5

Principles of treatment

CHAPTER CONTENTS

Introduction

Cyriax had a straightforward opinion about treating orthopaedic problems:

- All pain arises from a source
- All treatment must reach the source
- All treatment must exert a beneficial effect on it.

It is obvious that the method of treatment will depend largely on the existing type of disorder.

In orthopaedic medicine, disorders may be grossly categorized as follows:

- *Traumatic* – an injury resulting either from one single trauma or from multiple small traumas, the so-called overuse injuries
- *Inflammatory* – rheumatoid: poly- or monoarticular, infectious, traumatic
- *Degenerative*
- *Internal derangement* – loose bodies and displaced menisci in peripheral joints and intervertebral disc displacements in the spine
- *Functional disorders* – instability, weakness, proprioceptive disturbances
- *Psychogenic pain* – there is no existing functional or anatomical explanation for the pain.

However, most 'disorders' have a combined aetiology: traumatic inflammation or repetitive internal derangement may lead to functional instability or to weakening of the proprioceptive reflexes; long-standing functional disorders may lead to psychogenic decompensation.

Before any form of treatment is undertaken, precise diagnosis is mandatory; it is the type, extent and position of the disorder present which determines treatment. Therefore training in orthopaedic medicine must put great emphasis on how to reach a proper diagnosis. It is more difficult and requires considerable delicacy of approach to teach and learn how to diagnose and so to propose therapy chosen on logical grounds, than it is to instruct and learn treatment techniques. Other aspects must also be taken into account: how much pain can the patient bear? To what extent does the lesion interfere with normal activities? How eager is the patient to receive a quick

cure? And what is the patient's attitude towards certain therapeutic methods such as corticosteroids and manipulation?

Orthopaedic medicine based on a detailed functional examination requires more knowledge, skill, time and effort from the physician than just to order technical investigations, but leads to greater professional interest, more appropriate diagnosis and a higher degree of patient satisfaction. Clear diagnosis and consequent selection of treatment on logical grounds also leads to better understanding between doctors and therapists. Because the two groups work with the same types of patient, they must share a common approach. Therapists should no longer be regarded purely as technicians who listen to the physician and carry out orders. On the contrary, they should be aware that they have diagnostic and therapeutic responsibilities. Their opinion must be taken seriously and is important to avoid unnecessary delay in achieving a satisfactory outcome.

Techniques

The treatment techniques used in orthopaedic medicine thus depend entirely on the type of disorder. The different types of treatment we describe are:

- *Manipulation techniques* (rapid, small-amplitude, thrusting passive movement – also called 'grade C mobilization') are used to reduce small cartilaginous displaced fragments both in the spine and in peripheral joints (loose bodies). Manipulation is also called for to restore normal mobility in a joint restricted by ligamentous adhesion and in subluxation of bones.
- Gentle *passive mobilizations* (grade A and B mobilizations) are used to stretch capsular adhesions and to improve the function of ligaments and tendons. In the treatment of traumatic injuries they are often used in combination with deep transverse massage.
- *Active movements* and proprioceptive training are needed in the treatment of functional disorders and instability. In the treatment of minor muscular tears they are very useful in avoiding the formation of abnormal intralesional adhesion formation.
- *Injection and infiltration techniques* are used to reduce traumatic or rheumatoid inflammation. They are most valuable in arthritis, bursitis, ligamentous and tendinous lesions and in neurocompression syndromes.
- *Deep friction* is a very useful technique in treating traumatic and overuse soft tissue lesions. The rationale for using deep friction (which is in fact a form of soft tissue mobilization) is supported by experimental studies of the past several decades that confirm and explain the beneficial effects of activity on the healing musculoskeletal tissues (see Connective tissue).

Repair and remodelling of healing tissues respond to cyclic loading and motion.[1] Early motion and loading of injured tissues is not without risk, however, and excessive loading can inhibit or stop healing. Deep transverse friction imposes cyclic loading without bringing too much tension on the healing longitudinal structures of tendon or ligament and can therefore be considered as beneficial.

Deep transverse friction

Deep transverse friction (although the word friction is technically incorrect and would be better replaced by 'massage') is a specific type of connective tissue massage[2] developed in an empirical way by Cyriax.[3]

Transverse massage is applied by the finger(s) directly to the lesion and transverse to the direction of the fibres. It can be used after an injury and for mechanical overuse in muscular, tendinous and ligamentous structures.[4–6] In many instances the friction massage is an alternative to infiltrations with steroids. Friction is usually slower in effect than injections but leads to a physically more fundamental resolution, resulting in more permanent cure and less recurrence. Whereas steroid injection is usually successful in 1–2 weeks, deep friction may require up to 6 weeks to have its full effect.

The technique is often used before and in conjunction with mobilization techniques. In minor muscular tears, friction is usually followed by active movement, in ligamentous tears by passive movement and in tendinous lesions by active unloaded movements until full resolution has been achieved.

It is vital that transverse massage is performed *only at the site of the lesion*. The effect is so local that, unless the finger is applied to the exact site and friction given in the right direction, relief cannot be expected.

Over the years, and unfortunately enough, the technique has developed a reputation for being very painful for the patient. However, pain during friction massage is usually the result of a wrong indication, a wrong technique or an unaccustomed amount of pressure. Friction massage applied correctly will quickly result in an analgesic effect over the treated area and is seldom a painful experience for the patient.

Mode of action

Transverse massage should be used empirically for what it is and what it achieves; there is no scientific proof for any postulates about the underlying mechanism of action.

Only a few studies exist,[7,8,9] and more research is urgently needed. However, experienced therapists know in what kind of soft tissues they can expect good results with transverse massage and where the technique does not work. Transverse massage either is effective quickly (after 6–10 sessions) or not at all. Advice on indications, contraindications and modalities of the technique that are given in this book rely solely on the experiences of the authors and not on scientific research.

However, although the exact mode of action is not known, some theoretical explanations have been put forward. It has been hypothesized that friction has a local pain-diminishing effect and results in better alignment of connective tissue fibrils.

Relief of pain

It is a common clinical observation that application of local transverse friction leads to immediate pain relief – the patient

experiences a numbing effect during the friction and reassessment immediately after the session shows reduction in pain and increase in strength and mobility. The time to produce analgesia during the application of transverse friction is a few minutes and the post-massage analgesic effect may last more than 24 hours.[10] The temporary relief at the end of a session may prepare the patient for treatment with mobilization not otherwise possible, such as selective rupture of unwanted adhesions.

A number of hypotheses to explain the pain-relieving effect of transverse massage have been put forward:

- Pain relief during and after friction massage may be the result of modulation of the nociceptive impulses at spinal cord level: the *gate control theory* (see Ch. 1). The centripetal projection into the dorsal horn of the spinal cord from the nociceptive receptor system is inhibited by the concurrent activity of the mechanoreceptors located in the same tissues. Selective stimulation of the mechanoreceptors by rhythmical movements over the affected area thus 'closes the gate for pain afference'.
- According to Cyriax, friction also leads to increased destruction of pain-provoking metabolites, such as Lewis's substances. This metabolite, if present in too high a concentration, provokes ischaemia and pain.[3]
- It has also been suggested that prolonged deep friction of a localized area may give rise to a lasting peripheral disturbance of nerve tissue, with local anaesthetic effect.
- Another mechanism through which reduction in pain may be achieved is through diffuse noxious inhibitory controls, a pain-suppression mechanism that releases endogenous opiates. The latter are inhibitory neurotransmitters that diminish the intensity of the pain transmitted to higher centres.[11–13]

Effect on connective tissue repair

Connective tissue regenerates largely as a consequence of the action of inflammatory cells, vascular and lymphatic endothelial cells and fibroblasts. Regeneration comprises three main phases: inflammation, proliferation (granulation) and remodelling. These events do not occur separately but form a continuous sequence of changes (cell, matrix and vascular changes) that begins with the release of inflammatory mediators and ends with the remodelling of the repaired tissue (see Ch. 3). Friction massage may have a beneficial effect on all three phases of repair.

Friction stimulates phagocytosis

It has been suggested that gentle transverse friction, applied in the early inflammatory phase enhances the mobilization of tissue fluid and therefore increases the rate of phagocytosis.[14]

Friction stimulates fibre orientation in regenerating connective tissue

During maturation, the scar tissue is reshaped and strengthened by removing, reorganizing and replacing cells and matrix.[15]

It is now generally recognized that internal and external mechanical stress applied to the repair tissue is the main stimulus for remodelling immature and weak scar tissue – with fibres that are oriented in all directions and through several planes – into linearly rearranged bundles of connective tissues.[16] Therefore, during the healing period, the affected structures should be kept mobile by normal use. However, because of pain, the tissues cannot be moved to their full extent. This problem can be solved by friction. Transverse friction massage imposes rhythmical stress transversely to the remodelling collagenous structures of the connective tissue and thus reorients the collagen in a longitudinal fashion. Friction is thus a useful treatment to apply early in the repair cycle (granulation and beginning of remodelling stage): the cyclic loading on and motion of the healing connective tissues stimulates formation and remodelling of the collagen.[17]

Friction prevents adhesion formation and ruptures unwanted adhesions (Fig. 5.1)

In that transverse friction aims to achieve transverse movement of the collagen structure of the connective tissue, crosslinks and adhesion formation are prevented. In the early stages of proliferation when crosslinks are absent or still weak, friction must be very light so as to cause only minimal discomfort. Therefore, in the first day or two following an injury, friction is given with slight pressure only and over a short duration, e.g. 1 minute.

At a later stage when strong crosslinks or adhesions have formed, more intense friction is needed to break these

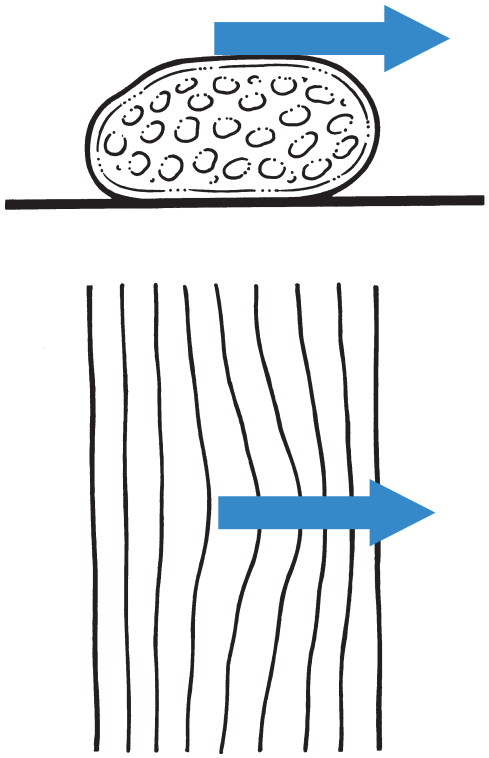


Fig 5.1 • Friction achieves a transverse movement between longitudinally arranged collagenous fibres.

down.[18–21] The technique is then used to soften the scar tissue and to mobilize the crosslinks between the collagen fibres and the adhesions between healing connective tissue and surrounding tissues. This, together with the local anaesthesia produced, prepares the structures for mobilizations that apply longitudinal stress to the structures and rupture the larger adhesions.

Friction induces traumatic hyperaemia

Forceful deep friction produces vasodilatation and increased blood flow to the area. It may be hypothesized that this facilitates the removal of chemical irritants and increases the transportation of endogenous opiates, so causing a decrease in pain. Such a forceful friction, resulting in hyperaemia is only desirable in chronic, self-perpetuating lesions.

Indications

Diagnosis

The reduction in pain achieved after a few minutes of localized transverse friction may be very helpful to define the exact location of the lesion. In muscular, tendinous or ligamentous lesions, a few minutes of massage on the suspected area results in diminished pain on testing immediately thereafter, so confirming the diagnosis as accurately as an infiltration with local anaesthesia.

Preparation for mobilizations and manipulation

Transverse massage is often applied before and in conjunction with other mobilizing techniques. In muscular lesions, friction is given before active or electrical contractions on an unloaded muscle. The purpose is to allow broadening of the muscle and so the prevention of adhesion formation between adjacent muscle fibres and/or bundles.

For reasons of pain relief, transverse massage is usually required before manipulative breakage of ligamentous adhesions is performed. This may be indicated in chronic ligamentous lesions at knee and ankle.

Deep and thorough friction also precedes manipulation of the elbow in type II tennis elbow. The technique is used for its desensitizing and softening effect which makes the manipulation more tolerable.

Therapy

Muscle bellies

Friction is given to a healing muscle belly after contusion, in minor muscular tears and in so-called 'myosynovitis'. In minor muscular tears the friction is often part of combined treatment because it is usually applied after an infiltration with local anaesthesia and is followed by active contractions.

The aim of treatment in muscular tears is to allow the torn fibres to heal in such a way that normal increase in breadth on contraction remains possible, a characteristic that can be disturbed by abnormal adhesion formation. Transverse friction aims to achieve a transverse sweeping movement over the longitudinal muscular fibres without pulling on the tear, so to prevent (in the early stage) or to break down (in the chronic stage) adhesion formation between the individual fibres and between individual fibres and the surrounding connective tissue. It is obvious that to break down crosslinks in a chronic stage, the friction can be given forcefully and for a duration of 15–20 minutes, whereas in more recent lesions the technique must be applied more gently and for a shorter duration. Friction to a muscle belly is always given with the muscle well relaxed.

In recent tears, especially in the large muscles of the lower limb, friction is followed by active or electrical contractions with the muscle in a position of maximal relaxation and without weight bearing, so that tension does not fall on the healing breach.

To avoid early recurrence, friction is given for 1 week after all clinical tests have become negative. During the period of treatment, all movements or activities that bring on pain should be avoided by the patient.

Theoretically, friction can be used for all muscle belly lesions. However, some lesions respond so well to local anaesthetic infiltration that friction is not used. This is the case in type IV tennis elbow (lesion at the muscle belly of the extensor carpi radialis). On the other hand, sometimes no alternatives exist to treatment with deep transverse friction (Box 5.1). A lesion of the subclavius or intercostal muscles for instance can be treated only by deep transverse friction.

Musculotendinous junctions

It is a common clinical experience that all musculotendinous junctions (containing both muscular and tendinous fibres) throughout the whole body can be treated only by deep transverse friction. It would seem that no alternatives exist: local anaesthetics, so curative for some lesions of muscle bellies, and steroids, so effective for tenoperiosteal lesions, have not the slightest effect on musculotendinous lesions, whereas deep transverse friction usually has.

Tendons

All overuse tendinitis can be treated by deep massage except for the tenoperiosteal origin of the extensor carpi radialis brevis (type II tennis elbow), which is best treated by an infiltration with corticosteroid or, in refractory circumstances, sometimes by manipulations.

Box 5.1

Muscle belly disorders that can be treated only by deep transverse friction

Subclavius
Brachialis
Supinator
Adductors of the thumb
Interosseus muscles of the hand
Intercostal muscles
Oblique muscles of the abdomen
Interosseus muscles of the foot

Tenosynovitis also usually responds well to deep transverse massage. In this condition, occurring in long tendons with a sheath, inflammation and roughening of the gliding surfaces of both tendon and sheath give rise to pain and sometimes to crepitus. Friction rolls the sheath around the stretched tendon, so facilitating functional movement between the tendon and its sheath. The technique is useful in both acute and chronic lesions.

Lesions at the tenoperiosteal insertion can be treated either with corticosteroid infiltrations or with deep transverse massage. Corticosteroid suspension quickly converts an inflamed and painful scar into one free of inflammation. However, the recurrence rate is rather high, between 20% and 25%.[3] The aim of the massage is to get rid of the self-perpetuating inflammation by breaking up the disorderly scar tissue and adhesion formation by converting it into properly arranged longitudinal connective fibres. This takes longer but once cure is achieved there will be less of a tendency towards recurrence. It may therefore be a policy to start treatment with infiltrations but if the trouble recurs after a few months to substitute with massage.

As a rule, however, friction is always selected as the treatment of choice in athletes or when the tendon is weakened (partial rupture). It cannot be denied that repeated use of corticosteroids, even in small doses and correctly applied, temporarily weakens a tendinous structure. Steroids also take away inflammation and pain, so giving the patient the false impression of being cured. The combination of a weakened tendon and abolition of pain can be disastrous – rupture may ensue.

There exist also a few conditions that seem to respond only to deep transverse friction. Steroid infiltrations are useless here. This is so in tendinous lesions of the interosseus in the hand and at the quadriceps expansion at the patella.

Lesions in the tendinous body, either traumatic or resulting from overuse, are contraindications for infiltration with corticosteroids. Ruptures have been reported after intralesional steroid infiltrations of long tendons and therefore deep frictions are the treatment of choice here.[22,23]

It is obvious that during the whole period of treatment of tendinitis, tenosynovitis or tenovaginitis, the patient must avoid all activities that provoke the pain, especially the loading of the affected contractile tissue.

Ligaments

Transverse massage is an excellent treatment in acutely sprained ligaments, especially in ligaments of the knee and ankle. The background, mode of action and technique differ considerably and depend on the stage of the lesion.

It has been explained (see Ch. 3) that early mobilization is extremely important for swift and full recovery of ligamentous sprains. However, in advocating this, one main difficulty is encountered: the intensity of the initial inflammatory reaction. The slightest movement causes pain which forces the patient to immobilize the joint and the ligaments. However, during immobilization, regenerating fibrils quickly start to form randomly organized scar tissue, leading to crosslinks and adhesion formation. This problem can be solved by gentle transverse frictions. Rhythmic movement across the inflamed ligament eases the pain and the tissue can be moved to and fro in an imitation of its normal behaviour.

In recent cases the friction need not last long nor be very vigorous – 1 or 2 minutes of daily gentle transverse sweeping movement over the regenerating fibrils is enough. As pain diminishes over subsequent days friction is progressively increased to about 4–5 minutes for 2 or 3 days and finally to a full duration of 15–20 minutes. From the third day, friction is followed by passive and active movements within the limits of pain to maintain normal gliding of the ligament over adjacent bones. When the lower limb is involved, the patient should be instructed to walk as normally as possible but without provoking too much pain.

In chronic ligamentous lesions, frictions are also used but in a totally different way. Here adherent scar tissue has formed abnormal attachments as the result of healing during a period of insufficient movement. As a result of the reduced mobility of the ligament, vigorous use of the joint re-sprains the ligament and in due course leads to recurrent sprains.

Treatment will consist of rupturing the adhesions by manipulation, for which vigorous deep friction to the site of the adhesions prepares the ligaments. The massage weakens and desensitizes the structure, making the forced movement practicable and painless.

Experience has shown that particular ligamentous lesions can be treated only by friction. This is the case for the posterior carpal ligaments at the wrist and the tibiotalar ligaments.

Joint capsules

Deep transverse friction can be applied to the capsules of the trapezium–first metacarpal joint, the temporomandibular joint and the cervical facet joints. The indication is traumatic arthritis or osteoarthrosis. Results are fair, provided the arthrosis is not too advanced. Indications and contraindications to friction are outlined in Table 5.1.

Contraindications

Ossification and calcification of soft tissues

Extensive ossification in muscles, tendons, ligaments or capsules is a bar to all active treatment. However the minor calcifications that may occur after a sprain can be managed by

Table 5.1 Indications and contraindications to friction

Indications	Contraindications
Diagnostic difficulties	Ossification and calcification of soft tissues
Preparative massage	Bacterial and rheumatoid-type tendinitis, tenosynovitis and tenovaginitis
Therapeutic massage:	Skin problems such as ulcers, psoriasis or blisters
• To muscle bellies	Neighbouring bacterial infection
• To musculotendinous junctions	Bursitis and disorders of nerve structures
• To tendons	Haematoma, if large
• To ligaments	
• To joint capsules	

friction. In supraspinatus tendinitis, calcification is regarded as responsible for complaints when the insertion is very tender to touch and a radiograph shows calcification. These findings are a contraindication to friction. In contrast, when calcification is present in the absence of severe tenderness, transverse massage can be given.

Bacterial and rheumatoid-type tendinitis, tenosynovitis, tenovaginitis

All types of bacterial and rheumatoid disorders, no matter at what stage of inflammation, are absolute contraindications to friction.

Skin problems such as ulcers, psoriasis and blisters

When normal skin has been abraided – sometimes by friction – massage should not be given. In skin disorders, it must be abandoned when stable skin–finger contact becomes impossible and friction aggravates the skin problem.

Neighbouring bacterial infection

Because these may be reactivated by or may extend if friction is used, it must be postponed until the infection has resolved.

Bursitis and disorders of nerve structures

When bursitis is mistaken for a tendinous or ligamentous disorder and friction is given, the problem will either increase or, at best, the pain will remain unchanged – it certainly will not improve. Friction to a nerve is also harmful.

Haematoma

A haematoma in a muscle belly or after an ankle sprain is not a contraindication to friction. Even if the haematoma is the result of deep friction, treatment may be continued unless the effusion is large.

Technique

Introduction

Transverse massage is not an easy technique. In order to produce results, three conditions must be satisfied.

First, the therapeutic movement should be applied to the exact site of the lesion which may occupy only a very small volume of tissue. In other words, an identification of the site to within 1 cm must be achieved which relies entirely on clinical diagnosis and palpation of the lesion, based in turn on anatomical knowledge. In some instances it will be necessary to palpate carefully the entire structure at fault so as to find the point that reproduces the patient's pain.

Secondly, friction should be applied transversely across the longitudinally orientated fibres, with sufficient sweep to reach all the affected tissue and firmly enough to produce movement between the individual connective tissue fibres of the affected structure.

Third, the movement can only reach deeply seated structures if the deep friction technique of Cyriax is used; that implies attention must be paid to different elements such as the position of the patient and of the therapist's hand, which fingers are used, the amount of pressure, the duration and frequency of the sessions. The patient's skin and the therapist's finger must move as one, so that the deep layers of the skin move over the affected fibres. Therefore all cream, ointments, powder or any other procedure, such as previous heat, that makes the skin sweat, must be avoided. Six to 12 treatments are normally necessary. Except in acute ligamentous disorders they are not given more often than every other day because otherwise the site of the lesion may still be too tender from the previous treatment to permit adequate massage.

Position of the patient

The patient's position must be *comfortable* because it must be maintained for up to 15–20 minutes. Sitting or lying is preferable.

The lesion must be brought *within finger's reach*. In some structures this can be easily attained but others such as the supraspinatus insertion and the anterior aspect of Achilles tendon, require more specific positioning of the patient.

In addition, positioning must place the affected structure under the *required amount of tension*. Full relaxation is necessary for a muscle belly in order not only to treat its surface but also to access a deeply seated lesion. Tendons with a sheath must be kept taut otherwise friction will be ineffective between tendon and sheath. The same applies in ligamentous lesions, which are also placed in tension but within the limits of pain.

Position of the therapist and the hands

The bodily position of the patient should be the most comfortable and least tiring for the therapist. Working height is of chief importance, so an adjustable high–low couch is ideal. To have some economy of effort the therapist should adopt a position that utilizes body weight to a maximum. Usually this is standing and with the patient on a slightly lower plane. The therapist should avoid flexed positions. The shoulder should also not be in abduction because this quickly leads to pain and cramp in the neck and shoulder girdle.

Massage is performed by the whole arm and is not just an activity of hand and digits. Movement is generated in the shoulder and conducted via elbow and forearm to the digits. One set of muscles is used to apply force and another to provide movement, for example pressure with the fingers, movement with the arms. Digits, hand and forearm should generally form a straight line and are kept parallel to the direction of movement.

The majority of friction techniques are performed in two phases: *an active movement*, usually as a result of flexor muscular activity and a *passive movement*, when the arm and hand are returned to the starting position. At the end of the passive phase there should also be a moment of rest during which the therapist fully relaxes the muscles.

The hands can be used in a variety of ways depending on the tissues to be treated and the surface worked on. The wrist and metacarpophalangeal joints should be kept in an almost neutral position. The interphalangeal joints are slightly flexed to avoid traumatic arthritis.

Three main techniques can be distinguished.

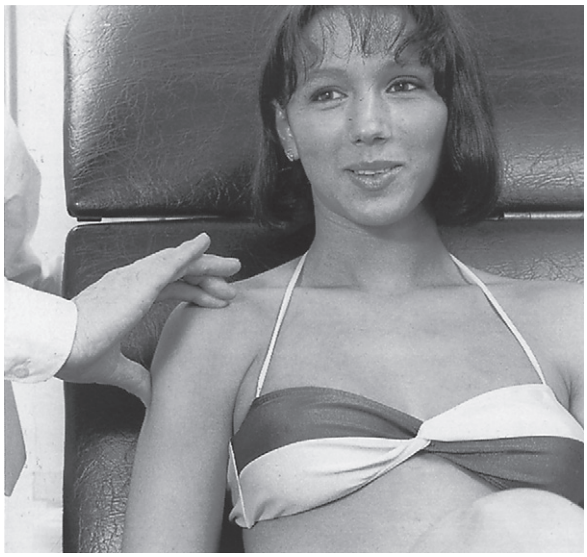
To-and-fro movements

These are used in the treatment of dense, round or flat collagenous bundles (tendons or ligaments) and in the treatment of tenosynovitis. The active phase is a sweep with the tip(s) of one or two digits across the tendinous structure. During the passive relaxation phase the finger is returned to the starting position, without losing contact between finger and skin. Movement is with the arm; friction is given by use of the pulpy part of the finger (Fig. 5.2). In large lesions, as in peroneal tendinitis, two or three adjacent fingers are used together. In deep-seated lesions as in tendinitis of the long head of biceps in the bicipital groove or at its insertion on the radius or in infraspinatus tendinitis, the thumb performs friction.

Counterpressure is usually provided to enable a good sweep. The finger(s) applying counterpressure and stabilization are most important in bringing those applying friction into the right position and also determining the direction of the friction. The thumb is used (to give counterpressure) when the sweep is performed by a movement of the index reinforced by the middle finger or the middle finger aided by the index finger. When the thumb does the massage, counterpressure is from the fingers (Fig. 5.3). The most common way of applying friction around a round edge on a flat surface is to use the index reinforced by the middle finger. Sometimes the opposite is done: the middle finger is reinforced by the index. Sometimes counterpressure is not given, for example in friction to the quadriceps expansion or intercostal muscles.

Pronation–supination

This technique is often used where the lesion is difficult to reach: the anterior aspect of the Achilles tendon, popliteus tendon and the dorsal interossei of the metacarpals. Massage



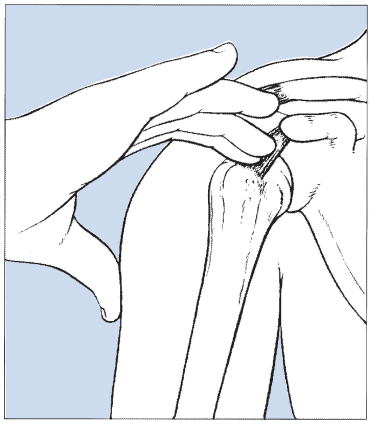


Fig 5.2 • Friction to the supraspinatus tendon: counterpressure is by the thumb.

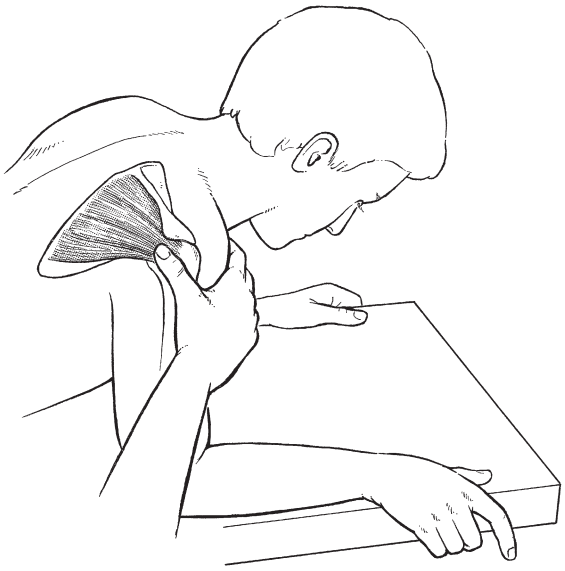


Fig 5.3 • Friction to the infraspinatus tendon: counterpressure is by the fingers.

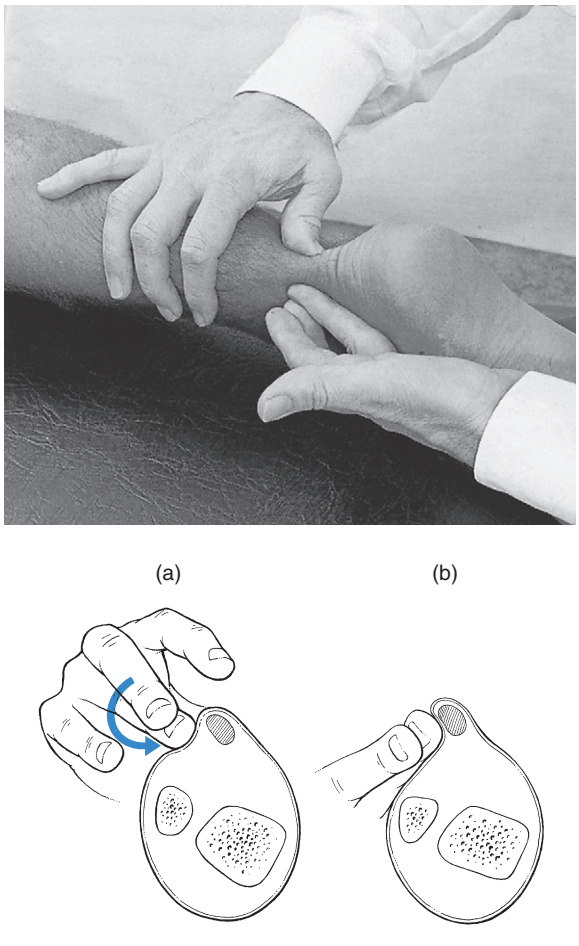


Fig 5.4 • Active phase of pronation–supination friction technique to the anterior aspect of the Achilles tendon. a, starting position; b, end of supination (active) movement.

is performed with the pulpy part of the third finger (long finger), reinforced by the index finger. The long finger is used because its long axis is the prolongation of the axis of pronation–supination rotation of the forearm (Fig. 5.4).

The active phase is usually on supination. No counterpressure is given. Caution is taken not to move the finger on the skin but rather to move the skin and the fingertip as a whole. The passive phase is the pronation movement that brings the frictioning finger back to the starting position without losing contact with the skin.

Pinch grip

This is the normal technique for a muscle belly. The pinch is between the thumb and the other fingers. The muscle is fully relaxed. The fingers are placed at one side of the affected area and the thumb at the opposite side (Fig. 5.5). By drawing the fingers upwards over the affected area, the therapist feels the muscle fibres escape from the grip until only skin and subcutaneous tissue remain.

During the passive phase the fingers are slightly relaxed and moved downwards into the previous deep position where the same movement starts again.

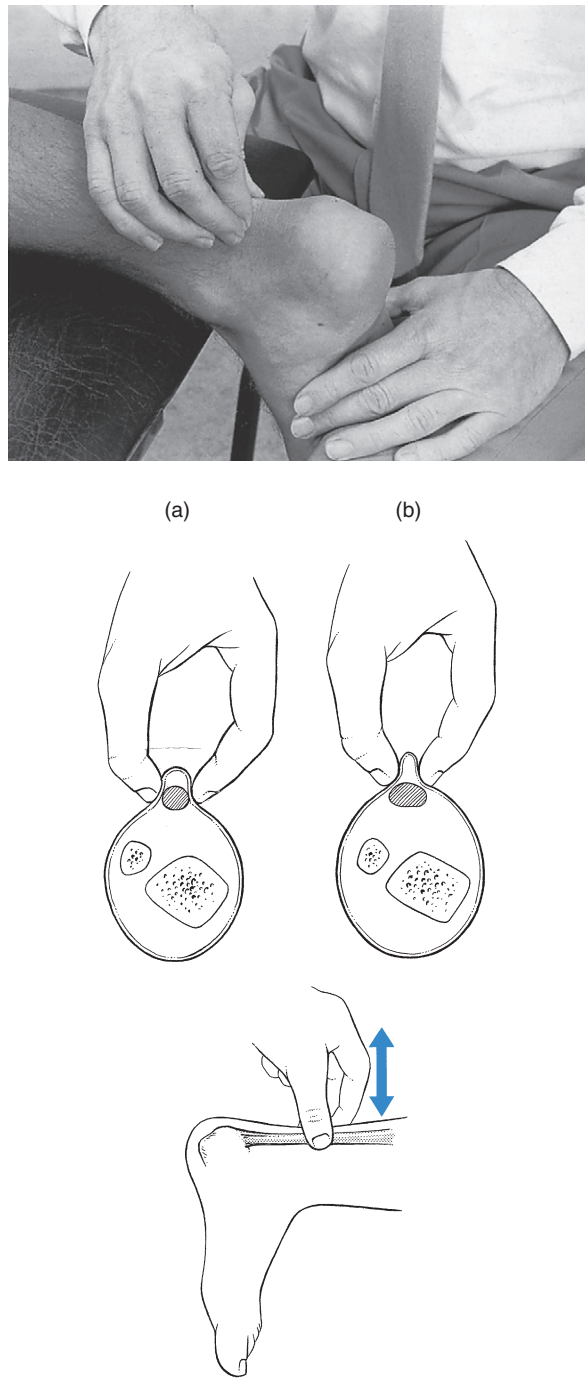


Fig 5.5 • Pinch grip friction to the Achilles tendon. a, starting position; b, end of active phase.

Sometimes the same technique is used in tendinous lesions, for example, at the sides of the Achilles tendon.

No movement between finger and skin is allowed

Deep friction can only be effective when skin and subcutaneous fascia are moved over tendon ligaments or muscles. No movement is allowed between the therapist's finger and the

patient's skin. If movement occurs between finger and skin, blistering soon takes place and usually indicates faulty technique. Sometimes it can be avoided by keeping the skin dry by the use of 95% alcohol in water and/or by placing a piece of cotton in between the finger and the skin.

In the obese, subcutaneous soreness and/or ecchymosis may occasionally occur and sometimes a nodule may form. For this reason the finger should not be in continuous contact with the same area but should displace the skin slightly to one or other side, before pressure is applied.

Direction of friction must be transverse to the tissue fibres

Longitudinal massage improves the circulation of blood and lymph but has no effect on musculoskeletal lesions. On the contrary, because lesions of tendons, muscles and ligaments are normally caused by a longitudinal force, longitudinal massage can possibly be harmful in that it may separate the ruptured ends further. To restore and/or maintain full mobility of a lesion, massage must be given across the fibres, so moving all fibres in relation to each other. To achieve this, the therapist must have a good anatomical knowledge of the direction of the fibres.

Sweep

The main goal of friction is to move fibres in relation to each other and adjacent structures. Enough sweep must be given to the friction for this purpose, so the frictioning finger starts at the far side of the lesion, glides over it and ends at the near edge. Pressure alone, however hard and painful it may be, is totally ineffective. Adequate sweep is sometimes limited by the amount and elasticity of the overlying skin. Initial displacement of skin over the lesion from the near to the far side may help increase sweep and reduce the risk of blistering.

Amount of pressure

Over recent decades, friction has been held in some disrepute in that it was perceived by some as synonymous with very painful treatment. Though it cannot be claimed as wholly pain-free, the pain should not be unbearable. When excessive pain is provoked, this is usually the result of a failure to understand the meaning of the term 'deep', which means 'as deep as needed to reach the lesion'. Many therapists misinterpret this in such a way that they feel that they always have to work hard physically, which obviously leads to pain and may do more harm than good.

The amount of pressure applied depends on three elements:

- *The depth of the lesion*: that friction must always reach sufficient depth to move the affected fibres in relation to their neighbours and sometimes the underlying bone or capsule, increased pressure must be applied to deeper structures.
- *The 'age' of the lesion*: recent sprains and injuries require only preventive friction because crosslinks or adhesions have not had time to form. In long-standing cases more pressure is needed to get rid of these. However, pressure should always be associated with movement and should not replace it because pressure alone is both painful and ineffective.
- *The tenderness of the lesion*: in severely inflamed lesions that are very tender to touch, friction with the usual amount of force may be very painful. Pain can be avoided by starting with a minimal amount of pressure – just enough to reach the lesion – and progressively increasing the force as treatment proceeds.

In order to avoid painful sessions of deep transverse friction it is good practice to grade its application. Begin with a sweep that is gentle and continue this for a few minutes; some numbness of the treated area follows which allows slight intensification of the amount of pressure, which in turn leads to more numbness. Finally, it will be possible to give effective massage that is practically painless to the patient.

Duration and frequency

Friction is usually given for about 10–20 minutes and, because of tenderness, on every second day. The ideal timing of the next treatment is when local tenderness caused by the previous session has resolved. If tenderness persists after 2 days, the pressure used during friction should not be diminished but the interval between sessions must be increased.

Massage immediately after a ligamentous sprain or a minor muscular rupture may be applied daily for the first week but should be of very low intensity and short duration.

Treatment is stopped once the patient is pain-free during daily activities and functional tests are totally negative. Local tenderness may persist longer but disappears spontaneously because it is the outcome of repetitive hard pressure. However, in a minor lesion of a muscle belly, massage is continued for 1 week after full clinical recovery to prevent recurrence (see Table 5.2; see also Box 5.2).

Passive movements

Treatment by passive movement is otherwise known as *mobilization*. It cannot be performed by the patient and requires the intervention of a therapist. Depending on its velocity and the range of movement that is aimed for, it can be graded as A, B and C *mobilization*:

- Grade A mobilization is a passive movement performed within the pain-free range.
- Grade B mobilizations are passive movements performed to the end of the possible range. The latter is indicated by an end-feel. All stretching and traction techniques are grade B mobilizations.
- Grade C mobilization is a minimal thrust with a high velocity and over a small amplitude. It is performed at the end of the possible range, i.e. the moment the therapist has reached the end-feel. Another word for grade C mobilization is *manipulation*.

Table 5.2 Transverse massages/modalities

Indication	Duration (min)	Pressure	Frequency	Combined treatment
Diagnostic	15–20	High	Once	
Acute ligamentous	30 sec	Very low	Daily	Effleurage before and active movement after the treatment
Subacute ligamentous	3–10	Low	Daily–3 times/week	Passive grade B movements after
Chronic ligamentous	15–20	High	3 times/week	Passive grade B movements after
Ligamentous adhesions	15–20	High	Once	Before manipulation (grade C mobilization)
Tendinitis – tenoperiosteal	15–20	Grading	3 times/week	Relative rest – unloaded active movement
Tenosynovitis	15–20	Grading	3 times/week	Relative rest – unloaded active movement
Musculotendinous	15–20	Grading	3 times/week	Relative rest – unloaded active movement
Myosynovitis	15–20	Grading	3 times/week	Relative rest – unloaded active movement
Muscular tear – acute	5–10	Low	Daily	Procaine infiltration before and active unloaded contractions after treatment
Muscular tear – chronic	10–15	High	3 times/week	Active unloaded contractions after treatment
Capsular lesions	15–20	Grading	3 times/week	

Box 5.2

Summary of deep friction technique

1 Position of the patient must:
be comfortable
bring lesion within finger's reach
be appropriate for the type of structure at fault:
- tendon/ligament under tension
- muscle belly: relaxed

2 Position of the therapist must:
be comfortable
facilitate economy of effort:
- alternating active and passive phases
- using large muscles

3 Use of the hand:
To-and-fro movement
Pronation/supination
Pinch grip

4 Use of the fingers:
Counterpressure
Friction using the fingers

5 Other points:
Fingers and skin move as one unit
Direction of friction must be transverse
Sufficient sweep must be used
The pressure must be appropriate
Duration and frequency must be appropriate

Indications

Grade A mobilizations

To promote healing of injured connective tissue

Passive movements within the pain-free range are usually called for in the treatment of injured connective tissue. A comprehensive literature evaluation and meta-analysis of experimental studies of the past several decades have demonstrated that regeneration of injured connective tissue is significantly better with the application of continuous passive motion. If the healing tissues are not loaded, regeneration results in unstructured scar tissue. Under functional load, the collagen fibres are oriented in a longitudinal direction and the mechanical properties are optimized.[24]

Grade A mobilizations are therefore applied early in the treatment of sprained ligaments to promote orientation of the regenerating fibres. They are given in conjunction with gentle transverse massage and within the pain-free range. Care should be taken not to bring the fibres under longitudinal stress in order not to disrupt the healing breach. The movements are of short duration but repeated often.

Distractions at the shoulder

Grade A mobilizations are also used on the capsule of the shoulder in stage III arthritis when stretching and intra-articular steroids are contraindicated (see Ch. 14). In this condition, long-standing stimulation of the nociceptors has increased neuro-sympathetic activity, giving rise to vasoconstriction, muscle spasm and pain.

Gentle and rhythmical grade A movements are performed in such a way that the fibres are stretched longitudinally, stimulating the mechanosensor mechanisms in the joint and so

inhibiting somatosympathetic reflexes that are co-responsible for the increased inflammation of the joint.

Deformity correction

Some cases of lumbago show persistent spinal deviation even after the pain has ceased. A quick thrust manipulation so effective in relief of pain is not effective in correcting the remaining deformity, but sustained translatory gliding in the opposite direction is most helpful. The movement is performed slowly and care is taken to keep the gliding within the pain-free range (see Ch. 40).

Reduction of an intra-articular displacement in a peripheral joint

When a meniscus or some other piece of intra-articular cartilage (with or without an osseous nucleus) becomes displaced and locks a joint, the logical treatment is either to remove it or manœuvre it into such a position that the joint can again move freely over a normal range. The technique needed for the latter is usually a series of manipulative movements which normally contain elements of traction combined with movements of rotation and flexion or extension. In general, these are first performed in the less painful direction of movement and repeated several times with progressively increasing force.

Unlike manipulations in the spine, the manœuvre to reduce an intra-articular loose body is not a grade C mobilization because the movement is not performed at the end of range nor does it contain a 'thrust' element. The flexion–extension movement is over a wide range and stops before the end-feel is reached. The rotation movements are performed to the end of range where end-feel is sensed by the therapist. The 'manipulation of an intra-articular displacement in a peripheral joint' is therefore a combination of grade A and grade B mobilizations.

Grade B mobilizations

To maintain a normal range at the joint

Paralysed muscles may lead to a loss of normal range of motion of the corresponding joint. This can be avoided by gently stretching the capsule, starting as soon as possible after the onset of paralysis. The approach should also be considered for joints that have been injured or subjected to surgery. In such circumstances, there may be the paradox that immobilization is needed for a fracture to heal but that movement is required to prevent loss of capsular elasticity. Often the problem can be solved by adapting the technique of capsular stretching so that it does not influence the site of the fracture.

To stretch the capsule of a joint

Grade B mobilizations may be required to stretch the joint capsule in non-acute arthritis and in early osteoarthrosis. The technique will be further referred to as *capsular stretching*. Capsular stretching is particularly useful in shoulder and hip joints but is applicable in all 'non-irritable' capsulitis. The condition is characterized by:

- a limitation in the capsular pattern (see Ch. 4)
- demonstration of a hard-elastic end-feel to restricted movements (see Ch. 4).

In the very beginning of arthritis, muscle spasm forces the joint to be held in a position of ease, so restricting movement in some directions more than in others (see Capsular pattern, Ch. 4). Immobilization and inflammation cause disordered deposition of collagen fibres in the joint capsule and lead to the formation of capsular adhesions, which in turn are responsible for more restriction of movement and pain. *Stretching* aims at restoring mobility and function by breaking micro-adhesions and producing elongation of the shortened capsule. To be applicable, however, the ligamentous end-feel must be reached before the protective muscle spasm begins. To be successful, the therapist should therefore be able to differentiate between an elastic and a spastic end-feel.

The technique is a slow and steady pressure, performed at the end of range over about 30 seconds to 1 minute with as much force as is reasonable for the patient to bear. Tension is slightly diminished for a few seconds, so affording the patient some respite, and then again increased. From time to time the procedure is completely interrupted. If tension is released too quickly, some pain may be felt and it is therefore wise to bring the limb back into neutral position under traction. The technique is not painless. The stretching causes some micro-ruptures, which result in an inflammatory response and after-pain that lasts for a few hours.

Normally, capsular stretching is given for 15–20 minutes, three times a week. The therapeutic effect is slow.

Capsular stretching can be preceded by application of heat, either through short-wave diathermy or ultrasound. This can relieve some pain and seems to lower the viscosity of the collagenous tissue, allowing more movement for less force. *In vivo* studies on the effects of heat on ligament extensibility have shown that sustained force applied after elevating tissue temperature produced significantly greater residual elongation.[25,26]

Manipulation of a joint capsule under anaesthesia is a grade C mobilization and is only considered for postoperative intra-articular adhesions. A joint that has been manipulated under anaesthesia requires daily intensive mobilization immediately afterwards in order to prevent the formation of new intra-articular adhesions.

To stretch a muscle

Children with short calf muscles can be helped by sustained stretching. The procedure consists of a series of alternating passive stretchings and active contractions. Stretching is maintained for about 8–10 seconds and is followed by full relaxation and active contraction of the muscle. These alternating movements are performed six to eight times per session, preferably daily but at a minimum of three times a week. The earlier the stretching is started, the better the result. Above the age of 15 not much improvement can be expected.

Traction

Traction is used to separate articular surfaces from each other and can be employed in two ways: as an accessory to manipulation or as the sole treatment. Reducing a displaced fragment is obviously easier when the bone ends between which it lies are pulled apart. If the fragment projects beyond the articular edge, tautening of the ligaments and capsule also provides a

centripetal force. In that traction diminishes the pressure on the fragment, pain decreases, which allows the patient to relax the muscles more.[18] In the cervical and thoracic spines, traction is a built-in safety measure for protecting the spinal cord during manipulation (see below) although the use of traction for this purpose and at these sites does not imply that manipulation can be performed on a basis of 'try and see what happens' without a proper diagnosis.[27]

In the spine, traction is used as the sole treatment only in nuclear disc protrusions, which are rare at the cervical and thoracic levels but are more common in the lumbar area. Spinal traction is always mechanical and is performed with the help of a harness (lumbar or low thoracic) or a sling (cervical or upper thoracic). Spinal traction distracts the intervertebral disc spaces. It also pulls the apophysial joints apart and slightly widens the intervertebral foramina.[27–31] At the same time, negative intradiscal pressure is produced with centripetal 'suction' on any protrusion. The posterior longitudinal ligament is tightened, which may help reduce a displaced fragment. All these elements are helpful in the progressive reduction of a nuclear disc protrusion. Reduction of herniated bulges has been demonstrated on epidurography[31–33] and on CT scan[34] during and after traction. The effect of traction depends on the amount of force applied, the length of time per session, the interval between each session and the total number of sessions.[35]

Grade C mobilizations

Grade C mobilizations or manipulations are forceful passive movements, performed at the end of range. Spinal manipulations are mainly to interrupt discodural or discoradicular contact. At the peripheral joints the purpose of a manipulation is to rupture unwanted adhesions between bone and ligament or bone and tendon or to reduce small bony subluxations in the wrist or foot.

Rupture of ligamentous adhesions

Small ligamentous adhesions sometimes develop between a healing ligament and bone. They usually result from a sprained ligament that has been immobilized during the healing process. The usual presentation is at the lateral ligaments of the ankle and at the medial collateral ligament of the knee. The clinical features are local pain during exertion and a small limitation of movement in one direction only. The adhesions can be ruptured by a high-velocity, small-amplitude thrust manipulation, after preparation of the affected ligament with intensive deep transverse friction.

The joint is stretched as far as possible in the limited direction and manipulated with a single firm thrust, during which a typical 'snap' is often heard. Harm is not caused to the ligament nor to the other parts of the joint because the adhesions bear the brunt of the force. The manipulation is almost painless and after-pain is not to be expected. A successful manipulation should achieve an immediate result. Active movements during the following days to maintain function should be highly encouraged.

Rupture of tenoperiosteal adhesions

In type II tennis elbow (tendinitis of the attachment of the extensor carpi radialis brevis), adherent and disorganized scar tissue causes a self-perpetuating inflammation. The manipulation aims to rupture the adhesions and produce a permanent elongation of the tendon. The high-velocity manœuvre is preceded by thorough deep transverse friction in order to numb and to weaken the spot. The manipulation is performed only once per session; 10–15 sessions may be required to achieve a result.

To reduce a bony subluxation

A subluxation of one of the carpal bones or of the cuboid bone can easily be reduced by digital pressure combined with translatory movement during traction.

Manipulation of the spine

Spinal manipulative therapy is a major part of treatment techniques in orthopaedic medicine and is discussed thoroughly below.

Contraindications to forced movements

Contraindications to spinal manipulations are discussed later in this chapter.

Capsular inflammation

Forced movements should not be performed when signs and symptoms of capsular inflammatory activity are present. These are spontaneous pain, pain especially at night, wide reference of pain, inability to lie on the affected side at night or to bear weight on the affected side. Local warmth and effusion are other pointers of a highly inflamed joint. However, if these symptoms and signs are present but the rest of the clinical examination demonstrates internal derangement (e.g. knee, hip, ankle), manipulation is indicated and can safely be performed.

Muscle spasm

Grade C mobilizations should never be applied to a joint that is protected by a muscle spasm. Grade B mobilizations may be used unless the end-feel of the movement that is intended to be forced through is also spastic.

Severe osteoporosis

Grade B mobilizations, for instance stretching of the shoulder or hip joint in elderly people, should always be carried out with caution for fear of fracturing the humerus or the neck of the femur.

Joints and ligaments not under voluntary tension control

Mobilization is also contraindicated for those joints and ligaments on which the tension is not under voluntary control. This is the case for the acromioclavicular, the sternoclavicular and the sacroiliac joints and the sacrococcygeal ligament.

Manipulation of the spine

Introduction

Spinal manipulative therapy includes all procedures of mobilizing or adjusting the spine by means of the hands. As in the peripheral joints, grade A and B mobilizations are movements of low velocity with varying amplitude but remaining within physiological limits and within the patient's tolerance and control.

A manipulation or grade C mobilization usually implies a single thrust of high velocity performed at the end of a passive movement after the 'slack' has been taken up, and over a small amplitude. It goes beyond the physiological limit but remains within the anatomical range. Precision of the movement and control of the applied force are required.[36] Spinal manipulative therapy is a valuable method in the treatment of mechanical spinal disorders. Although it has not been scientifically validated, some studies have shown beneficial effect.[37–40] However, its potential benefit should not be overestimated and the indications must be well defined and based on a sound clinical diagnosis. It must never be done as a test to see if it is effective. Therefore it should not be used on all those with back and neck pain although it may well cure a proportion who actually require it. To use McKenzie's words:

> *Even if you have a hammer in your hand not everything you see is a nail. Therefore indiscriminate use of spinal manipulative therapy must not be made if the criticisms that have been justifiably levelled at chiropractice and osteopathy are to be avoided. The development of postgraduate courses in manipulation is welcome, although some have overvalued the benefits of manipulative therapy. All who undertake manipulation have experienced the feeling of pride and joy in producing cure. It is the duty of those who have more experience of the benefits and limitations of manipulative therapy to moderate the understandable enthusiasm of those entering the field – a few successes may quickly lead to the temptation to manipulate every patient for any disorder.*[41]

Manipulation either helps quickly or not at all. Therefore if improvement does not occur after one or two sessions, manipulation is not likely to be successful and it is pointless to continue with it.

Historical note

Manipulation is as old as medicine and embraces both medicine and mankind in general. In recent times, the medical aspect has become structured and different methods have been developed which are subject to controversy and competition.

Osteopathy

The concept of osteopathy was introduced by A. T. Still (1828–1917) and developed out of frustration with traditional medicine. His ideas were based on two principles: (1) the body has within itself the processes to combat all disease, and (2) the cause of all disease is dislocated bones, abnormal ligaments or contracted muscles with consequent mechanical pressure on blood vessels and nerves.

Diagnosis is mainly based on palpation for restricted spinal mobility and treatment consists of a manipulative system in which joints are forced by a distant leverage. Cure is sought for all kinds of visceral and musculoskeletal disorders.[27]

Chiropraxy

This method was started in 1885 by D. Palmer. It is based on a revision of techniques that originated with Hippocrates and is also influenced by osteopathy. Chiropraxy was long regarded as maintaining osteopathic dogma in its most primitive form and having a strong commercial character.

Chiropractors also claim to cure visceral diseases via the musculoskeletal system. Diagnosis is made on palpation for vertebral displacement and manipulative pressure is applied directly to the bone.

Orthopaedic medicine

This term describes the system of diagnosis and treatment of musculoskeletal lesions introduced by J.H. Cyriax. It is the system on which this book is based. Diagnosis rests on careful history and functional examination. Treatment depends mainly on the type of lesion, and manipulation is applied only when indicated. In spinal manipulation, Cyriax proposed a fixed set of high-velocity, small-amplitude thrusts performed at a certain distance from the lesion and, characteristically for this method, usually under strong traction. The objective of Cyriax's spinal manipulative techniques is to alter the discodural or discoradicular interaction by moving a displaced cartilaginous fragment away from the sensitive dura mater and dural nerve sleeve. Spinal rotation manipulations apply a torsion stress throughout a whole part of the spine, not at just one level. With an intact posterior longitudinal ligament and annulus fibrosus, some of this torsion force exerts a centripetal force by suction on the protruding disc material.[42] This effect is not confined to one level and full reduction is not absolutely necessary for pain relief, in that when contact between dura and disc has ceased the problem is frequently solved.

Manual therapy

Treatment is characterized by rhythmic repeated movements within the physiological range. Oscillatory techniques had already been used by E. Cyriax (father of J.H. Cyriax) but were more widely employed by Maitland and later slightly changed by the different schools of manual therapy (Cyriax:[3] p. 40). Pressure is applied to what is believed to be the appropriate level.

Orthopaedic medicine technique

Before any manipulation is done an exact diagnosis must be made. The decision to manipulate is followed by choice of the correct manœuvre. The patient is put in a comfortable position and the manipulator adopts a stable stance. The floor and shoes should not be slippery, so that there is no risk of inappropriate movement.

Attention must be given to the following general matters, which are important for all manipulations.

Traction during manipulation

Most types of spinal manipulation in orthopaedic medicine are performed under traction. For the cervical and thoracic spine, traction is applied by the manipulator with the help of a fixing belt or by one or two assistants. At the lumbar level, traction is usually already built into the manœuvre. Traction facilitates the reduction of a displaced fragment and provides an important safety element against the possibility of a protrusion contacting the spinal cord during manipulation.

End-feel on taking up the 'slack'

All spinal manipulations are performed over only a small amplitude. Therefore all 'slack' must be taken up by moving the vertebral joints passively to the end of the normal passive range of movement. At this stage it is absolutely necessary to have a clear idea of the end-feel, which is nominally elastic for the entire spine. An end-feel that does not correspond with this – muscle spasm, or hard or empty end-feel – is an absolute contraindication to any manipulation and the manœuvre is not continued.

Final thrust

Immediately after the slack has been taken up in the surrounding tissues, a minimal amplitude, high-velocity thrust is given to affect the target tissue. The velocity is of great importance because tissues loaded quickly are stiffer so that the manœuvre will affect only the displaced fragment of disc and will not damage the surrounding structures.[43]

The amount of force used for the final thrust depends mainly on the patient and manipulator in that a tall manipulator will have to use less force in a small patient and vice versa.[44] The length of the lever (see later) is also important. The force should always be kept reasonable and may be progressively increased, according to the immediate result.

The manipulation thrust is often accompanied by an audible 'pop'.[29,45] Although it is a common belief that pops or clicks are provoked by the formation of a temporary vacuum, as occurs in small peripheral joints put under traction,[46–48] this is not definitely established for the spine. An alternative and more likely explanation is movement of cartilaginous fragments, as may be heard during manipulation for a loose body in the knee or hip. If the clicks were simply the result of the collapse of a vacuum they should also be – but are not – heard during mechanical traction, in which the traction force is much higher.

Leverage

The amount of force used depends on the length of the lever. If for example a rotation of the lumbar spine is forced via the shoulder and pelvis, the lever offered by the shoulder is the same length as that offered by the pelvis, so an equal amount of force must be used by both hands. But if the femur is used instead of the pelvis, the length of the pelvic lever doubles. The hand on the shoulder must apply double the amount of force that is used on the knee. The longer the lever, the less force is needed.

Reassessment

After each manœuvre the patient is assessed, the criteria of success being the absence of symptoms and the restoration of pain-free movement. The patient and not the manipulator is the arbiter.[49] Depending on the immediate outcome, the therapist decides whether to repeat the same manipulation, probably with increased strength, to try another manœuvre or to refrain from further manipulation.

It should be appreciated that after successful manipulation the anatomical lesion is still present: a piece of cartilage, although put back in place or into a neutral position, persists and may redisplace. For this reason, those who undertake manipulation should note the results obtained and what manipulations were used, in case of recurrence.

Figure 5.6 outlines the assessment of spinal lesions and their manipulation.

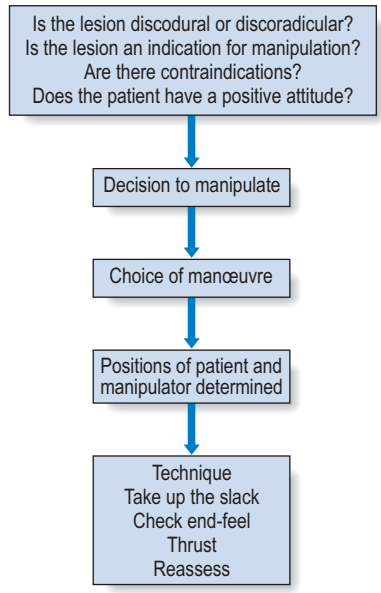


Fig 5.6 • Spinal manipulation.

Selectivity of a manipulative treatment

Selectivity must be considered both in diagnosis and therapy.

Selectivity of diagnosis

Osteopaths and manual therapists claim to have developed the clinical skills to localize by palpation the exact site of fixation, and are therefore able to perform the manipulation at the required level. Diagnosis is mainly based on segmental mobility tests: joint play, springing test or tests of passive physiological movements. Movement can be tested by exerting local pressure at one side of a vertebra while counterpressure is applied to the contralateral side of the vertebra above or below. For the lumbar spine, it can be done with the patient on the side with both hips flexed to 90°. Small movements of the thighs cause the lumbar spine to flex or extend which can be detected by palpation of the spinous processes.

Other practitioners look mainly for palpable soft tissue changes, such as local subcutaneous thickening or exquisite tender spots (trigger points) in muscles, ligaments (iliolumbar,

sacroiliac) and over bony prominences. All these are considered to be important diagnostic and therapeutic factors.

The great variability in the extent of spinal stiffness between subjects, or at different levels within the one subject, makes the determination of areas of abnormally increased stiffness difficult. Increased stiffness may in fact be a normal variant and bear no relationship to the patient's presenting symptoms. Few of those advocating segmental mobility tests have seriously examined the value of their tests. They have generally presumed that the tests were useful because their patients got better.[50] However, several studies have failed to demonstrate the reliability of these tests.[51–62] Therefore it must be made clear that judgement of small changes in the range of movement of a segment, in the absence of full restriction of movement, remains a very subjective finding, which depends mainly on the personal conviction of the examiner rather than on objective measurements. Moreover, in soundly based tests, findings must be reproducible and must show correspondence when performed by other investigators. In the establishment of 'joint play' the inter-observer discrepancy is too large to be acceptable.[63] In 1973, Cyriax attended a demonstration in which five therapists, all of whom specialized in mobility testing, examined over a period of a few minutes a patient with a neck problem. There was no agreement between these specialists about the level of the lesion (C2, C3, C4, C5, C6 or T2), or about the direction of restriction (see Cyriax:[64] p. 108). Similarly, a patient who had congenital fusion of the sacroiliac joints was examined by 10 manipulators. Each had his own diagnosis, such as left anterior sacrum, right anterior sacrum and bilateral posterior sacrum, although 'the tests were very positive' for all of them (see Maigne[65] and Cyriax:[64] p. 363).

Even if it were possible to identify with certainty localization of the hypomobile segment, the question remains as to whether this is also the site of the lesion. Studies have shown that frequently the lesion does not lie at the joint where motion is restricted but at one which appears to be normal.[55] Moreover, other disorders such as osteophytosis, congenital fusion and ankylosing spondylitis all give rise to restricted movement which is usually painless.

Selectivity of manipulation

Manipulation is often accompanied by immediate relief of symptoms and signs which, since success has been obtained, is logically taken as absolute confirmation of the precision of diagnosis and treatment. Such a deduction may be – and often is – totally wrong. The only thing proved is that the manipulation was efficacious. The erroneous reasoning that successful manipulation necessarily confirms the diagnosis has been and is still today an important argument for the false belief of some schools that manipulation can cure all kinds of disorders even including visceral diseases. A typical example is pectoral pain, resulting from a thoracic discodural interaction which is misdiagnosed as angina. The patient goes to an osteopath who manipulates the thoracic spine and the pectoral pain ceases immediately. Both patient and manipulator, misled by the wrong diagnosis, will believe that the manipulation has altered autonomic tone and cured the angina, whereas what it actually did was interrupt the discodural interaction.

In orthopaedic medicine most manœuvres used are non-specific long-lever manipulations. These include all procedures in which a force is exerted on a part of the body some distance away from the area where it is expected to have its beneficial effect. Levers may include the shoulder, transverse processes and parts of the skull, pelvis or thigh (Frymoyer *et al*:[45] p. 1594). Although some criticize the crudity of long-lever high-velocity manipulation it should be realized that it is not elegance, impressiveness, specificity or technical difficulty which count but effectiveness and safety. Furthermore, the use of a lever enables the manipulator to reach the lesion more effectively. During the preparative phase – on taking up the slack – all the normal joints are brought to their anatomical end position except for the joint that is blocked. When the additional thrust is given, the final extra pressure falls inevitably first and to the greatest degree on the deranged joint. The manœuvre thus becomes specific even though in general the techniques are regarded as non-specific.

Long-lever manipulations are in full contrast to what are called 'specific' short-lever high-velocity manipulations. Here the goal is to act specifically at what is believed to be the level of the lesion. The spinal segment and the facet joints adjacent to the lesion are locked by moving the spine to the physiological limit of passive movement and a high-velocity small-amplitude thrust is given to the short vertebral lever (transverse process or spinous process) in the specific direction that will liberate the restricted movement. However, it is technically not possible to lock all other joints and then to manipulate at just one level (Cyriax:[64] p. 108). It was even demonstrated that by mobilizing the sacroiliac joints after locking of the lumbar spine, the largest movement took place between L4 and L5.[66] Furthermore, if diagnosis fails to be absolutely right, how can there be certainty as to the exact level of the lesion to work on? Fortunately for those who employ 'specific' short-lever manipulations, these are much less specific than they think, because the manipulations actually cover a much larger part of the spine and so unintentionally also include the lesion.

Specificity is a false attribute. The methods that claim to lead to specific localization in both diagnosis and treatment are scientifically unacceptable. Claims of specificity are made in order to give prestige to manipulators who claim to feel something that cannot be felt. Manual therapists, chiropractors and osteopaths over-complicate their teaching and often create excessive patient dependency, instead of providing the patient with independence. Indeed, patients are encouraged to return at regular intervals for pointless prophylactic adjustment.[41] We support R. McKenzie's conclusion that demystification of spinal manipulative therapy is an urgent priority.[41] Chiropraxy, manual therapy and osteopathy, however, thrive by creating the impression that there is something complex and exclusive about the practice of passive end-range motion that only experts in these practices can understand or have the skills to feel. The belief is strong that expertise in the understanding and delivery of spinal manipulative therapy requires 3 or 4 years' training. The main advantages of the methods discussed in this book are that the manipulations are much simpler and at least as effective as those advocated by chiropractors, osteopaths and manual therapists. Non-specific long-lever manipulations are quickly effective, do not take long to perform and are

simple to learn. Moreover, they can take only about 180 hours of tuition, provided that the student has already gained qualifications in medicine or physiotherapy.

Mode of action of spinal manipulation

To date, the mode of action of manipulation has not been totally clarified, although many different models have been put forward. All pose unsolved questions, lack objective confirmation and are subject to dispute. Different attitudes towards spinal disorders determine theories and explanations.[67]

Those who believe in 'posterior facet joint' syndrome as a frequent source of back pain, believe that manipulation corrects a posterior joint dysfunction, in which either a minor subluxation of a facet together with an entrapment of the synovial fold, or of part of a small intra-articular meniscus, is held responsible, both of which may give rise to a blocked vertebral joint (Kirkaldy-Willis:[29] p. 296; Mathews and Yates[68]).

Others suggest that manipulation ruptures periarticular connective tissue adhesions or that it abolishes a muscle spasm.[69] In our opinion, a manipulation does not directly affect muscle spasm; instead, the latter disappears secondarily when the underlying problem is solved.

It has also been suggested that manipulations influence the mechanism of cutaneous pain tolerance as the result of release of endorphins, or that stimulation of mechanoreceptors of the facet joint capsules, ligaments and annulus fibrosus influences the neurophysiological gate that controls the perception of pain.[70] This could conceivably abolish pain immediately after manipulation but does not explain longer term improvement.

Some believe that manipulation may move an inflamed nerve away from the herniation[71] or that relief is achieved via a return to normal of neurogenic reflex activity.[42,72]

We strongly believe that spinal pain is the result of disc protrusion that gives rise to a conflict between the posterocentral or posterolateral rim of the disc and the pain-sensitive dura mater or dural nerve sleeve, and that a displaced fragment of an intervertebral disc can be moved by manipulation.[42,73–76]

This was the hypothesis of Cyriax[3] (see his pp. 38–50) and Maigne[77] and has been supported by the observations of Mathews and Yates,[68] who have shown by epidurography that in acute lumbago small lumbar disc protrusions diminished in size after manipulation. Manipulative interruption of contact, moving the displaced cartilaginous rim away from sensitive structures, is the objective for relief of pain and is best obtained by a non-specific long-lever, high-velocity manipulation.

Indications for spinal manipulation

Spinal manipulation is useful for all annular disc protrusions in the absence of any contraindications or of any signs or symptoms that indicate that manipulative reduction would not succeed. All these factors may vary for the cervical, thoracic and lumbar spine, and the indications are discussed in detail in later chapters.

Contraindications to spinal manipulation

All effective treatments are potentially dangerous and therefore possess contraindications. Although manipulative techniques are not hard to learn, years of experience are needed to learn when to manipulate, when not, and what sort of manœuvres to use.

Contraindications to manipulation are bleeding disorders, softening of bone, rheumatoid conditions, neurological deficit and danger to the spinal cord.

Box 5.3

Anticoagulants contraindicate spinal manipulation

Coumarin derivatives:
- Heparin
- Warfarin
- Phenprocoumon
- Acenocoumarol

Indandione derivatives:
- Diphenadione
- Phenindione

Bleeding disorders and anticoagulant use

When normal clotting of blood is not guaranteed, as in congenital or acquired (liver disease) bleeding disorders or because of the administration of anticoagulants (Box 5.3), spinal manipulations are potentially dangerous. Disastrous results can follow, such as intraspinal haemorrhage with the formation of a haematoma that may lead to sensory and motor deficit, to paraplegia, quadriplegia or death.[78] For this reason, a coagulopathy is an absolute contraindication to spinal manipulations. Manipulation can be safely performed only after blood clotting tests have returned to normal.

Spinal tumours, unstable fractures, vertebral infections and severe osteoporosis

(see Grieve:[27] p. 829)

These all result in weakening of bone with risk of further damage by manipulation. Long-lever manipulation is not safe in severe osteoporosis.

Rheumatoid arthritis, psoriatic arthritis, Reiter's syndrome and ankylosing spondylitis

The first three of these may be associated with ligamentous laxity and gross destruction of the joint with subsequent instability. Manipulation must not be undertaken. The same applies for the inflammatory stage of ankylosing spondylitis. In the unlikely event of a patient with this disorder developing a disc lesion, manipulation is not at all safe, especially in the cervical spine, where luxations, fractures and cord compression have been described.[79]

Neurological deficit and spinal cord compression

Segmental neurological deficit is characterized by disturbance of either motor function, with impaired reflexes and/or muscular weakness, or sensory function, with diminished sensibility. The two may be combined. Segmentally referred pins and needles due to compression of the sensory fibres of a nerve are not regarded as neurological deficit and are therefore not a contraindication. In neurological deficit, manipulation is usually

without value because deficit suggests a large protrusion that cannot be reduced. This opinion is not universally supported,[80,81] and some still manipulate when minor neurological signs are present. However, in all instances where progressive neurological deficit is present, manipulation must not be done.

A similar rule applies in cord compression or cauda equina syndrome when a very large posterocentral protrusion threatens the spinal cord or the cauda equina. This is true not only for obvious signs but also in the presence of even the slightest symptoms, such as extrasegmental pins and needles or pain in the S4 dermatome.

Hypermobility

In several schools of thought on manipulation, too much emphasis is placed on hypermobility. Although it is true that special attention must be given to hypermobility in the cervical spine, it is not important elsewhere. A hypermobile joint may move further than an ordinary joint, but once extreme range is reached it stops in exactly the same way as does an ordinary joint. More often the disc fragment itself is hypermobile, which may lead to frequent recurrences. This circumstance does not contraindicate manipulation but calls for extra measures to achieve stabilization, for example by infiltration with ligament sclerosant (see Cyriax:[3] p. 38).

For the cervical spine a history of frequent disc problems, alternating from one side to another, may be suggestive of hypermobility. When doubt exists the following tests may be useful: spinal flexion with putting the palms flat on the floor with knees straight, passive apposition of the thumb to the flexion aspect of the forearm, passive hyperextension of the fingers parallel to the external surface of the forearm and hyperextension of the elbow and/or of the knee of 10° or more. If one or several of these are positive hypermobility is likely.[82] Also, when the end-feel on passive rotation, extension or on preparation for a straight-pull manipulation is too elastic, further manipulation must cease.

Spinal manipulation under anaesthesia

Spinal manipulation should never be done in an unconscious patient. First, anaesthesia is unnecessary. Second, the final warning of potential danger offered by increased pain or abnormal end-feel on taking up the slack is completely lost, as is clinical assessment after each manœuvre. Consequently, complications are more frequent after manipulation under anaesthesia.[83]

Patients who have difficulties in relaxing during manipulation may benefit from being given diazepam before a session.

Evaluation of the effectiveness of spinal manipulation

Although several studies, mainly done on the lumbar spine, support the view that many patients benefit from spinal manipulation,[39–41,84–87] agreement on the effectiveness and the role of manipulation in spinal disorders is still lacking. Reports from clinical trials are not always clear and the effects of manipulation are often difficult to interpret[88] because of a small number of patients and their selection by symptoms rather than diagnosis. To make trials scientifically valuable a precise definition of manipulation is necessary – a record of which types of technique have been used and for what type of disorder and its duration. It should also be said that a double-blind randomized trial on spinal manipulation is not possible because of the absence of a placebo and the obvious knowledge by the patient and operator of what is being done.

Sims-Williams published a clinical trial on 94 patients with non-specific lumbar pain, who took part in a trial in which placebo physiotherapy was compared to Maitland mobilization and manipulation. Studies mainly showed that manipulation hastened improvement chiefly in those patients whose severity and duration of symptoms did not require specialist referral.[80,89]

Bergquist-Ullman and Larsson,[90] Coxhead *et al*[81] and Farrell and Twoney[39] found a significantly shorter duration of complaints in patients receiving manipulation.

Chrisman *et al*[91] stated that half of those suffering from sciatica showed clinical improvement after manipulation, but the improvement could not be objectively confirmed by myelography.

Hadler *et al*[86] compared the results of spinal mobilization to high-velocity thrust manipulation in patients with acute, uncomplicated low back pain and tried to exclude all elements of chronicity or compensation insurance. Patients treated by manipulation improved to a significantly greater degree and more rapidly than those treated by mobilization.

In one study, in which rotational manipulation was compared with simulated short-wave diathermy, those who received the former fared better immediately after the session.[92] However, when pain relief was compared 7 days after treatment there was no significant difference between the two groups.

In another study, 24 patients with complaints of less than 3 weeks' duration were followed. It showed that 92% of those treated by rotational manipulation were cured in less than 2 weeks.[93] Of those who received diathermy, only 25% got better in the same period of time.

A further trial in acute disc herniation compared conventional physiotherapy with manipulation and showed that the manipulated group scored significantly better.[94] All manipulated patients were able to return to work, whereas only 26% of the physiotherapy group could do so.

In a randomized clinical trial Koes *et al* compared the effectiveness of manipulative therapy, physiotherapy, treatment by the general practitioner and placebo therapy in 256 patients with non-specific back and neck complaints of at least 6 weeks' duration. They concluded that manipulative therapy showed a faster and greater improvement in physical functioning compared to the other three therapies.[95,96]

Controlled studies performed by Mathews *et al* clearly demonstrated that manipulation treatment for low back pain scored significantly higher in the subgroup with limited straight leg raising.[97,98]

Generally it can he concluded that manipulation and mobilization hasten both pain relief and the resolution of objective signs such as limitation of straight leg raising and of articular movement. Manipulation with high-velocity thrust seems to work better and quicker than more gentle mobilization techniques. The results are also better in recent-onset cases than

in those of longer duration. Manipulation helps either quickly or not at all; which means that manipulative therapy continued over a long period of time is not appropriate.

Complications of spinal manipulation

General considerations

Manipulation is, as with anything in medicine, not without danger and it must be admitted that even in experienced hands accidents may happen. Therefore manipulative treatment must never be undertaken recklessly, or on a 'hit or miss' basis.[3] Although it is probable that more accidents have occurred than have been reported, the risks must not be overstressed.[40,99] In 30 years of clinical practice Kirkaldy-Willis[29] (his p. 293) did not have one patient who was made worse by a manipulation. Dvorak and Orelli estimated that in 1 out of 400 000 manipulations severe neurological damage results, and in 1 out of 40 000 slight neurological signs appear.[100] It should not be forgotten that traditional treatment with non-steroidal anti-inflammatory drugs is also not without complications, in that they may give rise to severe gastrointestinal problems (mucosal bleeding, or reactivation of previous ulcers or initiation of new ones), haemolytic anaemia, leukopenia, thrombocytopenia and even fatal agranulocytosis, salt and water retention, albuminuria, nephritis, acute renal insufficiency, or to allergic reactions in all degrees of severity. No matter what treatment is given there will always be an inherent risk, but this should be reduced to a minimum by taking all necessary precautions.

Complications of manipulation can range from a temporary slight increase in pain to severe neurological deficit and death.

Postmanipulation pain

Immediate postmanipulation pain – which is usually not severe and is present in the whole area – can be relieved by using special techniques at the end of a manipulation session such as a lateral glide at the cervical spine or the rhythmic extension technique in the lumbar spine.

A degree of pain for a short duration – due to stretching of the muscles and ligaments – is normal in the elderly. It disappears spontaneously within 1 or 2 days. To avoid undue anxiety, patients should be warned of this. For the same reason, in older patients some manipulation-free days must be planned between sessions.

Increased pain

Worsening of the condition immediately after a manipulative manœuvre manifests by either an increase in original pain or by its movement more laterally. The implication is that the protrusion has been further displaced. This may occasionally occur in a manipulation which was perfectly performed and does not necessarily mean a poor technique. Further worsening can usually be avoided by performing a different manœuvre, very often by changing the direction of rotation. The same course is adopted when, after manipulation, pain moves to the other side – an indication that overcorrection has occurred.

Fracture

Exceptionally, manipulation may be complicated by a rib fracture, sternal fracture or fracture of a transverse process. These usually occur in the elderly and can be avoided by not using certain techniques in patients above 60 years of age.

Onset of neurological deficit

Sometimes uncomplicated root pain becomes complicated by neurological deficit, and it may occur after a manipulation that was correctly performed, but which has resulted in the protrusion being moved further laterally or the compression being increased. This event must be considered when root pain does not improve. Neurological reassessment must be done and, as a consequence, further manipulations will cease and, if necessary, epidural injections or sinuvertebral nerve blocks may be given. It is very seldom that the problem is so severe that neurosurgical intervention is needed.

Vascular interference and cord compression

Most severe problems arise from compression of blood vessels resulting in temporarily or permanent ischaemia of the cerebrum, brainstem or spinal cord, or as a result of direct compression of the spinal cord by a disc fragment or as a sequel to vertebral fracture or luxation. Para- or tetraplegia may follow, sometimes leading to death. These complications are usually encountered in the cervical spine and are extremely rare at the thoracic level. When they occur at the lumbar spine, they may give rise to a cauda equina syndrome, often followed by definite neurological features.

Risks in relation to level

The risks involved in manipulation differ at the cervical, thoracic and lumbar levels.

Cervical level

Serious neurological complications have been reported after manipulation of the cervical spine. The techniques that are blamed to cause most of the injuries are hyperextension manœuvres accompanied by excessive rotation.[45,102,103]

During a recent inquiry over a period of 2 years among 468 Californian neurologists, 55 strokes following osteopathic cervical manipulation were surveyed. Most of the patients continued to have persistent neurological deficits 3 months after the onset and about one-half were marked or severe. Nearly all of the strokes involved the posterior circulation and almost one-half were angiographically proven.[109] A Danish survey reported the incidence of cerebrovascular incidents (CVI) after chiropractic manipulation to be about 1 for every 120 000 cervical treatment sessions, manipulation to the upper neck being about four times more commonly associated with CVI than treatment of the lower neck.[110]

Neurological complications are mainly the result of a dissection of the vertebral artery[104–108]. Vertebral artery dissection (VAD) is an uncommon vascular wall condition that typically involves a tear at some point in the artery's lining and the formation of an intimal flap (see Chapter 9). The latter triggers off an arterial narrowing or even a complete obstruction of the lumen.[111,101] Although the pathophysiology of a dissecting vertebral artery is well understood, the underlying cause of intimal tears remains uncertain. Most experts link VAD to traumas of varying degrees of severity and maintain that because tearing occurs, previous trauma was necessarily involved. An article reviewing 606 cases of VAD reported that 371 (61%) were spontaneous. The remaining 39% were associated with trivial or other trauma, which included manipulation in 9% of the total cases.[112] However, VADs more commonly occur after

very minor trauma, and even everyday activities such as reversing a vehicle, coughing, vomiting, unusual sleeping positions or having one's hair washed at a beauty salon[113]. For that reason, evidence is mounting that the association between spinal manipulation and stroke is coincidental rather than causal and reflects the natural history of the disorder[114].

Thoracic level

Complications at this level are usually due to vertebral metastases or to severe osteoporosis resulting in fractures of vertebrae, ribs or sternum.

Lumbar level

The main complication is compression of the cauda equina because of a massive posterior sequestration of a lumbar disc.[115] Compression of the cauda equina complicating lumbar manipulations without anaesthesia is extremely rare, when it is considered that in the US in 1975 about 124 million office visits to chiropractors took place. Between 1911 and 1992 only 13 cases were recorded.[116] This potential complication should never be taken as contraindication to manipulation. However, anyone who manipulates must be able to recognize the syndrome immediately, so that no time is lost before surgical decompression is performed.

Measures to prevent complications

Although complications may occur and cannot be totally excluded by any means, each manipulator should try to reduce the eventuality to the lowest possible degree. It would be wrong to condemn the manipulator simply because a mishap or a complication occurred. If this was done it would mean that, instead of getting on with his work, the practitioner would forever be 'looking over his shoulder'. It is not possible to arm oneself against unpredictable events. Even if they do occur occasionally, this argument should not be used to condemn manipulation.[116]

Obviously all measures must be taken to decrease the risks as far as possible. In orthopaedic medicine the necessary steps are taken during the whole procedure, starting with the history, through clinical examination, technical investigations and ending with the manipulation itself. Safety measures and acknowledged warning signs are incorporated in each stage. These are discussed in detail in the relevant chapters and are only briefly outlined here.

History taking

Before any manipulation, history taking must be sufficiently thorough to elicit information on drug intake (anticoagulants) and the existence of other (visceral–rheumatoid) diseases. Severe pain in the absence of movement or pain worse at night may indicate that the lesion – whatever it may be – is in a highly inflamed state and unsuitable for manipulation. Expanding pain, excessive weight loss and recent operations may indicate metastases and must always be excluded. All these are severe warning signs.

Cervical root pain of more than 2 months' duration or root pain at lumbar level for over 6 months (unless there is still scapular or lumbar pain influenced by cervical or lumbar movements) does not respond to manipulative reduction. Hence no attempt to manipulate should be made.

Clinical examination

A complete clinical examination must *always* follow. In particular, in relation to the cervical spine, full attention must be paid to the end-feel on passive rotations and on extension. Even if the clinical examination suggests an ordinary disc lesion, if the end-feel shows muscle spasm is empty or if it comes to a bony hard stop, manipulation should not be done before serious disorders have been excluded. Muscle or empty end-feel may point to a disorder such as metastases, fracture or infection. A bony block end-feel implies that it is impossible to increase the range beyond this point, and therefore the lesion is unsuitable for manipulation.

A patient suffering from acute lumbago or sciatica usually cannot put weight on the joint, may suffer from constant pain day and night and on clinical examination may be found to have deviation and muscle spasm. When more severe disorders such as metastases, rheumatoid arthritis and ankylosing spondylitis have been excluded, a disc lesion is most likely and manipulation can be safely performed.

A protrusion of disc substance larger than the aperture from which it emerged – usually characterized by a neurological deficit – means that reduction is impossible. The same accounts for nuclear protrusions, which require traction.

Manipulation should never be used simply because 'no contra-indication has been discovered, no one can think what else to try, and a friend was recently relieved by this means' (Cyriax:[117] p. 31). If the diagnosis is unclear or if too many inconsistencies are found, manipulation should be avoided. Once again it should be stressed that manipulation follows only if the diagnosis of a discodural or discoradicular interaction has been established. For safety, the following must be added: 'If the diagnosis is established but it is uncertain if manipulation will work, then try. If the diagnosis is uncertain and it is unclear whether or not manipulation is safe, do not try.' (Cyriax[3]).

Radiographic appearances

Radiological changes are signs of structural alterations that usually cannot be treated, though it is of most importance to find out if they are relevant to the symptoms present. Osteoarthrosis of the spine cannot be cured by manipulation, but a manipulation can easily reduce a displaced disc fragment even in an osteoarthrotic spine.

Although the diagnosis of tumours of the lumbar spine is largely dependent on radiography examinations, it must be remembered that 30% of the osseous mass of a bone must be destroyed before this type of lesion becomes radiologically evident.[118] Therefore radiographs do not reveal early disease, and too much reliance on negative radiographic appearances can give rise to a false feeling of security. Radiographs that show no evidence of bone disease should not be taken to indicate that manipulation is safe (Cyriax:[64] p. 292). A decision to manipulate because the radiograph is normal carries a high risk of worsening the patient's condition and may even lead to disaster. The diagnosis of lesions in bone in the early stage is mainly dependent on history and clinical examination. Special attention must be paid to 'warning signs'. In several disorders, such as early invasion of bone by a secondary neoplasm, the clinical signs may precede the radiographic findings. In

doubtful cases, when routine radiography fails to support the clinical impression, a radioisotope scan must be obtained.

Appropriate technique

Manipulative techniques contain important safeguards against possible accidents. This is chiefly so for the cervical spine, in which dangerous techniques such as extension in combination with rotation should never be used.[36,119,120] Those with special interest in musculoskeletal disorders should not only read textbooks but must be prepared to take courses in order to learn the necessary theoretical and practical skills before undertaking manipulation.

Once a manipulation has started, the operator must always concentrate on the type of *tissue resistance* (end-feel) *while taking up the slack* just before the final thrust is given. If the end-feel is abnormal, he must stop immediately and must not manipulate. To push through muscle spasm protecting a joint should never be attempted.[117]

To prevent compression of the spinal cord all manipulations must he performed under *traction*.

The major aim of manipulation should always be to gain maximal benefit with the use of minimal force. Therefore it is good sense to start gently and progressively to increase the force if needed.

Each manipulation must always be followed by re-assessment. If the patient is worse, the same manœuvre should not be repeated but another manœuvre can be tried. If the latter also increases signs or symptoms, further manipulations should be abandoned.

Avoidance of overtreatment

Once symptoms and signs have cleared, treatment must be stopped. There is no sense in asking the patient to come back at regular intervals for 'prophylactic' manipulations.

Box 5.4 summarizes measures to prevent complications.

Box 5.4

Measures to prevent complications

History:
- Exclude anticoagulants
- Check for warning signs
- Ascertain duration of root pain

Clinical examination:
- Check for warning signs
- Assess end-feel
- Exclude neurological deficit

Radiographic appearances:
- Exclude structural alterations
- Do not rely on radiography alone; negative radiography does not guarantee absence of disease

When manipulating:
- Avoid dangerous techniques
- Check end-feel
- Use traction
- Start gently
- Reassess after each manipulation
- Do not overtreat

Active movements

The effects of immobilization on skeletal muscle, tendon, ligament, joint capsule and articular cartilage are dramatic and have been described thoroughly in Chapter 3. Physical activity is also the primary stimulus for the repair of musculoskeletal tissues. Therefore, most therapeutic modalities that are advocated in this book are in conjunction with movement. Active movements are defined as those undertaken by the patient via muscular contraction. In orthopaedic medicine they are not so often used as a sole therapy; their main role is in combination with other therapeutic techniques. However, there are a few situations (both therapeutic and prophylactic) where active movements play a particular role.

Simple active movements to gain or preserve normal range in a joint

A few examples make the above clear. Immobilization of the shoulder leads to the development of an arthritis with limitation of all movements in a capsular way if the shoulder is not brought daily through a full range of movement. Total rupture of the infraspinatus tendon leads to limitation of external rotation of the shoulder if the patient is not performing daily lateral rotations.

Treatment of sprains is essentially treatment with movement (see p. 48). Although the first measure is friction, passive and active movements within the limits of pain to maintain normal gliding of the ligament over adjacent bones should be encouraged. When the lower limb is involved, the patient should be instructed to walk as normally as possible but without provoking pain.

Ligamentous adhesions that have developed as the consequence of a chronic sprain at ankle or knee need to be ruptured manually: the joint is forced through its normal range of movement by a high-velocity, short-amplitude thrust manipulation (see p. 12). After the manipulation and in order to retain the mobility achieved, the patient should repeat the same movement actively and on a daily basis. After rupturing of adhesions under anaesthesia, active movements in addition to passive ones are also necessary to maintain the range that has been regained. They should be performed several times a day.

Isometric contractions

Isometric contraction is the development of tension within a muscle without significant change in its fibre length. Joint motion or work is not achieved.

In orthopaedic medicine isometric contractions are mainly performed to strengthen stabilizing muscle groups. The main example is in treatment of shoulder instability: in order to provide a firm foundation for the scapula, the muscles of the shoulder girdle (trapezius, serratus anterior, rhomboids and pectoralis minor) are strengthened by isometric training.

Isotonic contractions

Isotonic exercise is classically defined as the movement of a load at constant resistance through an arc of motion.

In orthopaedic medicine, isotonic contractions are performed in the following situations:

- *In minor muscular tears* after the lesion has been prepared by gentle transverse friction (see p. 4). The contractions are carried out with the muscle in a position of maximal relaxation and with minimal resistance so that no tension falls on the healing breach. They begin as soon as possible after the injury and are preceded by an infiltration with local anaesthesia and by transverse friction. The idea is to promote movement between adjacent muscular fibres to prevent abnormal formation of adhesions because these can disturb the normal increase in breadth on contraction.
- *To strengthen weakened muscles* as in arthritis or after local or generalized immobilization. If passive movements are limited, say by the arthritis, the isotonic exercises should be performed within the painless range to avoid increase of synovial inflammation.
- *To strengthen muscles* so they can protect joints or inert structures from being painfully overstretched. One example is the strengthening exercises of the short plantiflexor muscles and the lumbricals of the foot in the treatment of splay foot and chronic metatarsalgia. Strong muscles that contract properly at each step will take most of the body weight and relieve the metatarsal heads.

Eccentric contractions

Eccentric (lengthening) actions are characterized by elongation of the muscle during active contraction.[122] Over the last fifteen years, eccentric exercises have been promoted as treatment strategies for tendinopathies and muscle strains, especially for the lower limb (quadriceps and Achilles tendinopathy). Greater forces can be produced during eccentric contraction than during concentric (shortening) actions,[123] which leads to positive changes in tissue structure and mechanical properties. One study found that Type I collagen synthesis increased after eccentric training in a group of twelve soccer players with unilateral Achilles tendinosis, offering a possible explanation for the mechanism of tendon healing.[124] Another study described a decrease in tendon thickness and normalized tendon structure measured by ultrasound in a group of subjects with chronic Achilles tendinosis who were trained using an eccentric training protocol.[125] Systematic review of the literature revealed that eccentric exercise may reduce pain and improve strength in subjects with lower extremity tendinosis,[126,127] but whether it is better than other forms of rehabilitation has yet to be determined.

Electrical contractions

In some circumstances a strong voluntary muscle contraction is not possible. Muscles can be (temporarily) paralysed or they are affected by severe injury. In such a situation, daily application of electrical stimulation (ES) may retard the loss of muscle strength or even improve it in already weakened musculature. The gains are not long-lasting, however, and electrical stimulations should only be used temporarily while awaiting neurological recovery. ES can then be replaced by a good exercise programme.

Coordination exercises

During the last decades it has become clear that rehabilitation should not be restricted solely to procedures that improve mobility, strength and endurance but also that functional exercises allowing a better coordination of particular muscle groups should be included in the rehabilitation programme. This kind of training is particularly important in the treatment of problems of instability (e.g. in shoulder, knee and ankle).

The ability to control the position of a joint during active motions (proprioception) and to produce a voluntary muscular contraction to stabilize the joint and/or to alter the joint position so as to prevent excessive joint displacements is referred to as *reactive neuromuscular control*.

Proprioception is a specialized sensory modality that gives information about extremity position and direction of movement: stretch-sensitive mechanoreceptors within skin, capsular ligaments and tendons (see Ch. 3) are activated by tension, thus producing a muscular contraction to protect these structures at the extreme of motion.[128] This type of afferent sensory feedback is extremely important in mediating muscular control over joints and thus preventing them from overstretch and (sub)luxation.[129]

Numerous authors have recommended the training of proprioceptive skills and proper muscular coordination to re-establish the reactive neuromuscular control abilities in the joints at risk and to create a functional joint stability.[130–134] Several techniques exist, from the see-saw block or tilting board in the treatment of functional instability of the ankle to the use of dual channel electromyography biofeedback systems in the treatment of patellofemoral dysfunction[135] and glenohumeral instability.[136] However, most functional training techniques used to re-establish the proprioceptive skills make use of *eccentric training*.[137] Eccentric activation refers to the situation in which the muscle–tendon unit is lengthened while active. Small weights and multiple repetitions of the movements are used.

Proprioceptive neuromuscular facilitation (PNF) techniques can also be used to gain or improve neuromuscular stability at a joint. PNF techniques may be of value in the prophylaxis of recurrent periarticular shoulder lesions. PNF may be defined as a method *promoting or hastening the neuromuscular mechanism through stimulation of the proprioceptors*. Hence, PNF refers to the improvement of flexibility through stimulation of the nerves and muscles internally. The technique involves the use of the principles of reciprocal innervation and the stretch reflex: as a muscle is passively or actively stretched, it is brought to a point of limitation before pain develops. This is the point at which the proprioceptive organs send a message to the central nervous system to terminate the movement before further elongation occurs. At this point the muscles being stretched (antagonist) are contracted for a few seconds

at an intensity of 50% of maximum. This contraction allows for the inhibition of the muscle spindles and Golgi tendon organs and a subsequent initiation of the stretch reflex of the stretch receptors. After releasing the contraction, the muscle is stretched to a new point of limitation and held for another few seconds. The interested reader is referred to Alter's *Science of Stretching*,[138] that offers over eight PNF techniques and exercises.

Injection and infiltration

Musculoskeletal disorders such as tendinitis, minor muscular ruptures, ligamentous sprains and arthritis can usually be treated by infiltration. For an optimal effect the product administered must he put directly into the lesion and not in its surroundings. The descriptive terms 'injection' and 'infiltration' are used; each has a well-defined meaning and expresses a different way by which the product is administered. In *injection* the tip of the needle is placed in exactly the right place and all the product is deposited at one single push, as is done in an ordinary intramuscular injection. This technique is mainly used for intra-articular and caudal epidural injections. Once the tip of the needle has been brought within the joint or the epidural space, the full amount of product is put in. Local administration of a drug into a structure, as in bursitis, tendinitis, tenosynovitis, tenovaginitis, lesions of a muscle belly and also in ligamentous problems, is usually performed by *infiltration*. In this, maximal beneficial effect is obtained when all the different areas within the lesion receive some of the product. This can only be achieved if the tip of the needle is displaced several times while injecting a small amount of the product at each point. An infiltration is therefore a series of injections, given at slightly different places, within the lesion. Although the aim of all infiltrations is the same, the specific technique may vary depending on the type of lesion and its location.

In orthopaedic medicine three types of product are used: local anaesthetics, corticosteroids and sclerosant solution. Each of these has its own specific indications, contraindications and side effects. Although, in each group, several agents are available, it is better to use only one as this leads to optimal therapy.

General principles

To obtain maximal benefit with minimal side effects the following general rules must be observed.

Exact diagnosis

Any treatment must reach the lesion. Infiltrations, like deep friction, need a diagnosis accurate within a millimetre or two and must be directed to the precise site of the lesion. The steroids used in orthopaedic medicine are all suspensions of insoluble particles, so their action is mainly confined to the place where they are administered. An exact preliminary diagnosis must be made, together with proper localization of the lesion.[139]

Choice of product

Many different products are used in musculoskeletal disorders. Local anaesthetics and corticosteroids are most frequently used but occasionally a sclerosant solution containing phenol, glycerol and dextrose is needed. The type of the product, its concentration and volume depend on the structure affected, the nature of the lesion, the degree of inflammation and other additional elements such as age, activities and the general condition of the patient. Of main importance is increased liability to – or the presence of – general or local infections and allergy to the products.

A lesion of the muscle belly can be treated by infiltration of a local anaesthetic, usually procaine, whereas steroid is never used. Musculotendinous insertions do not respond to any product and therefore are never therapeutically infiltrated but are best treated by deep transverse friction. Procaine is of no curative value in tenoperiosteal insertions or periosteal attachments of ligaments; for these, steroid is used or friction is given. In lesions of the body of a tendon, steroid is never infiltrated into the tendon itself, but is put at the surface along the tendon.

For optimal results the appropriate agent at the indicated dose and concentration must be used. For example, 20 mg of triamcinolone at a concentration of 10 mg/ml means that a total volume of 2 ml is administered. This is not the same as 0.5 ml of a 40 mg/ml suspension, as the steroid administered in this way will be concentrated over a much smaller area and may not be sufficient in volume to reach the whole lesion. Moreover, a strong concentration of steroid spread over too small an area may cause an increased risk of tendinous or ligamentous rupture.

Equipment

If a certain amount of product is indicated, it should always be put into a syringe of the corresponding volume. If this is not done, infiltration may fail because of counterpressure offered by the tissue. Care should be taken to fit the needle firmly to the syringe because an infiltration into a ligamentous or tenoperiosteal insertion may demand considerable pressure on the plunger, which could lead to detachment of the syringe.

The needle to be used must be of appropriate length and be as thin as possible. These characteristics are always indicated throughout the text in subsequent chapters. An appropriate needle enables the therapist to recognize the type of tissue by the resistance it offers as the needle penetrates the structure: for example, ligaments and tenoperiosteal junctions have a totally different resistance from that of a muscle belly. Moreover, the thinner the needle the easier it is to recognize differences in resistance on the plunger during infiltration. Both types of resistance are important in giving a good indication of the localization of the tip of the needle.

The main characteristics of the needle types referred to in this book are given in Table 5.3.

Position of the patient

Before any attempt is made to infiltrate, the patient is positioned in the way that renders the lesion most accessible. For

Table 5.3 Main characteristics of needles used

Needle type*	Gauge		Length	
	G	mm	inches	mm
Preparation	19	1.1	$1\frac{1}{2}$	40
2.5 cm	25	0.5	1	25
3 cm	22	0.7	$1\frac{1}{4}$	30
4 cm	21	0.8	$1\frac{1}{2}$	40
5 cm	22	0.7	2	50
7 cm	20	0.9	$2\frac{3}{4}$	70
Spinal	22	0.7	$3\frac{1}{2}$	90

*Terminology used in this book.

each injection, the ideal positions from which to start are presented in later chapters; positions are usually the same as for deep friction. For intra-articular injections, different positions have been described. We present those which are the most simple to perform and which offer the least risk in relation to other neighbouring structures. The landmarks required and sometimes also the affected structure should be palpated and, if necessary, should be marked on the patient's skin.

Aseptic care

Careful aseptic precautions are always necessary in order to avoid, for example, a suppurative arthritis. Aseptic techniques include:

- Hand antisepsis
- Skin antisepsis at the site of insertion
- Disinfecting the rubber septum with alcohol prior to piercing it
- Using a new sterile syringe and sterile needle to draw up the fluid while preventing contact between the needle and the hands
- Removing the needle and using a fresh one for the injection
- Using a no-touch-technique: neither the tip of the needle, nor the skin at the site of insertion should be touched after skin antisepsis
- Using gloves? Gloves can only be used if an assistant handles the non-sterile packages and vials and prepares the syringes. In our opinion, the use of gloves does not add to aseptic safety, if the rules mentioned above are strictly followed.

Technique of infiltration

Two major techniques are considered here: dynamic infiltration, in which the product is injected during movement of the needle, and a static infiltration, in which the product is administered with the needle at rest.

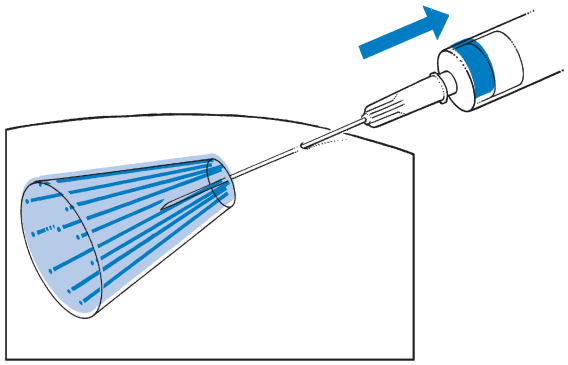


Fig 5.7 • Conewise infiltration.

Dynamic infiltration

This is used mainly when large amounts of product have to be administered in extensive lesions. Three different techniques are used, mainly conewise, fanwise and cylindrical infiltration. A further technique is used for static infiltration.

Conewise infiltration

This is the usual technique for a lesion of a muscle belly. The limb is brought into such a position that the muscle is well relaxed. The tender part is pinched between the thumb and fingers and the needle is inserted obliquely in between them until its tip passes beyond the farthest edge of the lesion. Some of the product is now administered while the needle is withdrawn until the tip is at a point just beyond the nearer border of the lesion. It is then reinserted at a slightly different angle and more product is infiltrated while the tip is again withdrawn (Fig. 5.7). This is repeated several times until the entire lesion has received some of the product. During the whole procedure, the fingers that hold the lesion verify and control the infiltration.

Cone infiltration is also used in bursitis lying within the reach of the fingers. After the lesion has been carefully defined, the needle is directed to the centre of the tender area and towards the underlying bone. The site of tenderness usually cannot be kept between the fingers. The product is infiltrated by a series of partial withdrawals and reinsertions at a slightly different angle.

Fanwise infiltration

This technique is similar to conewise infiltration but is two-dimensional. It is used in subacromial bursitis. The needle is directed towards the centre of the deep part of the subdeltoid bursa and to its full length. By a series of partial withdrawals and reinsertions in a horizontal plane, to the left and to the right from the centre (Fig. 5.8), the full amount of product is applied during withdrawal.

Cylindrical infiltration

A cylindrical infiltration is used to place the agent along the surface of a tendinous body. The tendon is first stretched to provide a stiff flat surface. The needle is tangentially inserted along the tendon between the tendon and its sheath, until the tip reaches the far edge of the lesion. During partial withdrawal as the needle traverses the surface of the tendon, constant pressure on the plunger maintains flow of the suspension. The

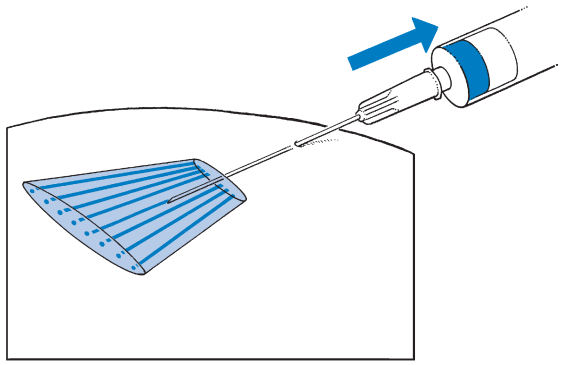


Fig 5.8 • Fanwise infiltration.

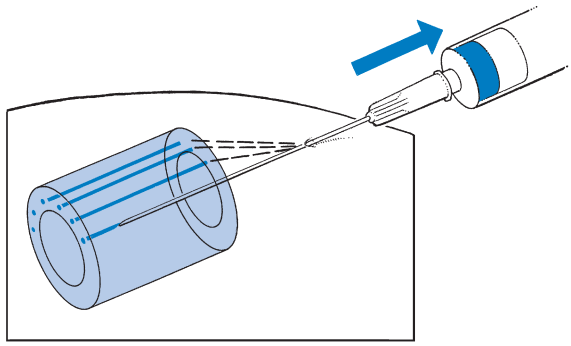


Fig 5.9 • Cylindrical infiltration.

needle is then reinserted parallel to its first position but 2 mm to one or the other side and the manœuvre repeated (Fig. 5.9). This is repeated four or five times until the full amount has been given.

Static infiltration

This technique is mainly used to put a small amount of fluid into a well-delineated area. It is indicated for tendinous insertions and ligamentous attachments to bone. These offer considerable resistance to depression of the plunger. Hence the smallest syringe must be used to provide enough purchase to force the product into the structure. When the tip of the needle lies at the exact site, a typical counterpressure is felt during insertion, just before its point hits the bone. Now a few droplets are injected with the tip of the needle in bony contact. The needle is then five to ten times partly withdrawn and inserted at slightly different angles and depths (Fig. 5.10) until the full amount has been administered and the whole lesion has been treated. The technique is sometimes referred to as *peppering*. During the entire infiltration a typical resistance is felt, much more marked than during infiltration of a muscle belly or a bursa, where resistance is minimal.

Follow-up and after-care

For maximal benefit, all infiltrations in any part of the contractile structures are followed by relative rest for 1–2 weeks. If full activity is continued without this rest, relapse is likely. When tendinous structures are infiltrated by steroid there is a second reason for rest, in that the agent may temporarily weaken the tendon.

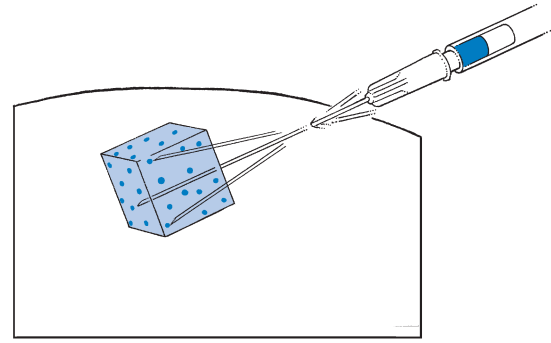


Fig 5.10 • Static infiltration.

The patient should be reassessed after 14 days and, if pain still remains, a second infiltration is given. A partial rupture of a muscle belly offers an exception to this in that it is infiltrated only once, followed next day by deep transverse friction, active exercises and electrical stimulation in the position of maximal relaxation of the muscle. Stress at the site of healing is avoided for about 3 weeks.

After infiltration into a sprained ligament, the joint is immediately used as fully as possible, allowing movements within the limits set by pain but avoiding stretching of the damaged structure. This leads to good functional results in a short period of time.

The advantage of this type of treatment is its rapid effect but on some occasions it may lead to recurrence in tendinous lesions. Recurrences are best treated by deep transverse friction.

Local anaesthetics

Cyriax first started using procaine purely for diagnosis. If the suspected lesion is infiltrated by local anaesthetic, the pain on functional testing should disappear almost immediately, so confirming the diagnosis. He was most surprised when some of those initial patients reported persistent improvement some time later. He continued to use procaine because he felt that the therapeutic results were better than with the alternative local anaesthetics. Nowadays local anaesthetics are still used for both diagnostic and therapeutic purposes.

Because prolonged action of the anaesthetic is never needed in orthopaedic medicine, adrenaline (epinephrine) is not added. In addition, vasoconstriction restricts the spread of the agent so diminishing any beneficial effect.

Types of local anaesthetic

Two major types of local anaesthetic are available: procaine and those belonging to the amide group (e.g. bupivacaine, lidocaine (lignocaine)) (Table 5.4).

Table 5.4 Local anaesthetics and their effects[141]

Name	Strength	Toxicity	Maximum dose (mg)	Latency (min)	Duration (min)
Procaine	1	1	500	5–10	45
Lidocaine (lignocaine)	4	2	200	2	60
Prilocaine	4	1, 5/4	400	2	60
Mepivacaine	4	2	350	1	100
Bupivacaine	16	8	150	2–5	360

Procaine

Procaine is an ester of para-aminobenzoic acid and was first synthesized in 1904 by Einhorn. Until 1943 it was the only anaesthetic available.[140] It is quickly and locally metabolized by an esterase, giving rise to the acid itself, which may act as an allergen. Its effect begins after 5–10 minutes and lasts approximately 45 minutes. The maximum dose used is 250 mg, which corresponds to 50 ml of a 0.5% concentration.

Although classical texts emphasize the hazard of allergic reactions, we have used procaine several times daily for over 20 years without any problems. Cyriax estimated the risk as 1 per 500 000 administrations.

The usual concentrations employed are 0.5 and 2%. Indications for 0.5% procaine are lesions of muscle bellies, most cases of chronic bursitis and caudal epidural injection. Procaine 2% is used to dissolve calcifications in tendons and bursae, and in sinuvertebral nerve blocks.

Amides

Newer local anaesthetics are the amides. They are metabolized in the liver and seldom give rise to allergic reactions. We use lidocaine (lignocaine) and prilocaine to anaesthetize only certain structures so allowing other interventions. For this reason, they are used to anaesthetize the skin and the intercornual ligament before inserting an epidural needle, and for skin and tenoperiosteal anaesthesia before a tenotomy in type II tennis elbow. Because their local anaesthetic effect is stronger and faster acting than that of procaine, they are also used for diagnostic infiltrations around nerves and in tendons, ligaments and bursae.

In countries where procaine is not available, or there is patient allergy, bupivacaine 0.125% is an alternative. The maximal dose used is 60 mg, which corresponds to about 50 ml of a concentration of 0.125%. The immediate effect starts after 2–5 minutes and continues over 3–6 hours.

Side effects

Side effects of local anaesthetics are traditionally divided into three groups:

- Psychogenic reactions
- Toxic side effects
- Allergy.

Psychogenic side effects

These minor side effects are mainly caused by somatosympathetic reactions on pain and fear and are not related to the drug as such. Nevertheless the symptoms may be quite similar to those of real toxic reactions: pallor, cold sweating, dizziness, nausea, yawnings, palpitations and vasovagal collapse with syncope all may be present.[142] They should be taken seriously because if the patient is not placed supine quickly, cerebral hypoxia may follow, with unconsciousness, tremor and convulsions.

To avoid these effects, all patients who require an infiltration should at least sit or lie down and be given a full explanation of what is to happen. If symptoms do occur, the patient is immediately placed in Trendelenburg's position (head and thorax low, legs up) and oxygen given. The patient usually improves promptly after 1–2 minutes.

Toxic reactions

These are dose-dependent side effects related to the amount of product that reaches the blood circulation.[143] They may be the result of unintentional intravascular injection, absolute overdose, swift absorption or delayed elimination of the drug.[144]

If local anaesthetics are used at the indicated dose, which is usually less than half of the maximum dose allowed, and in a proper way – taking care during the administration that it is not directly intravascular – toxic reactions should never occur. However, if they do occur during an injection, administration must stop at once.

Types of reaction

Toxic side effects can be divided into two groups. They may be related to the central nervous system or to the cardiovascular system or to both.

Effects on the central nervous system

Although local anaesthetics may provoke stimulation or depression of both cortex and medulla, stimulation is the more frequent but is less severe than depression. Normally the depression period is preceded by a stimulation stage, but it may come on at once without a prior stage of excitement.[145]

Some *stimulation* of the cerebral cortex and the upper centres may sometimes occur even with a low dose. It is

characterized by anxiety, excitement, logorrhoea, hypertension, headache, dizziness, tinnitus, diminished hearing, disturbed vision, metallic taste, muscular fasciculations around the mouth and tremor. None of these symptoms is severe as such, but they are all signs of the presence of a toxic reaction that could lead to cardiovascular collapse. Further stimulation may be followed by convulsions, which indicate that severe cortical stimulation is present and may progress to postconvulsive depression.[145] Stimulation of the emetic centre causes nausea and vomiting. Stimulation of the cardiovascular centre in the medulla may cause tachycardia and hypertension; respiratory stimulation is characterized by an increased depth and frequency of breathing.

The first feature that draws attention to *depression* of the cortex is sleepiness, together with dysarthria and a feeling of coldness. If injection is not stopped at once and the necessary measures instituted, the outcome may be coma and death. Depression of the medulla may suppress vasomotor control resulting in pallor and hypotension, later followed by syncope and cardiac arrest. Respiratory depression is first characterized by irregular breathing with periods of apnoea and dyspnoea and often cyanosis. Finally, total respiratory arrest may result. A depressive effect is far more dangerous than is stimulation.

Effects on the cardiovascular system

A direct peripheral effect on the blood vessels causes vasodilatation, leading to hypotension. Local anaesthetics have a depressive effect on the myocardium, which can lead to bradycardia, arrhythmia and cardiac arrest. In patients with already weakened myocardium, heart failure may result.

Local anaesthetics can alter the blood pressure in different ways. Stimulation of the CNS leads to hypertension, depression to hypotension. Hypotension may be intensified via a direct vasodilatory effect on the blood vessels and by direct myocardial depression. Furthermore, in lumbar epidural injection, hypotension may be due to blockade of the sympathetic nerves.[146]

Clinical appearance

Toxic side effects may clinically appear in two ways:[147]

- *A delayed reaction* may occur within 5–30 minutes after the infiltration. This is the most frequent reaction and is due to slow absorption until a toxic level is reached. It usually first gives rise to stimulation of the cortex before respiratory symptoms and cardiovascular collapse occur. For this reason the patient should always remain under supervision during the first half hour following an injection.
- *An immediate reaction* may occur within seconds to minutes of the administration, with all toxic reactions coming on at once. It is usually the result of intravascular injection or of swift absorption. Collapse may occur very quickly and death may follow rapidly if resuscitation is not begun at once.

Treatment

The most important measures, even if only minor signs of CNS or cardiovascular involvement are present, are to stop further infiltration at once and to administer oxygen. These may be sufficient to stop further development towards more severe conditions. The rest of the treatment should be in relation to the degree of toxic reaction:

- *Fear or anxiety attacks* are best treated by intravenous diazepam (5–10 mg).
- *Cerebral signs* – tremor and convulsions – require immediate administration of 100% oxygen via a mask. Small intravenous doses (5–10 mg) of diazepam may be given. Barbiturates and short-acting muscular relaxants should only be used by the experienced and should always be preceded by the administration of oxygen.[144]
- *Hypotension:* the patient is put into the Trendelenburg position. If this is not sufficient, administration of vasoactive drugs such as dopamine or noradrenaline (norepinephrine) may be required.[143] In circulatory depression, intravenous fluid must also be given. Bradycardia can be treated by atropine.
- *Cardiac arrest:* oxygen and external cardiac massage are given.
- *Respiratory depression* is treated by oxygen and artificial respiration (intubation) (see Box 5.5).

Allergic (anaphylactic) reactions

Side effects not related to dose can occur even after the administration of small amounts of the agent. Previous exposure and sensitization to the active product or preservatives (methylparaben) or any other accessory material present is an essential precondition.

Two types of allergic reaction may occur: an anaphylactic reaction, which may be life threatening, and a local reaction

Box 5.5

Summary of treatment of side effects of local anaesthetics

Always:
- Stop further infiltration
- Give oxygen at once

Tremors and convulsions:
- 100% oxygen via mask
- Diazepam i.v. 5–10 mg

Vascular collapse:

Hypotension:
- Trendelenburg position
- Vasoactive drugs i.v. (dopamine, isuprenaline hydrochloride, adrenaline (epinephrine))
- Fluid i.v.

Bradycardia:
- Atropine

Cardiac arrest:
- External cardiac massage

Respiratory depression:
- Give oxygen
- Artificial respiration (intubation)

presenting as dermatitis from local contact with the skin. The latter is usually encountered only in professionals who use the product, rather than in patients.

Although allergic reactions are frequently mentioned in relation to local anaesthetics they are in fact rare.[147] According to Cyriax, anaphylactic reactions occur in 1/50 000 procaine infiltrations, though they are more frequently encountered with procaine than with the amides.[144,146,148] Since an anaphylactic reaction may be very dramatic, with a mortality rate of about 3.4%, one must always be aware that it is possible.[149] Before local anaesthetics are administered the patient must always be asked for evidence of an allergic constitution. If a patient claims to be allergic to local anaesthetics, a careful and detailed history must be taken because 99 out of 100 reactions are due to toxic or psychogenic side effects and not to an allergy as such.[147] An intradermal test with a small amount of agent can be useful but is not 100% reliable.[147]

An anaphylactic reaction may come on immediately after the injection or some time later, up to about 30 minutes. It is the immediate type which is often dramatic. The initial feature of an anaphylactic reaction is often *flushing* occurring within 20 minutes after administration. This may be quickly followed by dyspnoea due to *bronchiolar constriction* and localized *oedema of the larynx and glottis*. It may end in *respiratory obstruction* which is the main cause of death.

The respiratory symptoms are accompanied by vasodilatation which leads to *hypotension* and *shock*. Occasionally other anaphylactic reactions such as *urticaria* and *angioneurotic oedema* may also present immediately, but are far less dramatic.

Treatment

Treatment is different for immediate and delayed allergic reactions. The treatment is outlined in Tables 5.5 and 5.6.

Immediate reaction

Even when only minor signs of anaphylactic reaction are present 0.3–0.5 ml of *adrenaline (epinephrine)* 1/1000 (0.3–0.5 mg) is immediately administered by the subcutaneous route to provoke vasoconstriction, bronchiolar dilatation and resorption of oedema. Since adrenaline (epinephrine) is broken down quickly, it should be repeated every 20 minutes. Subcutaneous administration of adrenaline can only be done if the general circulation is intact. When blood pressure is too low it must be carefully administered intravenously. In this event 3–5 ml of adrenaline (epinephrine) 1/10 000 must be administered in repeated shots of 1 ml (0.1 mg) until effect has been attained.[150] Small repeated shots are necessary to avoid ventricular fibrillation. Some also advise inhalation of a 1/10 000 adrenaline (epinephrine) solution via aerosol in case of laryngeal oedema. *Steroids* inhibit allergic reactions but act too

Table 5.5 Classification of anaphylactic reactions of increasing severity and their treatment

Severity	Symptoms	Treatment
I	Urticaria Red conjunctivae Fever	Antihistamine
II	Hypotension Dyspnoea Tachycardia Nausea Diarrhoea	Trendelenburg position 100% oxygen Adrenaline (epinephrine) Antihistamine Corticosteroid Aminophylline
III	Shock: circulatory collapse and angioneurotic oedema Life-threatening spasms of the bronchi	Trendelenburg position 100% oxygen Intubation Infuse: Adrenaline (epinephrine) Antihistamine Corticosteroid Aminophylline
IV	Cardiac arrest Respiratory arrest	Heart massage Artificial breathing

Table 5.6 Medication used in anaphylactic reactions

Drug	Dose	Notes
Adrenaline (epinephrine)		
Adults		
Normal blood pressure	1/1000, 0.3–0.5 ml s.c.	To be repeated every 20 min
Severe hypotension	1/10 000, 3–5 ml i.v.	1 ml per shot
Children	1/1000, 0.01–0.03 ml/kg s.c.	
Antihistamine (clemastine)	2 mg i.m./i.v.	Every 6 h for up to 24 h
Corticosteroids (dexamethasone)	4–8 mg i.v.	Every 6 h for up to 24 h
Aminophylline		
Adults, initial dose	240 mg i.v.	
Children		
Initial dose	5 mg/kg i.v./i.m.	
Follow-up dose	0.4 mg/kg/h i.v.	

slowly in this situation. Oxygen should also be given but may be of little value if the airway is severely obstructed. In the latter case, *aminophylline* should also be injected.

The patient should remain under supervision during the first few hours after the anaphylactic reaction.

Delayed reaction

If the allergic reaction comes on only after 30 minutes, administration of an antihistamine drug is sufficient.

Corticosteroids

The adrenal corticosteroids are classified into two groups: mineralocorticoids such as aldosterone, with sodium-retaining activity, and glucocorticoids, which influence the intermediary metabolism (nitrogen catabolism, increased glucogenesis) and have a strong anti-inflammatory and anti-allergic effect. The ability to suppress inflammation has made the glucocorticoids very useful but also potentially harmful. Administered in high doses, they may cause Cushing's syndrome.[151]

All corticosteroids used in orthopaedic medicine are glucocorticoids. The first was hydrocortisone, extracted from the adrenal cortex by Kendall in 1936, and first intra-articularly injected by Thorn in 1950.[152] Since then many other steroids have been synthesized. Efforts to increase the anti-inflammatory effect and to diminish the influence on metabolism have remained largely unsuccessful so far. Thus, unnecessary use should be avoided.

The ideal steroid should meet the following criteria: little discomfort to the patient during and after injection, a low level of absorption into the systemic circulation (if absorption does occur, it should be slow), together with a prolonged local effect without general and local side effects.[153] Some preparations are formulated specifically for local use and are available as a crystalline suspension. The less water soluble they are, the less they are absorbed into the general circulation. As a consequence they have a more prolonged local effect and fewer general side effects. Intrasynovial administration has the advantage of a maximal local benefit with minimum systemic side effect.[154]

The agent we use most often is triamcinolone acetonide, in a concentration of 10 mg/ml. Throughout this book, this is the product and concentration intended, unless indicated otherwise in the text. It has a mean duration of activity of about 14 days, whereas triamcinolone hexacetonide has more prolonged activity.[155] Normal doses used are 5 mg for small joints, 20 mg for medium-sized joints and 50 mg for the hip and knee.

Therapists who prefer another type of corticosteroid should always administer the dose equivalent to the one indicated in the text (see Table 5.7).

Table 5.7 Corticosteroids

Product	Anti-inflammatory effect
Hydrocortisone	1
Cortisone	0.8
Prednisone	2.5
Prednisolone	4
Methylprednisolone	4
Triamcinolone	5
Betamethasone	28
Dexamethasone	28
Beclometasone	40

Effects of local corticosteroids

Corticosteroid injected locally has a local anti-inflammatory effect due to stabilization of the lysosomal membrane with decreased liberation of cytotoxic enzymes. Steroids also impair the proliferation of fibroblasts and decrease the rate of production of mature collagen. They decrease plasma fibrinogen as well and have an increased fibrinolytic activity.[156] Furthermore, corticosteroids reduce oedema formation and the escape of plasma protein across the capillary membrane, and diminish the number of leukocytes in exudate at an inflammatory site. All these effects lead to reduction of pain and fibrosis.[157–161]

When injected into a joint, steroid is partly broken down by enzymes from the synovial membrane and is partly resorbed into cells of the synovial fluid and cells of the synovium. A small amount enters the general circulation.

Indications for local corticosteroids

Joints

Beneficial effects occur in traumatic arthritis, monoarticular steroid-sensitive arthritis, rheumatoid arthritis, crystal-induced arthritis (gout and pseudogout), ankylosing spondylitis, lupus erythematosus and psoriasis.[153] Steroids are ineffective in Reiter's disease (Cyriax:[3] p. 52).

Monoarticular steroid-sensitive arthritis is of spontaneous onset without any other signs of rheumatological disorders and resolves equally spontaneously over months or years. The joints affected are the glenohumeral, the elbow, the knee, the hip, the ankle and the temporomandibular. The treatment of choice is intra-articular steroids. Usually, the joint must be kept under continuous anti-inflammatory influence for some time. Hence a specific sequence of injections must be observed.

Improvement is subjectively felt by the patient in that pain and stiffness diminishes, and objectively shown by a decrease of local heat and effusion together with improved function. Patients should be warned against overactivity at weight-bearing joints for the first days after injection to avoid further destruction of cartilage.[162] Moreover, the efficacy of an injection is greater with relative rest.

In arthrosis, lasting improvement is not to be expected.[163] Some authors even suggest, although this has never been scientifically proven, that it may accelerate the degenerative process.[162] If synovitis complicates arthrosis, intra-articular injection may well be beneficial.

Tendons

Steroids may be indicated in tendinitis, tenosynovitis and tenovaginitis. It is often used in tendinitis of the supra- and infraspinatus tendons and the subscapularis tendon at the shoulder.

The same applies for type II tennis elbow and for golfer's elbow at the tenoperiosteal insertion. In the lower limb, steroid injection is mainly used in supra- and infrapatellar tendinitis and for tendinitis of the peroneal tendon.

To avoid rupture, infiltration should be at the tenoperiosteal insertion or between tendon and tendon sheath, never into the body of the tendon.[162,164–167] Ruptures have been reported mainly after intratendinous infiltration with agents of high anti-inflammatory effect or at too high a concentration or when too frequently administered. When the rules are respected as set out in this chapter, there should be no danger of rupture.

Ligaments

In the acute stage – within 24 hours of the injury – of a ligamentous sprain at the ankle or tarsus or of the medial and lateral collateral ligaments at the knee, a steroid infiltration quickly helps but should only be done at the ligamentous insertions. Because the inflammatory reaction ceases shortly after administration, the ligamentous lesion can heal in the presence of movement. This leads to better functional results and to absence of adhesions, which are later often the reason for chronic pain.

In sprain of the cruciate ligaments of the knee, steroid infiltration is the only possible treatment, no matter what the stage of inflammation. Steroid infiltration is also an important part of the treatment in sprains of the radial and ulnar collateral ligaments of the wrist and in plantar fasciitis.[168]

Bursae

Depending on the type and location of bursitis, steroid is used at once or after an infiltration with procaine has been found to be unsuccessful. Pain, local tenderness and functional impairment are all reduced.[169]

Nerves

Compression of the median nerve in the carpal tunnel of the ulnar nerve at the ulnar sulcus or of any nerve root by an unreducible disc protrusion all usually benefit from an infiltration with triamcinolone around the nerve.[170]

Local side effects

Unwanted side effects of local corticosteroids are minimal compared with those of even low doses of oral steroids.[153] They are traditionally divided into local and general side effects.

Musculoskeletal side effects

There are a number of musculoskeletal side effects of local corticosteroid injection.

Iatrogenic infectious arthritis

This complication is the most feared although it is seldom encountered. The incidence varies from author to author: it follows between 1/1000 and 1/40 000 injections.[153,171] The usual organism is *Staphylococcus aureus*; less often, Gram-negative organisms are involved.[172] The condition should not be regarded as a real side effect caused by the steroid but is due rather to inadequacy of aseptic care or contamination, chiefly occurring during preparation of the syringe. Patients who suffer from diabetes, or who are receiving oral steroids or are immunosuppressed (leukaemia, AIDS, drug abuse) are more vulnerable.[173] Suppurative arthritis may often lead to therapeutic difficulties, and death may follow.[174]

Obviously this complication should be avoided by good antiseptic care, especially when the injection is made into a high-risk patient and when infiltrating in the neighbourhood of a joint or in the joint itself. Although skin lesions in psoriasis are highly colonized by bacteria, it has not been documented whether intra-articular injections given through such plaques increase the likelihood of an infectious arthritis.

Destruction of joint cartilage and evolution of steroid arthropathy

It has been suggested that intra-articular steroids may hasten the process of arthrosis by a deleterious effect on cartilage, leading to changes that closely resemble a Charcot-like neuroarthropathy. Steroid depresses the synthesis of collagen and proteoglycans, which may result in a loss of stiffness of the cartilage. In non-weight-bearing joints this has little or no effect. In weight-bearing joints it may result in fissure formation at the surface of the cartilage and cystic degeneration in the middle zone.[175–178] However, rapid progression to degeneration has not been proved with certainty.[171,179] Cases have been reported of multiple intra-articular injections in some joints not leading to any abnormalities on later radiography.[180,181] Often effects of local steroid cannot be differentiated from those caused by general administration of the product,[182] prompting the question whether it is a local or general effect. Because it is difficult to differentiate the possible destructive effects of the steroids from the natural progression of the osteoarthrosis, even though the risk may appear small, it is a good habit to avoid frequent injections. Moreover, injection into cartilage should never be done. When too much counter-pressure on the plunger is present, the tip of the needle must be replaced. It is also wise to rest weight-bearing joints for 24–48 hours after an injection.[139]

Flare up of crystal-induced arthritis

During the first 48 hours after an intra-articular injection of a crystalline suspension, a synovitis may flare up as response to the crystals. The mechanism is the same as in gouty arthritis. An equally painful inflammatory reaction is occasionally encountered after a local tenoperiosteal infiltration. Normally it disappears within 12–48 hours. If the reaction is prolonged, iatrogenic infection must be excluded.

Rupture of ligament or tendon

Tendon ruptures have been described after one or multiple infiltrations.[166,183,184] Infiltration of steroids into acutely injured ligaments in the rat significantly impaired the healing process relative to a non-injected ligament at 10 days and at 3 weeks after injury.[185] However, after 6 weeks the tensile strength (the ultimate stress) of the ligaments that had been injected with the steroids returned to a value that was equal to that of the controls that had not received an injection.[186] Although other studies have not confirmed these findings,[187,188,189] infiltration into the tendon body should never be done. In tenosynovitis, steroid can safely be infiltrated between tendon and tendon sheath and at the tenoperiosteal insertion, although multiple repetitive infiltrations must be avoided.

Calcification

Punctate calcifications of joint capsules and pericapsular calcifications are common after intra-articular and periarticular injections. Steroid paste can be found on the surface of infiltrated tendons. These observations are not clinically important.

Neurovascular complications

Direct intrafascicular injection of steroid in peripheral nerves may provoke permanent damage, whereas extrafascicular injection does not appear to be harmful.[190] The mechanism of injury is multifactorial and can be related to direct trauma with the needle, to ischaemia and to a neurotoxic effect of the steroid or of the buffer agents and additives such as polyethylene glycol and benzyl alcohol. The first features are severe radiating pain and numbness or paraesthesia in the sensory territory of the nerve, together with motor deficit. The pain usually responds poorly to narcotics and may persist for many years.[191] As to the steroid itself, triamcinolone hexacetonide and hydrocortisone are most hazardous and dexamethasone causes minimal damage, whereas triamcinolone acetonide is intermediate.[190,192]

Damage to the nerve should be treated conservatively for about 12 weeks. If the neurological deficit does not improve after this time, neurological consultation is necessary.

Dermatological side effects

Fat necrosis, atrophy of skin and subcutaneous tissue and depigmentation of the skin may be encountered. These are due to a faulty injection technique or to leakage of the product after an intra-articular injection. The latter occurs often in smaller joints if the volume injected is excessive. Consequently, if resistance during the injection increases markedly, the injection should be stopped.

General side effects

Although injected intra-articularly or into the soft tissues, corticosteroids do enter the circulation. The causes are leakage and absorption. Therefore general side effects depend on the administered dose, the frequency of injections, the number of joints injected and the aqueous solubility of the agent. The greater the aqueous solubility, the higher the absorption rate. Less soluble microcrystalline suspensions remain within the joint for longer. Administration of a given dose equally divided between two joints produces more general side effects than if the same amount was injected into a single joint – the result of a larger absorptive surface.[172]

The majority of the more severe systemic effects can be avoided if no more than two joints are treated at the same time, using a maximum of 40 mg triamcinolone and allowing an interval of 1 month between two injections.[193] If treatments are performed as recommended in this book general side effects are extremely rare.

Endocrinological side effects

There are five categories of potential endocrinological side effects.

Disturbance of hormonal equilibrium

This can result in either hyperglycaemia or suppression of the adrenal cortex via depression of plasma cortisol levels:

- *Hyperglycaemia*: glucocorticoids have an important influence on the intermediary metabolism. They increase circulatory glucose via stimulation of gluconeogenesis and decrease the intracellular use of glucose. Therefore it is wise to advise diabetic patients to check their blood sugar more closely for the first few days after the use of steroid.
- *Suppression of the adrenal cortex via depression of plasma cortisol levels*: small doses of steroid may provoke some suppression of the adrenal cortex.[194] This seems to occur not only when steroids are administered orally but also after intra-articular injections.[195] Prolonged administration renders the adrenals atrophic and provokes suprarenal insufficiency with symptoms such as hypotension, anorexia, fever and generalized joint or muscular pain.

Iatrogenic Cushing's syndrome

The full syndrome with weight gain, depression, insomnia, amenorrhoea, diminished libido, thinned skin, muscular weakness, polyuria and polydypsia is seldom encountered after local use of steroids.[180] Occasionally facial hirsutism and acne may be seen.

Flushing

In the first few days after an intra-articular injection, some patients suffer from erythema and warmth in face, neck and chest. This is a totally benign but rather frequent sensation which is more common after the use of triamcinolone.

Shaking and chills

Very rarely patients suffer from chills and shaking after the use of steroid, a reaction that normally abates within 24–48 hours.[154]

Interference with the menstrual cycle

In female patients repeated injections with steroid may lead to dysfunctional uterine bleeding. Steroids may also interfere with hormonal contraceptives. There is no evidence for a teratogenic effect.[196]

Musculoskeletal side effects

In addition to the local musculoskeletal side effects already mentioned, there can be systemic musculoskeletal effects.

Osteoporosis and increased risk of fractures

It is difficult to estimate the exact incidence of osteoporosis provoked by corticosteroids. Nevertheless, special care should be taken when administering them to post-menopausal females because of the increased likelihood of these side effects.[193,197]

Steroid myopathy, spontaneous tendon ruptures and aseptic necrosis

Any of these may occur, although they are all very rare.[198]

Immunological side effects

Suppression of the inflammatory mechanism sometimes leads to a disappearance of symptoms in non-injected joints. Chronic use of steroids may increase the liability to infections.

An allergic reaction to steroids is not expected because they all have immunosuppressive and anti-inflammatory activity.

However, a number of well-documented allergic anaphylactic (type I) reactions to corticosteroid medications have been reported.[199] Recent reports have warned of potential (though rare) anaphylactic reactions after intra-articular or intralesional injection of triamcinolone acetonide.[200–202]

One recent study indicates that the triamcinolone acetonide component responsible for the patient's reaction is the suspending agent carboxymethylcellulose.[203] It is therefore suggested that care be taken and component testing eventually considered when patients experience allergic-type reactions to drugs.

Miscellaneous side effects

Central nervous system, gastrointestinal and ophthalmological side effects have been reported:

- Prolonged use of steroids may provoke changes in personality and mood.
- In patients who have previously suffered from peptic ulcer and pancreatitis, steroids should he cautiously used.
- After long-term use of steroids some patients may complain of worsening of vision. This may be due to glaucoma or cataracts.[204]

Indications for and contraindications to local corticosteroids

The indications for corticosteroid injection are given in Box 5.6. Contraindications may be divided into absolute and relative (Box 5.7).

Viscosupplementation

Over the past 2 decades, the use of intra-articular viscosupplementation in the non-operative management of patients with osteoarthritis has become quite popular. Viscosupplementation refers to the concept of synovial fluid replacement with intra-articular injections of hyaluronic acid (HA) for the relief of pain associated with osteoarthritis.[205] HA is a high molecular weight polysaccharide and is an important component of synovial fluid and extracellular matrix of articular cartilage. It contributes to the elasticity and viscosity of synovial fluid. HA acts as a fluid shock absorber and it helps to maintain the structural and functional characteristics of the cartilage matrix.[206,207] It also inhibits the formation and release of prostaglandins, induces proteoglycan aggregation and synthesis, and modulates the inflammatory response.[208] Any degradation of HA is therefore associated with increased vulnerability to articular cartilage damage. Treatment with HA is indicated for patients who are functionally limited due to osteoarthritic pain and who have failed to respond adequately to standard treatment options and wish to postpone or avoid surgery. Viscosupplementation is currently accepted as a useful therapeutic modality in treating patients with osteoarthritis of the knee or hip,[209,210] with beneficial effects on pain, function and patient global assessment.[211] Recently, promising results for viscosupplementation in grade I and II ankle osteoarthritis have also been published.[212,213]

Box 5.6

Indications for corticosteroid injection

Tendons

- Tendinitis at a tenoperiosteal junction
- Tenosynovitis/tenovaginitis: injection between tendon and tendon sheath, never into tendon

Joints

- All non-supportive types of synovitis
- *Exception*: Reiter's disease

Bursae

- Acute subdeltoid bursitis
- Retrocalcaneal bursitis
- Ischial bursitis
- Bursitis intractable to local anaesthetics

Ligaments

- Acute stage of a sprained ligament
- Plantar fasciitis
- Sprained cruciate ligaments at the knee
- Sprain of radial and ulnar collateral ligament at the wrist

Spinal disc lesions

- Epidural injection: in patients intractable to local anaesthesia
- Sinuvertebral block

Box 5.7

Contraindications to corticosteroid injection

Absolute contraindications

- Infection of a joint
- Severe infection of neighbouring skin
- Osteomyelitis in neighbouring bones
- Bacteraemia
- Bacterial endocarditis
- Active tuberculosis and herpes corneae
- Immune deficiency (leukaemia, AIDS)
- Allergy to steroid or its vehicle
- Osteochondral fracture
- Joint prosthesis
- Uncontrolled clotting disorder

Relative contraindications

- Anticoagulant treatment: the risk of bleeding from the needle puncture is small, but clotting should not be excessively delayed[171]
- Haemarthrosis
- Reiter's disease
- Markedly unstable joint
- Poorly controlled diabetes
- Adjacent abraded skin: chance of infection is real

Table 5.8 Phenol preparation for injection (P2G)

Component	% by weight
Phenol	2
Anhydrous dextrose	25
Glycerol	30
Water	43

Sclerosing agents

Introduction

Chemical agents such as phenol and dextrose are infiltrated into weakened ligaments and tendons in order to create the formation of strong, thickened fibrous tissue. Because of its proliferative effect on connective tissue, the technique is called *prolotherapy* or *sclerotherapy*.

Product

The original solution, used by Hackett and consisting of zinc sulfate and carbolic acid, provoked painful reactions and was not totally risk free.[214] The mixture used nowadays is the one chosen by Ongley which has a safe reputation as it was regularly used to sclerose varicose veins. It is formulated as described in Table 5.8 and is mentioned under the name P2G.[215]

Mode of action

The mechanism of action for prolotherapy has not been clearly established. The main hypothesis is that the infiltration produces a local inflammatory reaction which is followed by an increased proliferation of fibroblasts and production of new collagen fibres. The final outcome is tightening, reinforcement and loss of normal elasticity of the ligaments.

Liu *et al*[216] and Maynard *et al*[217] studied the histologic effect of injections with a sclerosant. Biopsies of infiltrated medial collateral ligaments of the knee of the rabbit showed not only increase in ligamentous mass and strength but also a normal alignment of the fibres. In other words, the newly produced connective tissue did not have the chaotic appearance of scar but appeared much the same as normal tissues, except that they were thicker, stronger, and contained fibres of varying thickness.

Klein *et al*[218] performed biopsies of posterior sacroiliac ligaments in three patients with chronic low back pain both before and after prolotherapy injections. After six injections at intervals of a week they found an increase in the average ligament diameter measured by electron microscopy from 0.055 micrometres to 0.087 micrometres. Light microscopy showed an increase in collagen-producing fibroblasts. The ligament orientation was organized and linear, as in normal ligaments.

In addition to the effects on fibrous tissue, phenol also has a neurolytic effect. When injected in or around the medial branches of the posterior ramus, it provokes a chemical denervation. This may explain the quick relief (sometimes from the day after the injection) obtained by a number of low back pain patients, treated with sclerosant injection.[219]

Another possible mode of action is through the sclerosing of pathologic neovessels that are frequently associated with painful tendinopathy.[220,221] Finally, the potential of prolotherapy to stimulate release of growth factors favouring soft tissue healing has also been suggested as a possible mechanism.[222]

Table 5.9 Prolotherapy: Indications

Ligaments	Lumbar spine	Lumbar instability
		Chronic postural backache
		Intractable backache
	Sacroiliac joints	Sacroiliac dysfunction (ligamentous pain)
	Peripheral joints	Carpal instability
		Tibiofibular ligaments
		Acromioclavicular ligaments
Tendons		Achilles tendinitis (midportion)
		Infrapatellar tendinitis
		Tennis elbow type II
		Recurrent supra- and infraspinatus tendinitis

Indications (Table 5.9)

Ligaments

1. The main indication for sclerosant therapy is at the lumbar spine. In recurrent disc protrusions or in chronic backache from postural ligamentous pain (see p. 459), a series of infiltrations is made in all the dorsal ligaments of L4–L5–S1 motion segments.

   Prolotherapy is also used for pain relief in 'intractable backache' of the lumbar spine (see p. 582). The positive effect after the injections is thought to be caused by the neurolytic effect of the phenol. The agent is infiltrated around the lateral or medial branch of the posterior ramus and may cause pain relief of months' or years' duration.
2. Sclerosing injections are also used in treating sacroiliac strains. Infiltration is always at the ligamentoperiosteal junction (see p. 608).
3. Recurring carpal subluxations or in the inferior tibiofibular ligament. Infiltration is into the remains of the ligament at the ligamentoperiosteal attachment. The injections can also be used in the treatment of recurrent subluxations and strain of the *acromioclavicular joint*.

Tendons

During the last decade some reports of good results with prolotherapy in the treatment of painful chronic mid-portion Achilles tendinosis were published.[223,224] It is suggested that neovessels play a key part in causing chronic tendon pain, hence the curative effect of their sclerosis.[225,226] Prolotherapy has also been used in the treatment of chronic infrapatellar tendinitis,[220] hip adductor tendinopathy[227] and chronic plantar fasciitis refractory to conservative care[228]. Also type II tennis elbow (tendinopathy of the origin of the extensor carpi radialis

brevis) in which previous infiltrations with steroid have given poor or only temporary relief is a good indication for sclerosing injections.[229,230]

Finally, proliferant infiltrations may also be required in recurrent supra- or infraspinatus tendinitis. Again the injections should be given tenoperiosteally.

Side effects and complications

Infiltration of a sclerosant is quite painful. Therefore 25% of a strong local anaesthetic should always be added to the sclerosant solution. After an hour and up to 2 days thereafter there is considerable after-pain, sometimes to such an extent that the patient needs strong analgesics. Apart from the after-pain there are very few reported side effects.

In 1993 Dorman published a survey of prolotherapy injections performed on a total of 494 845 patients.[231] Of these, 343 897 were treated for low back pain. Only 66 minor complications were reported. These included 24 reports of allergic reactions and 29 instances of pneumothorax. All of these resolved without serious problems. There were also 14 reports of major complications, defined as the patient needing hospitalization or having transient or permanent nerve damage.

Results

A double-blind controlled study of prolotherapy was published in *The Lancet* in 1987.[215] The investigators used a strict set of criteria (such as no litigation, long-standing pain, no severe medical illnesses and a diagnosis of ligamentous back pain). One half of a group of 81 patients received prolotherapy injections with a solution of dextrose, phenol, lidocaine (lignocaine) and glycerin, while the others were injected with saline. The average length of time of symptoms was 8.98 years in the treatment group and 10.72 years in the placebo group. The results showed a statistically significant difference in the two groups, with the prolotherapy group showing a marked decrease in subjective pain as compared to the saline groups ($p < 0.00l$ at 6 months). A later double-blind study in 1993 showed similar results.[232]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