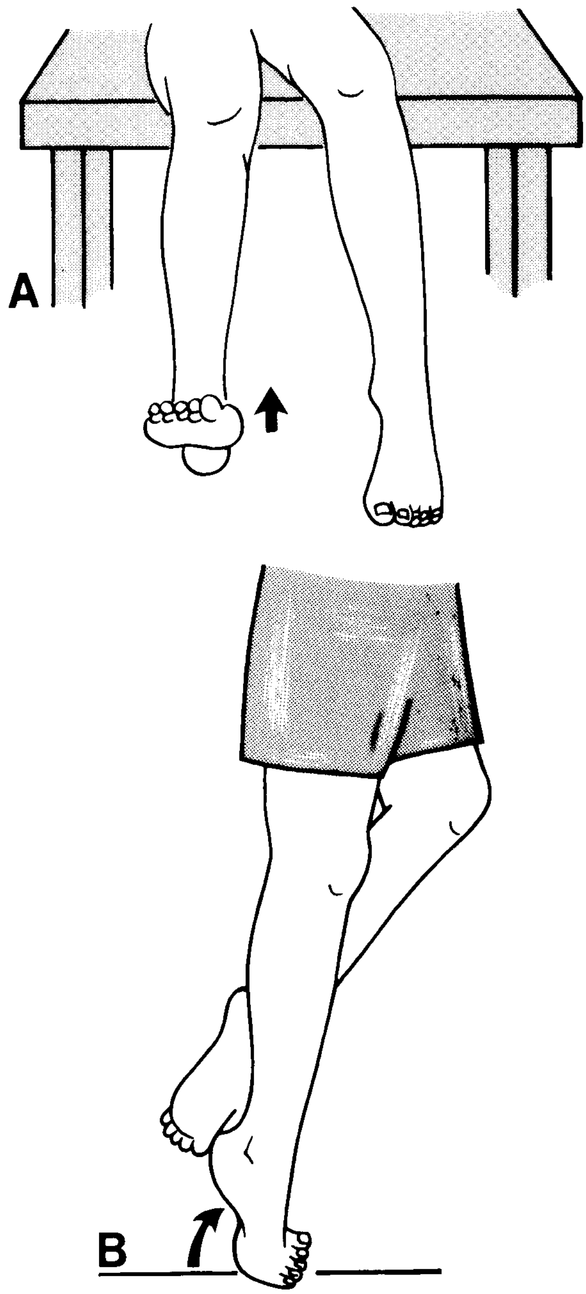


Fig. 6. Testing ankle muscles. Dorsiflexors (A); plantar flexors with the patient standing (B).

An alternative technique of testing ankle plantar flexors is with the patient lying supine (Fig. 6C); ask the patient to bend the foot down against some resistance exerted by your hand.

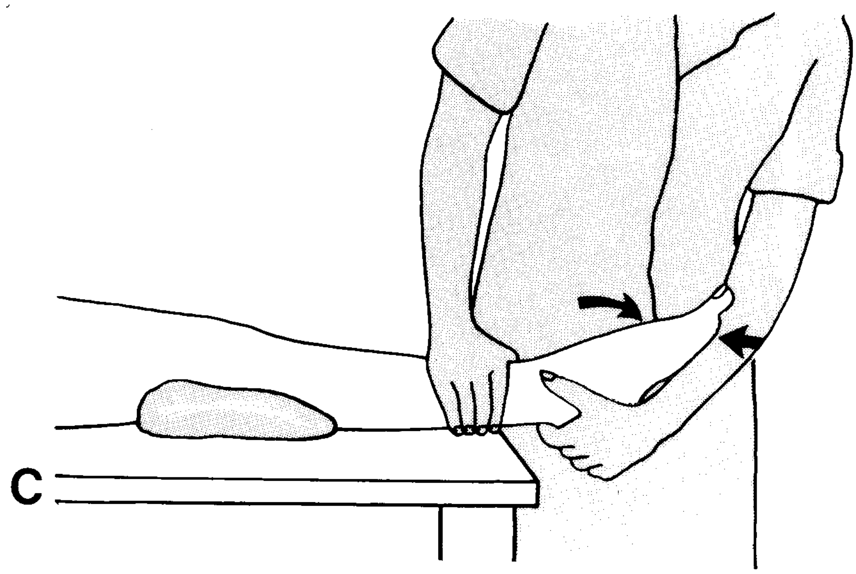


Fig. 6. Testing ankle muscles (*continued*). **Plantar flexors with the patient supine (C).**

Foot invertors (supinators)

The main foot invertors are the anterior tibial and posterior tibial muscles, which provide medial stability of the foot. The anterior tibial muscle inverts the foot in dorsiflexion, while the posterior tibial muscle inverts the foot in plantar flexion. When the invertors are paralysed, medial foot stability is impaired and valgus deformity develops. Contraction (shortening) of these muscles leads to varus deformity of the foot.

Testing technique. Ask the seated patient to lift up the medial border of the foot (invert the foot), first in dorsiflexion (Fig. 7A) to test the anterior tibial muscle, then in plantar flexion (Fig. 7B) to test the posterior tibial muscle.

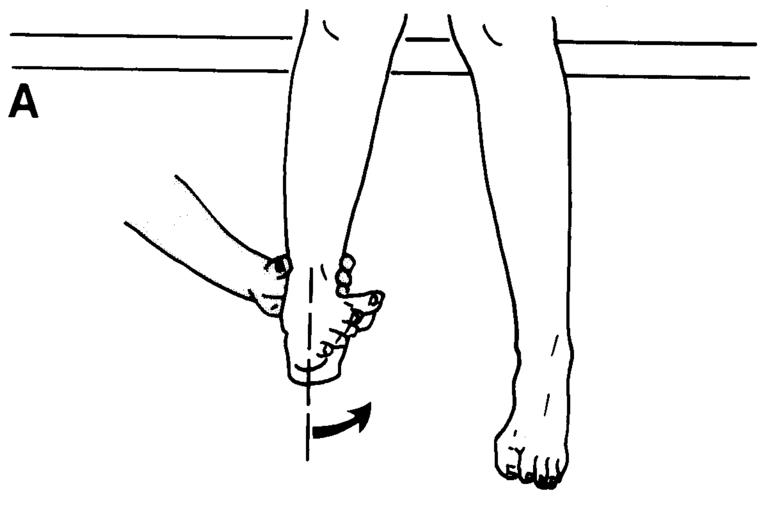


Fig. 7. Testing foot muscles. Foot invertors in dorsiflexion (A).

Foot evertors (pronators)

The long and short peroneal muscles evert the foot and provide lateral stability. If these muscles are paralysed, the foot twists inwards during walking and varus deformity develops.

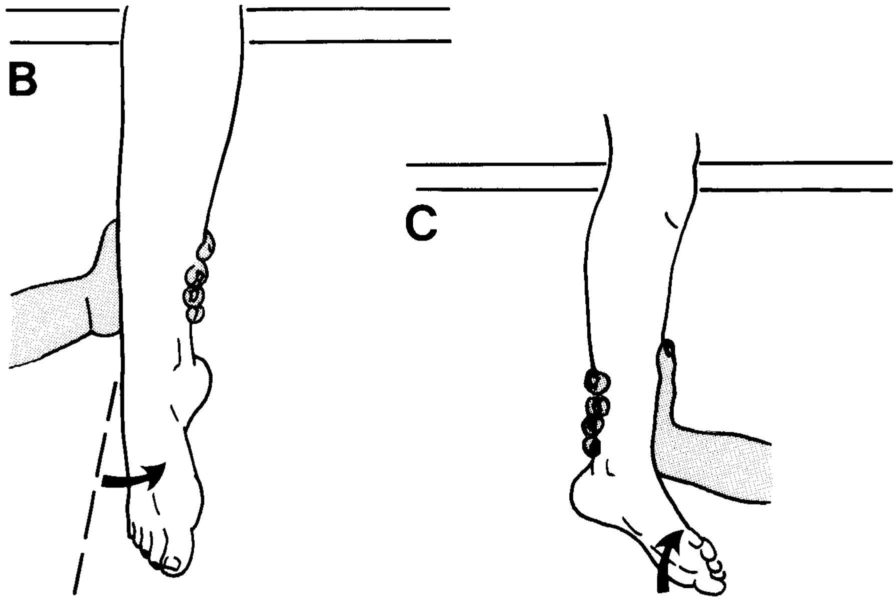


Fig. 7. **Testing foot muscles** (*continued*). **Foot invertors in plantar flexion (B); foot evertors (C).**

Testing technique (Fig. 7C). With the patient seated, ask him to elevate the lateral border of the foot (to evert the foot).

Toe flexors and toe extensors

These are groups of long and short muscles. The long muscles also assist in either plantar flexion or dorsiflexion of the foot.

Testing technique (Fig. 8). With the patient sitting or lying on a couch, ask him first to bend, then to extend, the toes.

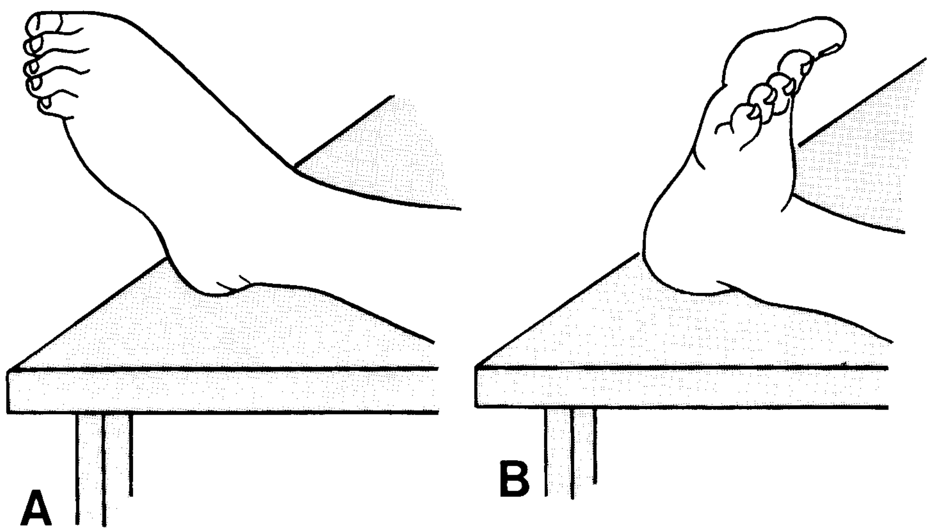


Fig. 8. **Testing toe muscles. Toe flexors (A); toe extensors (B).**

Testing trunk muscles

Although it is necessary to grade the trunk muscles as weak, fair or normal, it would be inappropriate in this case to use Lovett's grading system.

In some polio cases, the muscles of the trunk may be affected as well as the muscles of the lower limb. Normal trunk muscles provide active stabilization of the spine and ensure the stability and proper position of the pelvis in relation to the thorax and upper trunk. If these muscles are weak, the stability of the trunk and pelvis, and also standing and walking, are impaired. Polio victims with extensive lower limb paralysis associated with marked weakness of the trunk muscles have greater difficulty walking than those with unaffected trunk muscles. This is an important factor in planning treatment and selecting patients for surgery. Such patients require more extensive, thus heavier, bracing for walking after surgery.

Abdominal muscles

Symmetric weakness of abdominal muscles causes hyperlordosis of the lumbar spine, forward tilt of the pelvis, and an unsteady trunk. Asymmetric weakness of the abdominal muscles leads to the development of scoliosis (see p. 27).

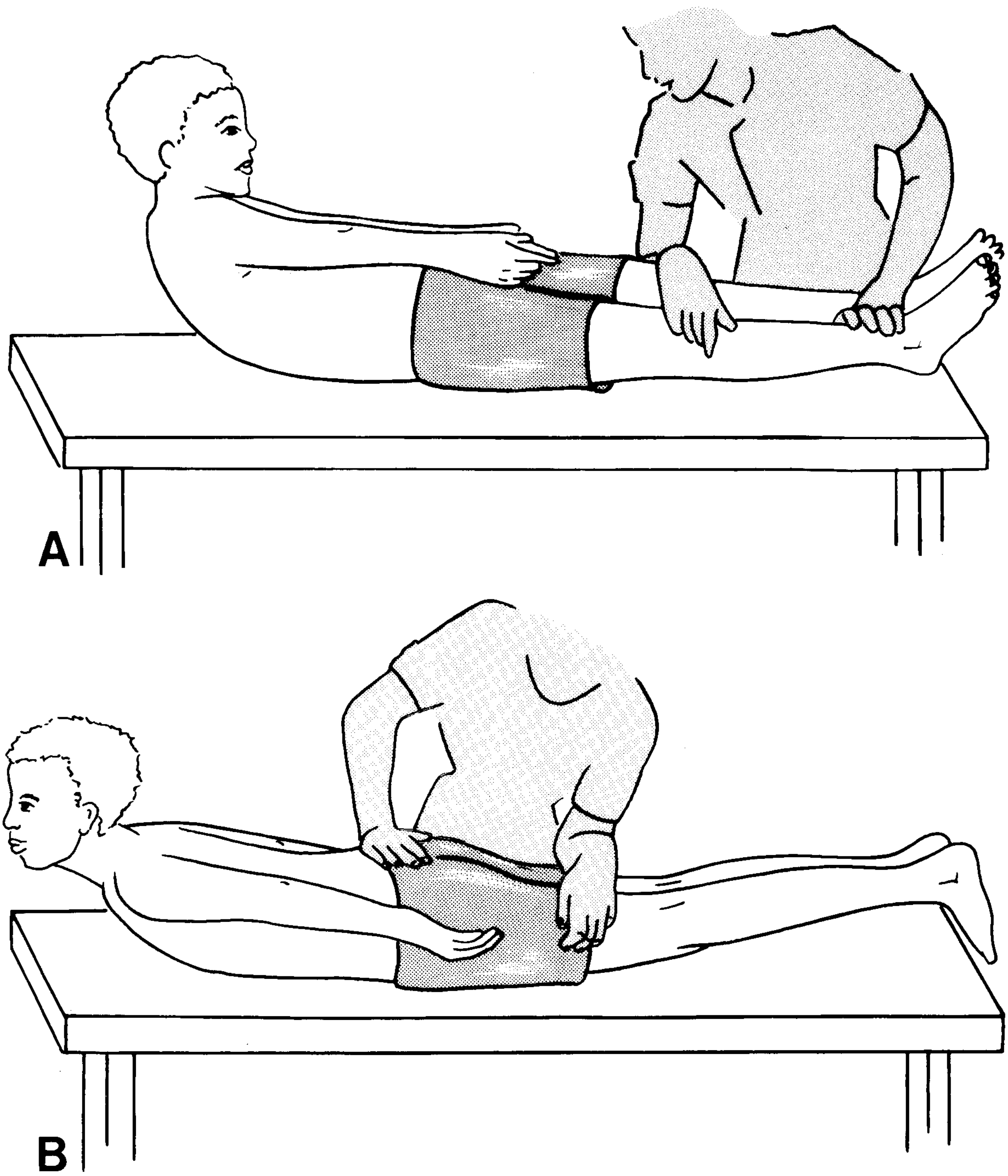


Fig. 9. Testing trunk muscles. Trunk flexors (A); trunk extensors (B).

Testing technique (Fig. 9A). Place the patient supine and steady his pelvis. Ask the patient to lift up the upper part of the body as if trying to sit up. Observe whether the manoeuvre is performed easily, with difficulty, or not at all: also watch whether the abdominal muscles become contracted and firm, or flail causing the abdomen to bulge. Bulging of the abdomen on one side, or in a particular site, indicates that an oblique abdominal muscle (or a part of one) is more affected than other abdominal muscles; in this case, check for the presence of scoliosis. Movement of the umbilicus up or down, or from side to side, also indicates asymmetrical weakness of the abdominal muscles.

Trunk extensor muscles

Weakness of trunk extensor muscles impairs posterior stability of the trunk, which then leans forward, making standing and walking difficult.

Testing technique (Fig. 9B). Place the patient in the prone position and ask him to lift up the trunk, so that his chest is clear of the table. Observe how he performs this.

Scoliosis

Asymmetric affection of the trunk muscles leads to the development of scoliosis which is a lateral curvature of the spine associated with torsion. The deformity tends to increase with time, and may create serious respiratory impairment. Surgical treatment of scoliosis is beyond the scope of the district hospital. It is mentioned here only because it may be a contraindication for lower limb surgery.

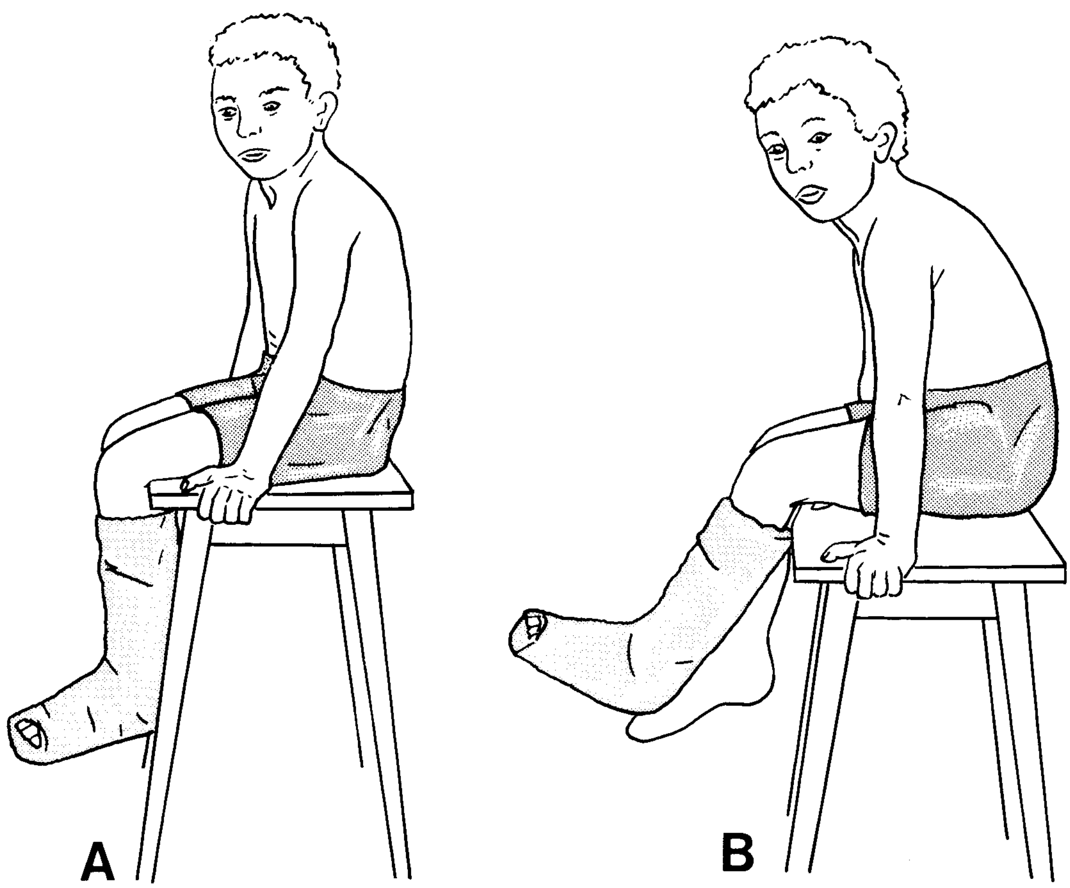


Fig. 10. Simple test for ability to use crutches. Patient sitting on a stool (A); patient lifting himself off the seat (B).

Testing upper limb muscles

Strong arms and hands are essential if the patient is to walk erect with crutches or a stick. The main muscle groups involved in effective use of crutches are the shoulder girdle stabilizers (depressors), triceps, wrist stabilizers, and the flexors of the fingers and thumb. Strong muscles provide a firm grip and steady support on a crutch or stick. Extensive weakness of upper limb muscles can prevent the patient walking erect, so that surgical correction of lower limb deformities is rendered useless.

Simple test

The ability to use crutches can be assessed generally by using one simple test (Fig. 10). Ask the patient to sit on a chair, grip its side edges, and lift up his body by supporting himself on his arms. If he is able to lift himself up off the seat, he will certainly be able to use crutches or a stick.

Classical tests for specific muscle groups

Shoulder girdle stabilizers

The term shoulder girdle stabilizers is used here to refer to the muscles that fix the scapula to the trunk (mainly anterior serratus, rhomboid and trapezius) and the muscles that steady the arm in relation to the trunk (mainly pectorals and latissimus dorsi). These muscles hold the shoulder steady and level, an important function when a patient is supporting himself on the crutches. For practical purposes these muscles are tested together as a group.

Testing technique (Fig. 11A, B). Have the patient sit on a chair, with the arms adducted (against the body) and the elbows bent to 90°. Stand in front of the patient, place your hands under his elbows and push his arms up vertically as if trying to lift him off the seat. Ask the patient to resist by pushing his arms down against your hands. If the shoulder girdle stabilizers are strong, the child will be able to keep his shoulders level as you lift him from the seat.

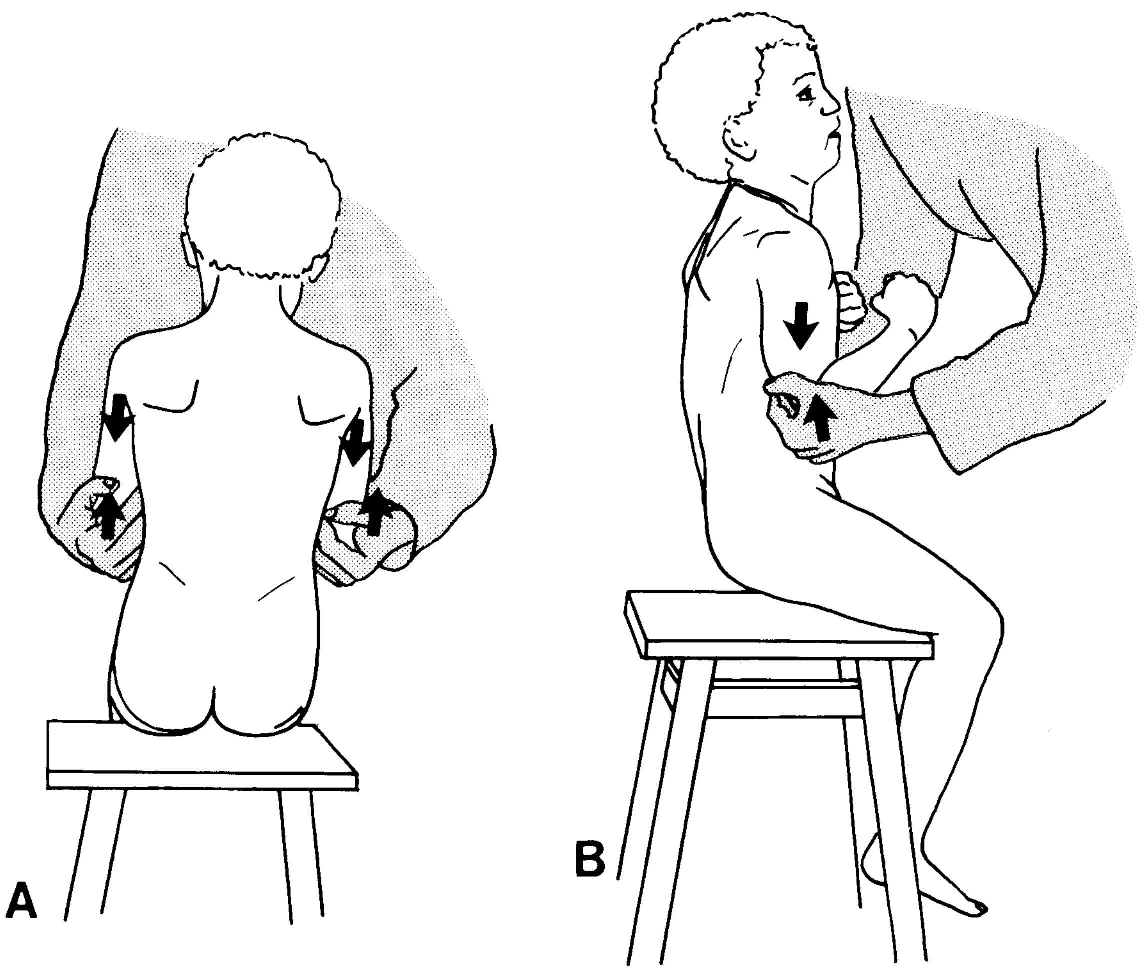


Fig. 11. Testing shoulder girdle stabilizers. Examiner lifting a patient with strong shoulder stabilizers — posterior view (A), lateral view (B).

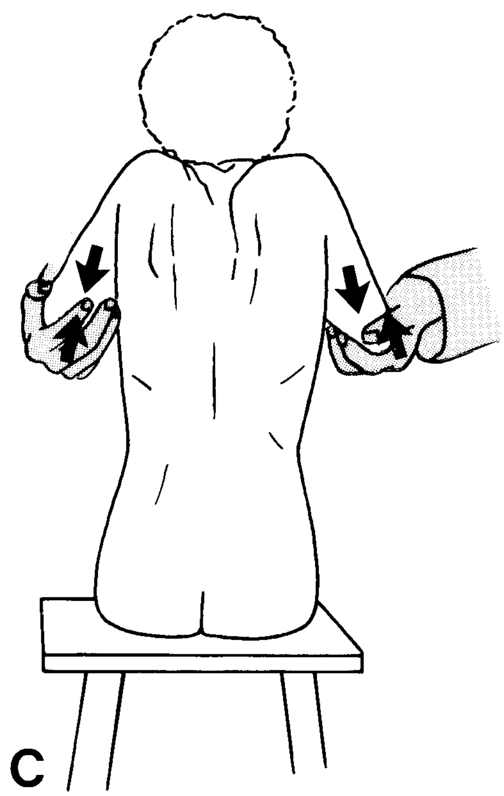


Fig. 11. Testing shoulder girdle stabilizers (*continued*)**. A patient with weak shoulder stabilizers (C).**

If the stabilizers are weak the shoulders will be pushed up, with little or no resistance (Fig. 11C). If this happens, the patient would not be able to support himself on crutches.

Triceps muscle

The triceps muscle is the main extensor and stabilizer of the elbow.

Testing technique (Fig. 12A, B). Place the patient on his back, holding his arm elevated vertically. Ask him to bend the elbow and then to straighten it. If he is able to straighten the elbow, the triceps muscle strength is at least grade 3. For safe walking with crutches, grade 4 or 5 is necessary. However, in some instances, patients can use crutches even with a very weak triceps muscle provided that the elbow has no flexion contracture and can be positioned in hyperextension.

Wrist stabilizers

The wrist extensors stabilize the wrist, allowing the flexors to act efficiently. In addition, they prevent the hand from dropping, i.e., bending down at the wrist.

Testing technique. With the patient standing or sitting and the forearm supinated (palm up), ask him to bend his wrist (Fig. 12C). Place your hand on the patient's palm and resist the movement. Assess the strength of the wrist flexors by the amount of strength needed to counter the movement. A patient needs strong stabilizers to be able to use crutches. To test wrist extensors, ask the person to extend his wrist with the forearm pronated (palm down) (Fig. 12D). Assess the strength of the extensors by the resistance needed to counter the movement. If the wrist is too weak to carry weight, consider a platform crutch.

Finger and thumb flexors

Testing technique. For practical purposes it is sufficient to test the strength of the finger and thumb flexors by asking the person to squeeze your fingers. If the grip on your fingers is firm, the flexors are strong enough for the patient to use crutches.

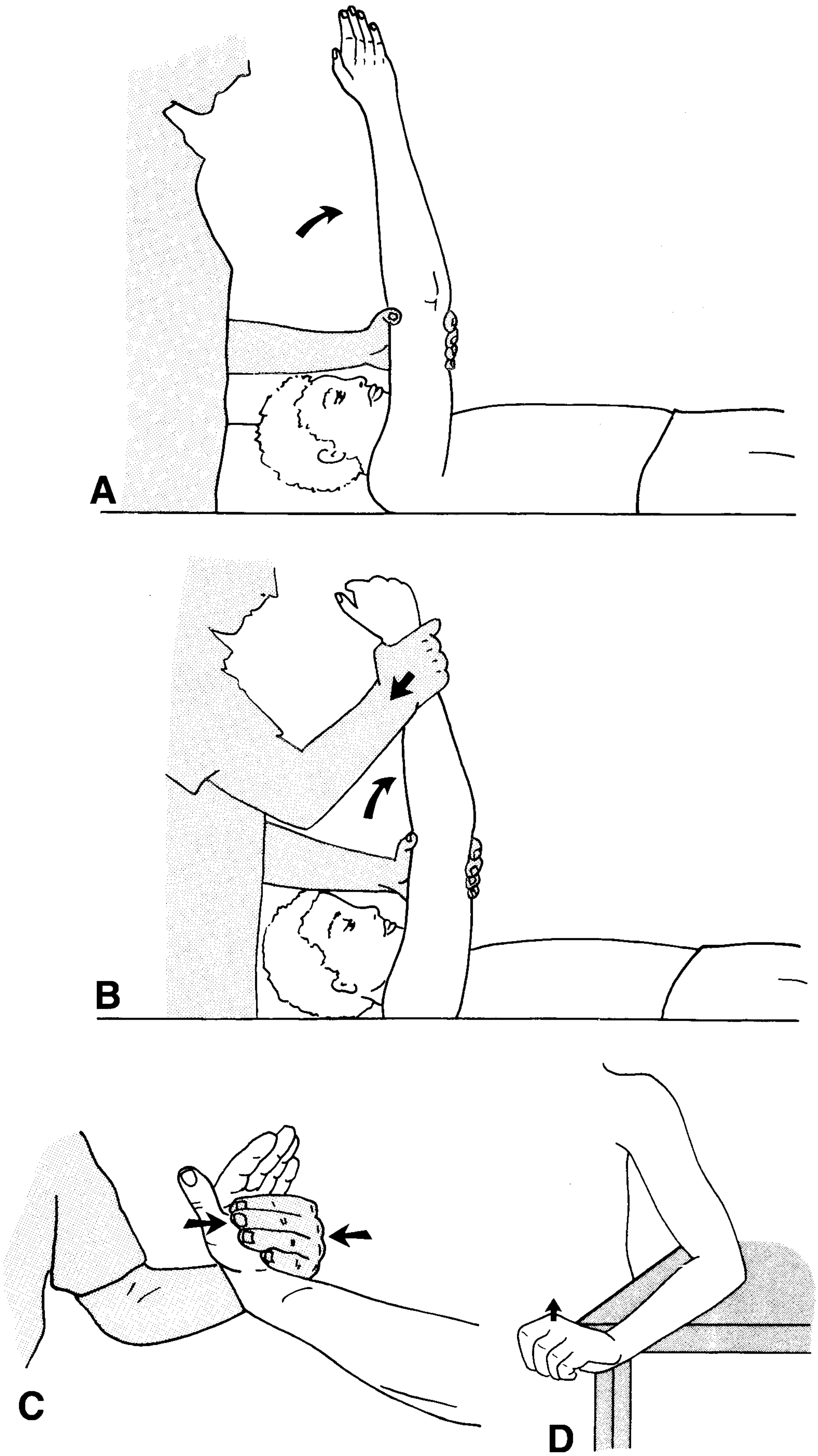


Fig. 12. Testing arm muscles. Triceps brachii — extending the elbow against gravity (grade 3) (A); extending the elbow against additional resistance (grade 4 or 5) (B); wrist flexors (C); wrist extensors (D).

Identification of deformities

Some deformities of the lower limb, e.g., flexion contracture of the knee, are evident and easy to identify, while others, e.g., deformities of the hip, may be less obvious and must be detected by special examination techniques. The deformities are measured in degrees.

Hip deformities

The most common deformity of the hip in patients who have had polio is a flexion–abduction contracture. It is often masked by lumbar hyperlordosis (Fig. 13A) and oblique position of the pelvis. To detect this contracture and determine its degree, the following technique should be used.

- Place the patient supine on a firm examination table. Hold the pelvis level, i.e., with the line passing through both anterosuperior iliac spines at a right angle to the long axis of the trunk. Hold the contralateral leg fully flexed at the knee and hip and brought up to the patient's chest, so that the lumbar spine becomes flat on the table. (The patient himself may hold this bent limb against his chest.) During this manoeuvre the limb being tested should be in a neutral position between abduction and adduction at the hip. If there is a contracture, the thigh will rise off the table (Fig. 13B). The degree of flexion contracture is determined by the angle between the surface of the table and the long axis of the thigh (Fig. 13C).

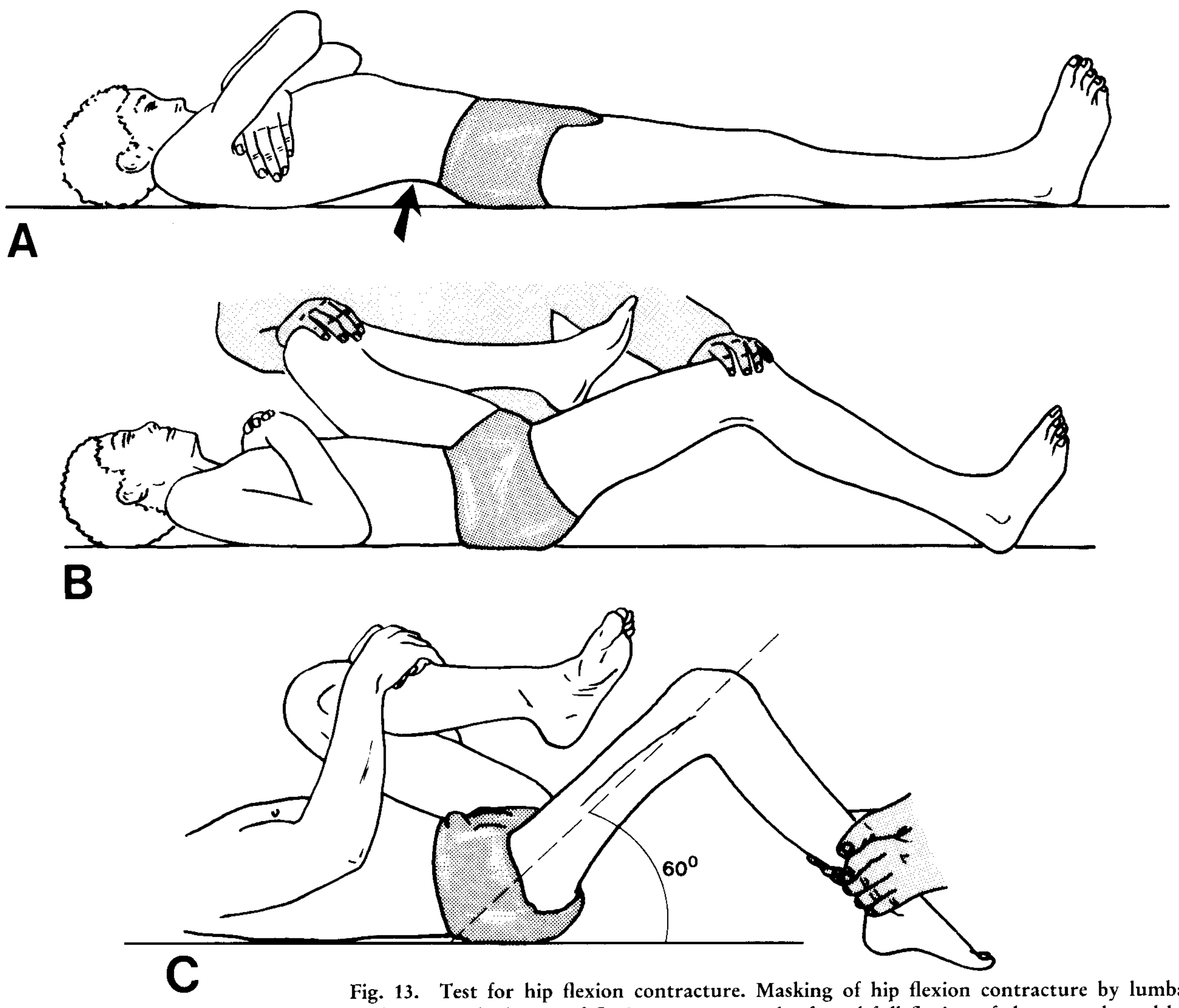


Fig. 13. Test for hip flexion contracture. Masking of hip flexion contracture by lumbar lordosis (A); disclosure of flexion contracture by forced full flexion of the contralateral hip (B); degree of contracture is determined by the angle between the long axis of the thigh and the plane of the table (C).

If this angle does not change when the hip is abducted, the contracture is one of flexion alone. If the angle of flexion diminishes during abduction and increases again on adduction, there is a flexion–abduction contracture (Fig. 14A, B). The degree of the abduction component of the deformity is determined by the angle between the long axis of the trunk and the thigh, with the pelvis level, and both the lumbar spine and the thigh under examination lying flat on the table.

Contracture of the hip in external rotation frequently accompanies the flexion–abduction contracture, and is detected in the following way:

- Have the patient sit on a couch or table with knees bent over the edge. The angle between the long axis of the lower leg and the vertical indicates the degree of rotation (in external rotation the lower leg points inward, while in internal rotation it points outward) (Fig. 14C, D).

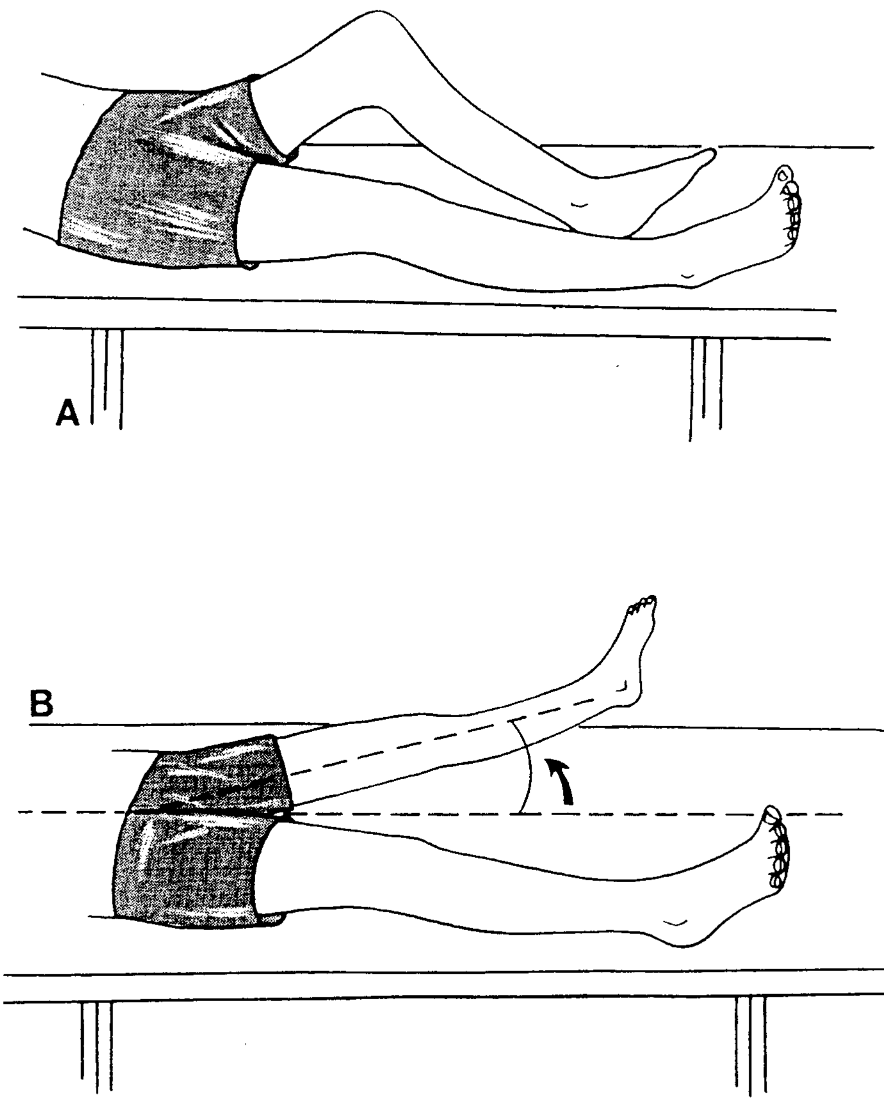


Fig. 14. Test for rotational contracture of the hip. In neutral abduction–adduction position, the hip stays bent (A); flexion contracture decreases when hip is abducted (B).

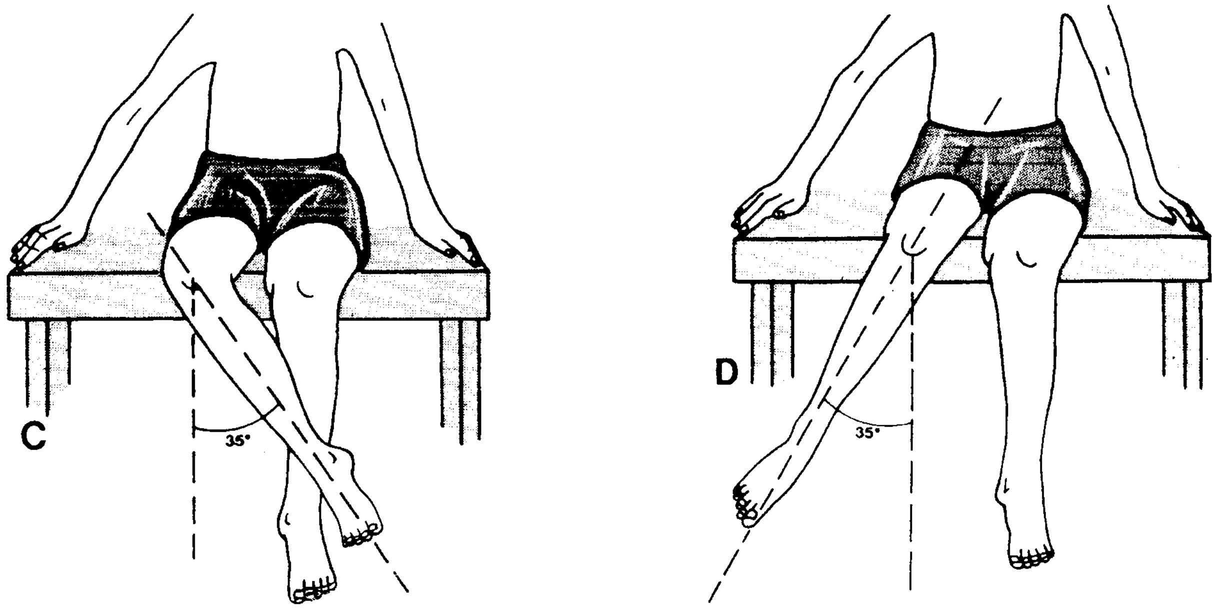


Fig. 14. Test for rotational contracture of the hip (*continued*). **Contracture of the hip with external rotation (C); contracture of the hip with internal rotation (D).**

In the case of adduction contracture of the hip, the thigh assumes an adducted position when the pelvis is held level on the table. An attempt to abduct the thigh clauses obliquity of the pelvis, the anterosuperior iliac spine on the affected side being displaced proximally. Adduction contracture is rare in polio.

Knee deformities

Flexion contracture of the knee is easily recognized. The knee stays bent in spite of passive straightening (e.g., by the person doing the examination). The angle between the long axis of the thigh and the lower leg indicates the degree of flexion contracture (Fig. 15). Flexion contracture may be accompanied by excessive external rotation of the tibia and valgus deformity of the knee, the exact extent of which may be difficult to determine when the knee is bent. To detect such complications, use the following technique:

- Keep the patient's thigh in the neutral position at the hip with the patella facing anteriorly. Observe the long axis of the foot: if the foot points outwards to any great extent there is an excessive external rotation of the tibia. There is a valgus deformity of the knee if the long axis of the lower leg is deviated more than 10° outwards in relation to the thigh.

Foot deformities

Foot deformities are often obvious. Equinus deformity refers to a foot which is fixed in plantar flexion at the ankle. The foot cannot be brought into a neutral position. The patient walks and stands on tiptoe. In a varus deformity, the foot is in an inverted position which cannot be corrected by manipulation. The patient stands or walks on the lateral or dorsolateral aspect of the foot. Valgus deformity is present if the foot stays in an everted position, which is more or less fixed. The patient stands and walks on the medial border of the foot.

Varus or valgus deformity may accompany an equinus deformity, giving rise to talipes equinovarus (Fig. 16) or equinovalgus, respectively. A valgus or varus deformity is a natural compensation for contracture of the gastrocnemius muscle.

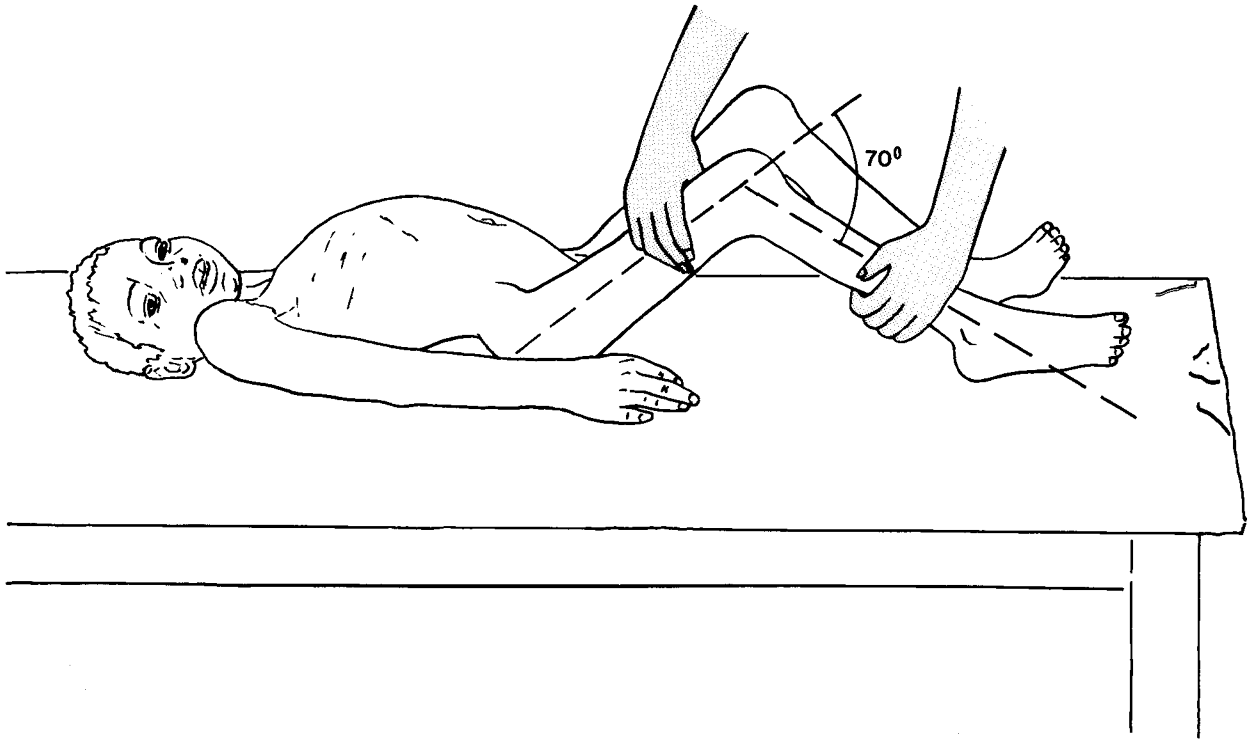


Fig. 15. Measuring the degree of knee flexion contracture.

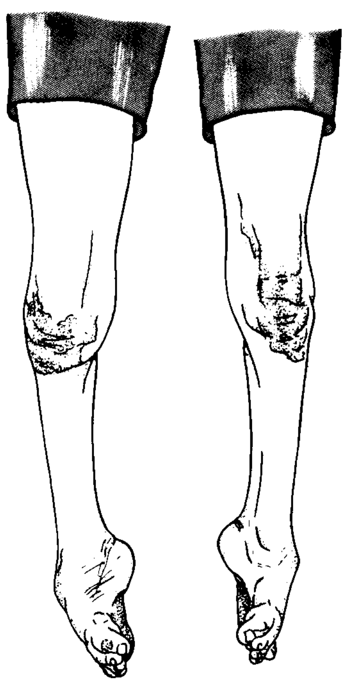


Fig. 16. Bilateral equinovarus deformity of the feet.

Functional assessment

Functional assessment focuses on stance, gait, and physical independence, including self-care. It is important to assess first whether the patient is able to stand unaided (as may be the case when only one leg is affected) or assisted, e.g., supported by another person, by holding on to firm objects (a table, parallel bars), or using crutches or canes. Next watch the person moving around; note whether he is able to walk erect and unassisted, with a cane, stick, or crutches, holding on to surrounding objects, or supported by another person, or whether he crawls on hands and knees. Crawling is common in patients with severe contracture of the hips or knees.

Find out the main cause of impaired locomotion, and identify the instability or deformities that are mainly responsible for the inability to walk erect. Assess the strength of the patient's arms. Strength and stability of the shoulder girdle, elbow and wrist, and a firm grip are needed for efficient use of crutches or sticks. Observe also whether the patient has found additional ways of moving around (e.g., using self-made aids), his performance in moving (speed and fatigue), and degree of physical independence in this regard. Finally, note whether the person can carry out routine activities of daily living, especially self-care.

Overall assessment

In addition to the physical and functional factors described above, the overall assessment should take into account socioeconomic and environmental factors, such as living conditions, any problems with schooling or employment, and whether rehabilitation training and follow-up are available. Certain personal factors are also relevant, such as the age of the patient, what he expects from surgery, his adaptation to his disability, and his emotional status and motivation for rehabilitation.

Selection of patients for surgery

The role and place of surgery in rehabilitation

The goal of basic rehabilitation surgery for polio patients is to help them become independent and self-sufficient, by correcting or reducing deformities and dysfunctions, thus enabling them to stand and move. To achieve this goal, the surgery must be part of a planned programme of rehabilitation, and must be followed by rehabilitation training, including not only provision of braces but also exercises and training in posture, positioning of limbs and walking. If such training cannot be guaranteed, it is preferable not to perform surgery.

The specific aims of surgery are:

- to correct deformities that either interfere directly with daily activities, in particular with locomotion, or contribute to the development of further deformities;
- to stabilize flail and unstable joints;
- to improve motor function of the affected part through tendon transfer.

Expected advantages and risks of surgery

Surgery may provide considerable functional and psychological benefits. For instance, children who have to crawl on their hands and knees have greatly limited mobility and, in some cultures, are subject to harassment and scorn. Release of contractures can enable such children to walk erect. Benefits are especially impressive if only one leg is involved. After the operation considerably less bracing and training are needed than for paraplegic patients, and the children are much more physically independent and mobile.

The benefits of surgery are less spectacular in children with extensive paralysis, involving both legs and trunk, or with severe deformities of all lower limb segments. In such cases, several surgical procedures (six or more) may be needed, followed by extensive bracing and long-term rehabilitation training, and even then the final outcome is always uncertain.

Similarly, the expected advantages of surgery in adults with "old polio" should be regarded with caution, particularly in patients over the age of 25 with marked deformities of long duration and involving many joints. Such patients have usually long adapted to their disability. The many surgical procedures needed to correct the deformities increase the risks of complications, and disturb the patient's adaptation. However, for younger people with a single moderate contracture, and especially with deformities of the foot, surgery can result in better function and appearance.

Rehabilitation surgery carries specific risks in addition to those inherent in any surgery (wound infection, haematoma, haemorrhage, dangers related to anaesthesia). Surgery may fail to meet the patient's expectations of improved function and appearance; for this reason, it is important to select patients carefully for surgery and to explain clearly to the patient and his parents the expected results of the operation. Accidental injury to nerves and vessels may be caused by the surgery or by overstretching after surgery. The risk of injury by overstretching is especially high in adults with long-standing deformities. Advice on avoiding or minimizing these risks is given in the relevant sections on specific surgical techniques.

With regard to the possible benefits and risks associated with basic rehabilitation surgery, patients may therefore be divided into three groups:

1. the benefits expected are considerable and the risks minimal provided that appropriate precautions are taken during and after the operation;
2. the benefits, though modest, outweigh the possible risks; and
3. the benefits are questionable or uncertain, while the risks are considerable. It is best to avoid surgery in this group.

Criteria for selecting patients

The following patients may be considered for surgery:

- Children with only one leg affected, who have difficulties moving because of contractures of the affected limb.
- Children with both legs affected, even if extensively, but who have good trunk muscles and strong upper limbs (the latter is a prerequisite for surgery).
- Young adults with one or a few moderate deformities, e.g., of the foot or the knee.
- Children and young adults with difficulties in self-care because of lack of active elbow flexion, so that the hand cannot, for example, reach the face and head. The hand must be functional and, in addition, the muscles that originate from the medial humeral epicondyle should be strong.
- Children with complete paralysis and marked deformities of both lower limbs and weak trunk muscles but good upper limbs may be considered for surgery, but only cautiously. A thorough preoperative evaluation and overall assessment should carried out.

Contraindications to surgery

Children in whom both lower extremities and the trunk muscles are severely affected and the upper extremities are weak do not qualify for surgery. Similarly, adults in whom there is extensive involvement of the limbs which is of long duration should not be considered for surgery.

4
Basic techniques

Procedures on soft tissues and on bones outside the joints may be performed on patients of any age from 2–3 years upwards.

To avoid repetition in chapters on specific surgical procedures, some technical details concerning the handling of muscles are described here.

Soft-tissue release

Soft-tissue release is aimed at correcting soft-tissue contractures. It involves division (section) of the shortened structures, such as fasciae (fasciotomy), fibrotic muscles (myotomy) or their tendons (tenotomy), and articular capsules (capsulotomy). If the muscle is shortened but good (grade 4 or 5), lengthening of its tendon is preferred to simple division in order to preserve function. The tendon may also be transferred to another site, thus eliminating its deforming action while providing a new useful function.

An electric knife (diathermy) should ideally be used to divide tight structures, since it results in much less bleeding. If diathermy equipment is not available, a knife and scissors may be used, as needed.

Procedures on bones

Procedures on bone should be carried out in absolutely aseptic conditions.

Osteotomy

Osteotomy consists of cutting through the bone and realigning it. Its aim is to correct deformities of the joints or bones that cannot be corrected by procedures on soft tissues.

Arthrodesis

In arthrodesis (Fig. 17A, B), the articular cartilage is resected along with the underlying bone, and the raw bony surfaces are then apposed to obtain fusion of the joint. The aim of arthrodesis is to stabilize the joint to improve the function of the limb.

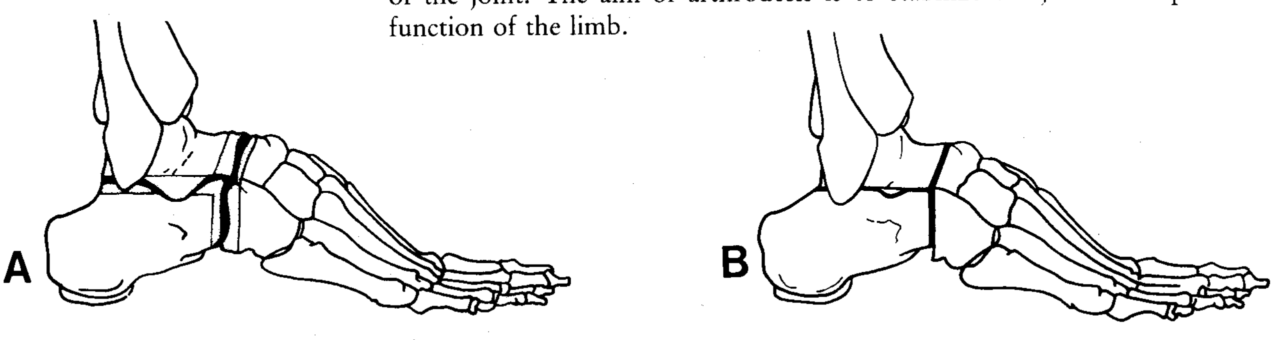
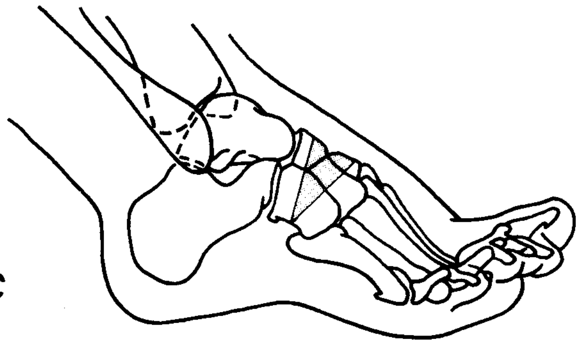


Fig. 17. Principles of triple arthrodesis of the foot and tarsal wedge resection. Midtarsal and subtalar joints to be excised (shaded area) (A); apposition of bony surfaces after excision (B).



C

Fig. 17. Principles of triple arthrodesis of the foot and tarsal wedge resection (*continued*). **Wedge resection of tarsal bones to correct cavus deformity of the foot (C).**

Resection

Bone resection (Fig. 17C) may be a part of arthrodesis when the unstable joint is also grossly deformed, such as in talipes equinovarus, in which case the articular cartilages are resected along with adjacent bone wedges to correct deformity. Wedge resection of bone to correct a fixed (bony) deformity may also be performed outside the joint, without excision of articular cartilages. Procedures that include excision of articular cartilages may be performed in teenagers and adults, but not in young children because of the risk of impairment of bone growth.

Tendon lengthening and tendon transfers

Tendon lengthening

Of the several techniques of open tendon lengthening, the most commonly used are Z-plasty and fractional lengthening.

Z-plasty is a classical tehnique which involves dividing the tendon, first longitudinally then transversely at each end of the longitudinal split (Fig. 18A, B). The longitudinal division can be made in the midline, sagittal, frontal or any oblique plane. The transverse divisions are made on opposite sides to each other; the three incisions together form a letter Z or reversed Z. The tendon is first dissected free and then slightly elevated from the underlying tissues, to facilitate cutting. The divided parts of the tendon slide against each other providing the desired lengthening. The two parts of the lengthened tendon are then sutured together side-by-side with a non-absorbable thread (Fig. 18C).

Fractional lengthening of the tendon (Tachdjian technique) may be used for lengthening of the iliopsoas or hamstring muscles (Fig. 18D). The tendon is incised transversely at two levels, about 2–3 cm apart. The incision is made only through the tendinous portion of the muscle and, as the hip or knee is extended, the tendon is lengthened by some 3–4 cm. Sutures are not used. This technique is particularly applicable to a short tendon with oblique insertion of muscle fibres.

Tendon transfers

Tendon transfers are undertaken to eliminate the deforming action of a muscle or to place a tendon in a position where it can assume a new corrective function. Details of specific tendon transfers are described in later chapters. All deformities have first to be corrected before tendon transfers are undertaken.

Any muscle to be transferred must have good power or be normal (grade 4 or 5). Both muscle belly and tendon should be handled gently, special care being taken not to damage the blood and nerve supply. The course of the transferred muscle and its tendon must be as straight as possible.

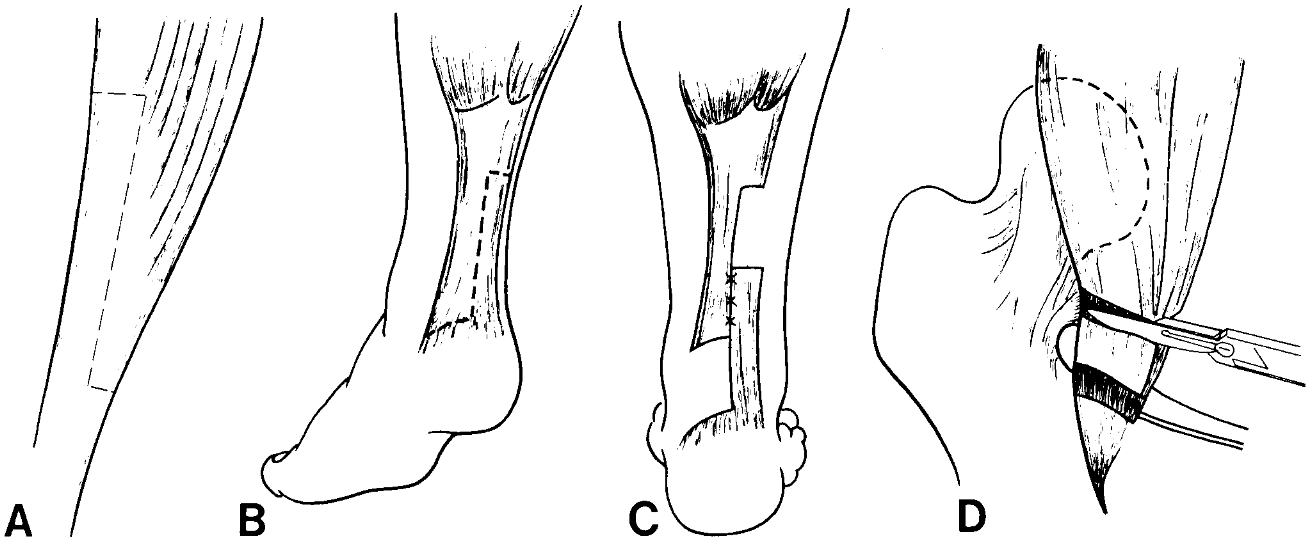


Fig. 18. Principles of tendon lengthening. Z-plasty of biceps femoris tendon (A); Z-plasty of calcaneus tendon (B, C); fractional lengthening of iliopsoas tendon (D).

Always attach the end of a transferred tendon firmly to its new site *under tension*. It will always stretch.

The tendon may be sutured to a firm fibrous structure, such as an intermuscular septum, or to the periosteum (which is usually thick and strong enough in children). However, the most secure fixation is to bone. Whatever technique is used for anchoring the tendon, a strong figure-of-eight whip suture should be inserted into the end of the tendon (Fig. 19A). Introduce the suture through the cut end of the tendon, cross it twice obliquely, then transversely, and pass it back to the cut end of the tendon.

To anchor a tendon to a bone in the foot, first make a hole through the bone, for example in the base of a metatarsal bone or in a cuneiform bone. Pass the ends of the tendon sutures, carried on a straight skin needle, through the hole and through the skin on the plantar surface (Fig. 19B, C). Pull the tendon down into the hole and tie the ends of the sutures over a rubber tube, button or a firm gauze sponge, applying moderate tension (Fig. 19D).

An alternative technique is used, for instance, with the biceps tendon in the posterior knee release (Fig. 19E, F). Make two transverse incisions, 7–8 mm apart, through the periosteum, and strip the periosteum off the underlying bone between the incisions. Freshen the exposed bone with a curette. Pass the ends of the tendon sutures under the elevated periosteum, and pull down the tendon until its end comes to lie on rough bone under the periosteum. Finally, pass the tendon sutures, on a curved bone needle, through fibrous tissues, periosteum and the underlying bone, and tie under considerable tension. Additional sutures may be inserted into adjacent periosteum and other fibrous tissues.

Local preoperative preparation

Tourniquet application

Operations on the extremities are made safer and less troublesome by the use of a tourniquet. The bloodless field facilitates identification and dissection of tissues and greatly reduces the loss of blood. However, the use of a tourniquet can be dangerous. A pneumatic tourniquet with a handpump and pressure

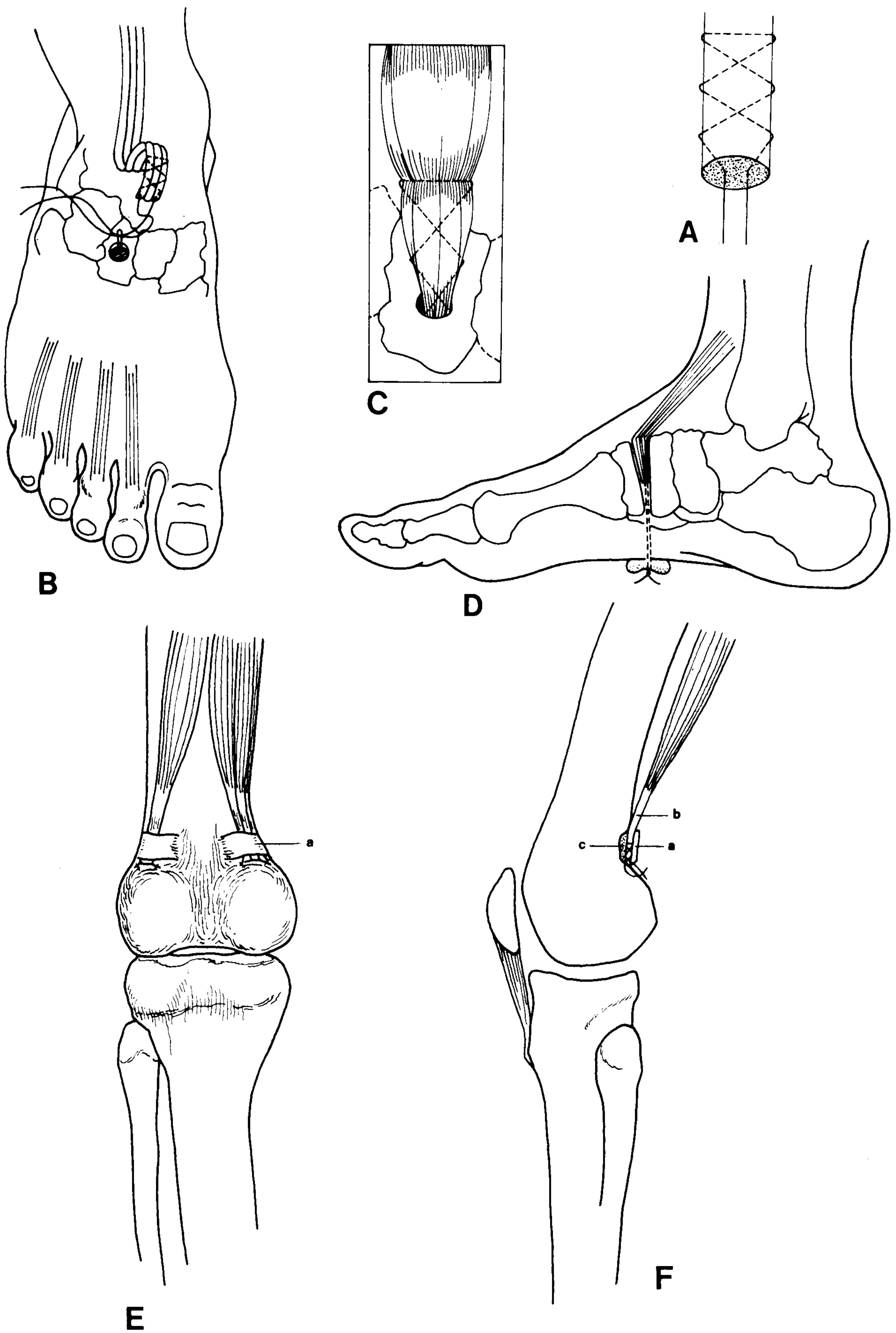


Fig. 19. Principles of anchoring tendon to bone. A whip suture inserted in the tendon (A); introducing the whip suture and tendon into the tunnel in the tarsal bone (B, C); fixing the suture on the plantar aspect over a gauze swab (D); anchoring the hamstrings to the femur—posterior view (E), lateral view (F).
a — periosteum, b — tendon, c — freshened bone.

gauge is safer than a rubber bandage type (such as an Esmarch or Martin bandage), since there is no way of determining the pressure being applied by a rubber bandage. A sphygmomanometer cuff may be used if a pneumatic tourniquet is not available.

Apply the tourniquet around the proximal or middle third of the thigh for procedures on the distal femur, knee, lower leg or foot. In the upper limb, a tourniquet applied around the proximal part of the arm will facilitate operations distal to this site. Express all air from the tourniquet before application.

Technique

Loosely wrap the completely deflated tourniquet around the thigh or arm. Elevate the limb and apply a rubber bandage, starting from the most distal part of the limb (toes or fingers) and proceeding proximally up to the tourniquet (Fig. 20A). The rubber bandage should be applied with sufficient tension to express the blood from the limb. Quickly inflate the tourniquet to the desired pressure (Fig. 20B)—about 300 mmHg for the lower limb. A slightly lower pressure is used in children and for the upper limb. Finally, remove the rubber bandage (Fig. 20C). Pressure in the tourniquet should be checked frequently during surgery. If it falls below the systolic arterial pressure, the operating field will start to bleed profusely because of venous engorgement.

A second rubber bandage can be used if a pneumatic tourniquet is not available. After expressing the blood with a rubber or elastic bandage, apply another bandage just proximal to it (Fig. 20D). Several (6–8) turns of the bandage around the thigh with moderate pressure will cut off the arterial blood flow. Then remove the distal bandage (Fig. 20E).

A tourniquet may safely stay in place for 1.5 hours on the thigh and 1 hour on the arm. The main complication in the use of a tourniquet is nerve paralysis which often results from excessive pressure, from keeping the tourniquet on too long, or from insufficient pressure leading to passive congestion and haemorrhagic infiltration of the nerve. It is therefore important to consider the local anatomy and also to avoid leaving a tourniquet in place for a long time.

Positioning the patient

The position of the patient on the operating table plays an important role in limb surgery. There are optimum positions for specific surgical procedures (see appropriate chapters). The supine position does not present particular problems, but the sacrum must be well padded to prevent pressure necrosis. The patient can easily be moved into the oblique or semilateral position and sandbags or pillows placed under the back and buttock on one side (Fig. 21A); in this case, the trochanter on the other side should be protected by padding. The prone position may create some problems for the anaesthetist and impair the patient's breathing. Therefore, place sandbags beneath the shoulders, and a pillow beneath the symphysis pubis and the hips to minimize pressure on the abdomen and chest (Fig. 21B).

Local skin preparation

Thoroughly wash the limb to be operated on with soap and warm water the day before the operation. Apply an antiseptic solution, such as 70% ethanol, and cover the limb with a sterile dressing. This is particularly important for operations on the feet and knees of crawling children or of patients with bent knees.

On the day of operation, remove the dressing in the operating room, apply a tourniquet if necessary, and place the patient in the desired position.

Clean the skin with a suitable antiseptic solution (for details, see Cook J et al., ed., *General surgery at the district hospital* (Geneva, World Health Organization, 1988)).

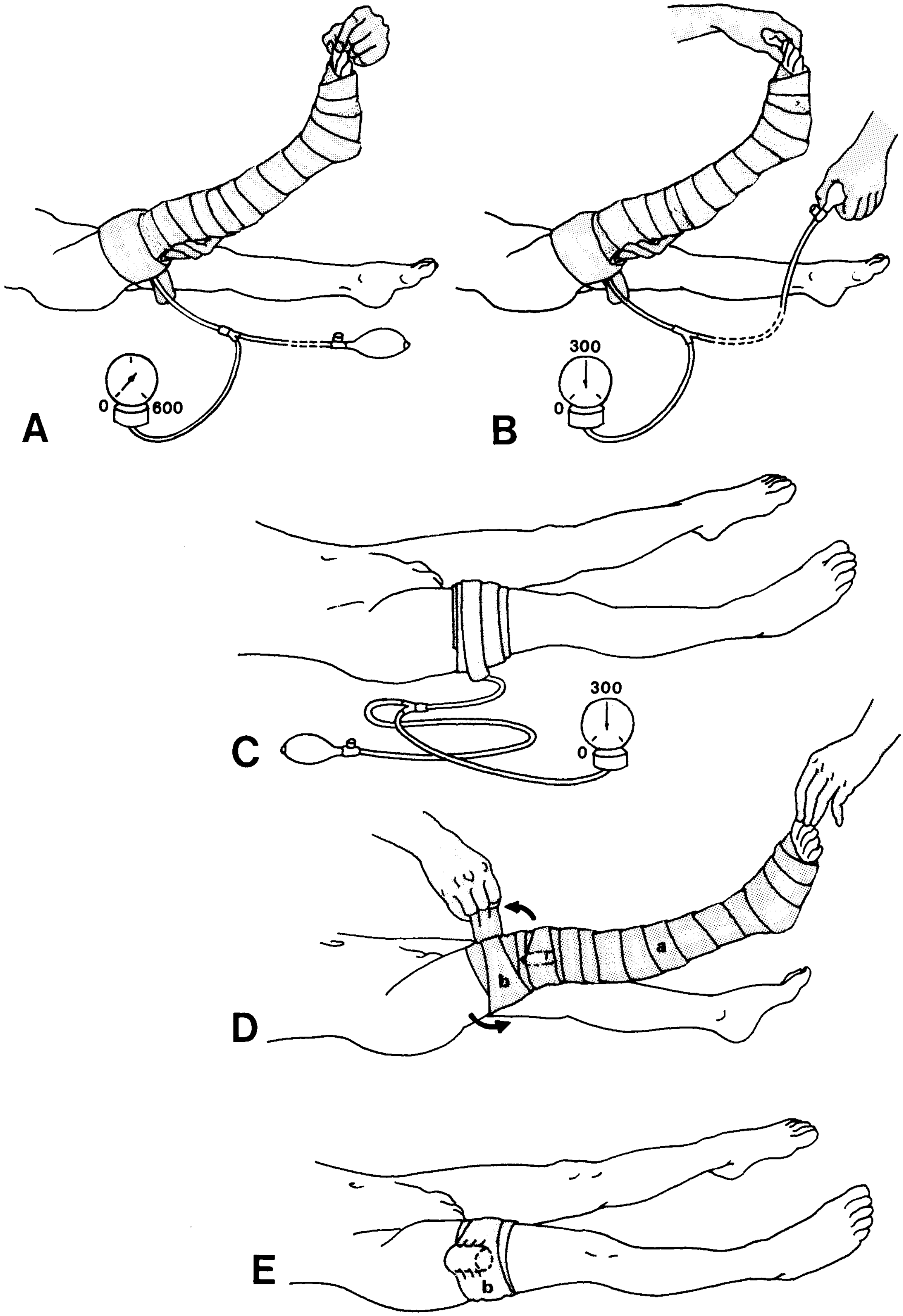


Fig. 20. Tourniquet application. Wrapping rubber bandage firmly around the limb, from the toes to the deflated tourniquet (A); inflating tourniquet to about 300 mmHg (B); rubber bandage removed (C); using a rubber bandage as a tourniquet, wrapped around the thigh several times to stop blood flow (D); rubber bandage tourniquet in place (E).

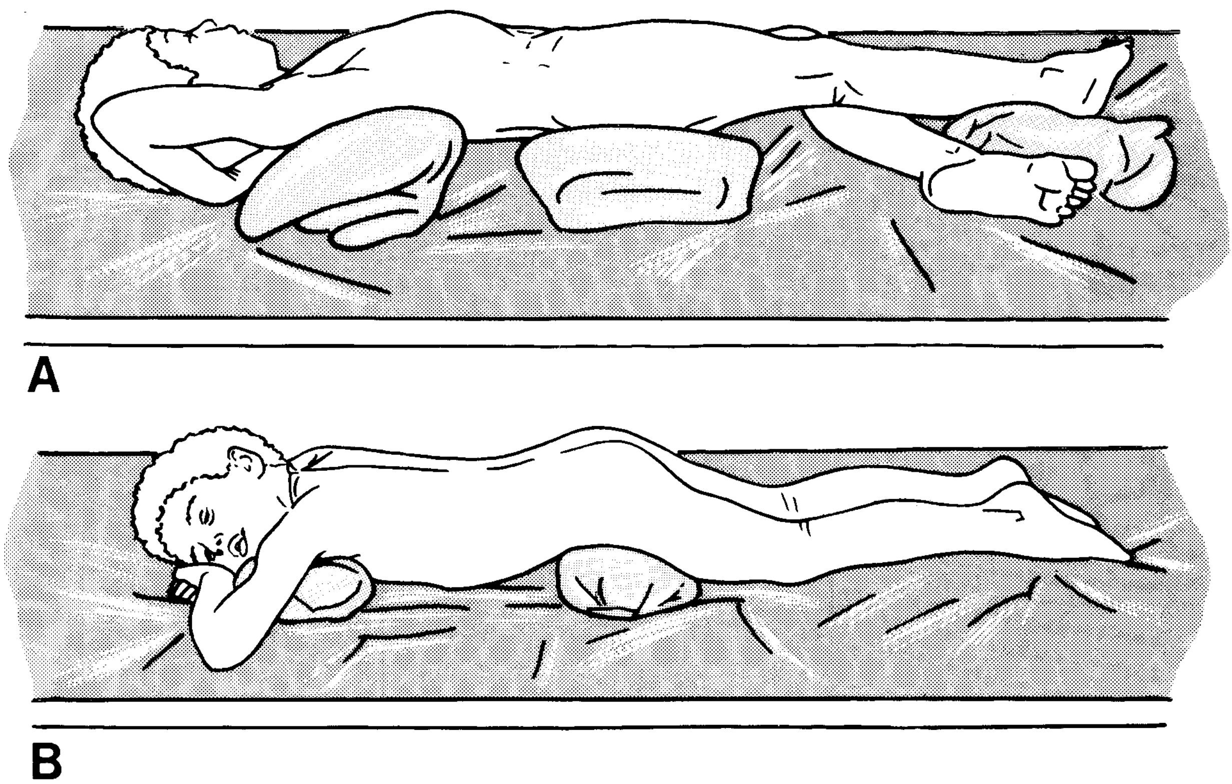


Fig. 21. Positioning of the patient for surgery. Supine oblique position (for hip release) (A); prone position (for posterior knee release) (B).

The sterile skin area thus prepared should extend well beyond the skin incision. For instance, for hip release surgery it should extend at least from the lower thoracic level proximally to the mid-calf distally.

Draping

Draping for surgery on the limbs does not differ essentially from draping in general surgery. All parts of the body must be covered, leaving only the operative field uncovered. However, more sheets and drapes are usually needed to keep the area free from contamination and also to allow for changing the position of the limb which is often necessary during an operation. Drapes should overlap the prepared skin area by at least 10 cm and be secured in place with towel clips. Use a sterile bandage or stockinette instead of towel clips on the lower leg and foot.

Postoperative care and training

The management of a patient after surgery may be divided into three phases: the immediate postoperative period (the first 3–4 days); from the fourth day to removal of the plaster cast; and the period of intensive rehabilitation training.

General after-care in the immediate postoperative period does not differ essentially from the routine in general surgery. Give analgesics and sedatives routinely, check blood pressure, pulse, body temperature and haemoglobin concentration, and administer antibiotics and fluids if indicated. It is, however, important always to examine the distal limb for changes in temperature or colour, movement of toes (or fingers), and for swelling. Temperature and movements should be checked regularly (for example, every 2–3 hours), especially after posterior knee release to ensure that there has been no overstretching with consequent impairment of nerve function and blood supply.

Postoperative immobilization

Plaster cast

Immobilization is necessary after a corrective procedure, in order to maintain the limb in its new position and to reduce pain. A plaster cast is most commonly used for this purpose. The cast must be well padded with cotton wool. Never use skin-tight plasters following surgery; there is a danger of limb ischaemia, pressure sores and nerve paralysis. In addition, the skin may be injured during splitting and removal of the cast. The most commonly used lower limb casts are a hip spica (Fig. 22A, B, C), a long leg cast (Fig. 22D), and a short leg cast (Fig. 22E).

Always split the plaster cast to accommodate swelling following surgery. Cotton wool should be put between the spread edges of the cast, and a bandage wrapped around to prevent "window oedema".

For further details on plaster cast technique and application refer to Cook J et al., *Surgery at the district hospital: obstetrics, gynaecology, orthopaedics, and traumatology* (Geneva, World Health Organization, 1991).

Keep the limb elevated for 3–4 days to reduce oedema.

The postoperative cast is usually kept on for three weeks. At the end of about three weeks, remove the cast and take out the stitches. If a plaster cast was not applied, remove sutures after 14 days. Apply a new cast if the operation included the bone. Otherwise the patient should start gentle passive and active exercises of the operated limb, and walking training. Apply a posterior plaster slab to stabilize the knee and foot, and protect the operation site during walking. Instead of plaster slabs, various splints made from local materials may be used.

If all the planned surgery programme has been completed, a final brace should be designed, made and provided.

Wedging cast

After posterior knee release, it is often necessary to leave the knee in residual flexion to avoid overstretching of popliteal vessels and nerves. Progressive correction is obtained by one or more sessions of wedging of the casts.

Technique

First, mark a pivot point on the medial and lateral sides of the cast, approximately at the level of the femoral condyles and one finger's breadth posterior to the mid-lateral line of the knee.

Cut out a wedge from the anterior side of the cast over the knee. Make a cut, 2–3 cm wide at the anterior midline, getting narrower as it approaches the pivot points (Fig. 23A).

Next, make a transverse cut through the posterior part of the cast, leaving intact one finger's breadth of plaster between the ends of the anterior and posterior cuts.

Reflect the edges of the anterior cut slightly outwards, and put some cotton wool under them.

Press on the knee from the front, or push the thigh down and the lower leg up, to extend the knee to the desired degree. The correction obtained is held by putting a piece of cork, wood or plaster wedge between the separated edges of the posterior cut (Fig. 23B), and applying several circular turns of plaster bandage around the site (Fig. 23C).

Wedging of the cast may be painful for the patient, who should preferably be given strong analgesics, or even a subanaesthetic dose of ketamine (0.5 mg/kg of body weight) (see Dobson MB, *Anaesthesia at the district hospital.* Geneva, World Health Organization, 1988).

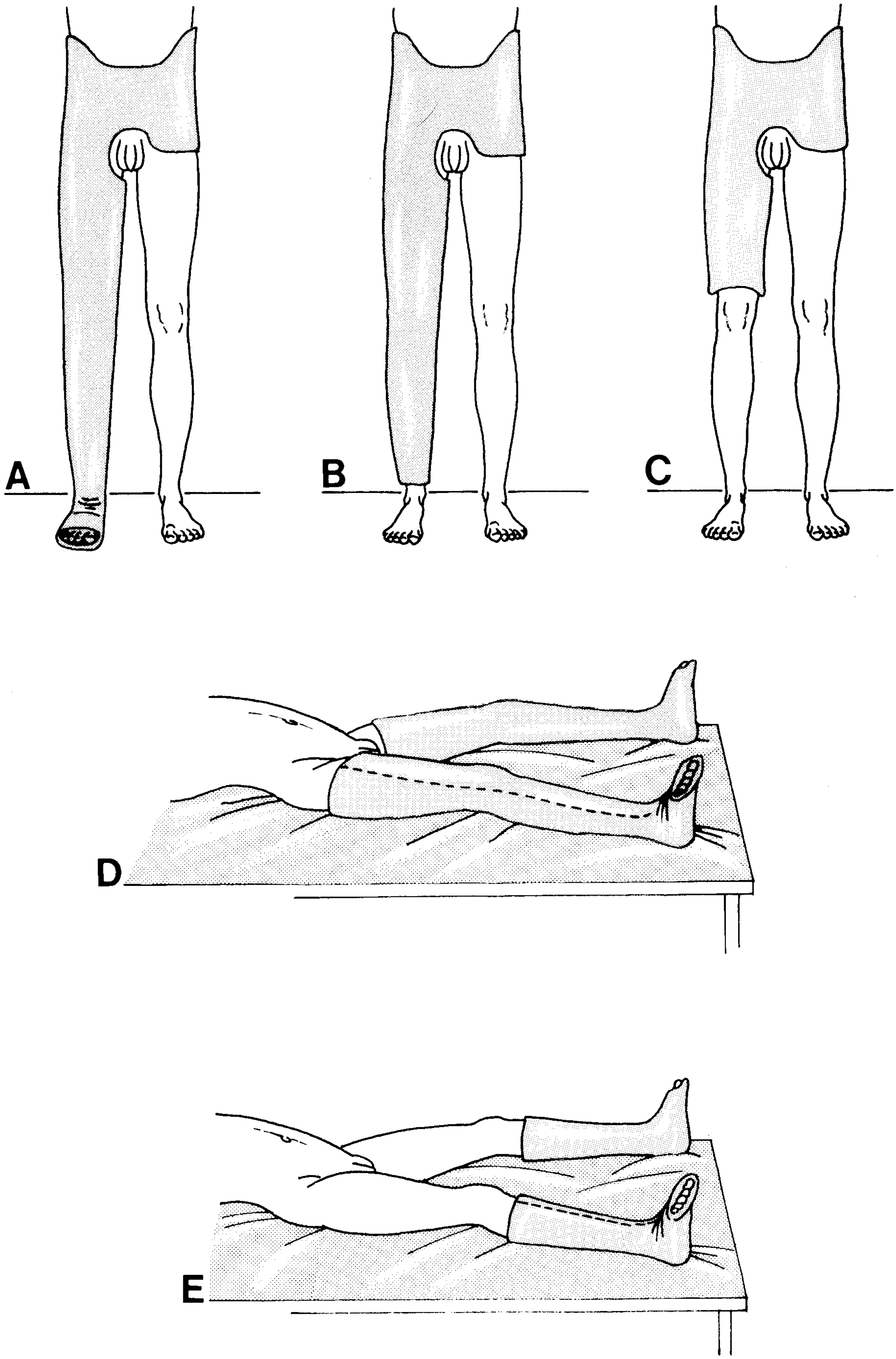


Fig. 22. Postoperative plaster casts. Hip spica, long with foot (A); hip spica, long without foot (B); hip spica, short (C); long leg cast (D); short leg cast (E).

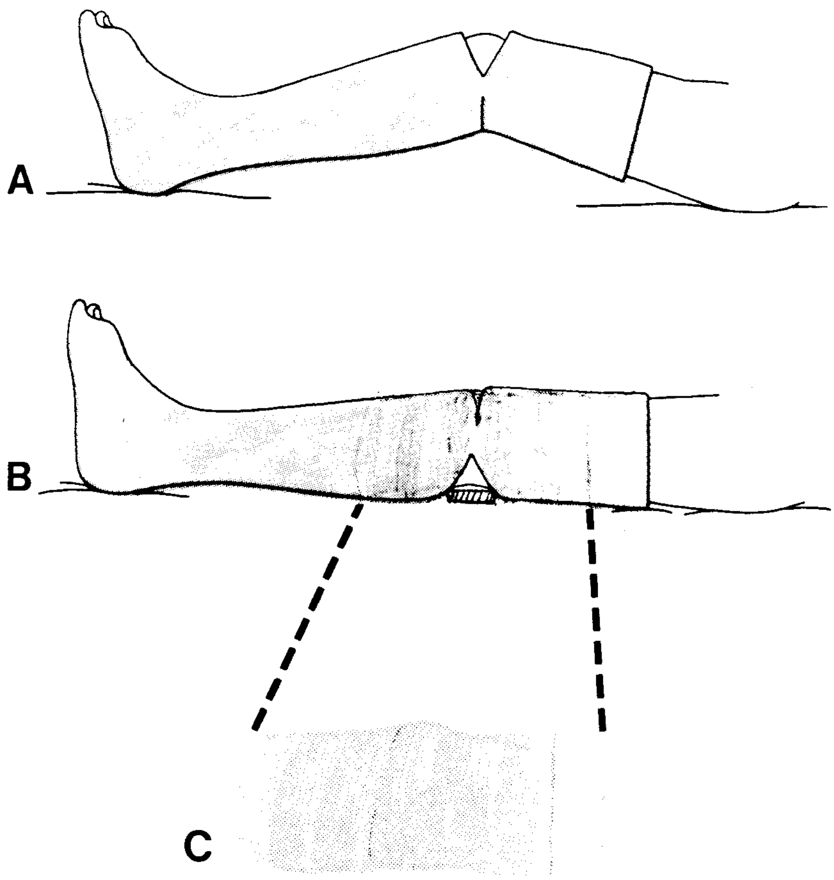


Fig. 23. Wedging cast. Wedge removed from anterior aspect of cast, and a cut made through posterior aspect (A); after correction, the anterior wedge becomes obliterated and the posterior cut becomes spread; a piece of cork is placed between the spread edges of the cut (B); detail of knee region, with several layers of plaster bandage wrapped around to hold the knee in the corrected position (C).

Skin traction

Skin traction is an alternative method of immobilization which may be used in children. It is often applied with adhesive tape. This may, however, produce skin irritation, especially when kept in place for several weeks. It is thus preferable to use foam-padded strips, kept in place with elastic bandage. If these are not available commercially, they can be made on the spot.

Technique

Prepare the following:

- two strips of foam, each 1 cm thick, 5 cm wide and the length of the patient's limb (Fig. 24A);
- a piece of plywood or plank, 6–8 mm thick, 5 cm wide and 10 cm long, with a hole of 5 mm diameter in the middle of it (Fig. 24B);
- adhesive tape 5 cm wide and double the length of the patient's leg plus 15 cm.

Stick the two strips of foam to the adhesive tape, leaving a free space in the middle for the piece of plywood, which is also stuck directly to the tape (Fig. 24C, D). Pass a traction cord through the hole in the plywood, and secure it in place with a knot.

Place the foam tape on both sides of the leg, with the piece of plywood 3–5 cm below the foot (Fig. 24E). Apply an elastic bandage under moderate tension, starting just above the ankle and proceeding proximally, to keep the foam tape in place (Fig. 24F). The foam tape adheres to the skin by suction.

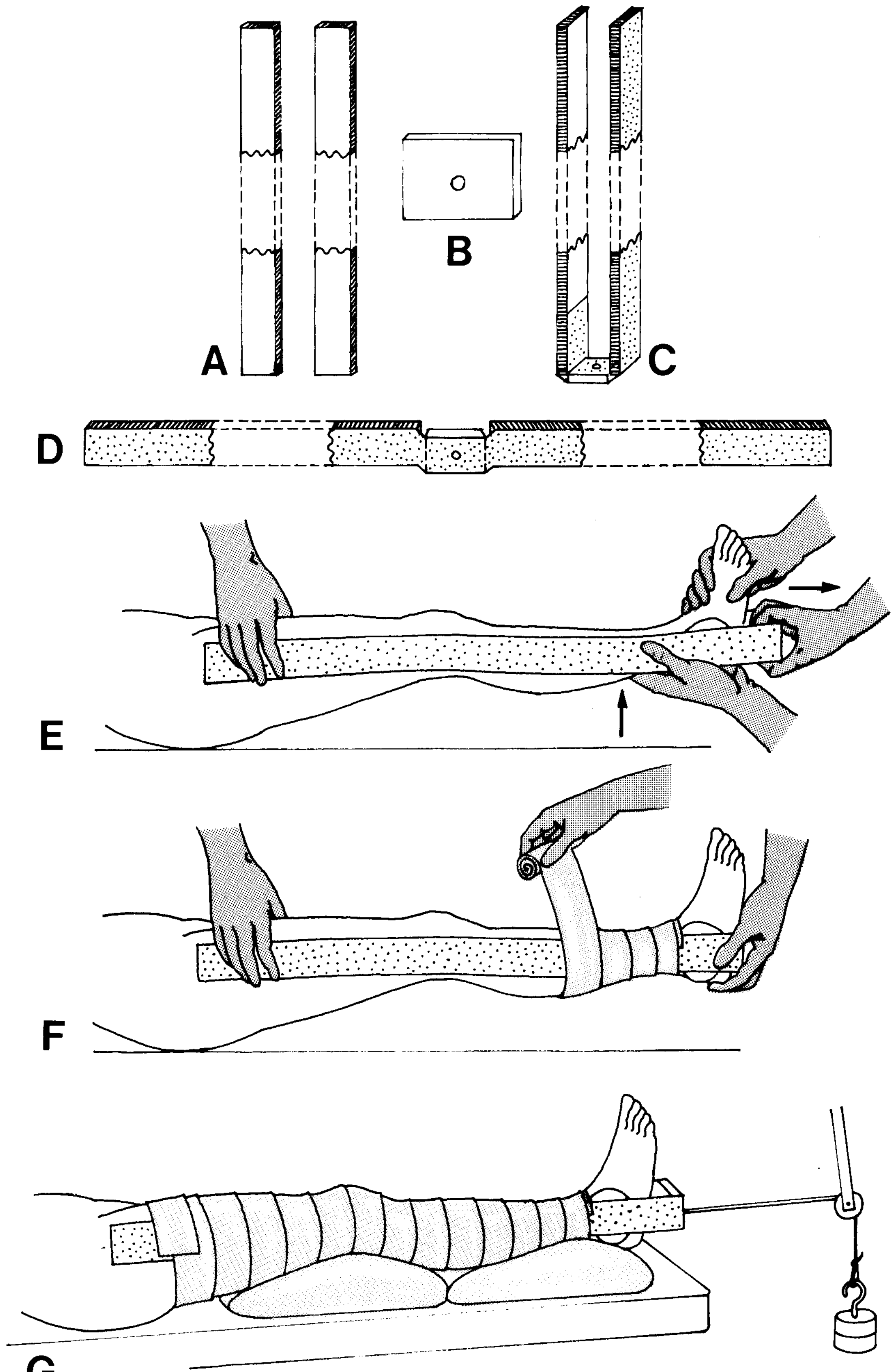


Fig. 24. Use of foam-padded strips for skin traction. Foam strips (A); piece of plywood with a hole for traction cord (B); foam strips and plywood connected with adhesive tape (C, D); traction set applied to the leg and kept in place with elastic bandage (malleoli protected by cotton pads) (E, F); weights exert traction over a pulley (G).

Finally, attach a weight of 2–5 kg to the other end of the traction cord, and pass the cord over a pulley at the foot of the bed (Fig. 24G). The foot of the bed should be raised slightly to counterbalance the traction, and prevent the patient being pulled out of bed.

Hospital stay

The patient's stay in hospital may vary from a few days to several weeks, depending on the planned surgical rehabilitation programme and various socioeconomic factors or home circumstances. Many patients can be discharged from hospital after 3–4 days, and given care on an ambulatory basis at the hospital, at a rehabilitation centre, or at home within the framework of a community-based rehabilitation programme. On leaving the hospital the patient must be given all necessary instructions concerning further management and follow-up. It is vital that the patient has braces fitted to the limb without delay after the last cast has been removed.

Follow-up

Surgery needs to be followed by a continuous process of rehabilitation, as well as periodic check-ups. Ideally such further care should be provided through a local community-based programme, which would be concerned not only with rehabilitation training and bracing, but also with schooling, family and social relations, job matters, etc.

A two-way communication and liaison system between the attending doctor and the local community rehabilitation programme is important. The doctor should provide all relevant information and advice concerning the patient to the local programme, which in turn should refer the person for check-up or intervention whenever necessary.

SPECIFIC SURGICAL PROCEDURES

5
The hip

General considerations

The most common deformity of the hip in poliomyelitis is a flexion–abduction–external rotation contracture. This is due to the pain and spasm of the hip flexors, tensor fasciae latae and hip abductors in the acute stage of illness. The child adopts a "frog leg" position to relieve the pain, which leads to secondary shortening of the iliotibial band, intermuscular septa, and enveloping fasciae. The fibrous tissue that replaces the paralysed muscle fibres also becomes shortened. With time the contracture grows more and more fixed. Contracture of the iliotibial band results not only in flexion–abduction contracture of the hip, but also in pelvic obliquity and hyperlordosis of the lumbar spine (Fig. 25A), and contributes to flexion contracture of the knee, genu valgum, and external tibial torsion.

Further sequelae of the iliotibial band contracture include discrepancy in leg length (the leg on the affected side is functionally longer) (Fig. 25B), and secondary talipes equinovarus due to external torsion of the tibia. A unilateral abduction contracture of the hip may also contribute to a subluxation or dislocation of the contralateral hip, which becomes adducted. With severe flexion–abduction contractures of both hips, locomotion is possible only on hands and knees.

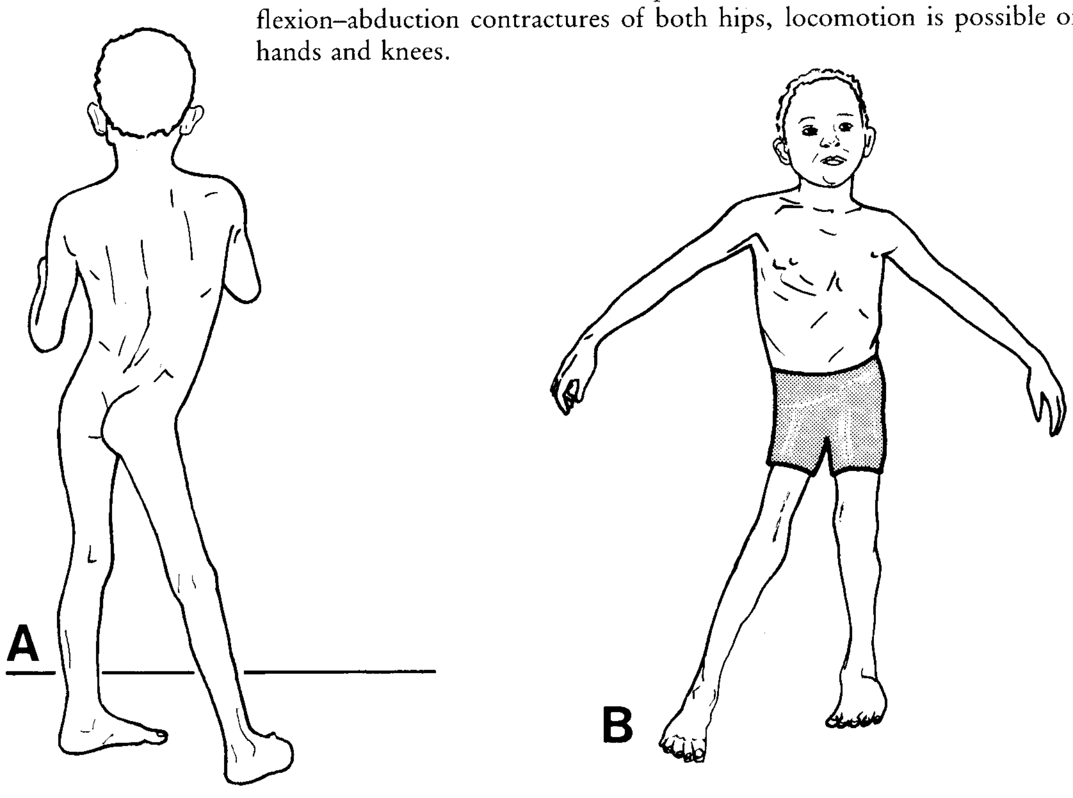
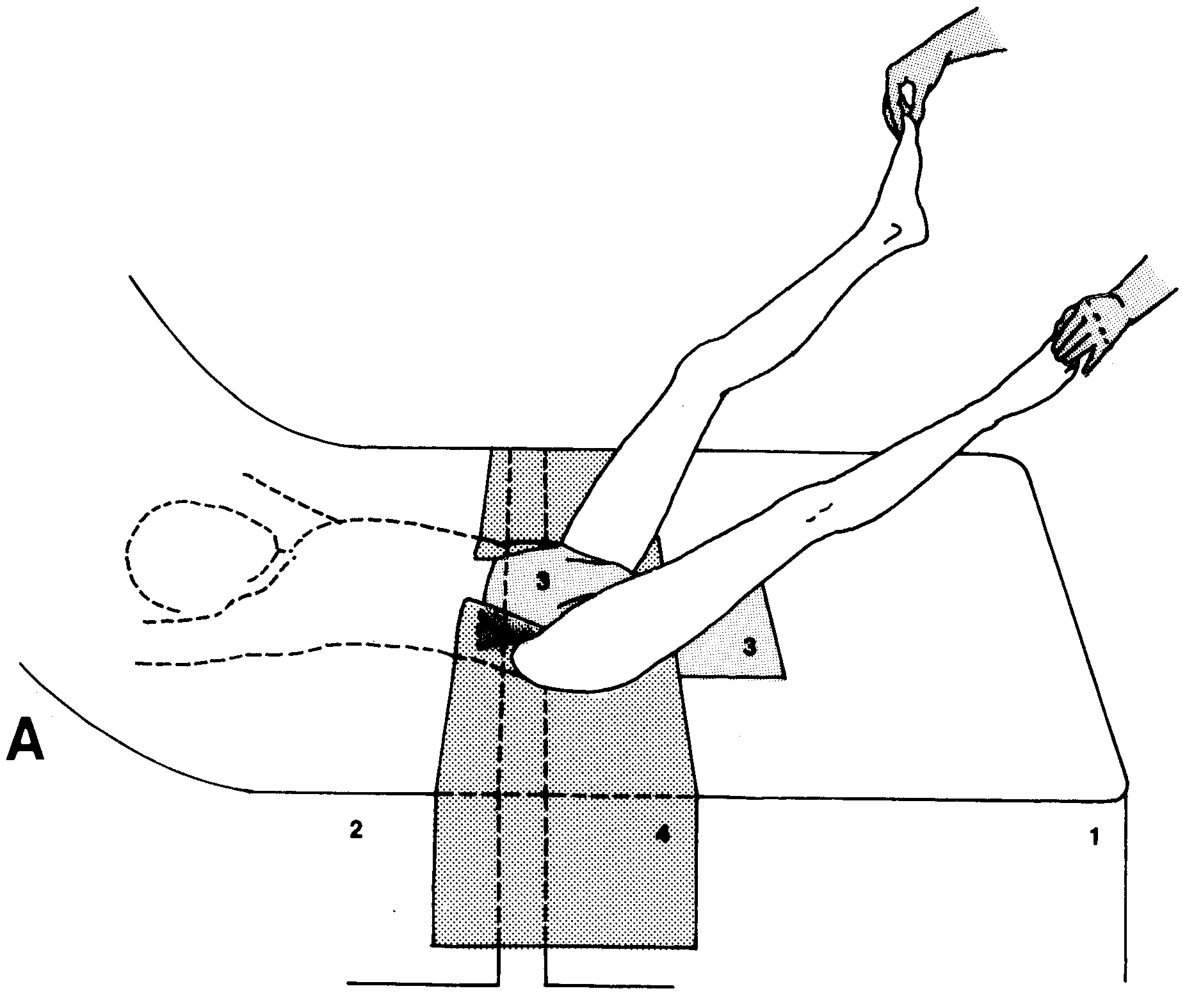


Fig. 25. Flexion–abduction contracture of the right hip, showing pelvic tilt and lumbar scoliosis (A); functionally longer right limb (B).



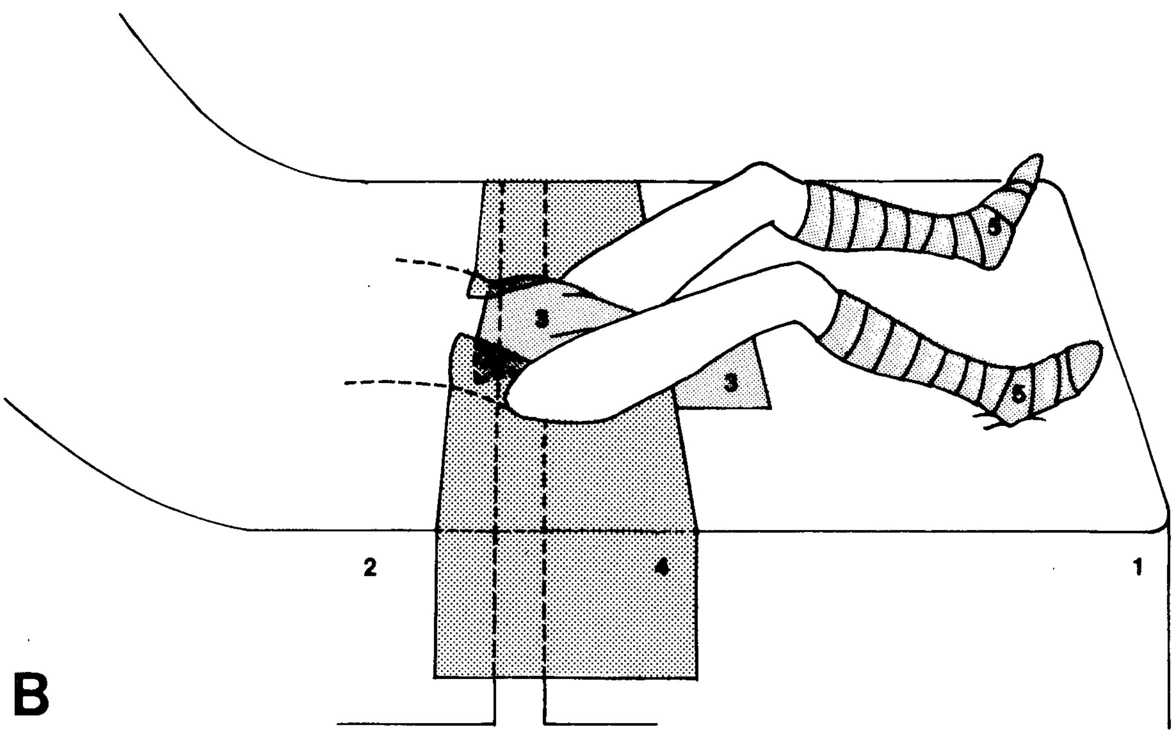


Fig. 26. Draping for hip surgery. Foundation drape (1); trunk drape (2); perineal drape (3); lateral drapes (4); draping of the feet and lower legs (5).

Soft-tissue release for flexion–abduction contracture of the hip

A fixed flexion–abduction contracture of the hip, even if only moderate, cannot be corrected by conservative methods. Surgical measures are necessary. The aim of surgery is to release all contracted structures to achieve full extension and some adduction of the hip, neutral rotation of the limb, and a horizontal position for the pelvis. The operation also aims to reduce the factors deforming the knee.

Always correct severe knee contractures before operating on the hip, because bent knees interfere with full extension of the hips.

Patients with contracture of both hips, who are otherwise in good health, may have the two sides operated upon at the same time. Intravenous fluids and blood for transfusion should be available.

The choice of procedure, from the three standard procedures described here, depends mainly on the severity of the contracture, the structures involved and the extent of surgery required.

General anaesthesia is preferred but most children can be operated upon under intramuscular ketamine, following premedication or sedation.[1]

Always have an assistant on hand, who has also scrubbed up. Clean the skin with antiseptic solution, e.g. 70% ethanol or 1% cetrimide. If the patient is male, hold the genitals away from the operating field with adhesive tape. Place the patient supine with a large sandbag under the affected hip extending to the chest, to give a tilt of about 45°. (For patients with bilateral deformity, deal with one side at a time.)

Apply a sterile waterproof sheet if available, then a full-sized drape (foundation layer of drapes), across the lower half of the table, underneath the limbs and buttocks. Wrap each foot and leg individually, up to just below the knee, and fasten the drape with towel clips. A circular bandage or stockinette may be used to keep the drape in place. Place a large sheet over the trunk of the patient, down to the level of the iliac crest. Place a smaller drape between the legs to cover the pubis and fasten with towel clips to the trunk sheet. Place further drapes on the lateral aspects of the pelvis and fasten them to the trunk sheet, and to the midline and posterior drapes (Fig. 26).

The draping described is suitable if both hips are to be operated upon, but is also recommended for surgery on one hip only. If the opposite limb is free and sterile, the control of correction during surgery is easier because the pelvis and the lumbar spine are steady.

Whatever technique of hip release is used, the assistant must force the hip being operated upon towards the correct position. The shortened structures must be as tight as possible while they are being sectioned.

Standard procedure

The standard procedure consists of dividing the shortened soft tissues on the anterolateral aspect of the hip (Fig. 27), namely the iliotibial band and fascia lata, the sartorius, tensor fasciae latae and rectus femoris muscles, and any other tight fibrous structures identified during the operation. The desired correction of the deformity usually follows but, if not, the iliopsoas tendon should be divided or lengthened and the capsule of the hip incised. In addition to the surgery on the hip itself, division or excision of the iliotibial band and the lateral intramuscular septum in the distal third of the thigh may be needed.

[1] See Dobson MB. *Anaesthesia at the district hospital.* Geneva, World Health Organization, 1988.

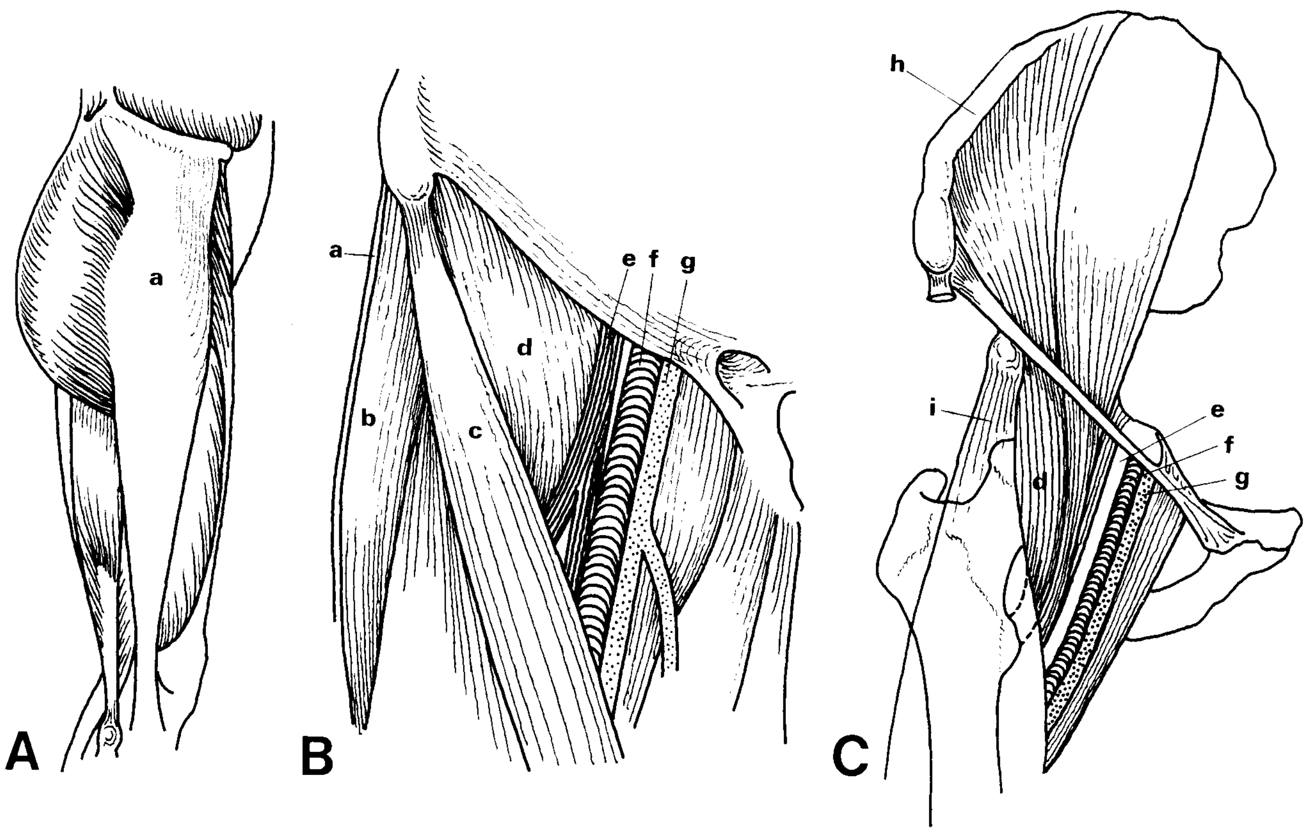


Fig. 27. Anatomy of the hip. Lateral aspect (A); anterior aspect, superficial layer (B); anterior aspect, deep layer (C).
a — iliotibial band; b — tensor fasciae latae muscle; c — sartorial muscle; d — iliopsoas muscle; e — femoral nerve; f — femoral artery; g — femoral vein; h — iliac crest; i — rectus femoris muscle.

Technique

Make an incision beginning at the level of, and just lateral to, the anterosuperior iliac spine and continuing distally in the long axis of the thigh for some 6–8 cm. Extend the incision at its proximal end along the iliac crest for some 3–5 cm (Fig. 28A). It may be extended further, if necessary. Undermine the skin together with the subcutaneous tissue over the deep fascia for a few centimetres medially, and slightly beyond the greater trochanter and proximal part of the iliotibial band posterolaterally. Retract the mobilized skin to expose all shortened structures.

Identify the origin of the sartorius muscle, divide it close to the anterosuperior iliac spine, and let it retract distally. Identify the tensor fasciae latae with its covering fascia. Dissect and free its anterior border, which is just lateral to the proximal part of the sartorius muscle, and place your finger under the tensor fasciae latae and proximal portion of the iliotibial band. Abduct the hip slightly to facilitate this manoeuvre. Now, divide the tensor fasciae latae and iliotibial band close to their iliac attachments, proceeding from superficially at the front to deep down and backwards. Both the anterior and middle prong of the iliotibial band must be cut off (Fig. 28B).

At this stage ask your assistant to extend and adduct the hip while keeping the contralateral hip fully flexed. This keeps shortened structures tight and keeps in view the progress of correction as tight structures are divided. Look for any shortened structures remaining, and expose and divide them. Ensure haemostasis and pack that part of the wound with gauze.

Now return to the anterior part of the wound. Locate the pulse of the femoral artery at the groin by palpation through the skin. Ask the assistant to keep a fingertip on the pulse. Incise the tight fascia lata below the inguinal ligament

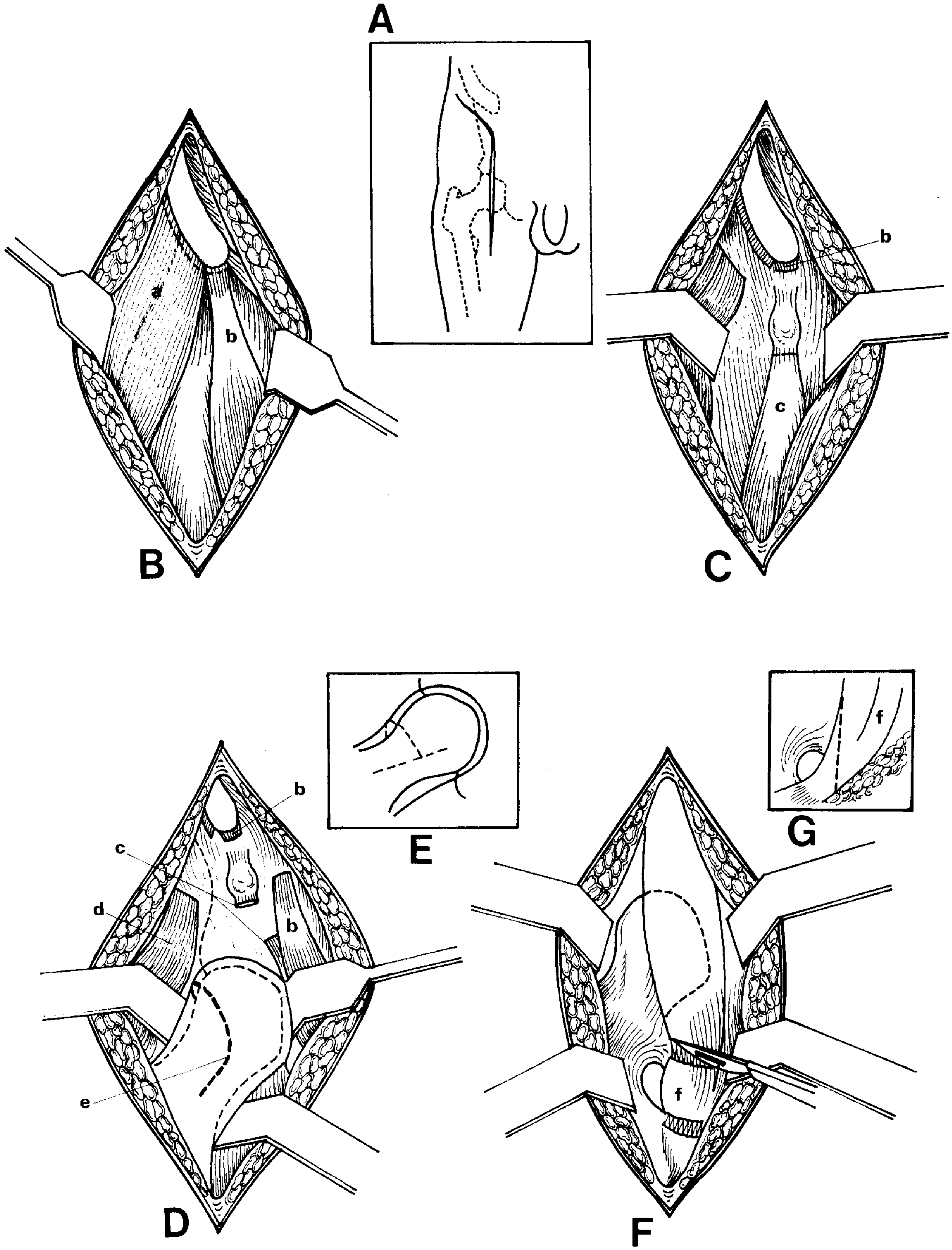


Fig. 28. Hip release for moderate to severe flexion–abduction contracture. Skin incision (A); dividing origins of sartorius muscle, iliotibial band and tensor fasciae latae muscle (B); dividing origin of rectus femoris muscle (C); hip capsulotomy (D); alternative technique of hip capsulotomy (E); fractional lengthening of iliopsoas muscle (F); alternative technique of iliopsoas release — oblique division of tendon (G).
a — iliotibial band and tensor fasciae latae muscle; b — sartorius muscle; c — rectus femoris muscle; d — tensor fasciae latae muscle; e — line of incision in the joint capsule; f — iliopsoas muscle.

and lateral to the femoral artery. Then, keeping close to the anterior border of the ileum, dissect the soft tissues down to the antero-inferior iliac spine. Identify the conjoined tendon of the rectus femoris muscle below the iliac spine, and divide it (Fig. 28C). While doing so, keep all tissues medial to the rectus femoris tendon retracted to protect the femoral vessels and nerve from injury. The desired correction is usually obtained by this stage. However, if there is still some flexion contracture, hip capsulotomy and lengthening or division of the iliopsoas tendon will be necessary.

If this is the case, expose the capsule of the hip by retracting medially the divided sartorius and rectus femoris muscles, along with the iliopsoas muscle and femoral nerve and vessels, and retracting laterally the tensor fasciae latae and gluteal muscles. Incise the capsule obliquely from up downwards, i.e., on its superior and anterior aspects (Fig. 28D). Alternatively, you can make an inverse T-shape incision of the capsule as shown in Fig 28E.

If the flexion contracture is still not fully corrected, expose the tendon of the iliopsoas muscle. Flexing and externally rotating the thigh facilitates access to the tendon. Dissect it free (confirm by running an elevator beneath it). Now make two transverse incisions 1.5–2 cm apart through the tendinous fibres, not the muscle (Fig. 28F). Avoid the femoral nerve. By hyperextending the hip, the tendon may be lengthened by 2–4 cm. If the iliopsoas muscle is paralysed, fibrosed and tight, simply divide its tendon and let it retract proximally (Fig. 28G).

On completion of surgery check the operative wound for haemostasis and remove all swabs. Close the wound in two layers by suturing only the subcutaneous tissue and skin.

Now palpate the iliotibial band at the distal part of the thigh and, if it is tight, divide it. Make a stab incision in the lateral aspect of the thigh, 2 cm proximal to the superior border of the patella and just posterior to the palpable tight iliotibial band. Insert the knife with the blade horizontally until the tip of the blade touches the femoral cortex. Twist the blade through 90° so that its sharp edge points vertically upwards. Incise the tight iliotibial band along with the lateral intramuscular septum and any other tight structures on the lateral aspect of the thigh proceeding from posteriorly to anteriorly. Close the wound with one or two stitches, if necessary.

Note

During any hip release procedure, care should be taken to avoid injuring the femoral nerve and vessels. The femoral pulse is easily palpable at the groin skinfold, midway between the anterosuperior iliac spine and the pubis. The femoral nerve lies just lateral to the artery.

Mark this point on the skin, and have the assistant keep a fingertip on it during operation in the area. When operating on deeper layers (e.g., dividing the rectus femoris muscle or iliopsoas tendon, or incising the joint capsule) protect the femoral nerve and vessels by retracting them medially away from the knife.

Yount's procedure for severe iliotibial band contracture

Percutaneous section of the iliotibial band and the lateral intermuscular septum above the knee is usually sufficient to obtain the desired release of those structures. However, in very severe cases involving both the hip and the knee, an open excision of a portion of the above structures may be necessary. This procedure, although technically a little more difficult, provides a better safeguard against recurrence of deformity.

Technique

Make a longitudinal incision over the midlateral line of the thigh, beginning just above the knee and extending proximally for about 6 cm (Fig. 29A). Incise the subcutaneous tissue in line with the skin. Undermine the wound

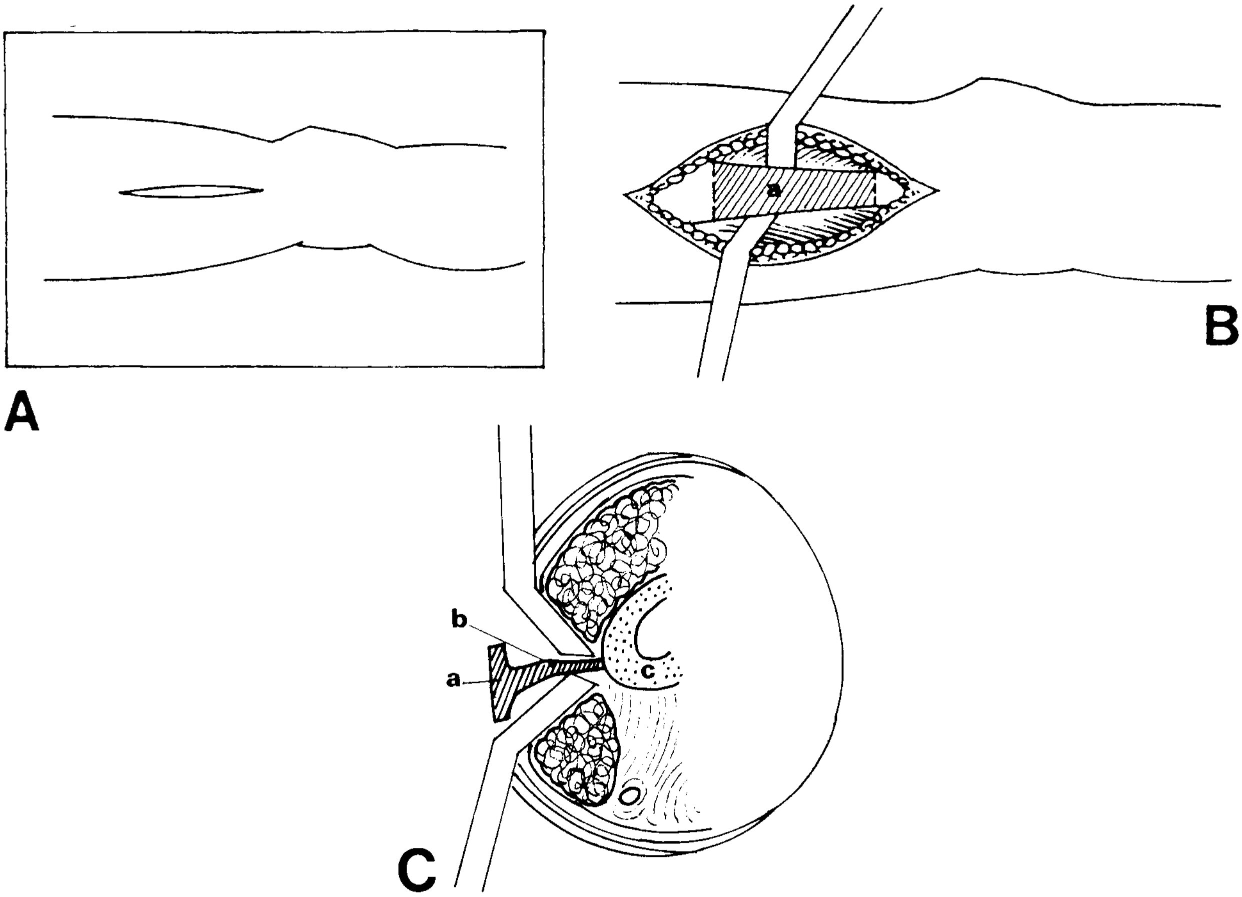


Fig. 29. Yount's procedure for severe iliotibial band contracture. Skin incision (A); portion of iliotibial band to be excised (shaded) (B); schematic cross-section of the thigh, showing portion of iliotibial band and lateral intermuscular septum to be removed (C). a — iliotibial band; b — intermuscular septum; c — femur.

edge by blunt dissection and retract it to expose the underlying muscles of the anterolateral aspect of the distal one-fourth of the thigh. Excise "en bloc" a segment of some 5 cm of the iliotibial band along with the fascia lata covering the vastus lateralis muscle, and the lateral intermuscular septum (Fig. 29B). It is important to excise the intermuscular septum down to the bone (Fig. 29C). Ensure haemostasis and close the wound in two layers (subcutaneous tissue and skin).

Alternative procedure for severe flexion–abduction contracture: modified Campbell's procedure

This procedure is indicated in a patient with a severe flexion–abduction contracture, in which the abduction is partly due to shortening of the gluteus medius and gluteus minimus muscles.

The original Campbell's procedure is similar to the standard one described above, except for two points:

1. The skin incision and exposure are more extensive, especially along the iliac crest.

2. All abductor muscles are stripped off from the outer iliac table down to the acetabulum and from the articular capsule.

The modified technique differs from the original Campbell's procedure in that:

1. The superior part of the iliac bone is not excised.

2. The iliacus muscle is not stripped off the inner table of the iliac bone.

The modified technique thus causes less bleeding and is better tolerated by the patient, while giving satisfactory correction.

Technique Make a skin incision along the anterior half of the iliac crest to the anterosuperior iliac spine, and proceed distally for 5–8 cm on the anterior aspect of the thigh (Fig. 30A). Divide the deep fascia down to the iliac crest. Using a periosteal elevator, strip the origins of the tensor fasciae latae, gluteus medius and gluteus minimus muscles down to the acetabulum. Free the proximal part of the sartorius muscle from the tensor fasciae latae muscle (Fig. 30B).

Divide the origin of the sartorius muscle close to the anterosuperior iliac spine and allow it to retract distally. Next denude the anterior border of the iliac bone to the anteroinferior iliac spine. Dissect free the conjoined tendon of the rectus femoris muscle and divide it distally to the anteroinferior iliac spine (Fig. 30C).

Hyperextension and adduction of the hip without increasing the lumbar lordosis should now be possible. If not, divide the capsule of the hip joint obliquely. If necessary, dissect free the iliopsoas tendon and either divide it transversely or obliquely, or make a fractional lengthening of it, depending on the state of the muscle. Close the wound, after haemostasis, with subcutaneous and skin sutures.

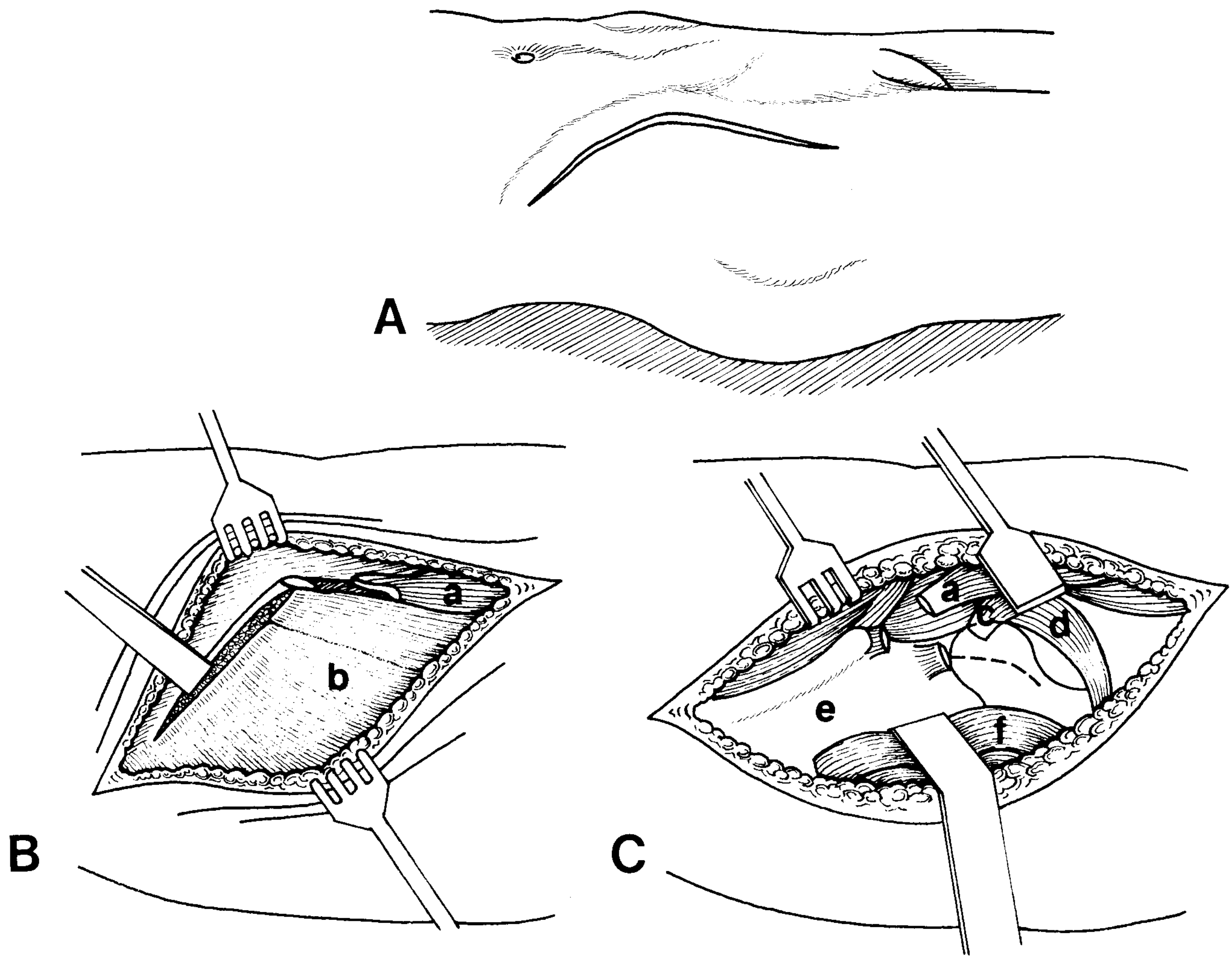


Fig. 30. Modified Campbell's procedure for hip release. Skin incision (A); releasing sartorius muscle, iliotibial band, tensor fasciae latae, gluteus medius and gluteus minimus muscles (B); exposed articular capsule of the hip and iliopsoas (C).
a — sartorius muscle (divided); b — iliotibial tract covering tensor fasciae latae and gluteus medius muscles; c — rectus femoris muscle; d — iliopsoas muscle; e — iliac bone; f — abductor muscles.

Percutaneous soft-tissue release (tenotomy): modified Huckstep's procedure

Many mild to moderate hip contractures can be corrected very satisfactorily by this simple procedure, thus avoiding more extensive surgery. The procedure consists of percutaneous division of all palpable tight structures over the anterolateral aspect of the hip and lateral aspect of the thigh.

Technique (Fig. 31)

Make an incision 2 cm proximal to the superior border of the patella, over the midlateral aspect of the thigh. Insert the knife horizontally just posterior to the iliotibial band (which is easily visible and palpable as a tight cord), until the tip of the blade touches the lateral cortex of the femur. Now twist the blade through 90° so that its sharp edge points upwards. Incise all subcutaneous soft tissues that lie anterior to the blade on the lateral aspect of the femur at that level.

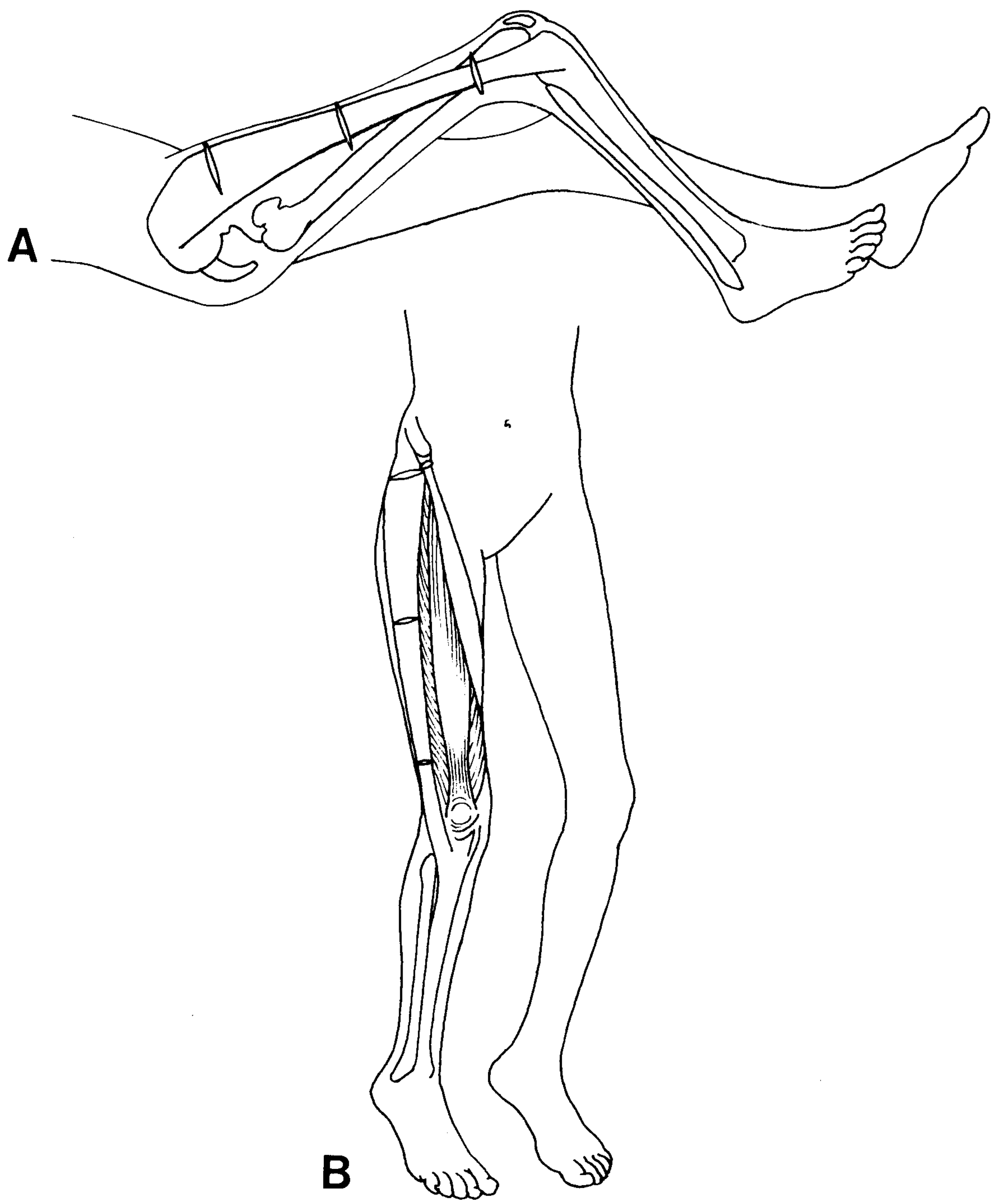


Fig. 31. Modified Huckstep's procedure for soft-tissue release. Lateral view (A); anterior view (B).

Make a second incision at the mid-thigh and divide the tight subcutaneous soft-tissue structures as before. The final incision is made one finger's breadth distal to the anterosuperior iliac spine. Keep the hip in maximal extension and adduction. Any tight tissues should be palpated through the skin before section. Take care to avoid the inguinal ligament and the femoral nerve and vessels. Insert the blade 2 cm deep in the median line and then turn the cutting edge of the blade laterally through 90° and incise all tight structures. When the contracted tissues on the anterior aspect of the hip have been divided, direct the blade so as to divide tight structures on the anterolateral aspect of the hip.

Note

A patient with an associated knee contracture may be treated by open division of the biceps tendon, followed by division of the iliotibial band just above the knee (see p. 65). It is important to isolate the common peroneal nerve before dividing the biceps.

After-care

Postoperative management is similar for all the hip release procedures described above. The hip should be held for 2–3 weeks in the corrected position of full extension and neutral abduction–adduction and rotation. This can be achieved with a hip spica plaster cast, skin traction, or controlled positioning in bed. The bed should be firm, with wooden boards or planks under the mattress.

Hip spica plaster cast

This is the preferred method. It holds the hip firmly, reduces pain, accelerates healing and facilitates care of the patient. The plaster cast, which should be well padded and moulded over the pelvis, is applied on completion of surgery. It should cover the lower part of the trunk, pelvis and the whole limb, or both limbs if both hips have been operated upon. The hip spica is usually applied on an orthopaedic table, although an ordinary table with a hip prop screwed to it may be used (Fig. 32A). If using an ordinary table, rest the

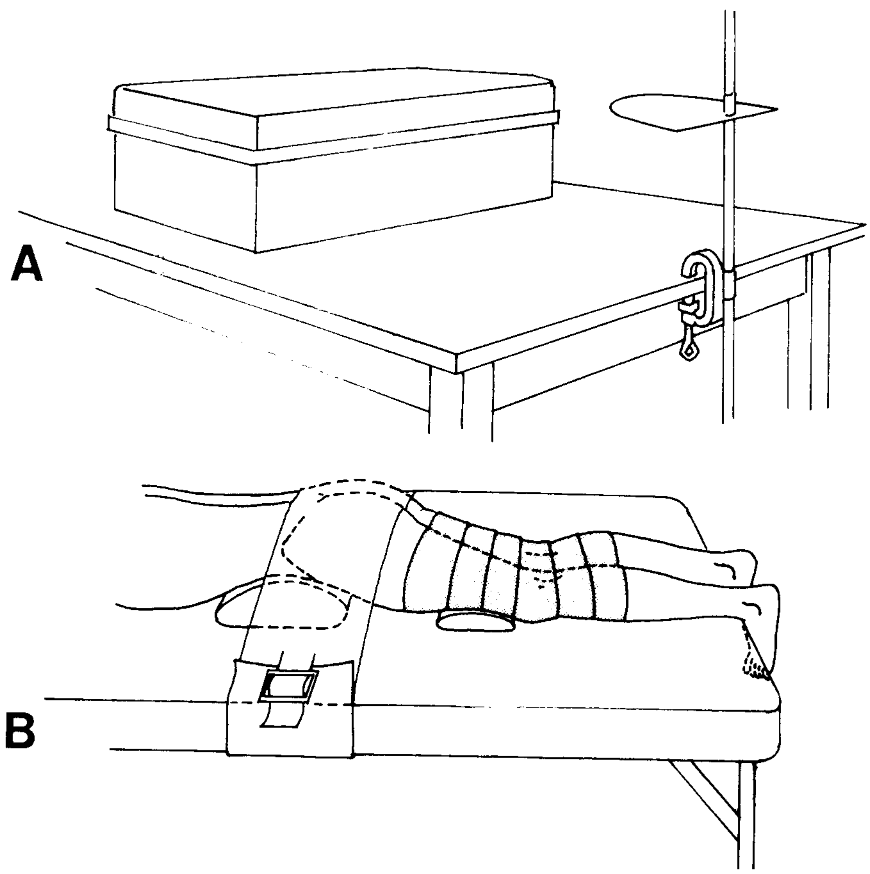


Fig. 32. Immobilization following hip surgery. Table with hip prop and box (A); controlled positioning in bed (B).

upper thorax and shoulders of the patient on a box, and ensure that the hip prop is well padded with cotton wool to minimize pressure on the sacrum. After 3 weeks the plaster cast is bivalved, the sutures removed, and passive and active exercises are started, with stretching of the hip, if necessary, to achieve full extension. Whenever possible, walking training should begin a few days later.

Skin traction

Traction may be used if plaster of Paris is unavailable. A firm bed is essential. Apply traction to both legs, which should be kept parallel and in a neutral position. More weight may be put on the non-operated limb to exert greater pull on that side of the pelvis. The operated limb may be bandaged to the non-operated one. If both hips have been operated upon, apply equal traction weight — usually about 2–4 kg, depending on the age and weight of the child. The patient should be confined to lying in bed for the first two weeks. After this, remove the sutures and start gentle exercises. Turn the child to lie prone twice daily for 1 hour, with a sandbag (2–3 kg) placed on his or her buttock. Stretching of the hip may also be done in this position.

Controlled positioning

If, for any reason, neither plaster cast nor traction can be applied, use "controlled positioning" (Fig. 32B). Place the patient prone, with the pelvis fixed and pressed down by a belt anchored to the bed. The patient's thighs may be tied together with a bandage. Place a flat cushion under the abdomen and another cushion under the knees to keep the thighs in hyperextension. This position should be maintained for 2 weeks, except for half an hour twice a day, when the child is turned over to the supine position.

The use of traction or positioning after a hip release operation is not as effective as a plaster cast in holding corrections. Since, in addition, the child is likely to be suffering from pain, muscle spasm and anxiety, it is advisable to give analgesics (starting with a strong one such as pethidine), sedatives and muscle relaxants (e.g., diazepam), three times a day during the first few days after surgery. Start passive stretching as soon as pain and muscle spasm have subsided, usually after about a week.

Adduction contracture of the hip

This deformity seldom occurs in poliomyelitis but is common in cerebral palsy. It develops when a child with *abduction* contracture of one leg keeps the other leg in *adduction* (i.e., parallel to the other leg). After a time, the habitual attitude of the leg leads to secondary shortening of the adductor muscles, especially if the hip abductor muscles of the leg are totally paralysed. The adduction contracture may contribute to paralytic subluxation or dislocation of the hip joint. Treat both hips (for abduction and adduction, respectively) at the same time.

The aim of surgery is to restore passive abduction of the hip and thus reduce the tendency to paralytic subluxation or dislocation of the joint. The operation consists of dividing the contracted adductor muscles close to their origins on the pubic bone. The procedure may be performed percutaneously or by an open method. Percutaneous tenotomy of adductors is often sufficient for deformities due to poliomyelitis.

Percutaneous tenotomy of the adductor muscles

Prepare the skin in a routine way. Draping is not essential but two drapes, one above and one below the operative area, may be useful.

Technique

Place the patient in the supine position and ask an assistant to hold the patient's legs apart. Mark the point on the skin over the palpable femoral pulse at the groin, and keep well away from it, medially, during the entire operation. Make a stab incision over the origins of the tight adductor muscles

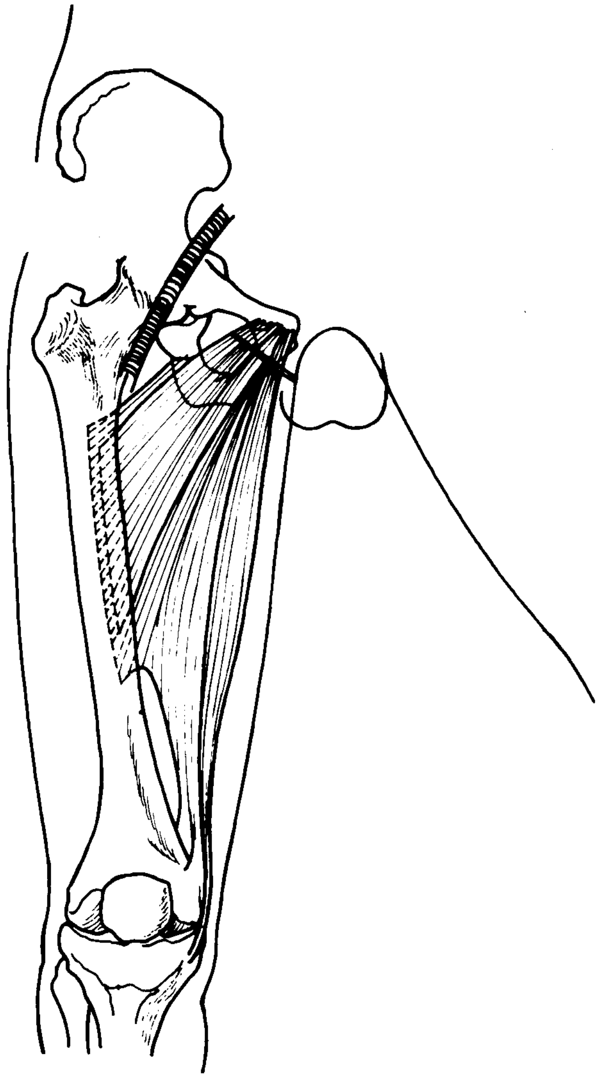


Fig. 33. Percutaneous tenotomy of adductors, showing relationship between site of incision and femoral artery.

in the groin, just below the symphysis pubis (Fig. 33). Hold the knife with the sharp edge of the blade pointing medially and parallel to the skin fold of the groin. Divide the tight muscles at their origin, working from the lateral to the medial side, until passive abduction of some 20–30° is obtained. On completion of the section, apply pressure over a sterile gauze, covering the incision for 5–7 minutes to control bleeding and reduce the possibility of haematoma formation. Finally, close the skin with one or two stitches as needed.

After-care

The leg should be kept in abduction using a pillow between the thighs, or by skin traction. Passive exercises can be started as soon as postoperative pain has subsided (usually after a few days).

6
The knee

General considerations

Flexion contracture of the knee is a common deformity in poliomyelitis. Although the deformity can develop alone, it is most often associated with hip contracture and foot deformities. There are two main causes of flexion contracture of the knee:

- *Muscle imbalance*, resulting from paralysis of the quadriceps muscle, while the hamstring muscles (flexors of the knee) are less affected. The continuous pull of the hamstring muscles leads to flexion contracture.
- *Habitual position* of the knee in flexion, e.g., through prolonged sitting with the knees bent, crawling on bent knees and hands, or keeping the knee flexed because of flexion contracture of the hip.

With time, in addition to the hamstring muscles, other soft tissue structures, such as the fasciae and especially the articular capsule of the knee, also become shortened leading to fixed flexion contracture.

The flexion component of knee deformity may be accompanied by external torsion of the tibia and genu valgum, caused by contracture of the iliotibial band.

Flexion contracture of the knee, alone or in combination with other contractures, makes erect walking very difficult or impossible. Flexion contracture of less than 30° can be corrected conservatively, by passive stretching or use of wedging casts, but for contractures in excess of 30° surgery is necessary.

The aim of surgery is to enable the patient to stand and walk upright. It involves dividing all shortened structures on the posterior and posterolateral aspects of the knee, so that the joint can be fully extended.

When excessive external torsion of the tibia or genu valgum is also present, additional corrective surgery, e.g., tibial osteotomy, may be necessary at a later date.

Release of posterior soft tissues

Several procedures may be performed on the shortened hamstring tendons, depending on the residual strength of the muscles.

- The tendon of a weak muscle (greyish in colour, 0 or 1 on Lovett's scale) is simply divided.
- The tendon of a muscle with fair strength (2 or 3 on Lovett's scale) is lengthened by Z-plasty or fractional lengthening.

- The tendon of a good or normal muscle (4 or 5 on Lovett's scale) may be either lengthened or transferred.

The choice of skin incisions may also depend on the severity of the contracture. Two separate, medial and lateral incisions are suitable for most contractures, although for contractures of more than 80° a Z-plasty incision is sometimes advisable.

If both knees are affected, the two sides can be operated upon at the same session. In addition, corrective procedures on the calcaneus tendon may be included if necessary.

Anaesthesia General anaesthesia is preferable for all corrective procedures on the knee.

Positioning For posterior release surgery, place the patient prone; for osteotomy of the tibia below the knee, place the patient supine.

Tourniquet Apply a tourniquet on the upper third of the thigh.

Skin preparation Wash the whole leg and apply an antiseptic solution from just below the tourniquet down to the toes.

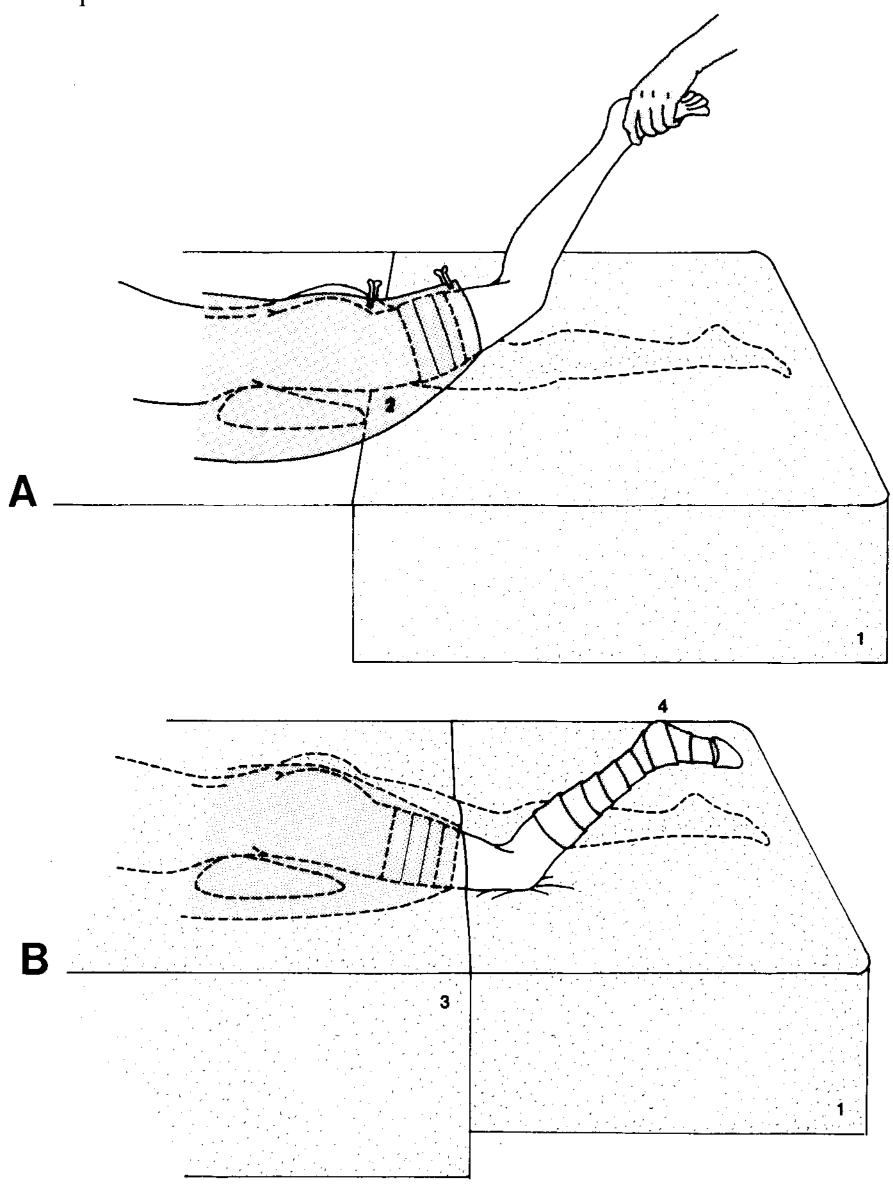


Fig. 34. Draping for surgery on the knee. Patient prone (A, B).
Foundation drape (1); femoral drape (2); trunk drape (3); draping of foot and lower leg (4).

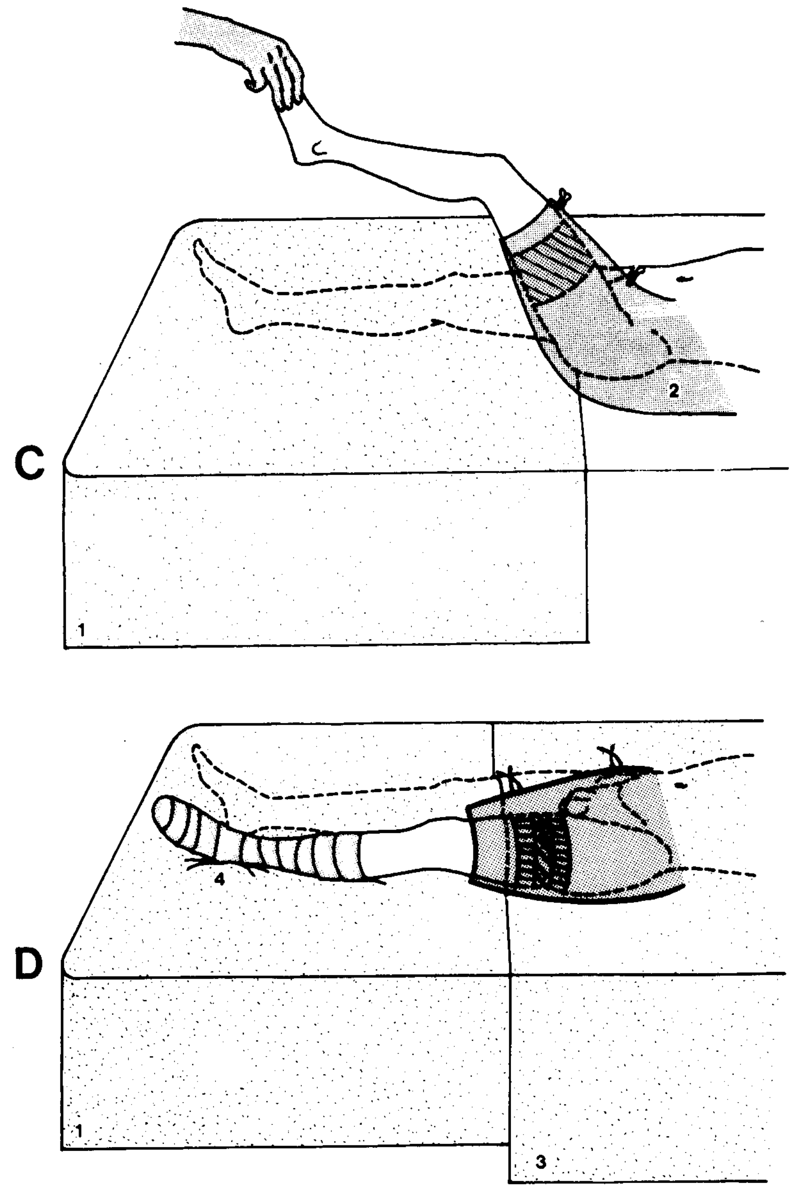


Fig. 34. Draping for surgery on the knee ***(continued)*****. Patient supine (C, D). Foundation drape (1); femoral drape (2); trunk drape (3); draping of foot and lower leg (4).**

Draping (Fig. 34)

Place the foundation sheet over the distal part of the table to cover the normal leg, but under the affected leg. Apply a drape over and around the tourniquet and fix it below the tourniquet with a sterile bandage or with towel clips. Next, place a large sheet over the trunk extending down to below the tourniquet drape and fix it to the skin 10 cm above the knee. Finally, wrap a drape around the foot and lower leg up to 10 cm below the knee, and keep it in place with a sterile bandage or towel clips. It is also a good idea to place an additional drape under the limb over the foundation sheet as a further safeguard against contamination.

In case of bilateral surgery, drape the two legs separately.

Technique

Make a longitudinal incision over the posterolateral aspect of the lower part of the thigh, along the biceps femoris tendon. Start the incision one finger's breadth distal to the head of the fibula, and extend it proximally for some 6–8 cm. Cut the subcutaneous tissue in line with the skin incision and expose

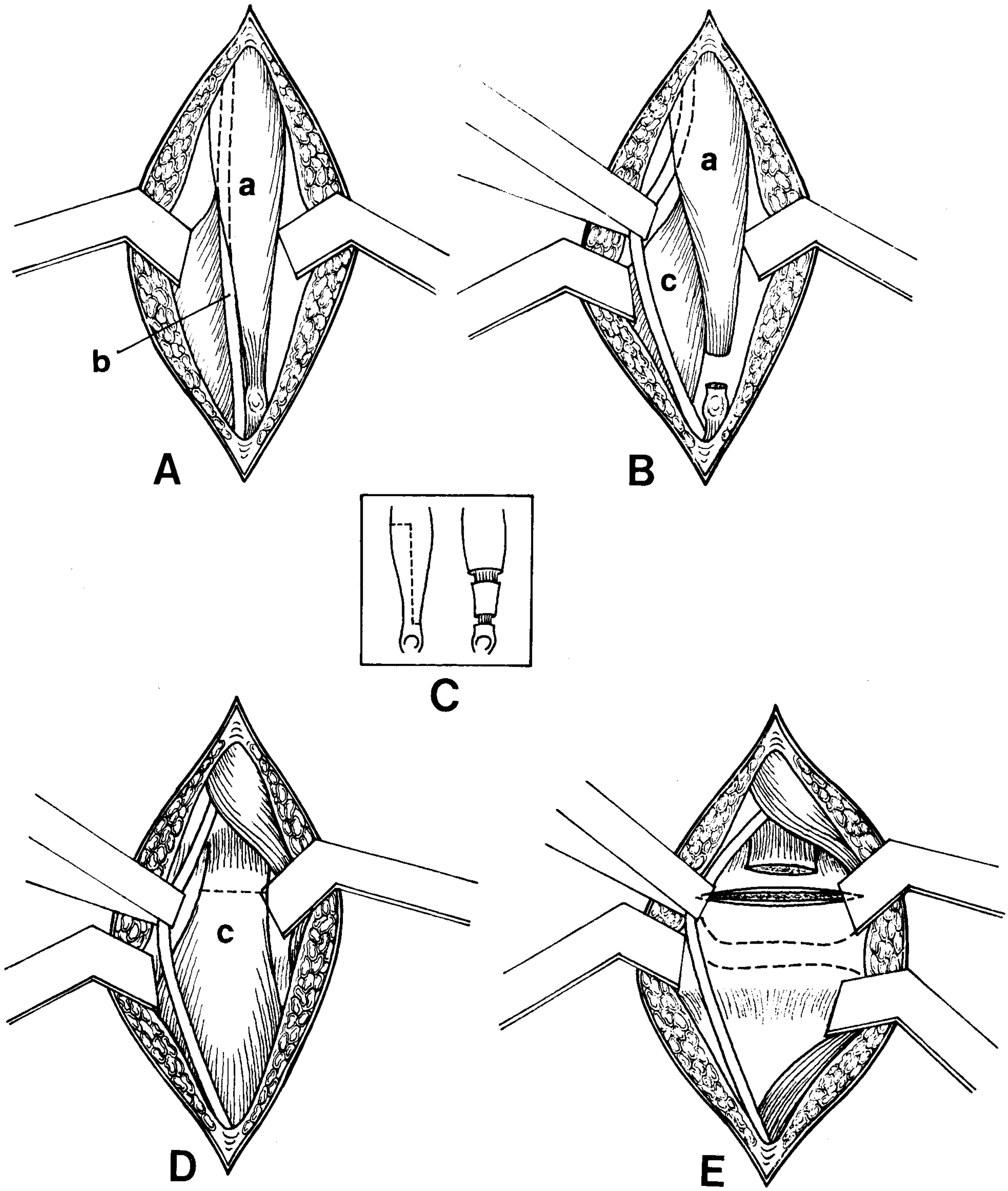


Fig. 35. Posterior knee release (lateral part). Exposure of biceps muscle and peroneal nerve (A); protecting peroneal nerve before biceps tenotomy (B); Z-lengthening or fractional lengthening of biceps tendon (C); exposure and division of lateral head of gastrocnemius (D); dividing posterior knee capsule (lateral portion) (E).
a — biceps femoris muscle; b — peroneal nerve; c — gastrocnemius muscle.

the biceps femoris tendon (Fig. 35A). Locate the common peroneal nerve on the posteromedial aspect of this tendon, gently dissect it and retract it medially. Next, dissect and free the biceps tendon and either divide it close to its insertion in the head of the fibula (Fig. 35B), or lengthen it (Fig. 35C), depending on the state of the muscle.

Palpate the distal part of the iliotibial band (just anterior to the biceps tendon). If it is tight, excise 2–3 cm of both band and septum.

Using a periosteal elevator and working close to the popliteal surface of the femur and posterior aspect of the joint capsule, mobilize and elevate "en bloc" the popliteal vessels and nerves along with the surrounding soft tissues. Retract them posteromedially to expose the lateral head of the gastrocnemius muscle and the posterolateral portion of the underlying articular capsule (Fig. 35D). If the head of the gastrocnemius muscle is greyish in colour, divide it transversely about 1 cm below its origin. If, on the other hand, it is reddish, place a curved artery forceps under the muscle, dissect it free from the capsule and the femoral condyle, divide it transversely close to its origin and retract it laterally. In addition, divide the exposed portion of the capsule over the bulging lateral femoral condyle (Fig. 35E). In dividing the capsule, first make a 1-cm incision to expose the glistening surface of the femoral condyle, ensuring that you are at the proper level. Then complete the division of the exposed part of the capsule over the femoral condyle. Pack the wound with gauze to ensure haemostasis, and cover with a piece of gauze.

Make a second skin incision over the posteromedial aspect of the distal part of the thigh, along the medial hamstring tendons. Start the incision at the level of the popliteal crease and extend it proximally for some 6–8 cm, cutting through the skin, subcutaneous tissue and deep fascia. Undermine and reflect the skin edges to expose the underlying structures. Identify and, by blunt dissection, free the tight tendons of the gracilis, semitendinosus and semimembranosus muscles. Divide or lengthen them one by one, depending on their state. Now, with a periosteal elevator, mobilize, elevate and retract laterally "en bloc" the popliteal vessels, the tibial nerve and the surrounding tissues (as in the first part of the procedure). Deal with the medial head of the gastrocnemius and posterior joint capsule as before. Extend the knee and check the fields of operation for any remaining tight structures; if any are found, divide them carefully, taking special care not to injure nerves or vessels.

Check the tension of the nerves and vessels while extending the knee, to determine the amount of correction for the first postoperative cast (see p. 44). Suture the lengthened tendons of fair and good muscles using non-absorbable stitches but leave unsutured all tendons of weak muscles. If the biceps muscle is good or normal, its tendon may be either lengthened or transferred and fixed to the bone just above the lateral condyle of the femur, as already described. A normal gracilis muscle may be sutured proximally to the medial intermuscular septum. Finally ensure haemostasis and close the wound in two layers.

Note The procedure described above is designed for treatment of severe long-standing contractures. In many knee contractures, division or lengthening of the hamstrings alone may be all that is required. An alternative method is the one described by Huckstep.[1]

After-care On completion of surgery but before releasing the tourniquet, apply a firm compressive dressing with gauze and elastic bandage over and around the operated site. Then deflate and remove the tourniquet, and keep the compression dressing in place for some 5–7 minutes. This helps stop capillary bleeding and prevents haematoma formation.

Remove the compression bandage and apply a long leg plaster cast, over a layer of cotton wool, with the knee in flexion as determined during the

[1] Huckstep RL. *Poliomyelitis. A guide for developing countries.* Edinburgh, ELBS and Churchill Livingstone, 1982: 125–140.

operation. Even if full correction is possible, it is safer to maintain the knee at about 30–40° of flexion in the first postoperative cast.

Every few hours check the blood circulation to the toes (temperature and colour) and active movements of the toes, especially extension, if these were present before the operation. If there is any doubt concerning toe movements or blood supply, reduce the correction (increase the flexion of the knee) by wedging the cast (see p. 44). Keep the limb slightly elevated for a few days to prevent swelling.

In the absence of complications, increase the correction (diminish the flexion) after 5 days by some 20–30°, by wedging the plaster. Increase the correction, if necessary, every 5–7 days until complete correction is achieved. A week after the last wedging, the cast may be removed and stitches taken out. A new cast is applied and bivalved to allow gentle flexion-extension exercises of the knee and limb to be started. Exercises should be undertaken twice a day and the limb kept in plaster in between. The patient may begin to walk with a posterior slab after a further week, if other contractures, such as of the hip, do not prevent it.

In young children with moderate flexion contracture (50° or less) complete correction can be obtained without overstretching the nerves and vessels at the application of the first plaster cast. For such patients, apply a long cast to the leg with the knee extended. The temperature, colour and movements of the toes must, however, be carefully checked during the first 3 days following surgery.

The rest of the management is similar except that the cast is bivalved 2–3 weeks after the operation, the stitches taken out, and gentle exercises may be started. Walking with a posterior slab or splint is allowed a few days later. The patient should wear the slab for a further few weeks during walking and at night.

Complications

Serious complications of posterior knee release operations include injury to the peroneal and tibial nerves or popliteal vessels, and overstretching of the nerves and vessels when the first postoperative plaster cast is applied. In the case of any abnormalities arising, proceed as described above under "After-care".

Osteotomy (for genu valgum and external torsion of the tibia)*

Mild genu valgum and tibial torsion may be accommodated in a long-leg brace. Moderate deformity can be corrected by division of the tight iliotibial band above the knee as described previously (p. 53). However, severe deformities require correction by osteotomy (Fig. 36). In particular, osteotomy of the proximal end of the tibia is necessary when marked genu valgum or excessive external torsion of the tibia interfere with bracing and walking, and cause secondary deformity of the foot (talipes varus).

For the operation, the patient is placed supine on the operating table. All other preoperative and immediate postoperative procedures are the same as for the posterior knee release. Corrective osteotomy of the tibia requires a preliminary osteotomy of the fibula.

Osteotomy of the fibula*

Technique

With the patient tilted 45° to the opposite side, make a longitudinal incision over the posterolateral aspect of the knee and fibula. Begin the incision 2–3 cm proximal to the head of the fibula and extend it distally for about

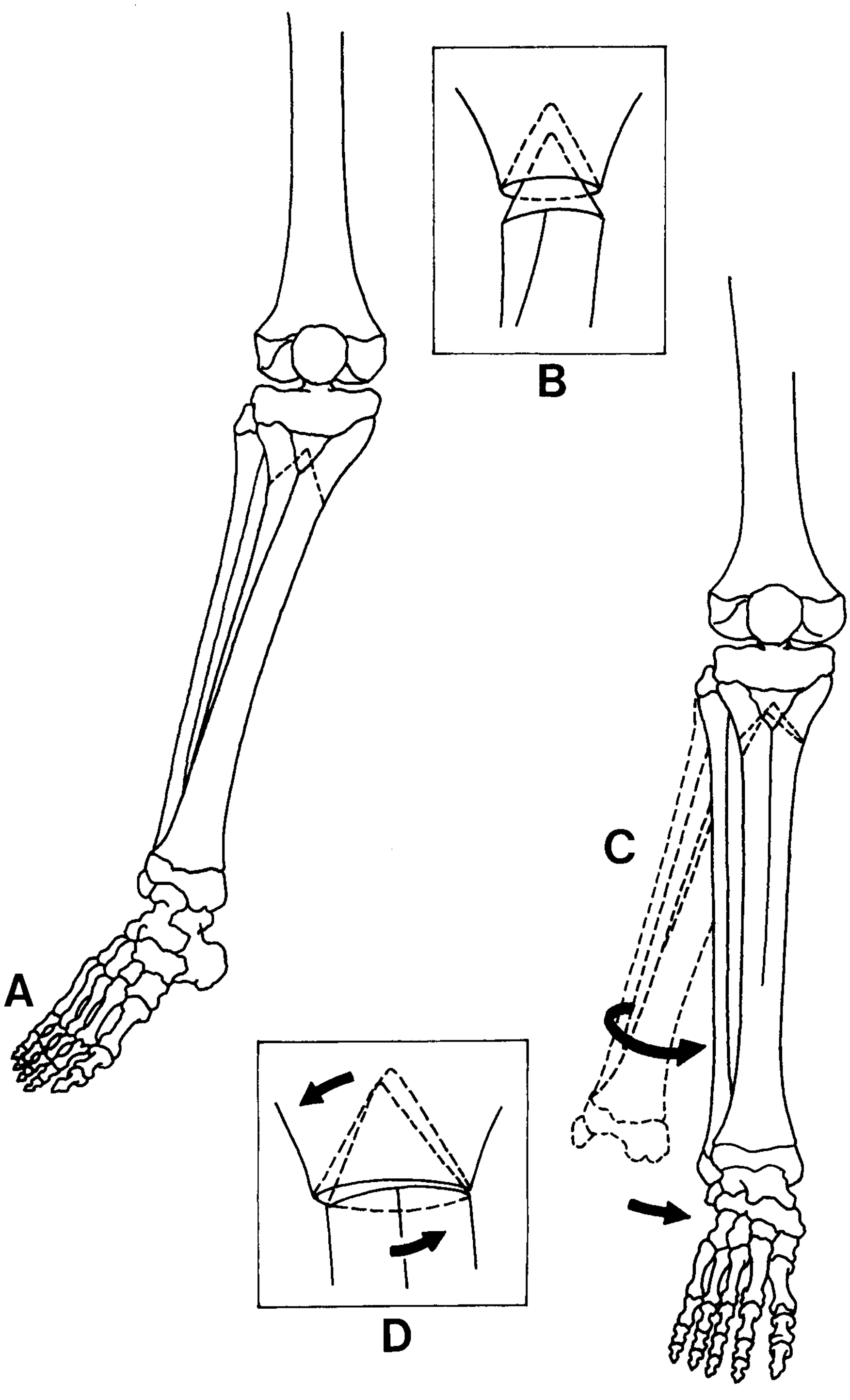


Fig. 36. Principle of corrective osteotomy of the tibia for genu valgum and external torsion of the tibia. Site of osteotomy (broken line) (A); palisade-shaped bone cutting (B); correction of valgus and external rotation deformities (C); situation at the site of osteotomy following correction (D).

8 cm over the posterior margin of the bone (Fig. 37A). Open the fascia in the distal part of the wound and extend the incision proximally over a grooved director to avoid injury to the peroneal nerve.

Isolate the peroneal nerve where it emerges from the posterior margin of the biceps tendon just above the head of the fibula (Fig. 37B). Carefully dissect the nerve free in a distal direction, and retract it anteriorly away from the head and neck of the fibula. With the nerve constantly in view, locate the plane of cleavage between the peroneal and gastrocnemius muscles. Retract the muscles and expose the fibula. Incise the periosteum for some 3 cm

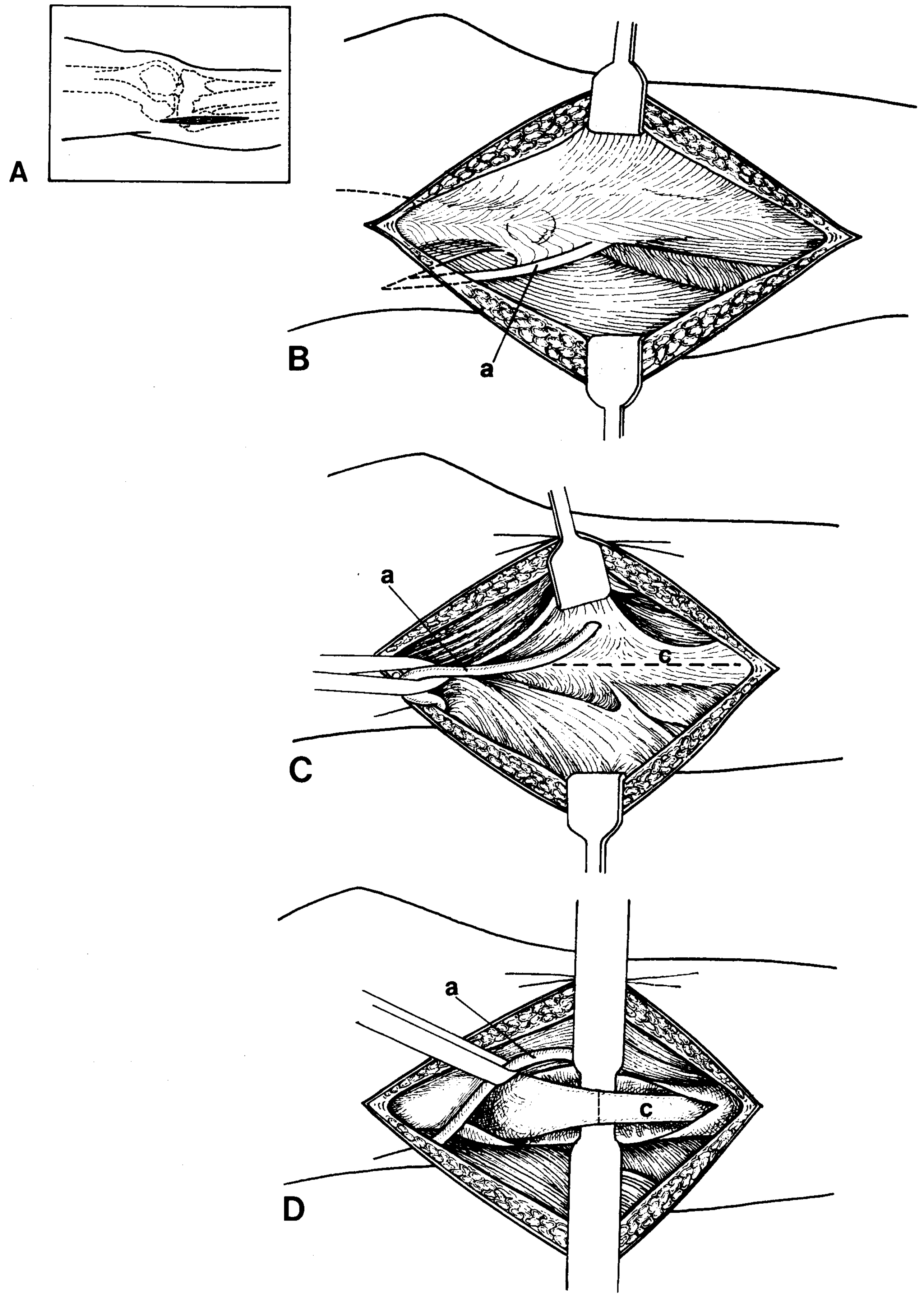


Fig. 37. Osteotomy of the fibula. Skin incision (A); exposing peroneal nerve (B); line of incision of fibular periosteum (C) (note peroneal nerve protected with a tape); site of osteotomy (D).
a — common peroneal nerve; b — head of fibula; c — fibula.

(Fig. 37C), and strip it around the bone with a periosteal elevator. Place curved bone levers under the periosteum to expose the site for osteotomy and to protect the structures behind the bone. With a narrow osteotome or bone-cutting forceps, excise a 1-cm segment of the fibula just below the neck of the bone (Fig. 37D). Pack the wound with gauze and temporarily cover it with a sheet of gauze and sterile towel.

Osteotomy of the tibia*

Technique

With the patient supine, make a curved incision over the anteromedial aspect of the proximal end of the tibia. Begin the incision at knee level and extend it distally for 6–8 cm, curving slightly anteriorly over the medial aspect of the tibia (Fig. 38A). Undermine and reflect the skin edges to expose the proximal end of the tibia, its medial and lateral condyles, and a small proximal portion of the diaphysis. Incise the periosteum transversely over the medial and lateral condyles at the level of the tibial tuberosity, then longitudinally just medial to the anterior edge of the tibia to a length of 4–5 cm, and again transversely over the tibial diaphysis (Fig. 38B). Now bend the knee some 50–60°.

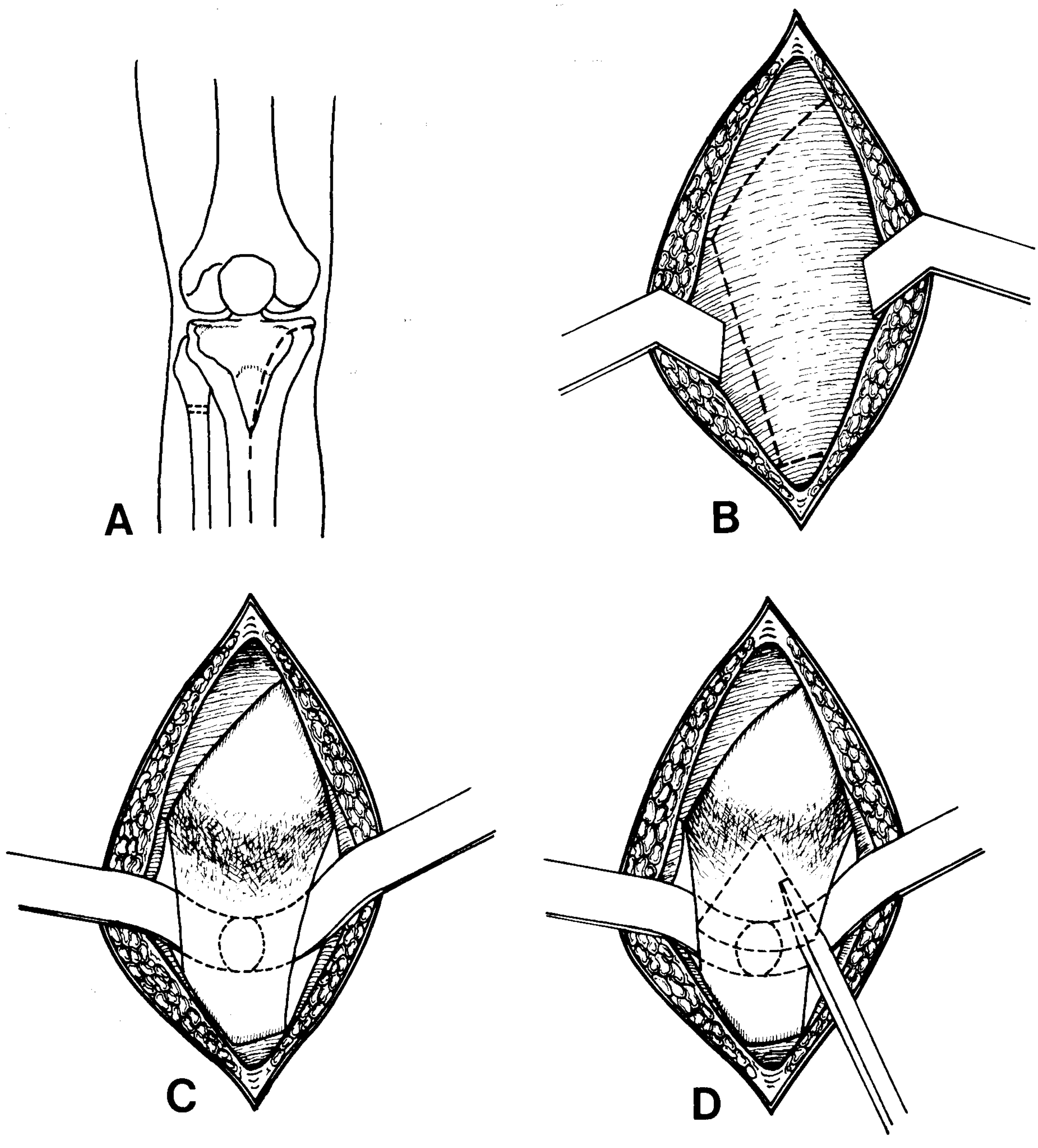


Fig. 38. Osteotomy of the tibia. Skin incision (A); line of incision of tibial periosteum (B); bone elevators placed beneath the tibia (C); completing the osteotomy (D).

Detach the periosteum all around the bone with a raspatory, and place curved bone levers under the periosteum to expose the site of planned osteotomy and to protect the structures behind the bone (Fig. 38C). Insert a 1–cm osteotome just below the tibial tuberosity, direct its cutting edge 45–60° towards the knee, and cut the bone progressively all around so that the proximal end of the distal fragment has the shape of the sharpened end of a pencil (palisade) (Fig. 38D). Rotate the distal fragment back and forth to facilitate completion of the osteotomy. Then extend the knee.

The distal fragment can now be set in the desired position, to correct any excessive tibial torsion or genu valgum. Because of the shape of the osteotomy, the fragments engage with each other and are relatively stable. The stability is increased by careful suturing of the periosteum, which in children is thick and strong. The repaired periosteum prevents transverse displacement of the fragments while allowing for desired torsional and angular changes during application of a postoperative plaster cast.

Close each skin incision (tibial and fibular) in two layers and apply a sterile dressing and elastic compression bandage. Remove the tourniquet, and after 5–7 minutes remove the compression bandage. Finally, apply a well-padded long leg plaster cast in the fully corrected position (with the knee extended). To ensure better immobilization, the cast may be extended proximally to include the pelvis.

Complications

Possible serious complications are injury to the popliteal vessels or the peroneal nerve, and extension of the osteotomy into the epiphyseal plate or knee joint.

After-care

After-care is the same as after knee release (see p. 67). On the third day take check radiographs (anteroposterior and lateral) of the leg. The radiograph should include the distal half of the femur and the proximal 2/3 of the tibia. The cast is bivalved and sutures removed after 3 weeks. Any necessary correction of the leg axis should be carried out, and a new cast applied and left for a further 5 weeks. No weight-bearing is allowed throughout this period. Thereafter, the plaster cast is again bivalved, and exercises of the knee and leg started. The patient may be allowed to walk without bearing any weight. Progressive increase of weight-bearing may begin from the tenth week postoperatively.

7
The foot and ankle

General considerations

Equinus deformity of the foot is very common and is usually combined with some varus or valgus deformities. The main causes of the deformity are muscle imbalance and gravity. If the extensor muscles of the foot are paralysed, the flexors, especially the triceps surae muscle, become contracted. Paralysis of extensors also causes drop foot which, with time, results in a fixed equinus deformity. The person then walks on his or her toes.

Varus deformity of the foot is caused by paralysis or weakness of foot evertors (peroneal muscles), while valgus deformity results from paralysis or weakness of foot invertors (tibialis anterior and tibialis posterior muscles). The weight of the body gradually worsens the deformity and therefore the stance and gait.

In addition to the direct causes of foot deformities, other factors can contribute indirectly to the development of an equinovarus foot. For example, an excessive external torsion of the tibia (caused by contracture of the iliotibial band) can force the foot into an equinovarus position in a long leg brace, or even without any brace if tibial torsion is combined with genu valgum.

Surgical correction of equinus deformity is not necessary if:

- The affected leg is shorter and the (slight to moderate) equinus deformity is just compensating for the discrepancy in length.
- The quadriceps femoris is paralysed and the slight equinus deformity is helping to stabilize the knee by encouraging extension or hyper-extension.

Equinus deformity should be corrected in the following instances:

- Both legs are of equal length but the equinus deformity makes the affected leg functionally longer, resulting in obliquity of the pelvis and scoliosis.
- The equinus is so severe (70–90°) that only the metatarsal heads bear any weight during walking, or it produces painful corns which worsen the cavus deformity of the foot.
- The equinus is combined with marked varus or valgus deformity.
- The equinus foot makes genu recurvatum worse.
- The equinus interferes with bracing in extensive paralysis of the limbs.

In addition, a varus or valgus deformity that interferes with walking or bracing should also be corrected. Surgery on the foot and ankle is contraindicated in a child or adult who would still be unable to walk because of the extent of paralysis of leg or trunk muscles.

The choice of surgical procedure depends on the age of the patient and the degree of deformity. For patients aged 10 years or less, procedures should normally be confined to the soft tissue, although Grice's sinus tarsi procedure may be used. For patients above this age it will be necessary to use both soft tissue and bone procedures.

Positioning

Operations on the calcaneus tendon are best performed with the patient in the prone position, but when they are carried out at the same time as other surgical interventions (e.g., on the hip) the supine position, with some tilt and leg rotation, will allow all procedures to be performed. For all other operations on the foot, place the patient supine with 45–60° tilt, if needed.

Skin preparation

The foot and leg up to the knee should be washed and cleaned with antiseptic.

Tourniquet

Apply a tourniquet for all operations on the calcaneus tendon and foot, except for percutaneous tenotomy of the calcaneus tendon.

Draping

Apply the foundation sheet and the drape over the tourniquet as described for knee operations (Fig. 39A). Then place a large sheet over the trunk and the leg and fix it to the skin on the upper third of the calf.

Finally, wrap the foot in a drape, leaving the heel uncovered; keep the drape in place with towel clips or a sterile bandage (Fig. 39B).

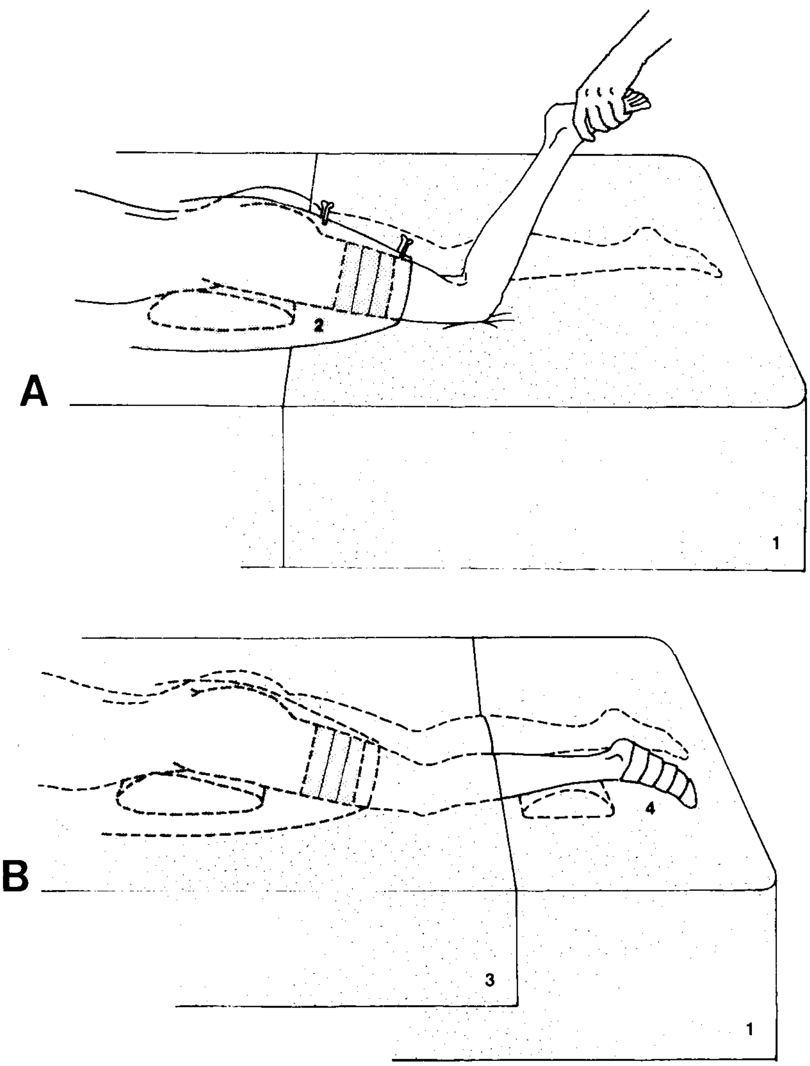


Fig. 39. Draping for surgery on the lower leg and ankle.
Foundation sheet (1); femoral drape (2); trunk sheet (3); foot drape (4).

Surgical procedures on the calcaneus tendon

The choice of technique from the four surgical procedures described below depends on the condition of the triceps surae muscle. While performing percutaneous or semi-open lengthening of the calcaneus tendon, remember that the fibres rotate. The tendon usually rotates through about 90° on its longitudinal axis between its origin and insertion. This anatomical arrangement determines how the tendon is incised.

Percutaneous tenotomy of the calcaneus tendon

This technique is most commonly used to correct equinus deformity of a severely paralysed foot with correctable varus deformity. A tourniquet is not needed and the patient does not need to be in the prone position.

Technique

Insert a narrow-blade knife flat percutaneously just medial to the calcaneus tendon, 2 cm proximal to its insertion (Fig. 40A). Turn the knife so that the sharp edge comes to lie below the medial edge of the tendon. Cut the tendon, beginning medially, without bringing the knife through the skin. The divided ends of the tendon will separate further when the foot is forcefully dorsiflexed (Fig. 40B), thus providing the desired correction. Insert one stitch in the skin, if needed.

Note

Keep the knife away from the neurovascular bundle (check the position of the bundle by feeling for the posterior tibial artery).

Percutaneous lengthening of the calcaneus tendon

This technique is indicated in a patient with a moderate equinus deformity and some residual function of the triceps surae muscle.

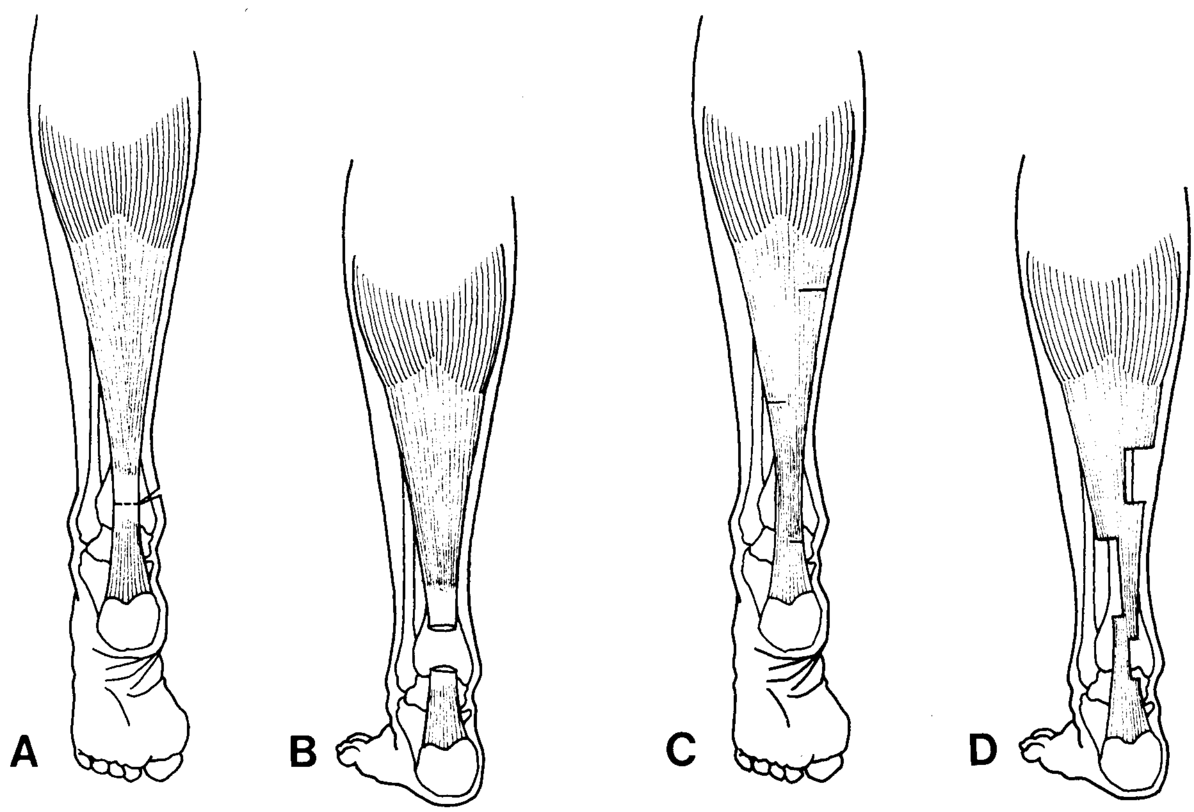


Fig. 40. Procedures on calcaneus tendon. Percutaneous tenotomy: line of division of tendon (A); correction of equinus deformity after tenotomy (B); percutaneous lengthening of calcaneus tendon: skin and tendon incisions (C); correction following forced dorsiflexion (D).

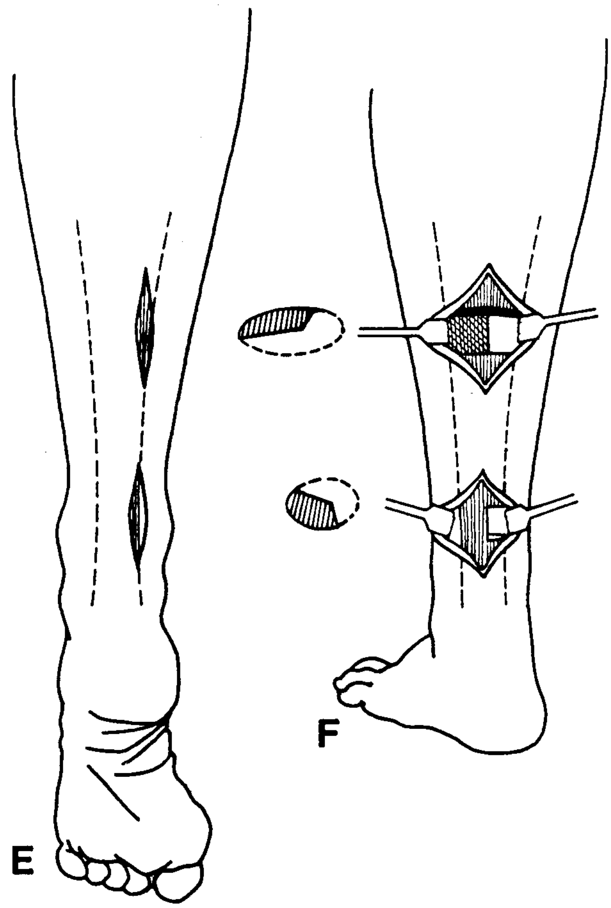


Fig. 40. Procedures on calcaneus tendon (*continued*). **Semi-open lengthening of calcaneus tendon: skin incisions (E); cutting through the tendon—anteromedial portion at distal site and posteromedial portion at proximal site (F).**

Technique

Insert the knife just medial to the calcaneus tendon and 2 cm proximal to its insertion (i.e., as for tenotomy), and cut through the medial third (only) of the tendon. Make a second percutaneous incision of the medial third of the tendon just below the musculotendinous junction (two-thirds down the calf). Make a third percutaneous incision in the lateral half of the tendon, between the two previous incisions (Fig. 40C). Now, forcefully dorsiflex the foot to make the cut ends slide on themselves while preserving continuity (Fig. 40D). Insert stitches in the skin incisions, if needed.

Semi-open lengthening of calcaneus tendon: modification of White technique

This procedure is suitable for patients with moderate equinus deformity and a fairly good triceps surae muscle.

The way of sectioning the tendon is determined by the rotation of its fibres. The fibres usually rotate 90° in the longitudinal axis, so that the fibres that are anterior distally become lateral proximally.

Technique

Make a 2-cm longitudinal incision over the medial border of the calcaneus tendon, just above its insertion (Fig. 40E). Expose the tendon, and divide transversely the anteromedial half or two-thirds of the tendon (Fig. 40F). Make a similar incision 5–7 cm proximally, and divide transversely the posteromedial half of the tendon. Finally, dorsiflex the foot to produce a sliding elongation in continuity. Close the skin incisions in two layers.

Open lengthening of the calcaneus tendon by Z-plasty

Open lengthening is indicated in patients with moderate or severe equinus deformity and a good triceps surae muscle. This technique provides the best control of the degree of tendon lengthening.

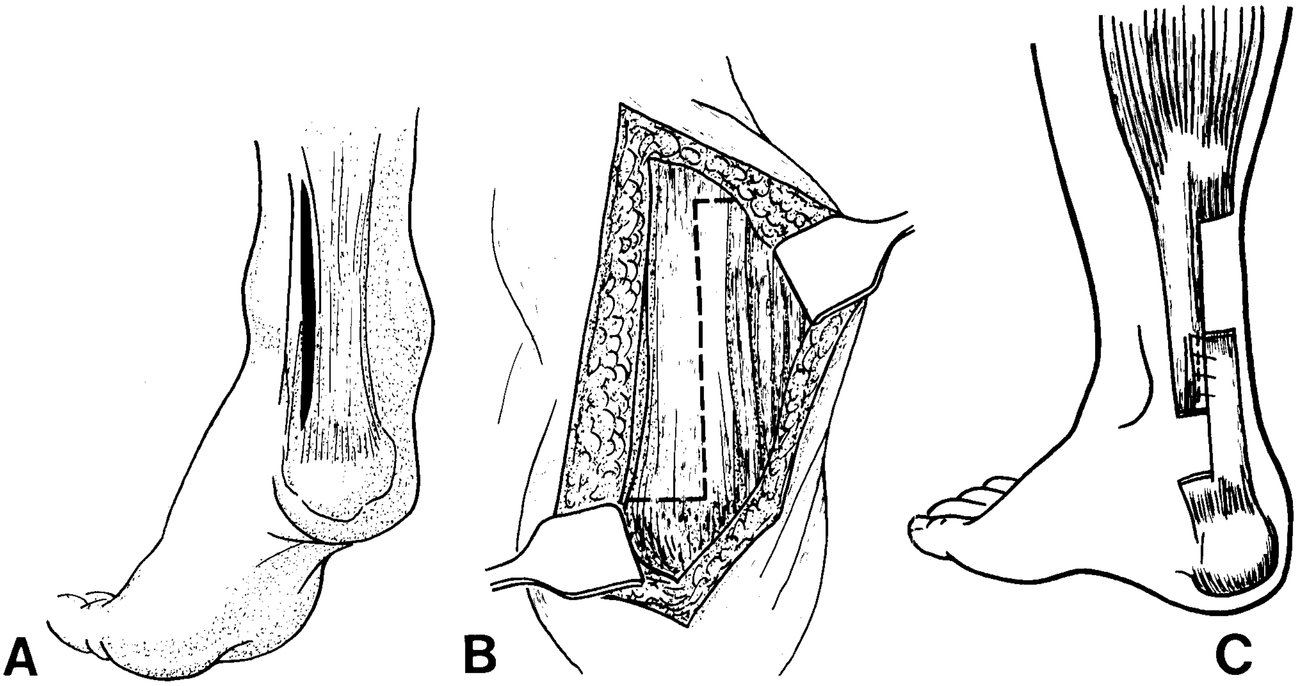


Fig. 41. Open lengthening of calcaneus tendon. Skin incision (A); Z-shaped division of tendon (B); lengthened tendon resutured (C).

Technique

Make an incision about 6–8 cm long, along and just medial to the calcaneus tendon (Fig. 41A). Divide the subcutaneous tissue and tendon sheath in one plane so that the latter remains attached to subcutaneous tissue; this will facilitate subsequent closure. Retract the skin edges and slightly lift the tendon using elevators placed under its proximal and distal ends. Now, insert the knife in the midline of the tendon and split it longitudinally for about 5–7 cm. Insert artery forceps in the split to keep the two halves a little apart. Next, divide transversely each half of the tendon, one distally, the other proximally (Fig. 41B). If there is a tendency to varus deformity, then divide the medial half distally and the lateral half proximally, and *vice versa* in the case of valgus deformity. (For equinus deformity alone, split the tendon in the frontal plane, and divide transversely the ventral part distally and dorsal part proximally.) Dorsiflex the foot to correct the deformity, so that the two halves of the tendon slide against each other. (If the deformity cannot be corrected, perform a posterior capsulo-ligamentotomy (see below).) Suture the two ends together in the lengthened position, keeping the foot in 5° of dorsiflexion (Fig. 41C). Stitch the tendon sheath with chromic catgut, and close the skin.

After-care

On completion of surgery, regardless of the technique used, apply a well-padded long leg plaster cast with the foot in 5–10° of dorsiflexion and the knee slightly flexed (5–10°). Elevate the leg on pillows during the first three days, and examine the toes regularly for any changes in circulation or movements. Remove the sutures after 2–3 weeks, and replace the plaster by a shorter one (below the knee) if the knee is stable, otherwise by another long one. The patient may now be allowed to walk. Removed the second cast 6 weeks after surgery and fit a brace.

Posterior capsulotomy of the ankle and subtalar joints*

Where full correction is not obtained after Z-division of the calcaneus tendon, a posterior capsulo-ligamentotomy is indicated. The operation consists of sectioning the posterior part of the capsule of the ankle and subtalar joints, and dividing the calcaneofibular ligament and posterior part of the deltoid ligament. Capsulo-ligamentotomy, if indicated, should be carried out as part of the procedure for Z-plasty lengthening of the calcaneus tendon.

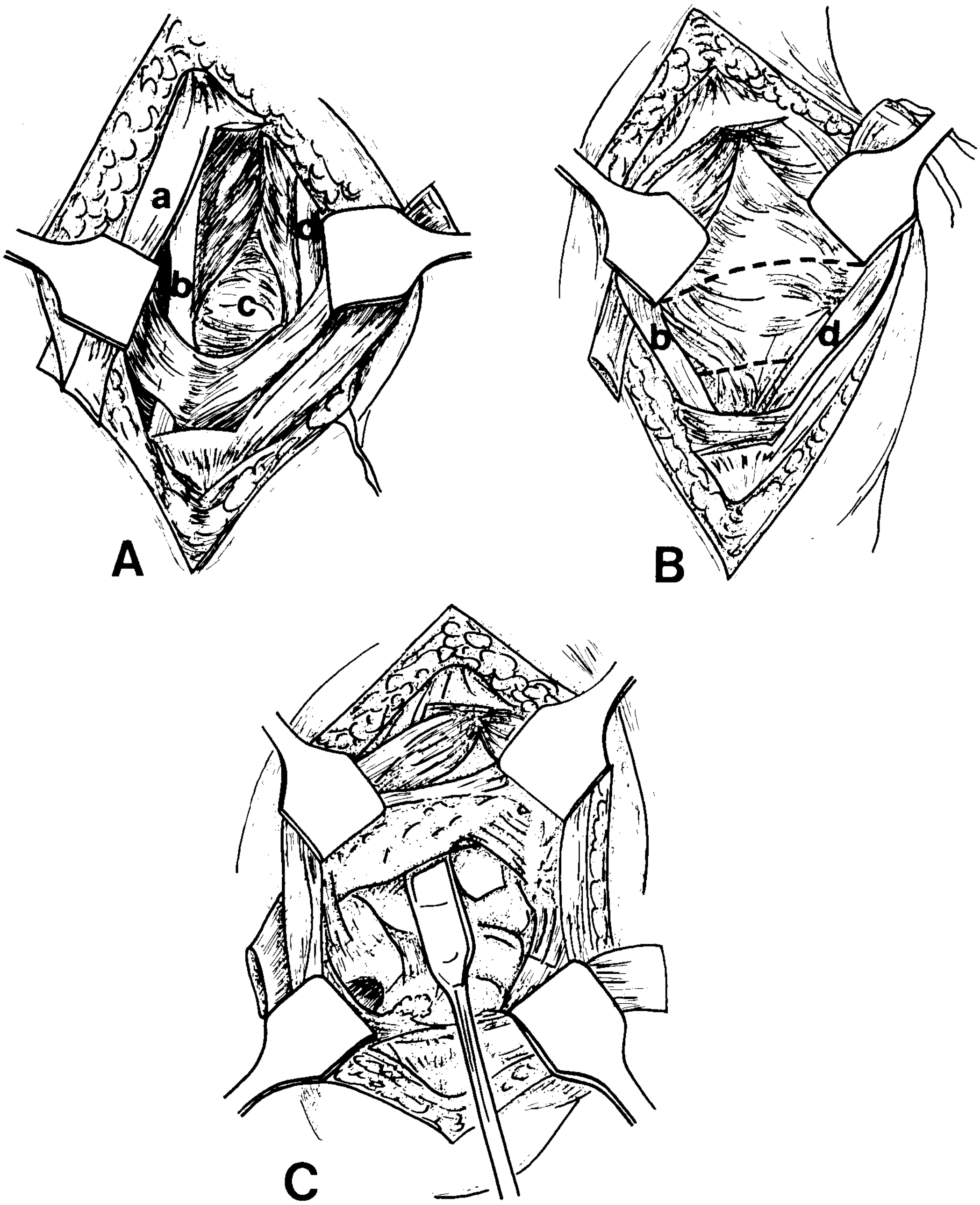


Fig. 42. Posterior capsulotomy of the ankle and subtalar joints. Exposing posterior aspect of the ankle after Z-lengthening of calcaneus tendon (A); lines of incision of ankle and subtalar joints (B); ankle and subtalar joints open (C).
a — calcaneus tendon retracted after Z-plasty; b — flexor hallucis longus tendon; c — capsule of the ankle joint; d — tendon of peroneus muscle.

Technique

After dividing the calcaneus tendon, dissect free the flexor hallucis longus tendon and retract it medially; retract the peroneal tendons laterally. Protect the neurovascular structures behind the medial malleolus where they lie medial to the flexor hallucis tendon. Once the posterior aspect of the ankle and subtalar joint is exposed (Fig. 42A), divide the exposed part of the capsule of the ankle and subtalar joints completely with scissors rather than with a knife to avoid damage to the articular cartilage (Fig. 42B). Divide the calcaneofibular ligament laterally, if it prevents ankle dorsiflexion. As you divide the ligament, keep the peroneal tendon retracted laterally and protect nerves and vessels from injury (Fig. 42C). On the medial side, divide the posterior part of the deltoid ligament, next to its calcaneal attachment to avoid injury to the posterior tibial vessels and nerve.

Note Avoid injury to the posterior tibial nerve and vessels by retracting them posteromedially along with the flexor hallucis longus tendon. Also take care not to damage the distal epiphyseal plate of the tibia in children.

Procedures for deformities of the foot

Triple arthrodesis*

Varus deformity accompanying equinus deformity in children below the age of 10 is usually moderate and can be corrected conservatively by manipulation (stretching) and use of plaster casts. However, surgery on the calcaneus tendon is often necessary for the equinus component. Children aged 10–12 years should be considered for corrective surgery if an equinovarus foot is causing difficulties in walking, footwear problems or pain. In teenagers and adults with fixed bony deformities of the foot, triple arthrodesis may be necessary.

A triple arthrodesis consists of excision of the articular facets of the subtalar (talocalcaneal) and midtarsal (calcaneocuboid and talonavicular) joints of the foot. The underlying bone is resected along with the articular facets in the form of wedges, shaped so as to correct the deformity of the foot (Fig. 43). The resulting opposed raw surfaces of bone fuse together, and the operation thus provides both a correction of the deformity and lateral stability of the foot.

Tourniquet, skin preparation and draping are the same as for procedures on the calcaneus tendon (see p. 74), except that the whole tarsus is left uncovered.

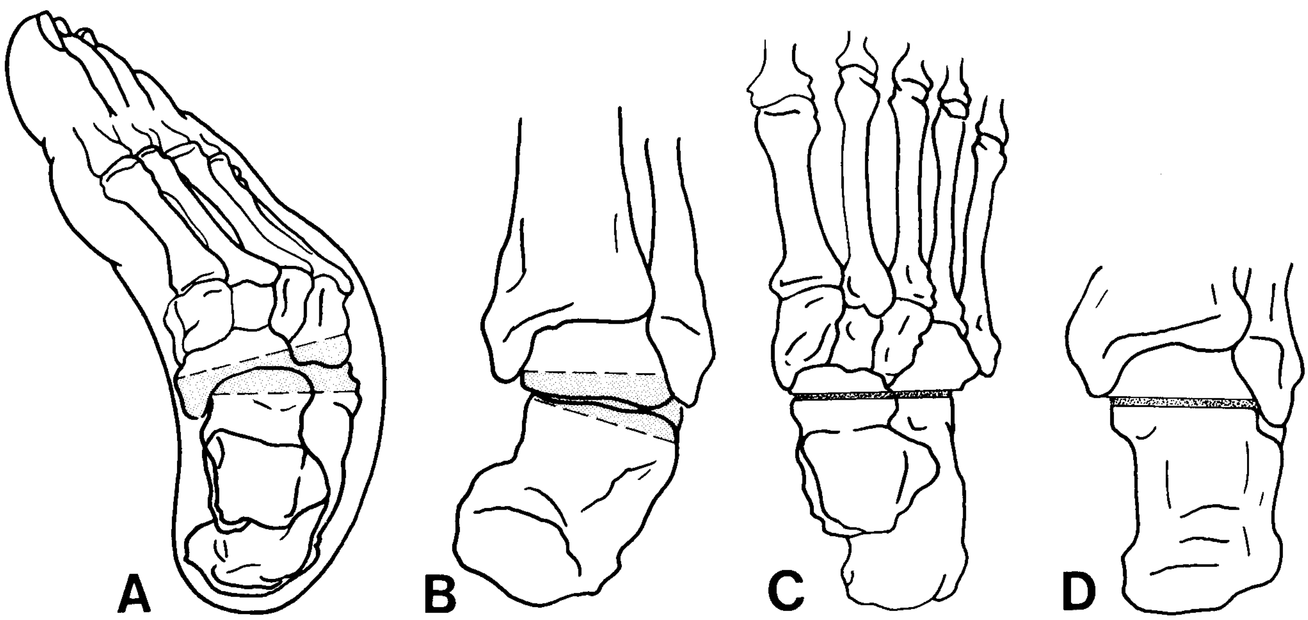


Fig. 43. Triple arthrodesis of the foot. Bone wedge of midtarsal joint to be resected (A); bone wedge of subtalar joint to be resected (B); position of foot corrected by resection (C, D).

Technique With the patient in a semilateral position (with sandbags placed under the hip and foot of the affected side), make a curvilinear incision beginning 1 cm posterior to the tip of the lateral malleolus, proceeding 1 cm below it, extending distally over the lateral aspect of the tarsus for about 3 finger-breadths and then turning medially towards the base of the second metatarsal bone (Fig. 44A). Carry the incision deep to the calcaneus bone and to the muscle bellies of the short extensors of the toes (which arise partly from the

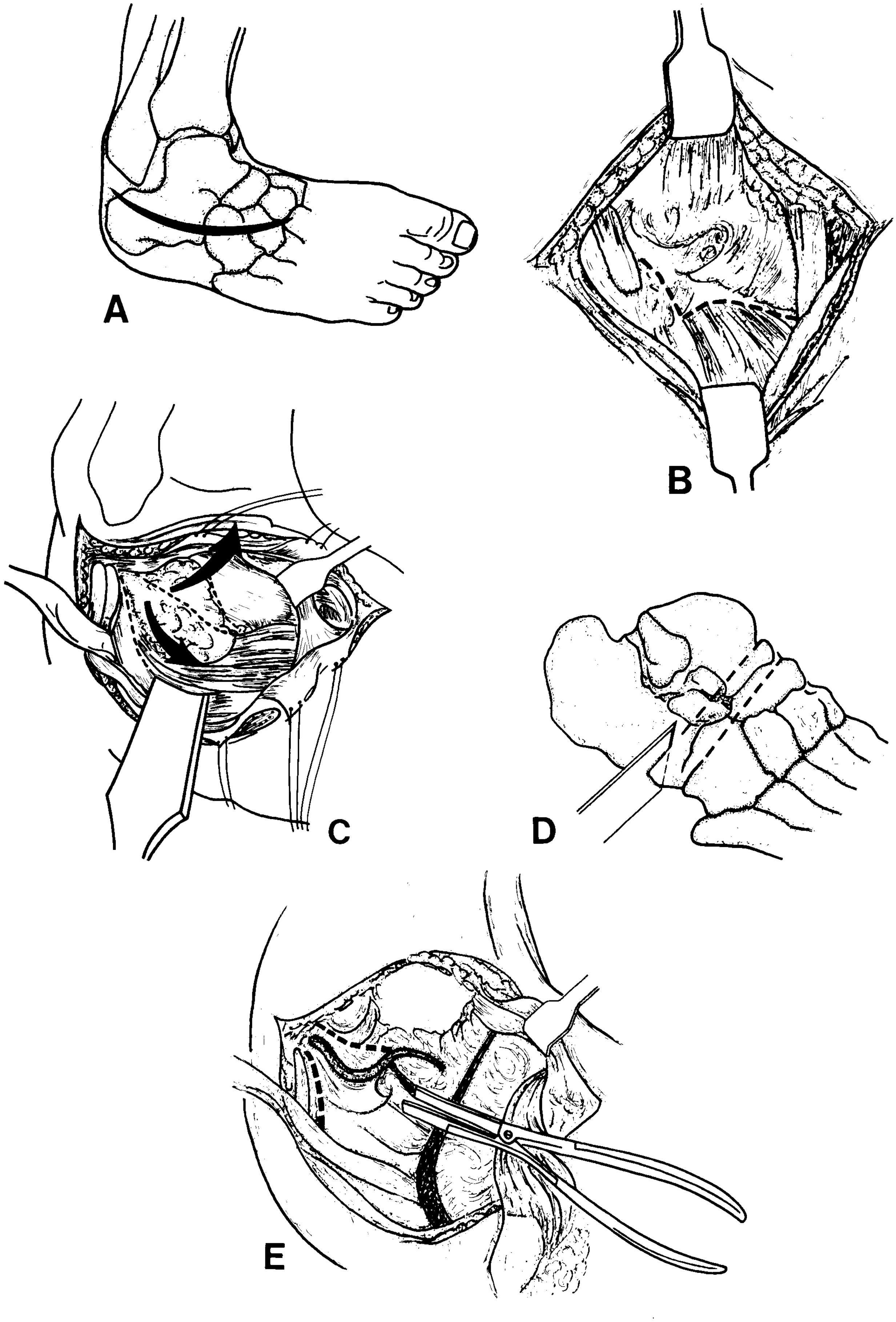


Fig. 44. Triple arthrodesis of the foot. Skin incision (A); exposure of midtarsal and subtalar joints (B, C); excision of midtarsal joint (D); excision of subtalar joint (E).

anterior portion of the calcaneus and partly from the cuboid bone). Do not undermine the skin at this stage of the operation. Using sharp dissection and a periosteal elevator, free the periosteum of the calcaneus from the contents of the sinus tarsi and origins of the short extensor of the toes. Reflect the edges of the wound distally and medially to expose the calcaneocuboid, talocalcaneal and talonavicular joints (Fig. 44B, C). To avoid necrosis of the upper skin flap it is essential that it be thick and reflected with the underlying tissues. The peroneal tendons, visible in the wound, should be retracted posteriorly, or divided if the muscles are completely paralysed.

Incise the capsules and open the joints, first the calcaneocuboid, then the talonavicular and finally the talocalcaneal. In the same order, excise the joint facets along with appropriate wedges of the underlying bone to correct the deformity. For better exposure, the assistant should hold the foot in the maximum varus-adductus position. Access to the calcaneocuboid and talonavicular joint is usually good (Fig. 44D). Resection of the posterior facet of the talocalcaneal joint may be difficult; to make it easier, place a spreader in the sinus tarsi and resect the joint surfaces starting anteriorly and proceeding posteriorly (Fig. 44E). Take care to avoid injury to the neurovascular bundle on the medial side of this joint. On completion of the resections, set the foot in the fully corrected position and check the contact of the excised surfaces. You may use cancellous bone chips from removed bone wedges to pack the sinus tarsi and fill any small empty spaces. Close the wound in two layers.

Note

Internal fixation is not usually needed. Triple arthrodesis alone may completely correct the varus or valgus component of a foot deformity, but only partially the equinus component. If an important equinus deformity is still present at the completion of triple arthrodesis, the calcaneus tendon should be lengthened, either at the same operative session or at a later date.

After-care

On completion of the operation, apply a well-padded plaster cast. Although a below-knee cast may be sufficient, a long leg cast is preferable, with the foot fully corrected and the knee flexed to 45°. The cast should be split over the dorsum of the foot and ankle, with the edges slightly spread apart (bivalved) and then held together with an elastic bandage. The patient should stay in bed with the leg elevated for the first 3–5 days. Remove the plaster cast at the end of 3 weeks, take out the sutures, and apply a new below-knee walking plaster cast. Some additional correction can be made manually if necessary before the plaster cast is applied.

Walking with weight-bearing can be permitted in the 4th week. The leg should be kept in a plaster cast for 12 weeks (with change of cast if necessary), after which time, apply an elastic bandage around the foot and ankle for a week or two to control post-cast oedema.

Extra-articular arthrodesis of the subtalar joint (Grice procedure)*

Paralysis of the foot invertors (supinators) results in a lateral instability of the foot accompanied by valgus deformity. The instability is worse if the evertors (pronators) of the foot are also paralysed, impairing walking especially on uneven ground. The affected foot may be stabilized either by bracing or surgery.

Triple arthrodesis is contraindicated in children below the age of 10 years because it arrests growth of the foot. On the other hand, an extra-articular arthrodesis can be safely carried out. The procedure consists of blocking the sinus tarsi (which lies outside the joint) with a bone graft taken, for example, from the tibia. The sinus tarsi can easily be located by percutaneous palpation. While manipulating the foot into the equinovarus position, you can feel with your fingertip a depression between the tarsal bones, about 1 cm in front of the tip of the lateral malleolus.

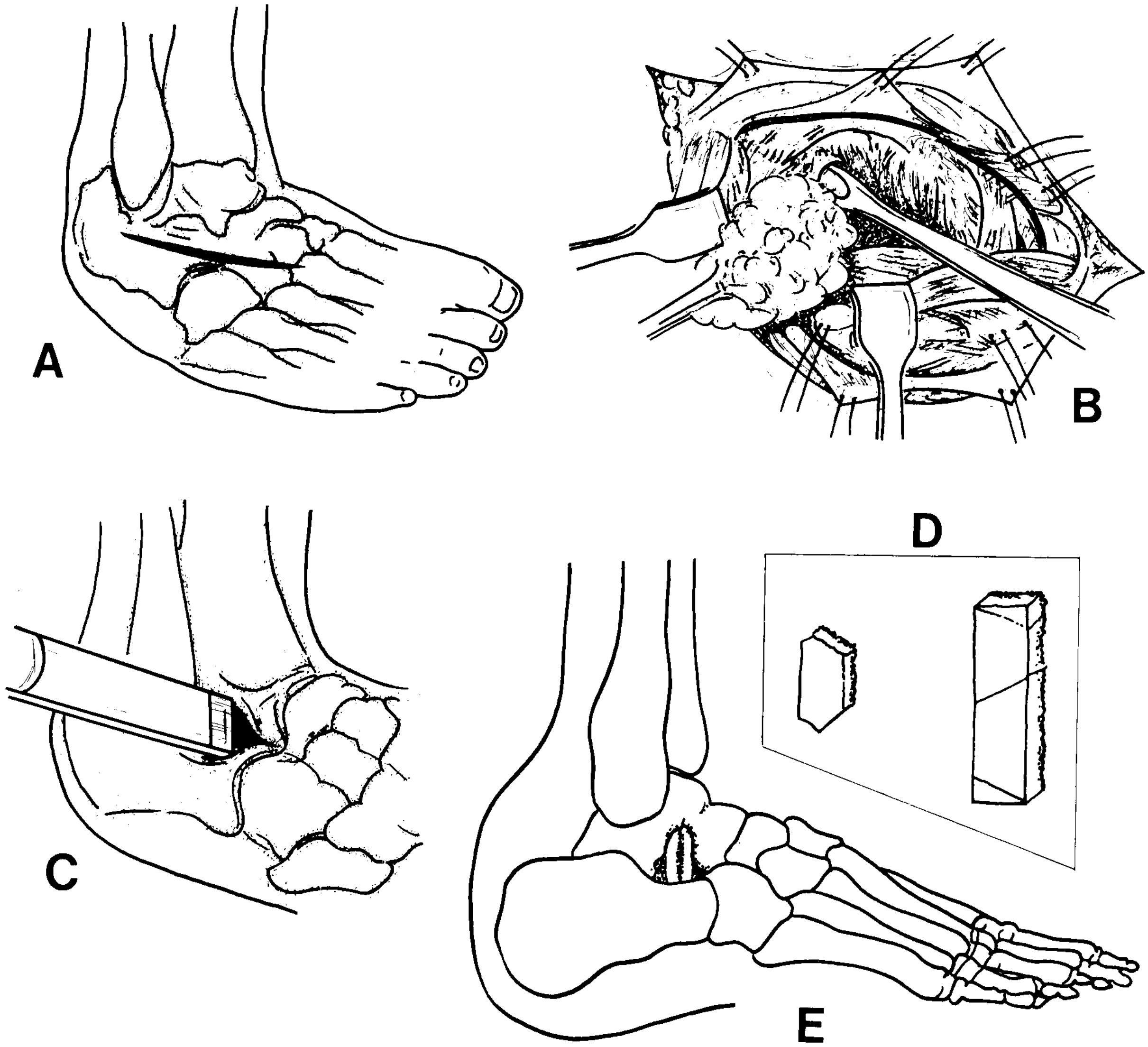


Fig. 45. Grice's extra-articular arthrodesis of the subtalar joint. Skin incision (A); removing fat from sinus tarsi (B); preparing bed for bone graft (C); position of bone grafts (D) in sinus tarsi (E).

Technique

With the child in a semilateral position, make a slightly curved incision 4–5 cm long over the lateral aspect of the foot, centred over the sinus tarsi (Fig. 45A). Deepen the incision down to the sinus tarsi, which is normally filled with a fibrofatty tissue. Incise the periosteum surrounding the sinus tarsi, starting on the neck of the talus which forms the roof of the sinus tarsi and moving to the calcaneus in the floor of the sinus. With the foot in the equinovarus position, remove all the soft contents of the sinus tarsi with a sharp curette (Fig. 45B). Now bring back the foot to the neutral position in order to determine the size of the bone graft needed. Manipulate the foot back into the equinovarus position and insert an osteotome to prepare a bed for the graft (Fig. 45C). The bed should be about 3–4 mm deep and 6–7 mm wide in both the roof and floor of the sinus. The bed should be such that the graft lies in the long axis of the tibia, or slightly inclined so that its distal end is a little anterior to the proximal end.

Take a bone graft of appropriate size from the anteromedial surface of the proximal part of the tibia (see pp. 83–84). Cut the graft into two trapezoidal pieces of appropriate equal size (removing their corners as may be necessary for inserting the grafts) (Fig. 45D). Hold the grafts with their cancellous surfaces together and, with the foot inverted, insert the grafts into the previously prepared bed. As the foot is brought to the neutral position, the grafts countersink into the cancellous recipient bones (Fig. 45E). Make sure the grafts are well locked with no tendency to lateral displacement, and that the foot is in the desired position and has the required stability. Close the wound in two layers.

After-care

Apply a long leg cast with the foot in the corrected position and the knee flexed 30°. Walking on crutches without weight-bearing may be allowed after 3 weeks. Weight-bearing, in a long or short leg cast (as necessary), can be allowed after 6 weeks. The cast should be removed 12 weeks after the operation.

Taking a bone graft from the tibia

Bone grafts are widely used in orthopaedic surgery. Cortical grafts are commonly taken from the tibia. The technique described below is suitable for taking a graft for use in Grice's procedure for stabilization of the foot. Grafts can also be taken from the rim of the iliac crest or from the fibula. The procedure for taking a bone graft for other purposes does not differ significantly from that described, except for the length of the incision and the size of the graft. Although a bone graft can be taken using a hand drill and a sharp osteotome, the procedure is much easier if an electric saw is used.

Technique

Make a curved incision starting at the level of the knee joint, medial to the patellar tendon, extending distally, parallel and slightly lateral to the anterior margin of the tibia for about 7–9 cm, and then swinging across the tibia to the medial margin (Fig. 46A).

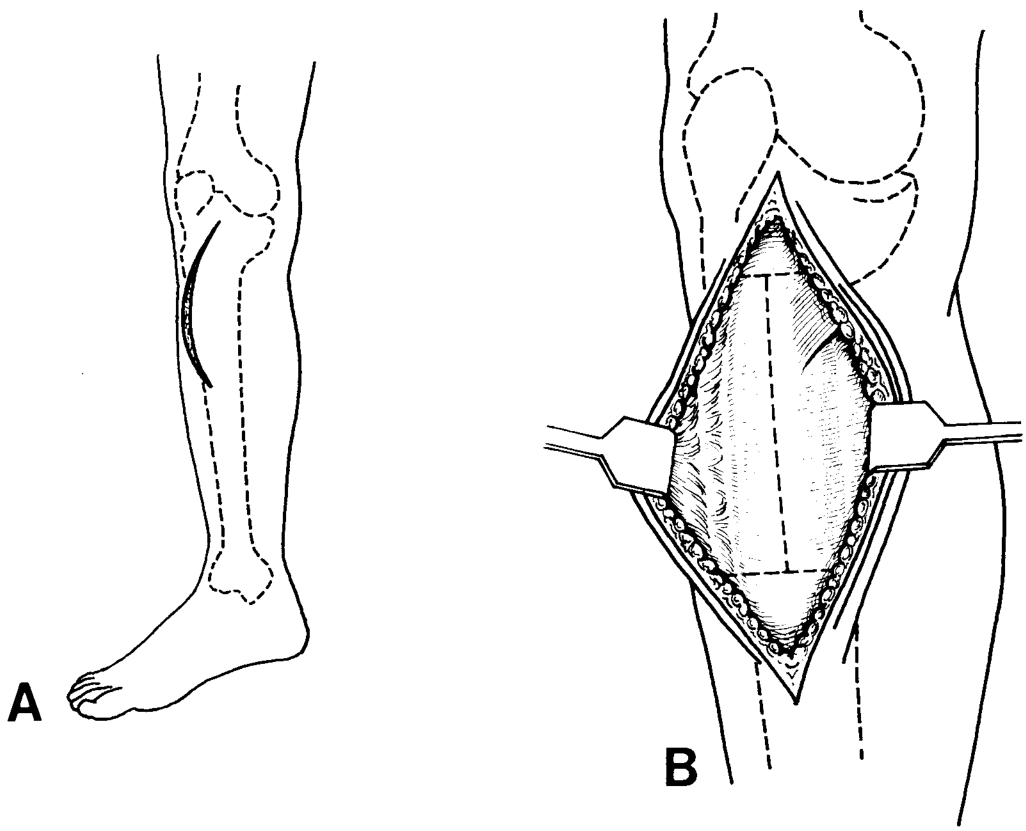


Fig. 46. Taking a cortical bone graft from the tibia. Skin incision (A); lines of incision of the periosteum (B).

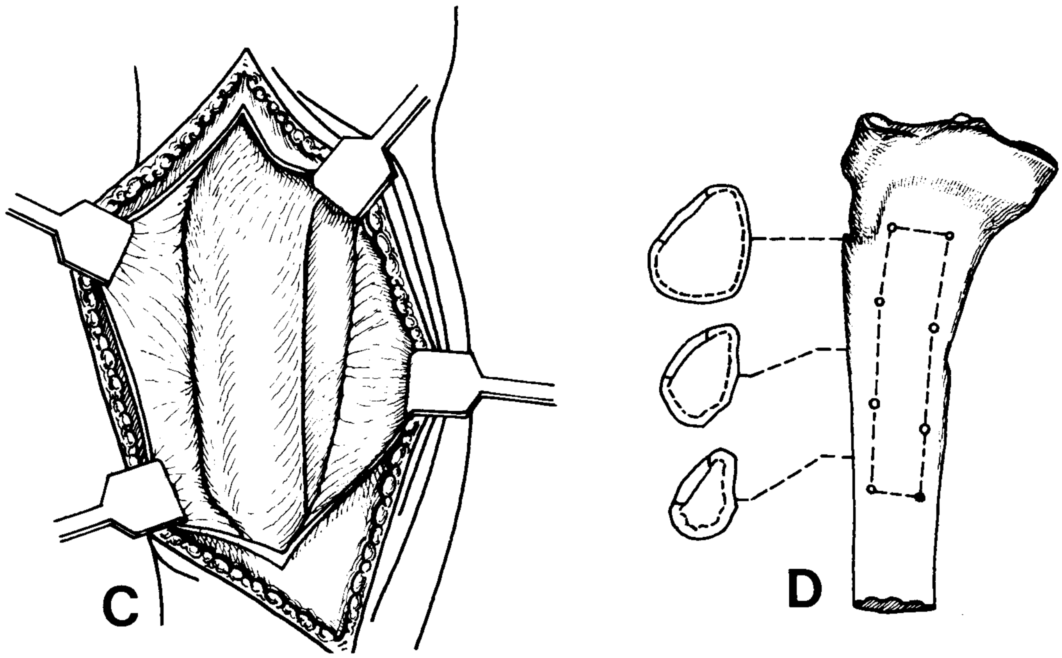


Fig. 46. Taking a cortical bone graft from the tibia (*continued*). Exposure of anteromedial aspect of the tibia (C); holes drilled in cortical bone (D): broken line indicates shape of graft to be taken.

Mobilize the skin margins and retract them to expose the medial surface of the tibia. Incise the periosteum for 6–7 cm along the midline of its medial surface and then transversely at both ends of the longitudinal incision (Fig. 46B). Elevate the periosteum along with the pes anserinus in the proximal part of the incision to expose the underlying bone (Fig. 46C). Drill four holes through the cortex to mark the corners of the graft. For Grice's procedure, the graft should usually be about 6 cm long and 1.5 cm wide. You may make a few additional holes through the cortex in a line to facilitate cutting out and removing the graft (Fig. 46D). Use the pointed edge of a thin-bladed osteotome to cut through the cortex, first transversely between the holes marking the corners of the graft, then longitudinally. When cutting longitudinally drive the osteotome in obliquely through the cortex. After removal of the graft, some cancellous bone may be taken (if required) from the tibial condyles in the resulting window. Use a bone curette for this purpose, and take care to avoid penetrating the growth plate in children. On completion of the procedure, suture the periosteum and close the wound.

Soft-tissue procedures for cavus deformity of the foot

Cavus deformity is a fixed equinus position of the forefoot on the hindfoot, which manifests itself by an excessively high longitudinal arch of the foot (Fig. 47A, B). Painful corns and callosities can develop below the metatarsal heads as result of excessive pressure and weight-bearing.

Surgical treatment is indicated when the cavus deformity is severe and disabling. It is also indicated as part of treatment for other deformities (e.g., equinus or equinovarus deformity) when there is an associated moderate cavus deformity. The choice of procedure depends on the age of the patient and the severity of the deformity. Operations on soft tissues should be performed in younger patients with moderate deformity. Operations on the tarsal bones are indicated when the deformity is severe, usually in patients above 12 years of age.

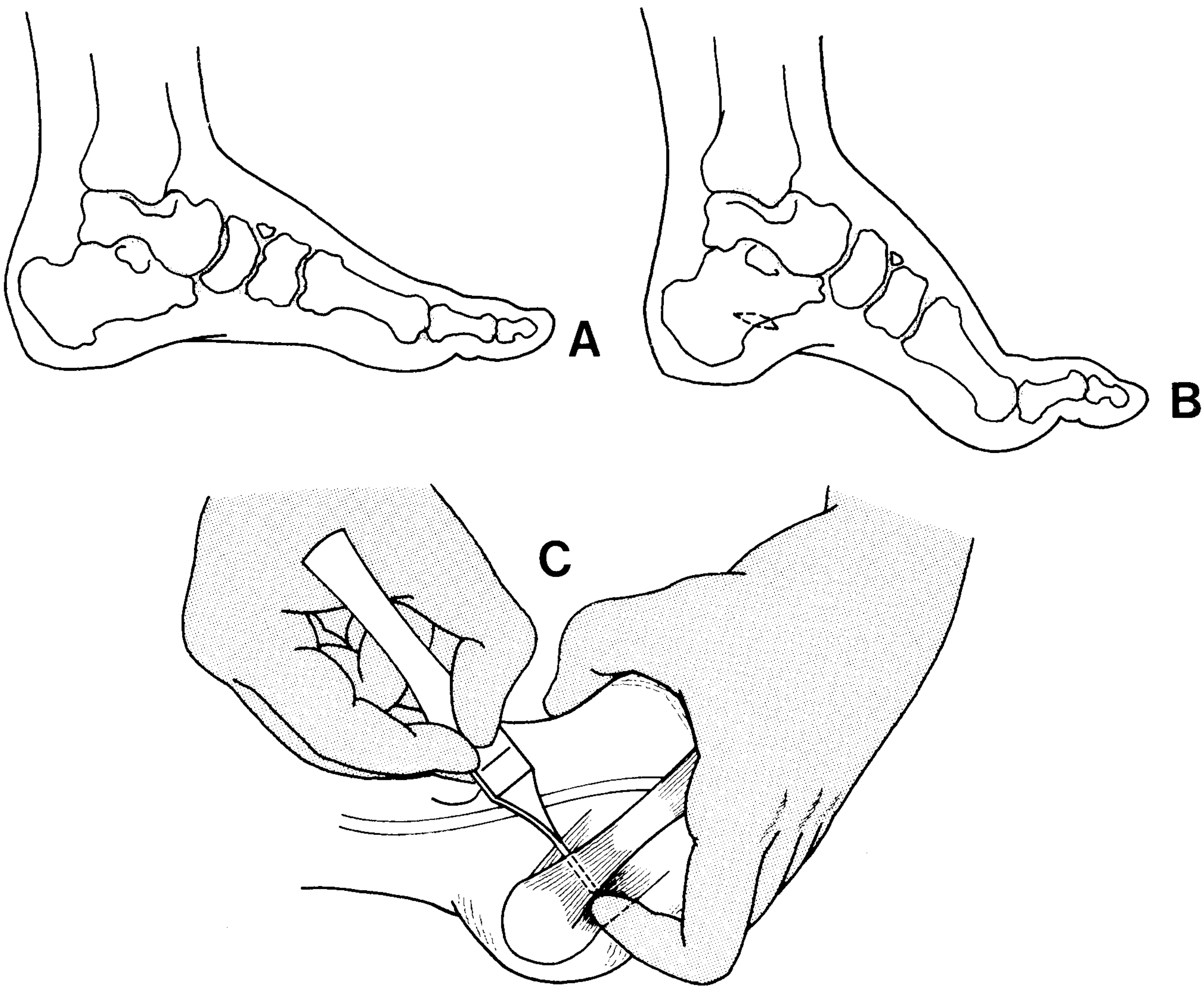


Fig. 47. Cavus foot deformity. Normal foot (A); cavus deformity of foot (B) (broken line indicates site of incision for percutaneous plantar tissue release); percutaneous plantar tissue release (C).

Cavus deformity caused by poliomyelitis is usually moderate and associated with other deformities of the foot, such as equinus or equinovarus deformity. Release of contracted plantar soft tissues is usually sufficient. The procedure is usually performed with other procedures on the calcaneus tendon or with triple arthrodesis, in the first part of the operation. The operation involves dividing the contracted plantar fascia and short plantar muscles at their origins on the calcaneal tuberosity. In most cases it can be performed percutaneously.

Percutaneous plantar soft-tissue release

Technique

First locate, as accurately as possible, the site over the lower medial aspect of the calcaneus, where the plantar fascia blends with the calcaneus tuberosity. It is slightly behind and about 3 cm below the tip of the medial malleolus. Take a narrow-bladed tenotome (do not use a knife with a disposable blade as it may break in the depths of the wound), hold it with the blade flat and insert the point through the skin to touch the lower medial surface of the calcaneus. With slight up-and-down movements displace the blade towards the sole of the foot until there is loss of contact with bone (Fig. 47C). The blade is now below the calcaneus on its plantar aspect and just where the plantar fascia and the short plantar muscles emerge from the calcaneal tuberosity. Advance the knife deeper until you feel its point under the skin just below the lateral aspect of the calcaneus. Now stretch the plantar structures by grasping (with your other hand) the forefoot around the metatarsal heads and forcefully dorsiflexing it. Rotate the sharp edge of the blade 90° so that it points towards the sole of the foot. Cut through the origins of the short plantar muscles and plantar fascia, pushing them against the knife with the index finger of the hand holding the forefoot. Proceed with cutting from the lateral to the medial side of the foot. Check, by palpation, that all contracted structures have been released. Apply pressure over gauze for haemostasis. Skin suture is usually not needed.

Note

Take care to avoid damage to the neurovascular bundle, which lies about 1 cm behind and below the medial malleolus and continues on the medial side of the hindfoot and the plantar aspect of the foot. Locate the posterior tibial artery by palpating its pulse just behind and below the medial malleolus. Inserting the knife well below that point will avoid any accidental damage to the neurovascular bundle.

Open plantar soft-tissue release (Steindler procedure)

Open plantar soft-tissue release is done for cavus deformity alone in younger children, when bone surgery is contraindicated.

Technique

Make a longitudinal incision along the medial side of the calcaneus and continue it distally 4 cm anterior to the medial calcaneal tubercle. Dissect and free the superficial and deep surfaces of the plantar fascia from the muscles throughout its width. Incise the fascia transversely close to where it blends into the plantar surface of the calcaneus. Next insert a blunt instrument (e.g., an elevator) between the plantar surface of the calcaneus and the flexor digitorum brevis, adductor hallucis brevis and aoductor digiti quinti muscles, close to their origins. Elevate these muscles and release them by stripping their origins from the calcaneus with a periosteal elevator. After haemostasis, close the skin with interrupted sutures.

Bone procedures for cavus deformity of the foot*

In rare instances, when cavus deformity is very severe in children above 12 years old and adults, who are suffering from painful callosities and corns, operations on the tarsal bones may be indicated.

Anterior tarsal wedge osteotomy*

The aim of the procedure is to correct severe cavus deformity (where the apex of the cavus is within the anterior tarsal bones). It does not correct any varus or valgus deformity of the hindfoot.

Technique

Make a dorsal longitudinal incision in the midline of the foot, beginning just proximal to the midtarsal joint and extending distally for 6–8 cm to the level of the middle of the metatarsal shafts (Fig. 48A). Separate the extensor tendons (usually between the third and fourth toe extensors). Expose and incise the periosteum longitudinally, then elevate and retract its edges medially and laterally. Identify the metatarsal bones. Now make an almost vertical transverse osteotomy through the centre of the navicular and cuboid bones down to the plantar surfaces of the bones. Make a second transverse osteotomy distal to the first, so that the two join at the plantar surface of the tarsus. The distance between the two osteotomies is determined by the severity of the deformity to be corrected, but is usually about 1.5–2 cm (Fig. 48B). Remove the bone wedge (Fig. 48C) and elevate the forefoot to close the defect (Fig. 48D). Check whether the desired correction has been obtained. If not, excise another wedge of bone. Close the periosteum and the skin with interrupted sutures.

After-care

After-care is the same as that following triple arthrodesis (p. 81).

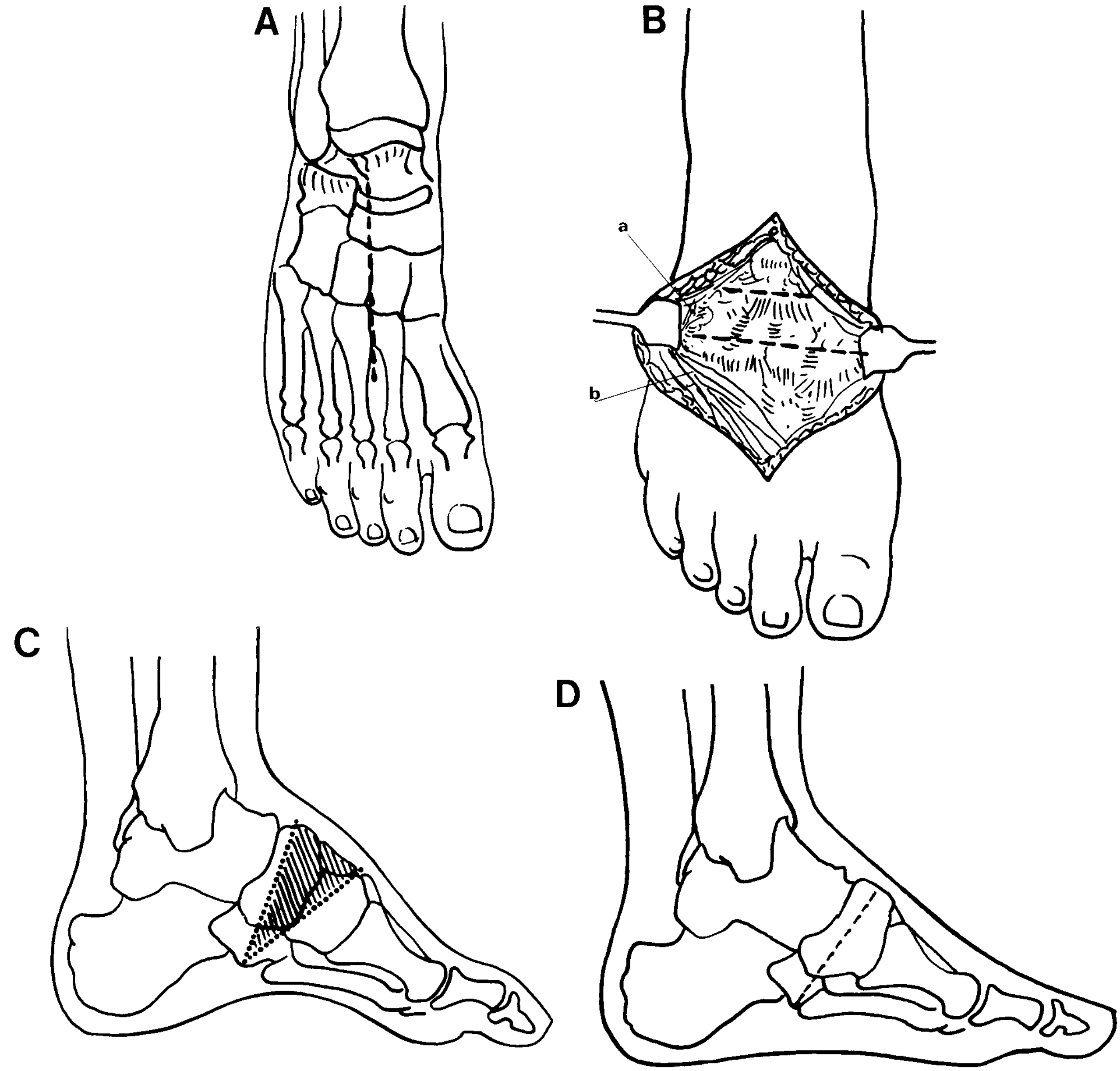


Fig. 48. Tarsal wedge osteotomy. Line of incision (A); site of osteotomy indicated by broken lines (B); lateral view of osteotomy (C) (shaded area indicates the bony wedge to be removed); closure of gap to correct cavus deformity (D).
a — cuneiform metatarsal joint; b — extensor digitorum brevis and peroneal tendons are retracted laterally.

V-Osteotomy of the tarsus (Japas procedure)*

A wedge-type tarsal osteotomy provides good correction of a severe cavus deformity, but at the expense of the length of the foot. The foot becomes shorter because of the excision of bone. The Japas osteotomy gives correction with little or no shortening, and is especially indicated in teenagers, whose feet are still growing.

Technique

Begin with percutaneous or open plantar soft-tissue release (Fig. 49A). Then make a longitudinal incision of 6–8 cm on the dorsum of the foot (Fig. 49B). Continue the dissection between the second and third extensor tendons and retract the tendons medially and laterally, respectively. Free and retract laterally the extensor digitorum brevis muscle.

Expose (extraperiosteally) the dorsum of the foot from the talonavicular joint to the tarsometatarsal joints. Make a V-shaped osteotomy as follows: Begin

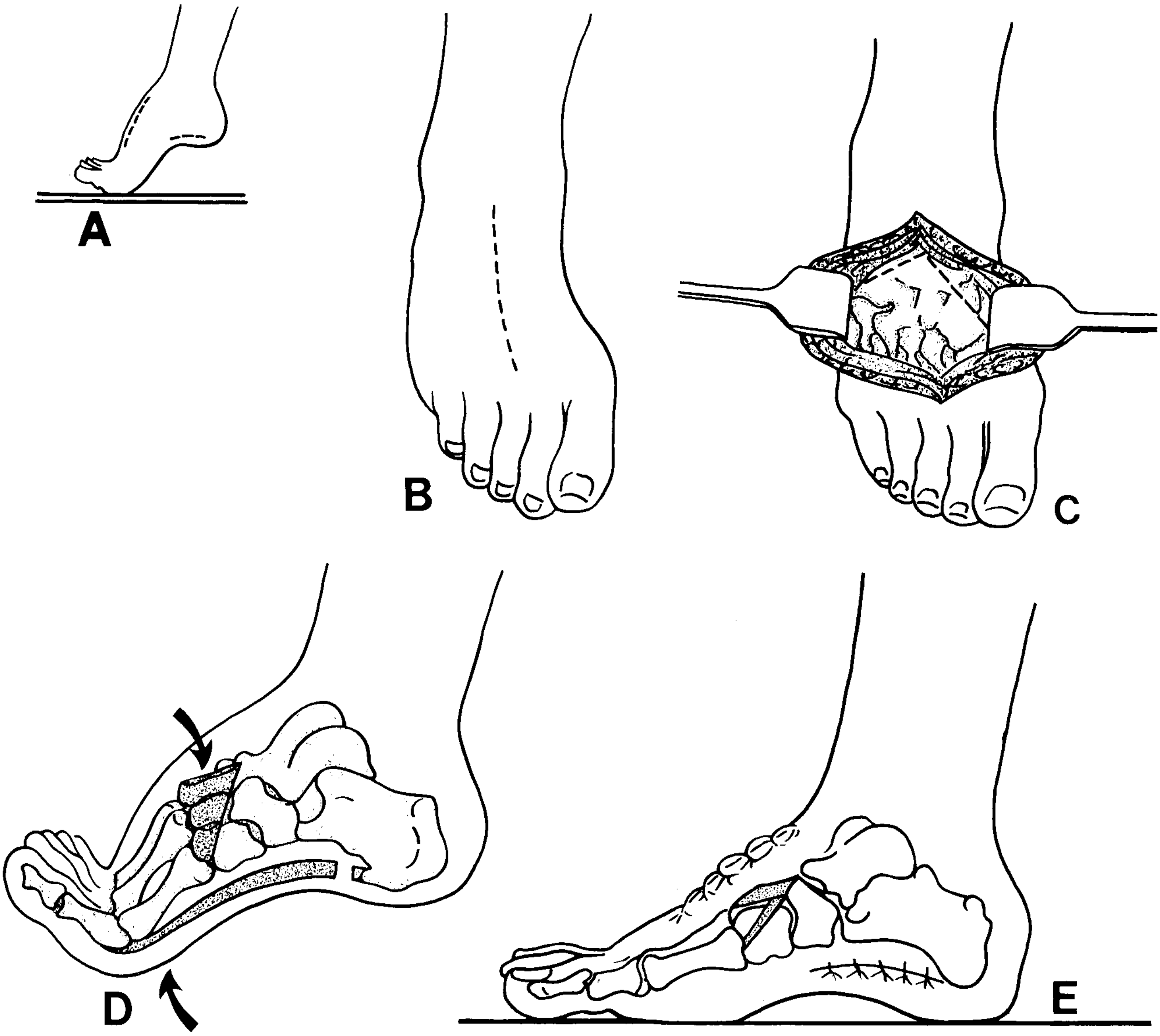


Fig. 49. Japas procedure for V-osteotomy of the tarsus. Lines of incision for open plantar soft tissue release and for tarsal wedge osteotomy (A); incision on dorsum of foot (B); exposure of tarsal bones (C) (broken lines indicate lines of osteotomy); depression of forefoot at the site of osteotomy and elevation of metatarsal heads (D, E).

the medial "limb" of the osteotomy in the first cuneiform bone just proximal to the metatarso-cuneiform joint, and the lateral "limb" in the cuboid bone immediately proximal to its joint with the fifth metacarpal bone. Carry the "limbs" proximally to join in the midline of the foot at the apex of the cavus deformity (usually within the navicular bone) (Fig. 49C). Take care not to enter the midtarsal joint. After the osteotomy has been completed, apply traction to the distal fragment, depressing its proximal margin towards the plantar surface while elevating the metatarsal heads (Fig. 49D). This manoeuvre is facilitated by inserting the end of a periosteal elevator below the proximal fragment with the rest of the elevator over the distal piece. Correct any abduction or adduction deformity of the forefoot by simple manipulation. Close the wound (Fig. 49E). Apply a plaster cast to hold the foot in the corrected position.

After-care Postoperative management is the same as that following triple arthrodesis (p. 81).

Tendon transfers for drop foot

A person with drop foot who, because of paralysis of the foot dorsiflexors, drags the foot along the ground during walking, should be provided with bracing. If bracing is not available, tendon transfers may be an alternative provided that there are normal muscles available for this purpose. In practice, the two tendons often suitable for transfer are those of the posterior tibial and long peroneal muscles. The end of the transferred tendon may be sutured to the base of the second or third metatarsal bone, or to the corresponding cuneiform bone if the tendon is not long enough. For a successful tendon transfer its muscle must be at least grade 4, and preferably grade 5, on Lovett's scale. Any fixed deformity of the foot should be corrected before tendon transfer. Tendon transfer procedures are best performed with the use of a tourniquet and under general anaesthesia. Skin preparation and draping are the same as for triple arthrodesis.

Anterior transfer of the posterior tibial tendon

The posterior tibial tendon can be transferred to the dorsum of the foot either through a subcutaneous (subfascial) tunnel, or through the interosseus membrane. The former technique is easier to perform and provides comparable results.

Technique

With the patient in a semilateral position, make an incision over the medial aspect of the foot. Begin the incision just below the tip of the medial malleolus and extend it distally for 3–4 cm over the navicular bone. Make a second incision along, and 1 cm posterior to, the subcutaneous medial border of the tibia. Begin the incision at a point 3–5 cm proximal to the tip of the medial malleolus and extend it to half-way up the length of the tibia (Fig. 50A).

Return to the first incision and identify the posterior tibial tendon; divide its sheath, free the tendon and cut it transversely at its insertion into the bone. Insert a strong whip suture at the distal end of the tendon (Fig. 50B). Next, identify the posterior tibial tendon in the second incision, incise the covering sheath and free the tendon. (Identification of the tendon in the second wound is facilitated by traction of its cut distal end.) Gently pull the tendon up into the second incision using moist sponges (Fig. 50C). Once the tendon is delivered into the second incision, free the belly of the muscle well up the tibia. Close the first incision.

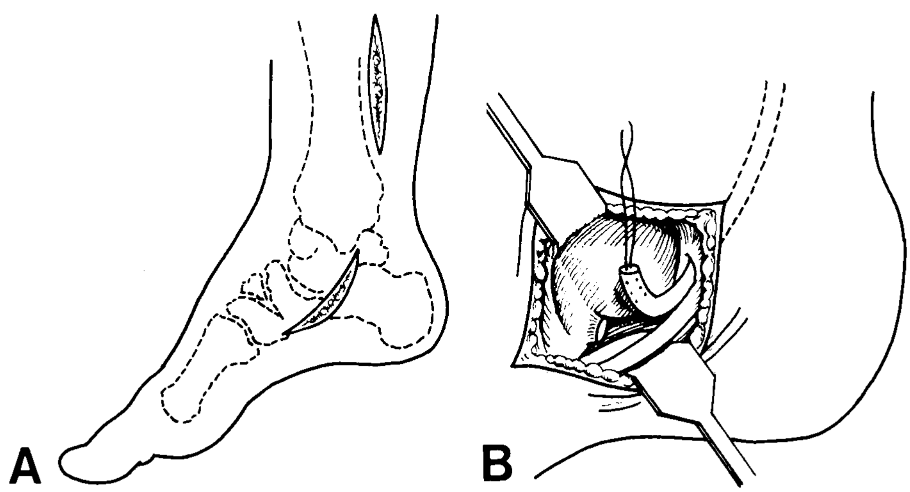


Fig. 50. Anterior transfer of posterior tibial tendon. Skin incision (A); posterior tibial tendon cut from its insertion — whip suture in place (B).

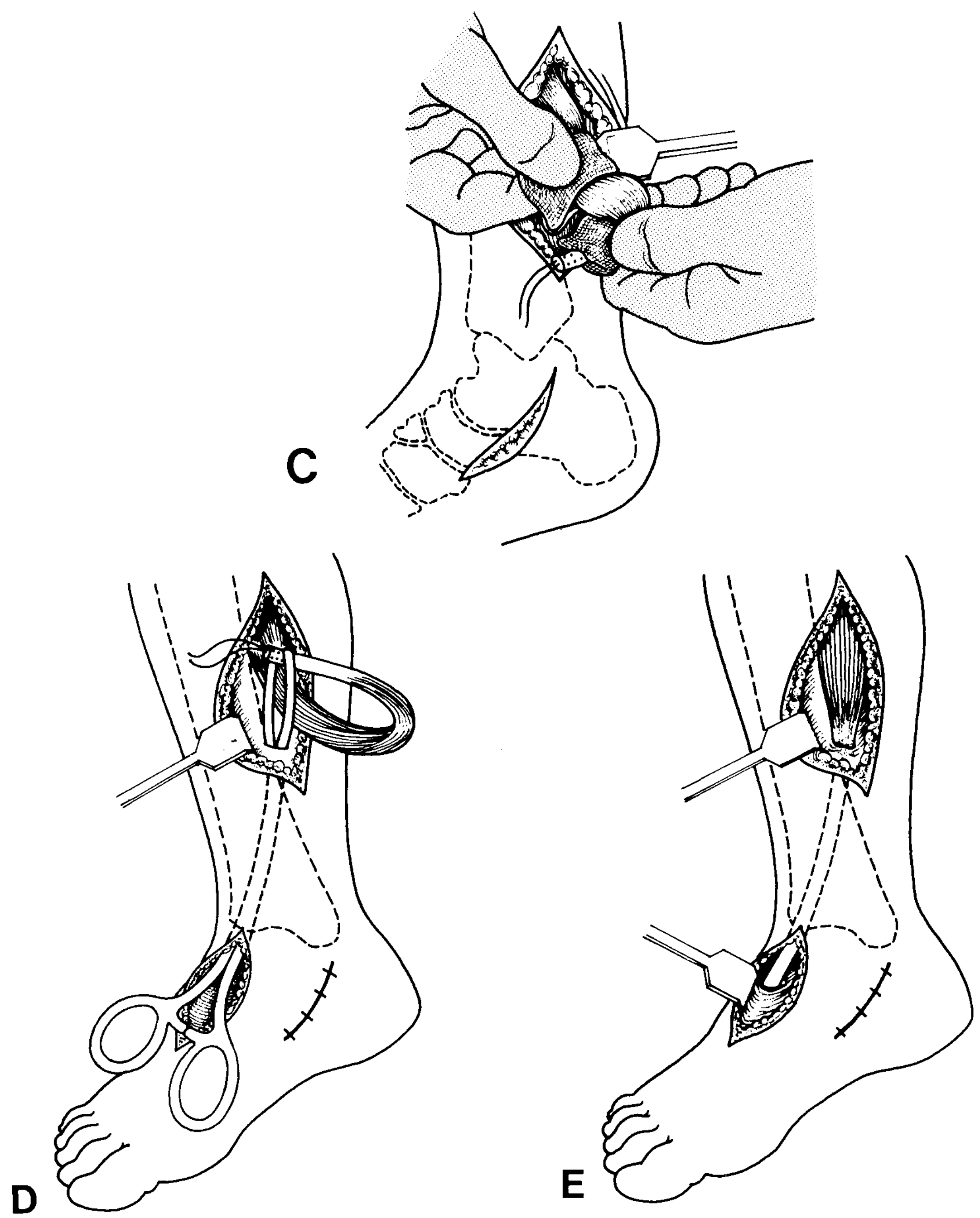


Fig. 50. Anterior transfer of posterior tibial tendon (*continued*). Pulling tendon up to proximal incision (C); rerouting tendon subcutaneously to dorsum of foot (D); anchoring tendon to bone (E) (see also Fig. 19, page 40).

Make a third incision over the dorsum of the foot, centring it on the third cuneiform bone. Expose the bone, incise the periosteum and drill a hole in the bone. Pass a curved artery forceps up from the incision through the anterior tibial compartment, under the fascia and cruciate ankle ligaments, to the second incision on the lower leg (Fig. 50D). Grasp the whip suture of the tendon and pull it down to the third incision. Suture the distal end of the tendon to the third cuneiform bone in the manner described on page 39 (Fig. 50E). Close the wounds.

After-care

Apply a short leg cast for 3 weeks, then bivalve it and remove the sutures. There are two methods of further management. Either apply a walking cast to be used for a further 3–4 weeks; or have the patient start exercises of active foot dorsiflexion, twice daily, and use a plaster slab for walking between exercises.

Anterior transfer of long peroneal tendon

Technique

Place the patient in the semilateral position with a sandbag under the hip on the affected side. Make an incision over the lateral aspect of the foot, extending from the base of the fifth metatarsal bone to a point 1 cm distal to the tip of the lateral malleolus (Fig. 51A). Expose and dissect free the peroneal tendons.

Make a second incision over the posterolateral aspect of the leg, beginning 3–4 cm above the lateral malleolus and extending proximally for about 7 cm (Fig. 51A). Incise the subcutaneous tissue and fascia and expose the peroneal tendons by dividing their sheaths. Inspect the belly of the long peroneal muscle (which lies superficial to the short peroneal muscle) to ensure that its gross appearance is normal; then free it proximally for a short distance.

Return to the first incision. Divide the short peroneal tendon close to its bony attachment (Fig. 51B), and insert a whip suture into the distal end of the tendon. Divide the long peroneal tendon as far distally as possible (Fig. 51C) and suture its distal stump to the short peroneal tendon (Fig. 51D). Insert a whip suture in the distal end of the long peroneal tendon and gently

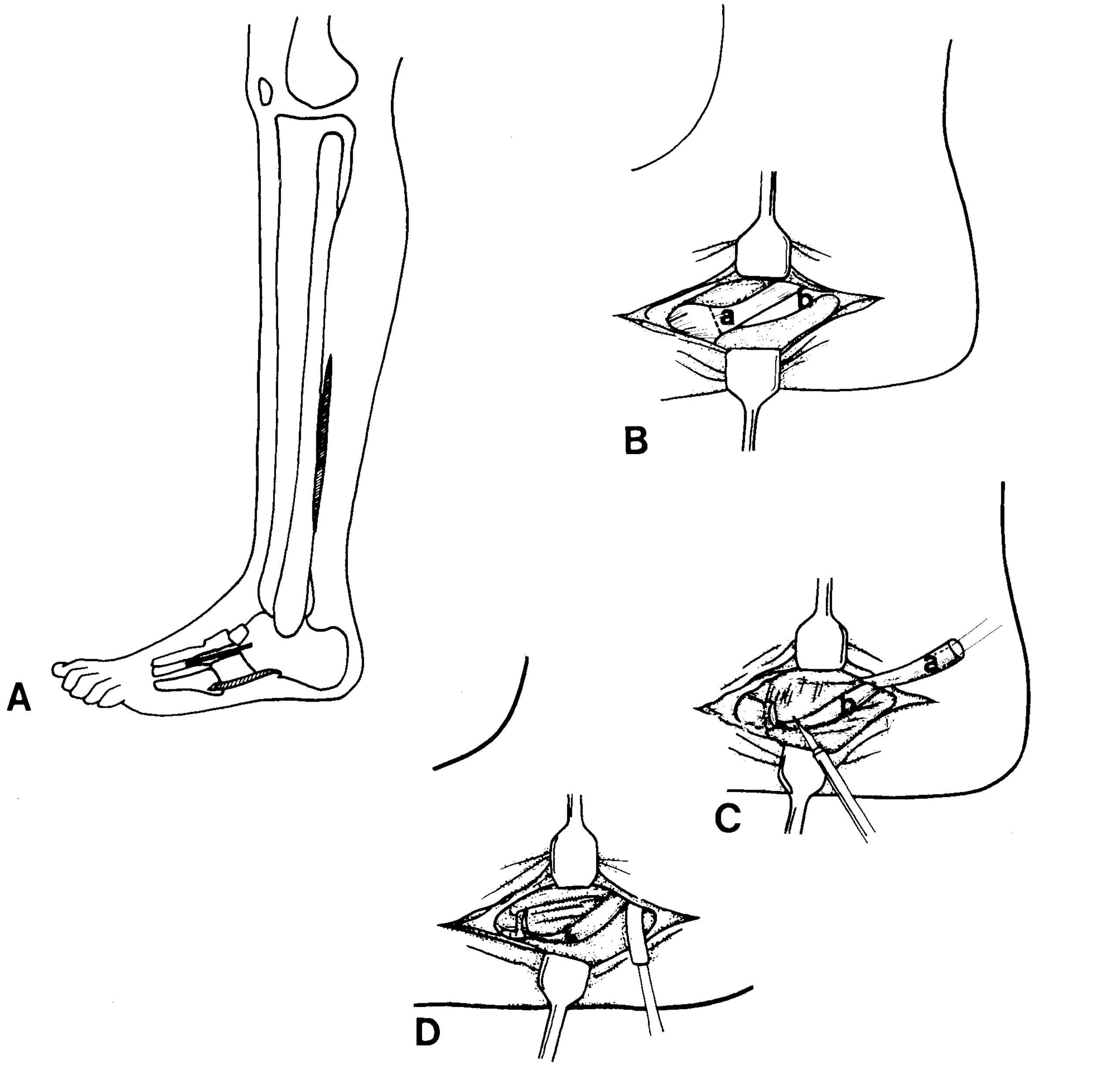


Fig. 51. Anterior transfer of long peroneal tendon. Skin incisions (A); dividing short peroneal tendon (B); dividing long peroneal tendon (C); stump of long peroneal tendon sutured to short peroneal tendon (D).
a — short peroneal tendon; b — long peroneal tendon.

pull up the tendon into the second incision using moist sponges. Finally, make a third incision over the dorsum of the foot, centred on the base of the second metatarsal or second cuneiform bone. Expose the bone by retracting the tendons of the toe extensors. Pass a curved artery forceps from this last incision towards the second incision under the fascia and deep to the cruciate ankle ligaments. Grasp the whip suture of the tendon and pull it down to the incision on the dorsum of the foot. Make a hole through the recipient bone and fix the tendon to the bones as described on page 39. Close the wounds.

After-care

After-care is the same as described for the transfer of the posterior tibial tendon (p. 90).

8
The elbow

Procedure for elbow flexion paralysis

Loss of elbow flexion resulting from paralysis of the biceps brachii and brachialis muscles means the patient cannot bring the hand to the head, mouth or trunk. This greatly interferes with eating and self-care. The disability may be improved by muscle tendon transfers, provided that a suitable muscle is available.

Of the several transfer techniques available, the most simple and effective is Steindler's flexorplasty. The procedure consists of transferring proximally the common origin of muscles attached to the medial epicondyle of the humerus.

For a successful transfer the muscle group to be transferred must be strong (4 or 5 on Lovett's scale); the hand must have a useful function (i.e., not paralysed); and the flexion of the wrist should be fairly strong.

The operation can enable the patient to gain a range of active flexion of the elbow from 30° to 110° on average. This is sufficient to lift and bring to the mouth objects weighing up to about 1.5 kg. Flexion contracture of the elbow of 30–40° is a side-effect of surgery, but is of no trouble to the patient. Use general anaesthesia and apply a tourniquet to the arm.

Technique

Place the patient supine, with the arm externally rotated, and elbow slightly flexed on a small side-table. Make a curved longitudinal incision over the anteromedial aspect of the elbow. Begin the incision about 8 cm above the medial epicondyle of the humerus, extend it distally to the epicondyle, and then turn it anterolaterally for about 6 cm (Fig. 52A). Cut through the subcutaneous tissue and the fascia in line with the skin incision (Fig. 52B). Mobilize widely and retract the skin flaps. Identify the ulnar nerve, and dissect it free from the groove in the triceps brachii muscle, from the posterior aspect of the medial epicondyle of the humerus and for a short distance distally. Pass two tapes around the nerve and retract it posteriorly (Fig. 52C).

With an osteotome, detach the common origin of the flexor muscles "en bloc" with a piece of the epicondyle a few millimetres thick (Fig. 52D). By blunt and sharp dissection, mobilize the mass of the flexor muscles away from the joint capsule and the ulna bone for 4–5 cm. Place a strong suture in the common origin of the flexors (Fig. 52E). Identify and retract the biceps muscle, median nerve and brachial vessels laterally, and split the atrophied brachialis muscle longitudinally. Incise and elevate the periosteum on the anterior and medial surfaces of the humeral diaphysis. Flex the elbow 120° to determine the site for fixing the transfer (it is usually about 5 cm above the elbow). Freshen the bone at the selected site. Because of the acute flexion of the elbow which results, it is advisable to close the distal part of the wound before anchoring the transplant to the humerus. Use a screw to anchor the

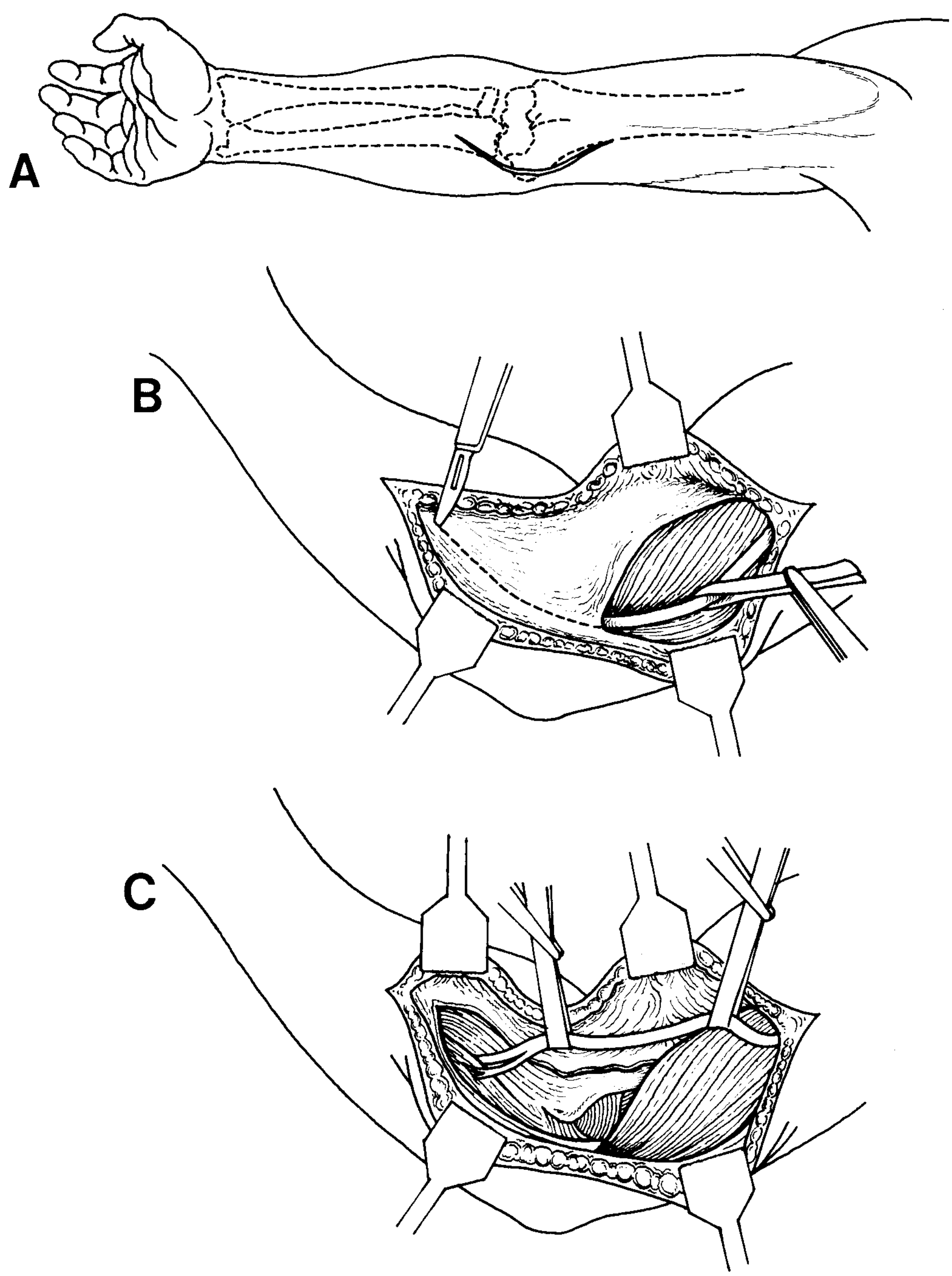


Fig. 52. Steindler's flexorplasty of the elbow. Skin incision (A); exposure of ulnar nerve (B); ulnar nerve protected with tapes (C).

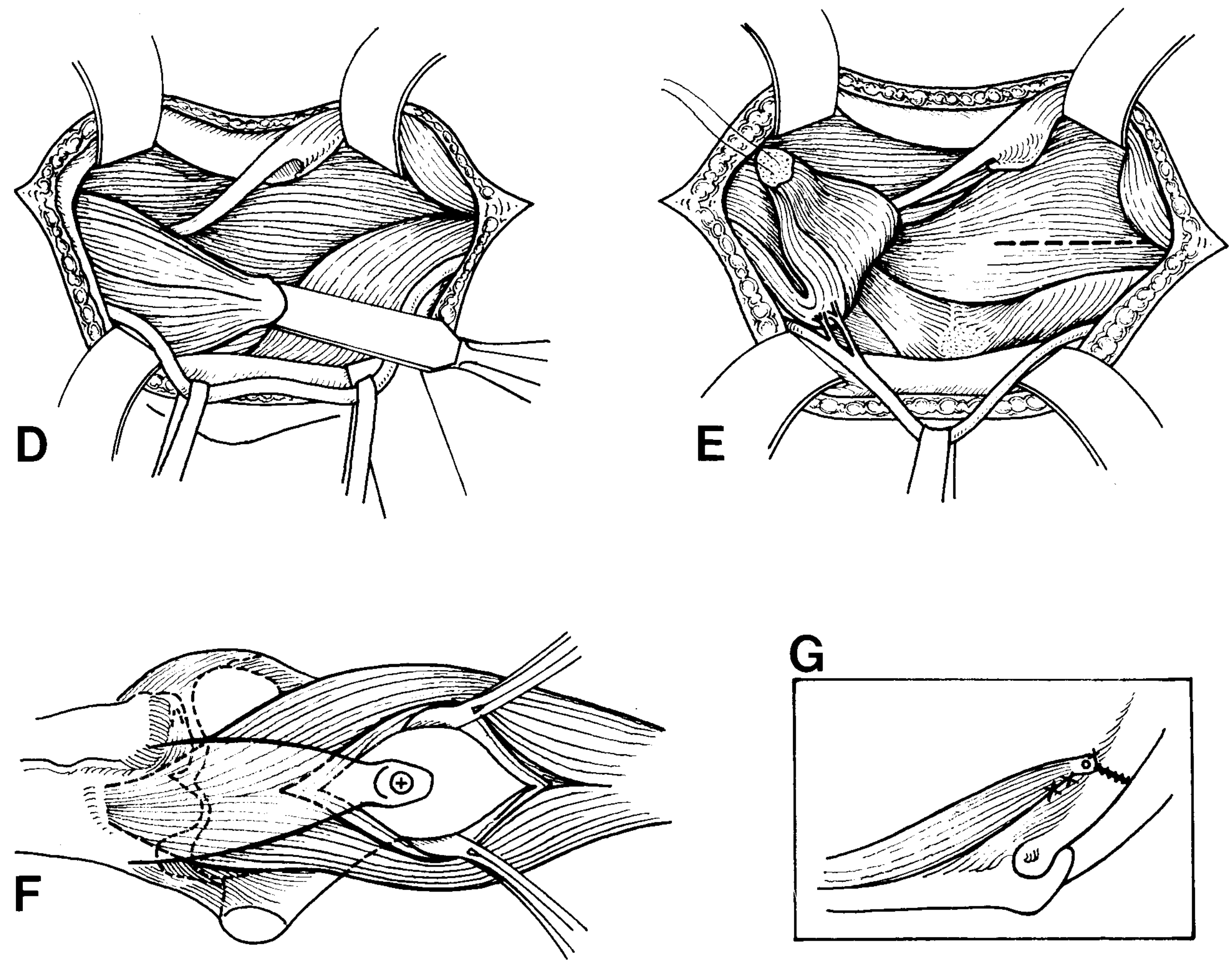


Fig. 52. Steindler's flexorplasty of the elbow (*continued*). Detaching a piece of the medial epicondyle together with the common origin of the flexor muscles (D, E); proximal transfer of epicondyle and flexors to anteromedial aspect of the humerus (F); lateral view after transfer (G).

transferred muscle origins with the attached fragment of the epicondyle to the new site (Fig. 52F). In addition, using non-absorbable sutures, stitch the transferred muscle origins to the periosteum, intramuscular septum and any other firm fibrous tissue (Fig. 52G). Reinforce fixations by suturing the incised periosteum around the anchorage site. Close the wound.

After-care Apply a long arm cast with the elbow in acute flexion and the forearm in full supination. Keep the cast in place for 6 weeks, and then bivalve it to allow for assisted and active exercises of the elbow.

9
The trunk

The management of patients with weakness of the trunk as a result of poliomyelitis is beyond the scope of this manual. Persons with severe paralysis of the trunk muscles, especially those with collapsing paralytic scoliosis, usually have serious breathing difficulties. All these patients should be referred. Pending referral they may be helped by some kind of temporary external support, such as a corset or trunk brace, in conjunction with rehabilitation training.

Annex 1

Surgical trays and equipment for specific procedures

This annex lists the instruments, equipment, and materials that should be included, as a minimum, on the surgical trays used for the procedures described in this handbook; these items must be sterilized before use. Items of orthopaedic equipment that do not need to be sterilized are listed separately. For most procedures, dressings and drugs, apart from local anaesthetics, are not included.

Application of plaster

Non-sterile equipment
Plaster bandage
Tape measure, 1
Cotton wool
Gauze bandage
Bucket filled with water
Bandage scissors, 1 pair
Plaster scissors, 1 pair
Plaster spreader, 1
Scalpel handle with blade, 1
Plaster saw, 1

"Bloodless field"

Non-sterile equipment
Pneumatic tourniquets, 1 small, 1 medium
Rubber bandages, 5 cm, 7.5 cm and 10 cm wide

Making plaster bandage

Non-sterile equipment
Gauze bandage, 500 cm long and 15 cm wide
Plaster of Paris powder
Gloves, 1 pair

Procedures involving bone

Add the following to the tray for *Soft-tissue procedures*

Hand drill and drill bits, 1 set
Mallet (e.g. Heath), 38 cm head, 1
Small mallet, 1
Straight osteotomes; broad, 18 × 160 mm, 2; medium, 12 × 160 mm, 2; narrow, 6 × 160 mm, 2
Straight chisels (Stille), 2
Straight gouges, 2
Orthopaedic self-retaining retractors, 1 small, 1 medium
Tissue forceps (Lane), 2
Spoons (Volkmann), 2 small, 2 medium
Bone-holding forceps (Fergusson or Lane), 2
Bone levers (Lane) (periosteal elevators), 2
Bone levers (e.g. Hohmann), 2
Rugine (Farabeuf), 1 small, 1 medium

Bone nibblers, 1 small, 1 medium
Bone-cutting forceps. 19 cm, 1
Bone file, 1
Oscillating saw, 1

Removing plaster

Non-sterile equipment
Plaster saw (Tenon), 1
Plaster saw (Engel), 1
Shears, 1 pair
Plaster scissors (Böhler), 1 pair
Bandage scissors (Lister), 1 pair
Plaster spreader, 1
Scalpel handle with blade, 1

Skin traction

Antiseptic solution

Non-sterile equipment
Adhesive strapping (5 cm and 7.5 cm wide)
Tape measure
Wooden spreader, 1
Cotton wool or felt
Crêpe or gauze bandage (10 cm and 15 cm wide)
Weights, cord, and pulley
Thomas splint (child size and medium size)
Bandage scissors, 1 pair
Strips of foam (5 cm and 7.5 cm wide)
Blocks for elevating foot of bed (10 cm, 15 cm and 22 cm thick)

Soft-tissue procedures

Sponge forceps, 4 pairs
Tissue forceps
Scalpel handle and blade, 1
Tenotome, narrow blade, 1
Small dissecting scissors, 1 pair
Stitch scissors, 1 pair
Sutures, 2/0, 3/0, and 4/0 chromic catgut, ties and with atraumatic needles
Sutures, 2/0 and 3/0 thread, ties and with cutting needles
Small, curved artery forceps, 3 pairs
Small, straight artery forceps, 3 pairs
Large, curved artery forceps, 2 pairs
Needle holder, 1
Rake self-retaining retractor, 1
Dissecting forceps, toothed, 1 pair
Dissecting forceps, non-toothed, 1 pair
Syringe, 5 ml with needle, 1
Syringe, 10 ml with needle, 1
Lidocaine 1%
Gallipot, 1
Kidney dish, 1
Skin hooks, 2
Towel clips, 4
Corrugated drain
Petrolatum gauze
Gauze swabs
Antiseptic solution
Adhesive tape
Sterile drapes
Sterile gloves, 2 pairs

Annex 2

Essential surgical instruments, equipment, and materials for the district hospital

This annex lists the instruments, equipment, and materials needed, as a minimum, for the practice of surgery in the district hospital. It contains all the items listed in Annex 1, with the exception of local anaesthetics, containers for laboratory specimens, and chemical products such as antiseptics and lubricants. It also includes operating-room and anaesthetic equipment, and instruments required for the surgical procedures described in *General surgery at the district hospital* (Geneva, World Health Organization, 1988) and *Surgery at the district hospital: obstetrics, gynaecology, orthopaedics, and traumatology* (Geneva, World Health Organization, 1991).

Surgical instruments

General instruments

	Quantity	*Size*
Sponge forceps (Rampley)	4	25 cm
Instrument pins (Mayo)	4	
Towel clips (Backhaus)	6	11 cm
Artery forceps (Crile): straight	6	16 cm
curved	6	16 cm
Artery forceps (mosquito): straight	6	13 cm
curved	6	13 cm
Curved artery forceps (Mayo or Kelly)	6	20 cm
Straight artery forceps (Spencer Wells)	6	20 cm
Tissue forceps (Allis)	4	15 cm
Standard dissecting forceps: toothed	2	14.5 cm
non-toothed	2	14.5 cm
Long dissecting forceps, toothed	1	25 cm
Long dissecting forceps, non-toothed	1	25 cm
Straight dissecting scissors (Mayo)	2	17 cm
Curved dissecting scissors (Mayo)	1	23 cm
Dissecting scissors (Metzenbaum)	1	18 cm
Stitch scissors, with blunt ends	2	15 cm
Rake retractors (Volkmann), 4-toothed	2	22 cm
Rake self-retaining retractors	2	21 cm
Retractors (Langenbeck): narrow	2	6.0 mm wide
medium	2	9.5 mm wide
Retractors (Deaver): medium	1	25 mm blade
large	1	75 mm blade
Hook retractors	2	15 cm
Needle holders (Mayo): medium	2	15 cm
large	2	17.5 cm
Scalpel handles No. 3 (Bard-Parker)	12	
Scalpel handles No. 4 (Bard-Parker)	12	
Scalpel handles No. 5 (Bard-Parker)	4	
Suction nozzle (Yankauer)	1	28.5 cm
Nozzle (Poole-Wheeler)	1	

		Quantity	Size
	Diathermy electrodes, coagulating and fulgurating	2	
	Flexible probe, with round point	1	20 cm
	Grooved director (Kocher)	1	20 cm
	Stainless-steel sponge bowls: small	6	
	medium	6	
	large	6	
	Stainless-steel kidney dishes: small	4	
	medium	4	
	large	4	
	Stainless-steel gallipots	2	
	Sinus forceps	2	
Abdominal instruments	Self-retaining retractor with 3 blades (Balfour)	1	
	Proctoscope (anal speculum, Goligher):		
	child-size	1	6 cm
	adult-size	1	7.5 cm
	Sigmoidoscope, complete with pump: child-size	1	
	adult-size	1	
	Light source with cable, to fit sigmoidoscope	1	
	Biopsy forceps	2	
	Clamps (Moynihan), box-joint	6	23 cm
	Gallbladder trocar and cannula (Ochsner)	1	
	Gallstone forceps (Desjardin)	1	
	Malleable probe and scoop (Moynihan)	1	
	Lacrimal probes, set of 3	1	
	Tissue forceps (Duval): medium	2	15.5 cm
	large	2	19 cm
	Crushing clamps (Payr): small	2	21 cm
	large	2	36 cm
	Crushing clamps (Schoemaker): small	2	17 cm
	large	2	20 cm
	Malleable copper retractors (spatulae)	2	
	Occlusion clamps (Doyen); straight	2	22.5 cm
	curved	2	22.5 cm
	Twin occlusion clamps (Lane)	1	31.8 cm
	Intestinal tissue-holding forceps (Babcock)	4	24.0 cm
	Glass rods	2	
Chest instruments	Chest-drainage set, including tube and calibrated bottle	1	
Craniotomy instruments	Self-retaining retractors (West)	2	
	Periosteal elevator (Farabeuf)	1	
	Dissector (Macdonald)	1	
	Brace (Hudson), burrs and perforators with 3 sizes of bits	1 set	
	Bone forceps (De Vilbis)	1	
Dental, plastic surgery, and maxillo-facial instruments	Standard skin-grafting knife (Humby), with spare blades	1	
	Electric dermatome	1	
	Wooden skin-grafting boards	4	
	Pin-cutting forceps	1	
	Straight bone-awl (Kelsey Fry)	1	
	Straight elevator (Warwick James or modified Kelsey Fry)	1	
	Curved elevators: right	1	
	left	1	

		Quantity	Size
	Dental mirror	1	
	Dental forceps: universal upper	1	
	universal lower	1	
	Wire cutters	1	
	Skin hooks (Gillies)	4	
	Small hook retractors	2	
	Fine dissecting forceps: toothed	1	
	non-toothed	1	
	Curved artery forceps (Crile)	6	14 cm
	Handle holder (Mayo-Hegar) or needle holder (Gillies)	1	15 cm
	Dental probes/spoons	2	
Gynaecology instruments	Vaginal specula (Sims): small	1	1
	large	1	3
	Weighted vaginal speculum (Auvard)	1	38 × 75 mm
	Vulsellum forceps (Teale or Duplay)	2	28 cm
	Episiotomy scissors	2	
	Vacuum extraction apparatus	1	
	Amniohook	1	
	Uterine sound (Simpson)	1	30 cm
	Double-ended uterine dilators, set of 6	1	
	Uterine curettes (Sims)	1 set	26 × 7 mm to 26 × 14 mm (various sizes)
	Ovum forceps (de Lee)	1	24 cm
	Cranial perforator	1	
	Straight hysterectomy forceps (Péan)	6	22.5 cm
	Craniotomy forceps	2	
	Uterine haemostasis forceps (Green-Armytage)	8	20 cm
	Obstetric forceps: low	1	
	midcavity	1	
	Retractor (Doyen)	1	
	Anterior vaginal-wall retractors	2	
	Punch biopsy forceps	1	
	Endometrial biopsy cannula	1	
	Suction cannulas, set of 4	1	
	Colposcope	1	
Ophthalmic instruments	Eyelid speculum (Clark)	1	
	Eyelid retractors (Desmarres)	2	
	Small rake retractors	2	
	Pterygium knife	1	
	Dissecting forceps, toothed	1	0.5 mm
		1	0.9 mm
	Dissecting forceps, non-toothed	1	0.5 mm
		1	0.9 mm
	Conjunctival scissors	1	
	Conjunctival forceps	2	
	Extracapsular forceps	1	
	Chalazion clamp	1	
	Chalazion curettes, set of 3 sizes	1	
	Enucleation scissors	1	
	Straight ring scissors	1	
	Spring scissors (Westcott)	1	
	Corneal scissors (Castroviejo): right	1	
	left	1	
	Iris scissors	1	
	Iris forceps	2	

		Quantity	Size
	Needle holder, curved with lock (Castroviejo)	1	
	Operating loupe (or similar magnifying device)	1	
	Capsule forceps, non-toothed	1	
	Simple ball-type cautery	1	
	Muscle hooks	2	
	Strabismus hooks	2	
	Cystotome	1	
	Vectis	1	
	Periosteal elevator	1	
	Iris retractor	1	
	Iris spatula (repositor)	1	
	Irrigating cannula	1	
	Meibomian curette	1	
	Eyelid clamp (and/or Trabut plate)	1	
	Flat cataract curette	1	
	Knife needle	1	
	Spirit lamp with hot-point cautery	1	
	Punctum dilator	1	
	Tear-duct probes	1 set	4/0–4
	Irrigating cannula	1	
	Air cannula	1	
	Eye spud (Walton)	1	
Orthopaedic instruments	Plaster instruments:		
	plaster saw (Tenon)	1	
	plaster saw (Engel)	1	
	shears (Stille)	1	46 cm
	scissors (Böhler)	1	25 cm
	opening shears (Daw)	1	
	bandage scissors (Lister)	1	
	plaster spreader	1	
	Pneumatic tourniquet	1	
	Rubber bandages (Esmarch)	2	
	Pins (Steinmann), with covers for ends		
	Hand chuck for introducing pins (T-handle)	1	
	Stirrups (Böhler)		
	Wires (Kirschner)		
	Wire stirrups (Kirschner)	6	
	Hand drill and drill bits (Zimmer)	1 set	
	Mallet (Heath)	1	38 mm head
	Small mallet	1	
	Tenotome, narrow blade	1	
	Straight osteotomes (Stille): broad	2	18 × 160 mm
	narrow	2	6 × 160 mm
	Straight chisels (Stille)	2	
	Straight gouges	2	
	Orthopaedic self-retaining retractor	1	
	Tissue forceps (Lane)	2	
	Spoons (Volkmann): small	1	17 cm
	medium	1	21 cm
	Amputation knife	1	20 cm
	Amputation saw (Satterlee)	1	
	Finger saw	1	
	Bone-holding forceps (Fergusson or Lane)	2	
	Bone levers (Lane)	2	
	Rugine (Farabeuf)	1	
	Compound-action bone nibbler (rongeur)	1	

		Quantity	Size
	Compound-action bone-cutting forceps	1	19 cm
	Bone file	1	
	Skull callipers (Crutchfield)	1	
	Skull callipers (Cone), with spanner	1	
	Auriscope and aural specula	1 set	
Otolaryngology instruments	Ear syringe	1	
	Head mirror	1	
	Nasal specula (Thudicum), set of 4 sizes	1	
	Angled dressing forceps (Tilley)	2	
	Self-retaining retractor (West)	1	
	Aural probe, hook, and curette	1 set	
	Myringotome	1	
	Mouth gag (Boyle–Davis): child-size	2	
	adult-size	2	
	Angled tongue depressors	2	
	Small suction tubes	2	
	Small catspaw retractors (Kilner)	2	
	Tracheal dilator (Bowlby)	1	
	Assorted tracheostomy tubes or tracheostomy sets (Chevalier Jackson): child-size		
	adult-size		
Urogenital instruments	Curved urethral bougies (Clutton)	2 sets	10–24 Ch.
	Straight bougies (Powell)	2 sets	10–24 Ch.
	Filiform bougies	2 sets	33 cm long 2–6 Ch.
	Bougies (Guyon), for use as filiform guide	2	12 Ch.
	Bougies, 5/8 of a circle, olive-tipped (Hey Grove), set of 3	1	
	Soft penile clamps	2	
	Suprapubic trocars and cannulas	1	25 Ch.
		1	30 Ch.
	Catheter introducer (Malecot)	1	
	Catheter introducer (Foley)	1	
Vascular instruments	Bulldog clamps	4	22 mm
	Clamps (Satinsky), with 3 different blade shapes	1 set	
	Narrow-jaw needle holders (Hegar)	1	17.5 cm

Operating-room equipment

		Quantity
Fixed equipment	Fixed operating-room light	1
	Ultraviolet light source	1
	Scrub basins with hot and cold running water	
	Exhaust fans	
	Electric autoclave with horizontal drum	1
	Electric or kerosene sterilizer for boiling instruments	1
Other equipment	Operating table, universal frame-type with headpiece	1
	Plaster, orthopaedic fracture table (modified Watson-Jones)[1]	1
	Utensil sterilizer for bowls, boiling-type	1
	Electric or kerosene hot-air sterilizer	1
	Forceps sterilizers (Cheatle), heavy-duty	2

[1] If this is not available, there should at least be a table with a hip prop box (see Fig. 32, p. 60).

	Quantity
Forceps sterilizers (Harrison)	2
Instrument trolleys	4
Anaesthetic trolleys	2
Instrument stands with trays (Mayo)	4
Instrument stands with bowls: single	2
double	2
Stands for swabs	2
Portable aspirating surgical suckers, electric	2
Portable aspirating surgical suckers, foot-operated	2
Cylindrical sterilizing drums: 24 cm diameter	4
29 cm diameter	4
34 cm diameter	4
Stainless-steel buckets with covers	4
"Kick-about" receptacles, on frames with roller casters	4
Revolving operating stools of adjustable height (enamel finish)	4
Footstools	2
Dressing trays: small	4
medium	4
large	4
Portable operating-room lights, with stands	2
Diathermy machine	1
Radiograph viewing boxes	2
Dispensers for hot and cold sterile distilled water (4 litres/hour)	2
Stretchers with combination wheel and adjustable sides	4
Labour and delivery beds, with two-piece mattresses	2
Folding stretchers	4
Covered instrument trays	4
Covered instrument/dressing trays	4
Instrument trays with handles	4
Instrument and catheter trays	4
Stainless-steel jugs: 3 litre	2
4 litre	2
Stainless-steel funnels, 200 ml	2
Stainless-steel graduated measures with handles, 1 litre	2
Utility basins, 3 litre	2
Self-retaining 4-wing catheters (de Pezzer), sizes 8, 14, 16, and 18 Ch.	
Self-retaining balloon catheters (Foley), sizes 8, 14, 16, 18, and 22 Ch.	
Urethral catheters (Nelaton), solid-tip, sizes 8, 10, 12, and 14 Ch.	
Urethral catheters, coudé, sizes 8, 10, 12, 14, and 16 Ch.	
Urinary bags	
Graduated drainage (collecting) bottles, glass, 1.5 litre	
Surgeon's latex gloves, sizes 6, 6.5, 7, 7.5, 8	
Rubber rectal tubes, funnel-end, 20 Ch., 50 cm long	
Rubber rectal tubes, funnel-end, 28 Ch., 50 cm long	
Colostomy bags	
Nasogastric tubes (Levin), 12 Ch.	
Polythene nasal feeding tubes:	
infant-size, 8 Ch., 38 cm long	
adult-size, 16 Ch., 80 cm long	
Metal irrigating syringe (Kramer), 90 ml	1
Glass irrigating syringes, 100 ml	2
Syringes: insulin, 1 ml	
tuberculin, 1 ml	
hypodermic, 2, 5, 10, 20, and 50 ml	
Hypodermic needles, gauges 18–25, 27, and 28	
Stomach tubes, 24 Ch., 150 cm long	
Face masks and caps	

	Quantity
Washable footwear, antistatic	
Drapes	
Gowns	
Surgeon's handbrushes with nylon bristles	
Sutures/ligatures:	
chromic catgut and plain catgut, with and without needles — 6/0, 4/0, 3/0, 2/0, 0, No. 1	
nylon and silk, with and without needles — 8/0, 6/0, 5/0, 4/0, 3/0, 2/0, 0, No. 1	
soft, stainless-steel wire, 0.35 mm thick (about size 0)	
Regular-eye needles, assortment of different types and sizes	
Scalpel blades, No. 10, 11, 12, 15, 21, 22, 23	100 of each size
Aneurysm needles: right	3
left	3
Stitch removal scissors	2
Heavy-duty "counter" scissors	2
Cannulas: stainless-steel	2
curved intravenous (Webster Luer)	2
transfusion (Luer), 1.25 × 41 mm (gauge 18)	2
transfusion (Luer), 0.90 × 41 mm (gauge 20)	2
transfusion (Luer), 0.70 × 41 mm (gauge 22)	2
Disposable scalp-vein infusion sets	
Polythene tubing, 0.86 mm inner diameter, 1.27 mm outer diameter	
Polythene tubing, 1.40 mm inner diameter, 1.90 mm outer diameter	
Polythene tubing, 1.67 mm inner diameter, 2.42 mm outer diameter	
Latex tubing: 3.2 mm inner diameter	
7.5 mm inner diameter	
10.0 mm inner diameter	
Soft rubber tubing, 2.0 mm inner diameter	
Connectors for tubing, assorted, including T-shape and Y-shape	
Utility apron, opaque plastic 90 cm × 100 cm	
Plastic sheeting, clear vinyl, 91 cm wide	
Rubber sheeting, double-coated, 91 cm wide	
Foam rubber	
Corrugated latex drain	
Gauze bandage: 25 mm × 9 m	
50 mm × 9 m	
75 mm × 9 m	
Absorbent gauze (for dressings, swabs, abdominal packs, petrolatum gauze, etc.): 20 cm × 6 m	
1 m × 100 m	
Linen tape: 5 mm wide	
10 mm wide	
Surgical adhesive tape, 25 mm × 10 m	
Adhesive zinc oxide tape, 75 mm × 5 m	
Non-adhesive elastic bandage, 75 mm × 5 m	
Absorbent cotton wool	
Eye pads	
Eye shields	
Umbilical tape, 3 mm wide	

	Quantity
Indelible pencils	
Safety pins, medium size	
Rubber bands, assorted	
Garters, elasticated	
Manually operated hair clippers, narrow	2
Clipboards, 23 × 32 cm	2
All-metal safety razors, 3-piece	
Double-edged safety-razor blades	
Battery-operated wall clock, with hands showing time in seconds, minutes, and hours	1
Laboratory balance, 2 kg capacity	1
Sandbags	
Stainless-steel rulers	2
Aneroid sphygmomanometer, range 0–300 mmHg, with cuff	1
Stethoscopes, binaural (bell and diaphragm)	3
Oesophageal stethoscope	1
Fetal stethoscope	1
Tape measure, 1.5 m	1
Clinical thermometers: oral	1
rectal	1
Shiötz tonometer	1
Torch, battery-operated	1
Clothes-pegs	
Wooden spatulae	

Orthopaedic equipment

Gauze bandages, 10 cm and 15 cm wide	
Crêpe bandages	
Stockinet, assorted sizes	
Plaster of Paris powder (anhydrous calcium sulfate)	
Triangular cloth bandages (for arm slings)	
Thomas splints: child-size	8
medium-size	8
adult-size	8
Pearson attachments for Thomas splints:	
child-size	4
medium-size	4
adult-size	4
Half-ring Thomas splints: right side	4
left side	4
Multi-purpose board splints, 3 sizes	1 set
Cramer wire splints: narrow, medium, and wide	
Frames with pulleys (Böhler-Braun)	3
Pulley systems: free	6
in frames	6
Wooden spreader bars, square: 7 × 7 cm	10
10 × 10 cm	10
Non-elastic traction cord	
Blocks (for elevating bed), 10 cm, 15 cm, 22 cm and 30 cm high	
Overhead traction suspension frames	4
Weights for traction	

Anaesthetic equipment

	Quantity
Anaesthetic face masks, infant-size to large adult-size	2 of each size, total 14
Oropharyngeal airways, sizes 00 to 5	2 of each size, total 12
Laryngoscopes	2 handles + 3 pairs of blades, or 4 plastic laryngoscopes (2 adult + 2 paediatric)
Spare bulbs for laryngoscopes	12
Batteries for laryngoscopes	30 (or 8 rechargeable batteries + charger)
Endotracheal tubes, sizes 2.5–10 mm (internal diameter) in 0.5 mm steps, Oxford or Magill or similar, with cuffs only on sizes >6 mm	
Urethral bougies, for use as intubating stylets	
Magill's intubating forceps (in an emergency, ovum forceps can be used instead)	2 pairs
Endotracheal tube connectors, 15 mm plastic (can be connected directly to the breathing valve)	3 for each tube size
Catheter mounts (sometimes also called endotracheal tube connectors), antistatic rubber	4
Breathing hose and connectors:	
lengths of 1 metre antistatic tubing	2
lengths of 30 cm tubing for connection of vaporizers	4
T-piece for oxygen enrichment	1
Breathing valves (universal non-rebreathing type): child-size	2
adult-size	6
Breathing systems (for continuous-flow anaesthesia):	
Ayre's T-piece system	2
Magill breathing system	2
Self-inflating bellows or bags: child-size	1
adult-size	1
Anaesthetic vaporizers, for ether, halothane, and trichloroethylene (draw-over type)	
Needles and cannulas for intravenous use, including paediatric sizes and an umbilical vein catheter	
Intravenous infusion sets	
Spinal needles, range of sizes, 18-gauge to 25-gauge	

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