Rehabilitation surgery for deformities due to poliomyelitis

Techniques for the district hospital

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CONTENTS

Preface 7

Introduction 9

Poliomyelitis and the fundamentals of rehabilitation surgery

1 Basic information on poliomyelitis 13
   General remarks
   Clinical forms
   Clinical course

2 Sequelae of poliomyelitis 15
   Paralysis
   Deformities

3 Evaluation of the patient before surgery 17
   Muscle-testing
   Identification of deformities
   Functional assessment
   Overall assessment
   Selection of patients for surgery

4 Basic techniques 37
   Soft-tissue release
   Procedures on bones
   Tendon lengthening and tendon transfers
   Local preoperative preparation
   Postoperative care and training
Specific surgical procedures

5 The hip
General considerations
Soft-tissue release for flexion–abduction contracture of the hip
Adduction contracture of the hip

6 The knee
General considerations
Release of posterior soft tissues
Osteotomy (for genu valgum and external torsion of the tibia)

7 The foot and ankle
General considerations
Surgical procedures on the calcaneus tendon
Procedures for deformities of the foot

8 The elbow
Procedure for elbow flexion paralysis

9 The trunk

Annex 1 Surgical trays and equipment for specific procedures

Annex 2 Essential surgical instruments, equipment, and materials for the district hospital

Index
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.

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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 mémorable. 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 III). 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.

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.

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 his¹ body forward to extend the hip passively against the couch.

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

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.

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**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.

![Testing ankle muscles (continued). Plantar flexors with the patient supine (C).](image)

**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.

![Testing foot muscles. Foot invertors in dorsiflexion (A).](image)

**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 ab ducted, 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).

![Diagram of hip abduction and flexion](image)

**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 causes 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 environmentalal 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 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.
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).*
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**

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

**Z-plasty** is a classical technique 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 iliopectoas 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., *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

Technique

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.

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).
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.