Physiotherapy ESSENTIALS

Evidence-Based
Therapeutic Massage

A practical guide for therapists

THIRD EDITION

Elizabeth Holey
Eileen Cook

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evolve learning system

Evidence-Based

Therapeutic Massage

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Evidence-Based Therapeutic Massage

A practical guide for therapists

THIRD EDITION

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Preface to the third edition

This edition is published thirteen years after the first. Then, we were proposing a new way to think about massage. This was to ensure that the skill of massage was practised within a scientific framework, with sound clinical decisions based on the best evidence. The second edition considerably updated the research-base. The third edition has refreshed the text and considerably developed the sports massage section (chapter 13). This chapter has been written by Julie Sparrow, a chartered physiotherapist with considerable experience of working with athletes at all levels, including international athletes both with and without disabilities. The text is supported by electronic ancillaries, designed to support your learning.

Preface to the first edition

Therapeutic massage is undergoing a regeneration. There is a need for the availability of theoretically based education to enhance the standard of practice both inside and outside orthodox health care. Professionals are progressing towards evidence-based practice to satisfy the requirements for optimum effectiveness. This book has been written to fulfil the need for a massage textbook which presents currently available evidence to guide the therapeutic application of massage. It will assist the student and therapist in extending and justifying the use of massage in health care, whether orthodox or complementary, publicly or privately funded. It encourages the integration of practical massage skills with an understanding of the research-based biological foundation, enabling the application of a problem-orientated approach to therapy.

The anatomy, physiology and pathology included in the text is directly related to massage, so that it informs students of the effects and helps them to appreciate the various massage techniques. This is extensive evaluation of the massage literature to guide and support the student.

Liz Holey
Eileen Cook

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Section 1

The theoretical basis

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Massage in context

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CHAPTER CONTENTS

The philosophy of massage

A practitioner of massage may choose to be either a technician or a therapist. A technician is competent to administer massage as a manual skill. A therapist, in addition to being competent in the manual techniques, understands human anatomy, physiology, pathology and psychosocial issues, and will apply this knowledge when practising massage. For the therapist, massage is one tool available for her to choose when, following a full assessment of the client's needs, an evaluated problem-based treatment plan is designed. This book is intended for those who aspire to be therapists.

The image of massage, as frequently presented in the media, is of a mystical technique which is practised by intuition. Experienced therapists may appear to work intuitively but they are, in reality, applying previously learned and internalised knowledge. It is that vast pool of clinical experience which a proficient therapist draws on during her working day, expanding and modifying her internal memory base as new knowledge is acquired. In its real sense, 'intuition' means immediate unreasoned perception; to state that massage is intuitive is to imply that it can be practised by the use of instinctive actions in the absence of any reasoning.

Instinctual massage is not the way of the professional therapist, whose skills are grounded upon both sound biological and scientific principles and experience gained in clinical practice. This does not invalidate the 'feel-good' factor of massage, which can be as important as any therapeutic effect—massage can both feel good and be of therapeutic value: there is no reason why these two objectives should be mutually exclusive. Of course, these principles need apply only to the professional therapist. Family members, friends and participants in group therapy may have other objectives, such as the giving and receiving of caring touch to promote interaction and feelings of well being. These aims may also apply to massage with certain client groups, such as people with learning disabilities.

Massage and holism

Holistic health care practice is an approach to treatment which recognises the inseparable wholeness of the human organism and views it in the context of its environment, the implication being that every aspect of human functioning interacts with every other aspect and that to isolate one component for therapeutic purposes means that their complex interactions are ignored. Holism is the antithesis of the dualistic Cartesian division of mind and body, which has been integral to the development of

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Western medicine. Although the concept of holism is not new in global terms, it is only relatively recently that it has been accepted in the West and, in common with other new converts to a cause, we have embraced the idea with enthusiasm without always being aware of the implications. Therapists who work holistically must, by definition, have a detailed knowledge of all the body systems to enable them to coordinate the responses of these systems with a therapeutic intervention. Clearly, this is the opposite of working instinctively and in the absence of a broad knowledge base; massage in those circumstances restricts both the recipient and the therapist to an emotional level only, which is not considered to be holistic.

Properly trained and experienced therapists are able to influence the health of the whole person by using appropriate techniques to achieve the desired effect. For example, they will decide at which interface in the tissues it is necessary to work, light pressure affecting only the epidermis while heavier pressure affects progressively the dermis, fascia, muscle, tendon, ligament, viscera, periosteum of bone and their attendant reflexes. The technique to be utilised will be determined by thorough assessment of the patient, together with the employment of intellectual and clinical skills that are sensitive to both psychosocial and physical needs.

Complementary or orthodox?

Is massage a complementary or an orthodox therapy? Certainly there is ample evidence that massage has been used, at least since the early twentieth century, as part of mainstream medicine for orthopaedic rehabilitation. In England in 1895 the Society of Trained Masseuses was founded to increase the status of massage and of the professionals who practised the technique under the supervision of medical doctors. In 1907, Araminta Ross, the principal of the Dublin School of Massage, wrote *The Masseuse's Pocket Book*, a small textbook describing the various strokes of massage and how they are to be used for various medical conditions. British-trained physiotherapists (physical therapists) have practised massage as a 'core skill' since the inception of physiotherapy as a profession. Despite this history, in many areas of medicine, in the UK massage is now regarded as a complementary therapy. In palliative care, for example, it is a therapy usually administered by massage/complementary therapists who often train specifically for that purpose (MacDonald 1999). The answer to the question may lie in the definition of complementary therapy: '[it] is diagnosis, treatment and/or prevention which complements mainstream medicine by contributing to a common whole, by satisfying a demand not met by orthodoxy, or by diversifying the conceptual frameworks of medicine' (Ernst et al 1995). This definition was adopted by the Cochrane Collaboration (Ernst et al 1998). Perhaps it is not the technique or the therapy which is either mainstream or complementary, but the context in which it is used and the perceived status of the therapist using it—in other words, the system of medicine in which it resides and the approach of the individual therapist. Medical systems are embedded in a cultural framework which has an overriding influence on the scientific perspective. For example, there are many similarities among Chinese, Thai and Japanese traditional medicines; therapies which have been regarded as mainstream in the East for centuries are looked upon as complementary in the West because they do not easily or immediately fit into the Western cultural medical framework.

In the USA and some European countries, massage may be used professionally only by those with medical training or those who have undergone massage training and have been licensed to practise, while in other countries anyone may practise, even without training. It would not be in the interest of massage as a dynamic and evolving therapy, or in the interests of society, if massage were to be monopolised by a particular group. If the practice of massage were to be confined to one profession with a relatively narrow interest, its various branches would atrophy and the facility for the exchange of ideas would be lost. This opinion should not, however, be taken as a charter for those who wish to arrive at a quick method of 'practising bodywork'. A good attitude, a caring disposition and a desire to help people are not of themselves qualifications for the practice of massage. The way forward is to acknowledge that by creating factions the path to new discoveries may be obstructed. Adapting to the demands of the time, accepting that the needs of society are changing health care practice and that people require massage for many different reasons is a realistic approach. Being responsive to the views of other groups and professions, but furthering the practice of massage through the scientific method will justify public spending on it and, thus, safeguard its widespread availability. In addition, those who practise massage in a therapeutic context need to be adequately trained.

What is massage?

There are many definitions of massage. Reproduced here are a number of published definitions that highlight the variety of opinions which abound:

> Massage is the term used to express certain scientific manipulations which are performed by the hands of the operator upon the body of the patient. It is a means used for creating energy where such has become exhausted, from whatsoever cause, and is a natural method of restoring the part, either locally or generally injured, to its normal condition.
>
> (Ross 1907)

> Massage may be described as a scientific way of treating some forms of disease, by external manipulations, applied in a variety of ways to the soft tissues of the body. There are many varieties in the technique of massage, but the manipulations in general may be classified as follows . . . [*lists the techniques of Swedish massage*]
>
> (Goodall-Copestake 1926)

> The scientific manipulation of the soft tissues of the body, as apart from mere rubbing.
>
> (Prosser 1941)

> The hand motions practised on the surface of the living body with a therapeutic goal.
>
> (Boigey 1955)

> Manoeuvres performed by the hands of a therapist on the skin of a patient and through the skin on the subcutaneous tissues. Massage manipulations may be stationary or progressive; they may be variable in intensity of pressure exerted, surface area treated and frequency of application.
>
> (Boni & Walthard 1956)

> Massage is the aware and conscious manipulation of the soft tissues of the body for therapeutic purposes.
>
> (Westland 1993)

The authors offer the following definition for *therapeutic* massage:

> Massage is the manipulation of the soft tissues of the body by a trained therapist as a component of a holistic therapeutic intervention.

The latter is an inclusive definition which embraces the many varieties of manual therapy commonly associated with massage, for example Swedish, classical, segmental, connective tissue, aromatherapy and shiatsu; it identifies the integrative nature of the therapy but restricts massage, as a therapeutic intervention, to those who are competent to administer it.

Origins of massage

Stroking and rubbing of the tissues probably evolved from the instinctive contact observed in other mammals. At some time during the course of evolution it is likely that intellectual development led to massage becoming integrated into folk medicine and later into systems of medicine.

The word massage derives from the Arabic *mass*, meaning to press. Many ancient civilisations developed a system of therapeutic massage, notably in China, India, Arabia, Greece, Italy and Egypt. Numerous references survive from these cultures which indicate that massage was used for various medical conditions.

The emergence of therapeutic massage in the West is attributed to French missionaries who, upon returning from China in the early nineteenth century, brought with them *The Cong Fou of the Tao-Tse*, which are Chinese medical writings dating from about 2700 BC. The translation of these writings into French is the reason some massage terminology is still in French to the present day, for example effleurage (from *effleurer*, meaning to skim over), petrissage (from *pétrir*, meaning to knead) and tapotement (from *tapoter*, meaning to pat or tap).

The popularity of massage grew when it was incorporated into a system of medical gymnastics by Per Henrik Ling (1776–1839), who founded a central institute of gymnastics in Stockholm, Sweden, in 1813. Ling's system was published by Augustus Georgii, a pupil of Ling, in 1847 under the title *Kinestherapie*, and the system we now know as Swedish massage began to spread in Europe. Institutes of Swedish massage were founded in London in 1838 and in New York City in 1916.

Massage became a popular treatment in health spas throughout Europe from the mid-nineteenth to early twentieth century. The interest of the medical establishment was aroused by the work of Just Lucas-Championniere (1843–1913), who used massage in the management of fractures. This period also saw the publication of several notable books on massage, among them *Traité de la Massothérapie* (Weber 1891), *Technik der Massage* (Hoffa 1897) and *Practical Treatise on Massage* (Graham 1884).

Hoffa's massage was based upon the now classical techniques of Swedish massage. His system emphasised the treatment of individual muscles or muscle groups, rather than specific body regions or the whole body, which is the more usual approach in other systems.

In the USA the technique of massage was advanced by Mary McMillan, director of physical therapy at Harvard Medical School, and later by Gertrude Beard, director of physical therapy at Northwestern University, Evanston, Illinois. In England, in 1895, the Society of Trained Masseuses was founded to increase the status of massage and of the professionals who practised the technique. Further credibility for massage within medicine was established by Dr J. B. Mennell (1890–1957), author of a work entitled *Physical Treatment by Movement, Manipulation and Massage*, first published in 1917.

Interest in massage continued to grow in Germany following new discoveries concerning somatic reflex zones. This led to the publication of Dicke's *Meine Bindegewebsmassage* in 1953 and Gläser and Dalicho's *Segmentmassage: Massage Reflektorischer Zonen* in 1955.

This short summary is the history of massage only in so far as the West is concerned. As with the history of anything, it is confined to information that has been preserved in the form of texts which, in this case, are usually derived from the orthodox medical establishment. There is probably an alternative history of massage in folk medicine. In addition, massage in China did not stop evolving when it was discovered by Westerners, but only in recent years have translations become available of massage techniques currently used in China. Typically, a practitioner of massage in China is a doctor with at least 5 years' training in both Western and traditional Chinese medicine and whose practice is informed by the results of prolific recent research studies. Similarly, Russian medical massage is a well-developed system.

Recent trends

The interest in massage within the orthodox medical establishment has been variable. Conversely, within the field of alternative and complementary medicine, vigorous enthusiasm for the modality has been awakened via the growth of the human potential movement and a consequent interest in natural therapies. The American Massage Therapy Association was founded in 1943 and has continued to promote massage and training for massage therapists. Although there is no unification of massage training in the UK outside orthodox medicine, there has been a growth of interest in massage as a profession, and practitioners often link it with various Eastern therapies and spiritual, psychological and energetic forms of healing. A tension exists between the esoteric belief systems underpinning some massage approaches and the drive towards establishment acceptability which is dependent on a sound evidence base. At the time of writing, voluntary regulation of massage professionals by the Complementary and Natural Health Care Council is encouraged. Eleven massage associations are members of the General Council for Massage Therapists. No longer restricted to the physiotherapy profession, massage is being used by nurses and others within the health care environment and many papers on the technique are published in the nursing literature. In the USA there is a thriving National Association of Nurse Massage Therapists. In the UK, Chartered Physiotherapists Interested in Massage and Soft Tissue Therapies (CPMaSTT) has recognised clinical interest group status within the Chartered Society of Physiotherapy.

Since the 1980s there has been a persistent trend within society demanding the availability of massage, which indicates that the effects of massage are valued by recipients. During the same period, pressures on the health economy have precipitated a move away from the empirical basis of therapy towards evidence-based practice. As a result, although it has the support of popular demand, the scientific foundation of massage as a therapy must continue to expand if it is to survive changes in health care policy.

Finally, where massage is used within physiotherapy, it must be used as an enabler, as part of an integrated rehabilitation programme. The programme must be as active and client-centred as possible, enabling the client's personal empowerment to achieve his/her potential. Massage should be incorporated with clear outcomes in mind and should not be used as a lone, passive intervention to replace a dynamic, complex process.

Key points

- Therapeutic massage cannot be practised by instinct alone.
- Holism recognises the inseparable wholeness of the human organism.
- Therapists who practise holistic therapeutic massage need expertise in human sciences and psychosocial skills.
- The practice of massage is embedded within orthodox medicine and has, more recently, become known as a complementary therapy.
- Continuing research is required to maintain massage as an evidence-based therapy.

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A biological basis

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CHAPTER CONTENTS

Touching, stroking and rubbing the skin is an integral part of our lives. Through these actions, we communicate and transmit feelings and emotions to one another. Skin rubbing and caressing can become more formalised and take the form of a massage, to aid relaxation and promote a feeling of well being. For the massage to progress to a more specific therapeutic outcome it must be directed towards a more specific purpose and be aimed at promoting physiological and/or psychological change. It must therefore be based on sound theoretical principles. The structure, function and dysfunction of the body must be understood so that clinical decisions may be made and appropriate techniques selected to induce desirable change. This chapter discusses a range of anatomical, physiological and pathological issues, providing an essential basis for the therapeutic use of massage. The chapter covers topic areas specific to massage; extrinsic material can be found in greater detail in other texts.

Skin

The skin is the tough, waterproof, external surface of the body. It is also known as the integument, or cutaneous membrane. What makes the skin such a fascinating structure is its ability to combine a protective and insulating function of great physiological significance with an important role in communication. It conveys emotional responses through its vascular changes (flushing with pleasure or embarrassment, blanching with shock or fear, for example); it plays a part in expressing words or emotions through its transmission of the coordinated contractions of the underlying muscles of facial expression and is essential for tactile communication. By being sensitive to these reactions, the therapist may learn a considerable amount about the patient's psychological and emotional state and can modify massage treatment subtly and appropriately. By using her awareness of these properties, the therapist can communicate attitudes essential to obtaining trust and relaxation—respect, friendliness, approachability, concern and understanding—even before touching the skin, thereby enhancing her personal approach.

Skin varies in thickness between 0.5 and 2–3 mm. It is of vital importance for survival: it forms a protective layer for deeper structures and is a richly innervated sensory organ (the largest in the body) to feed information about the environment to the nervous system, thus acting as a warning system and protective mechanism. It regulates temperature due to its neurovascular mechanisms and insulating properties (fat, found in the hypodermis, conducts

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heat two-thirds less efficiently than other tissues); prevents fluid loss; allows excretion and absorption of substances; and acts as a chemical and bacterial barrier. The rate of blood flow into the vascular plexi associated with the skin varies from 0 to 30% of total cardiac output. It is controlled by the sympathetic response to core or environmental temperature changes, which alters the degree of vasoconstriction of the arterioles and arteriovenous anastomoses feeding into the venous plexi of the skin. This changing of blood flow affects core body temperature as heat is then lost from the body by radiation, a composite of conduction whereby heat is lost into anything the body touches (for example, a chair or bed), and is thus self-limiting, and convection whereby heat is removed as the surrounding air circulates. Heat is consequently lost through evaporation: 0.58 kilocalories of heat are lost for each gram of water that evaporates. It is therefore important to cover any parts of the body not directly involved in the massage or that are awaiting massage, to avoid excessive heat loss during a treatment session.

The first thing to be noticed by the massage student when touching the skin is that it is usually soft and, in most parts of the body, smooth. This top outer layer which can be touched is the *epidermis*, the epithelium of the skin. It consists of keratinised, stratified, squamous epithelium which is arranged in five laminae according to their cell type (Fig. 2.1). These five layers are arranged in two zones: the deeper is known as the *zona germinativa*, a single layer of columnar cells, and the more superficial zone is the *stratum basale*. Terminology, however, varies between anatomists and biologists (Thibodeau & Patton 2007). Cells are continuously being lost from the surface and replaced from the deeper layer.

This natural process occurs constantly, but certain events will speed it up. Friction on the skin, for example, caused by the clothes when dressing or during massage, results in desquamation. Massage will often remove the top layer (stratum corneum), which is readily replaced. This occurs when skin may be seen to ‘rub off’ or may be left on the treatment plinth following treatment. This is a normal and painless process. It tends to be excessive if the skin is very dry or visibly flaky (following removal of a plaster cast, for example) and can be reduced by the application of an oil-based lubricant. In severe cases, a soap and oil solution is particularly beneficial. The epidermal cells become gradually flatter and more keratinised as they move to the surface—more than 90% of epidermal cells are keratinocytes (Thibodeau & Patton 2007). Keratin, a protein, is important for hydration of the skin. Dry skin has reduced water content and the keratin allows swelling when the skin is wet. This is useful information to have when selecting the appropriate media for massage: the choice of oils, creams or talcs should be based not only on the type and purpose of massage but also on the individual skin quality. Keratin provides protection, and skin that has been soaked and has a whitened, wrinkled appearance should not be massaged as the effects of treatment on the superficial layer will be difficult to predict and monitor.

The *dermis* lies beneath the epidermis and forms most of the skin thickness. Whereas the epidermis is composed mostly of cells, the dermis contains collagen and elastin fibres, which give the skin its mechanical properties. The dermis is flexible and varies in thickness from the dense layer on the soles of the feet to the thin layer of the eyelids. It is composed of connective tissue (see below) arranged in two layers: the papillary layer is superficial to the deeper reticular layer.

The more superficial papillary layer of the dermis connects the epidermis with the dermis. Tiny conical projections, the papillae, project into the undersurface of the epidermis. These are sensitive and vascular, and range from being sparse to lying in dense lines which are seen as ridges on the surface of the skin, for example on the pads of the fingers and toes. They create friction for gripping and are used for fingerprint identification.

The reticular layer contains mainly thick collagen fibres (for strength) interspersed with reticular and elastin fibres (the latter for stretch and pliability) which form a tough interwoven layer. The directional lay of the skin in different parts of the body results from some of these fibres lying parallel to the skin surface. Skin is always under tension and the lines along which this tension lies are known as Langer’s or Kraissl’s lines (Fig. 2.2). They are important because they dictate the natural variation in tension when the skin resists movement and when it heals. If a cut in the skin follows the tension lines, scarring will be minimal as there will be minimal stress on the wound—an important principle utilised by surgeons. The fibroblast cells (which secrete the precursor for collagen) and phagocytes, important in immune defence mechanisms, are found in this layer.

The wrinkling in the skin around the nipple and scrotum is caused by the presence of smooth muscle fibres in the dermis. Stretch marks (striae gravidarum) follow partial rupture of the fibres of the

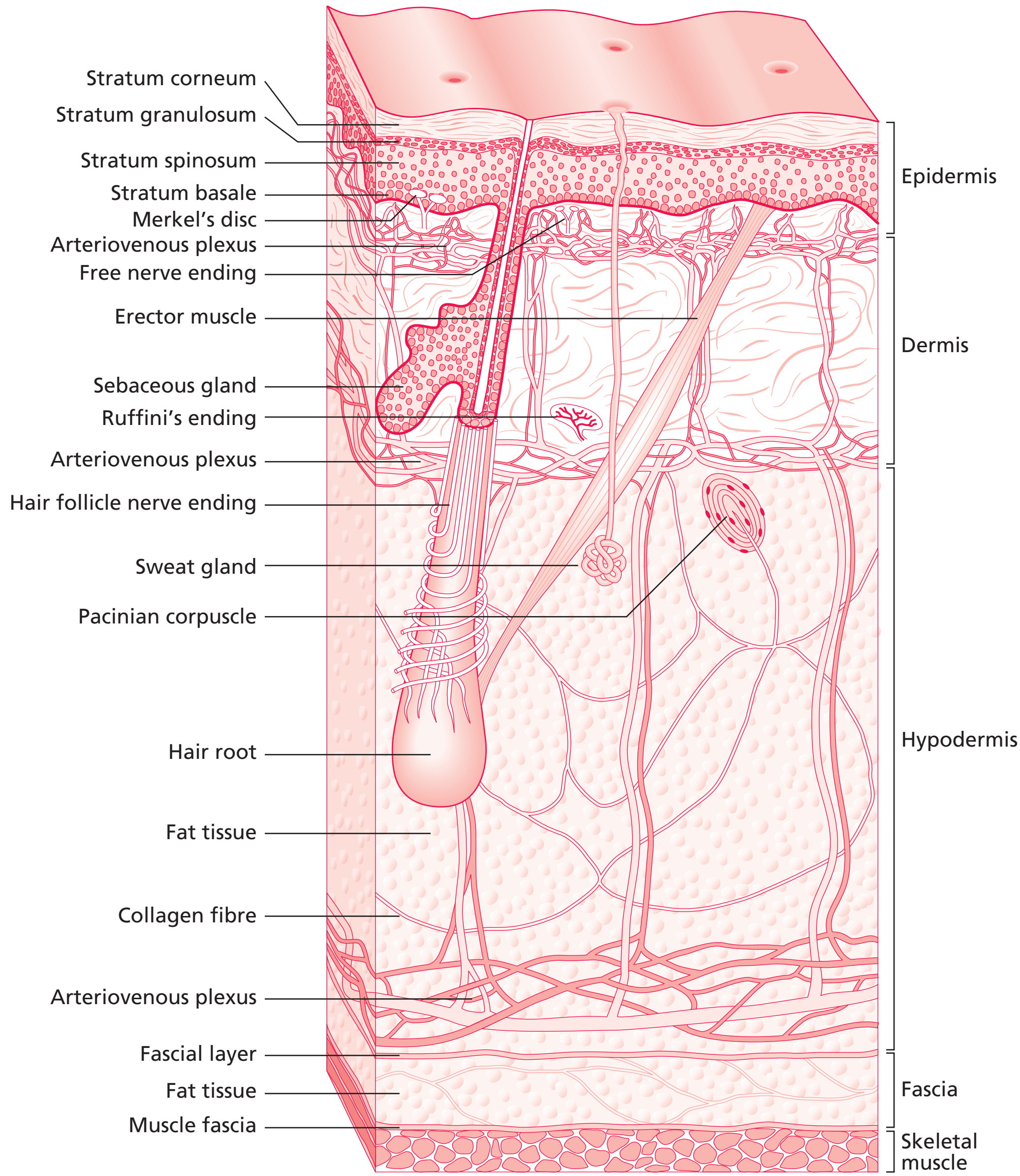

Figure 2.1 • Layers of the skin and circulatory plexi. Reproduced, with permission, from Holey (1995). Originally published in Schuh I 1994 Bindegewebsmassage. Fischer-Verlag, Stuttgart.

reticular layer. It is commonly thought that this follows stretching of the skin in pregnancy, or fat deposition. This does not explain the common occurrence of these marks in thin people or the nulliparous, often on or above the sacrum, which could indicate weakening of the dermis due to the action of hormones or disease. As these marks show some fragility of the tissues, care should be taken when handling them. In particular, this tissue should not be overstretched by manipulation, to avoid possible further rupture of fibres and more extensive marking.

Circulation in the skin

Blood supply to glabrous (non-hairy) skin is maintained by arteriovenous anastomoses, found in the deeper layers of the dermis. They are surrounded

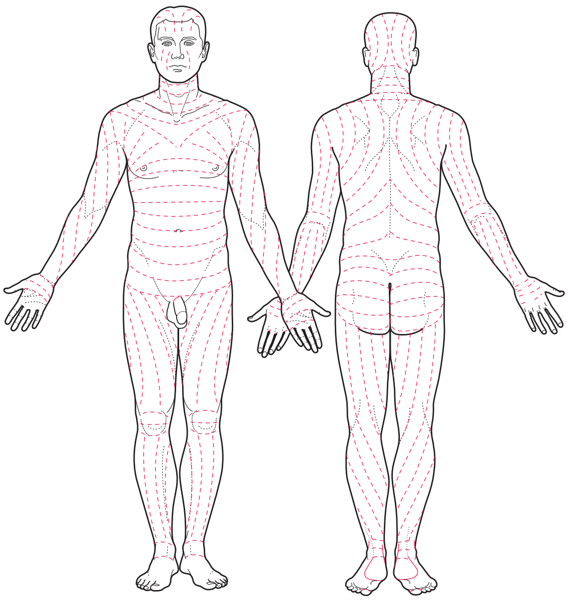

Figure 2.2 • Tension lines of the skin. Reprinted from *Anatomy: regional and applied*, Last (1984), with permission from Elsevier.

by smooth muscle, the glomera, which maintain blood supply to the skin, despite variations in blood flow due to vascular responses aimed at maintaining body temperature.

Blood vessels within skin are found lying in and running between three flat horizontal plexi, as shown in Figure 2.1. Here, it can be seen that small arteries pierce the superficial fascia and form a horizontal plexus known as the *rete cutaneum* at the interface between the dermis and superficial fascia. It gives off vessels to supply the adipose tissue, glands and follicles. Some vessels reach the junction between the reticular and papillary layers of the dermis where they form another flat plexus, the *rete subpapillare* or *superficial plexus*. From here, capillaries supply the dermal papillae before travelling back to the venous plexus immediately below the superficial plexus, draining into the flat *intermediate plexus* in the middle of the reticular layer of the dermis which connects to the *deep laminar venous plexus* at the dermis–superficial fascia junction.

As the vessels tend to lie in plexi at the different interfaces of skin, movement in the form of manipulation *between* layers will influence the circulation. Capillaries running *through* the layers will be similarly influenced by gross movements of the tissue as a whole. This is discussed in more detail in Chapter 3.

Subcutaneous tissue

The layer of connective tissue under the dermis is adipose (fat) tissue and may be termed the hypodermis or subcutis. It is a layer of superficial fascia in which fibres from the reticular layer of the dermis extend to lie in bundles between fat lobules, giving it its sometimes characteristic appearance. It varies in density and thickness in individuals; for example, it is generally thicker in women than in men, and varies in different parts of the body. This layer is important in that, apart from its insulating properties, it gives mobility to the skin. One of the effects of massage is that it maintains or restores this mobility, particularly at the tissue interfaces. The sliding of the layers on each other can easily be felt.

Innervation of the skin

Skin has an important sensory function, which gives it a role in communication, reproduction, protection and coordinated movement. Responsibility for this is held by the many nerve endings responsive to sensory information. This is transmitted along nerves of the peripheral nervous system to the central nervous system, where it is interpreted and a response is made. The area of innervation of any one nerve fibre varies considerably, with overlap between the receptive fields of two adjacent nerve fibres. In the fingers, for example, each single fibre supplies a small area of skin. This is accompanied by a low sensitivity threshold and a high degree of spatial localisation. This means that the nerve is easily triggered by sensory stimuli and the brain can pinpoint the location of the stimulus very precisely. This high degree of sensitivity is particularly marked on the lips and external genitalia. On an area such as the back, however, a single nerve fibre will supply a larger area of skin, the nerve has a higher sensitivity threshold and the brain is less precise in its spatial localisation.

These nerves penetrate the superficial fascia and ramify through the dermis. They lie in plexi in the papillary layer of the dermis and around the hair follicles. The nerve endings are predominantly myelinated and non-myelinated 'free' nerve endings found in the dermis and lower parts of the epidermis. They monitor temperature and some pain. In addition there are specialised end-organs which include:

- Merkel discs which respond to *shear* forces and *vertical* pressure: this stimuli is magnified by hair follicles and structural ridges grouped into Iggo dome receptors, on the underside of the epithelium;

- Meissner's corpuscles, found in the dermal papillae: these are rapidly adapting mechanoreceptors which are responsive to *mechanical deformation*;
- Pacinian corpuscles in the deeper layers of the skin and superficial and deep fascia: they are innervated by a single axon only, and respond to a narrow range of *vibration* frequencies and rapid changes within the tissues; and
- Ruffini's corpuscles in the deeper dermis and hypodermis respond to stretch: they have an important tactile function.

The endings show specificity as a result of their differential sensitivities, and interpretation of the modality of sensation is due to the location of their termination in the brain. The endings listed above are those which have most relevance to massage. They are stimulated by mechanical deformation which stretches the membrane, thus opening the channels through which ions pass to depolarise the nerve fibre. The Meissner's corpuscle consists of a central nerve fibre surrounded by terminal nerve filaments within an elongated capsule. The construction of the Pacinian corpuscle consists of a central nerve fibre surrounded by capsular layers (Fig. 2.3). The fibre is distorted in various ways by compression of any part of the capsule. The fluid in the corpuscle immediately redistributes so that the deformation is no longer transmitted to the central fibre until the force is removed. Thus, repetitive forces rather than continuous ones will affect the nervous system more strongly; this demonstrates the importance of the continuous movement in massage.

Sensory stimuli are carried in nerve fibre types II (type A β and γ), III (type A δ) and IV (type C), which are the smaller, slower conducting types. The stimulus enters the spinal cord via the dorsal horn and diverges or converges via neuronal pools. It passes to the brain either (1) through the dorsal column, crossing to the opposite side in the medulla, to the medial lemniscus and the thalamus, or (2) by crossing to the opposite side of the spinal cord, passing through the anterior and lateral white columns to the brainstem and thalamus. The former is for rapid, sensitive transmission of sensation and the latter for a slightly cruder response. The thalamus relays the sensory information to the cerebral cortex for localisation, interpretation and controlled response.

The epidermis and dermis filter mechanical and thermal stimuli, which attenuate in different ways as they are transmitted through the layers. This is probably because different stimuli need to be strongest at specific depths in order to have maximum impact on sensory end-organs.

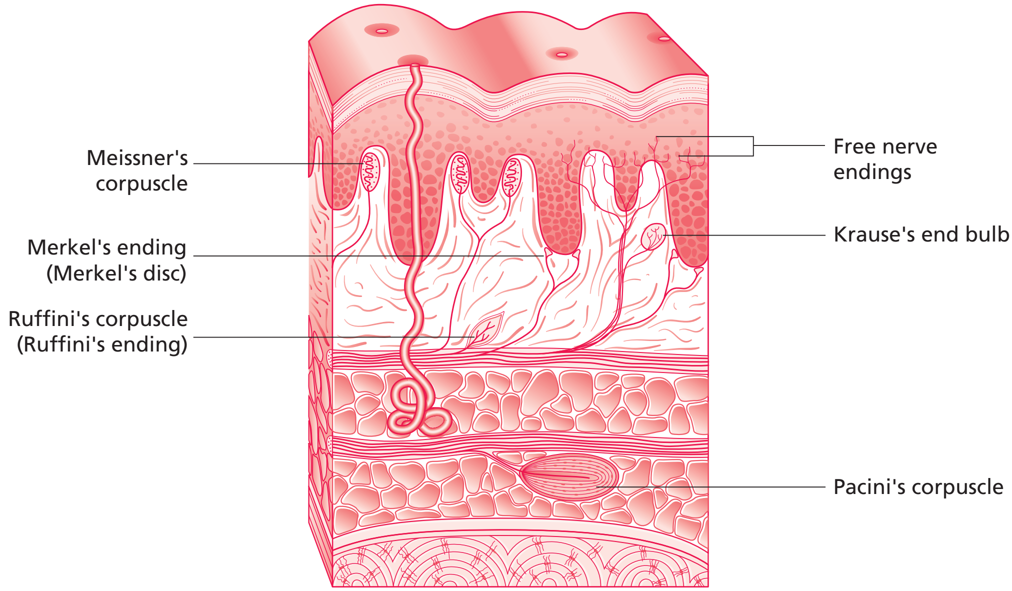

Figure 2.3 • Somatic sensory receptors - exteroceptors. Reprinted from *Anatomy and Physiology 6e*, Thibodeau & Patton (2007) with permission from Elsevier.

Connective tissue

Skin is a type of connective tissue. The connective tissue that lies *under* the skin is important as a base for providing attachment to skin, providing both anchorage and mobility. These tissues are all formed from the embryonic mesoderm (middle layer) and all are basically composed of the same constituents. The presence of specialised cells, or an alteration in the predominance of any constituent in a particular tissue, ensures that the different connective tissues are adapted and well suited to their purpose. Thus, the appearance and properties of the different connective tissues vary significantly. They range from fascia, ligament and tendon to specialised types including cartilage and bone.

The cells of connective tissue lie within a matrix formed by fibres lying in ground substance. The fibres are collagen, reticulin and elastin fibres, the first offering resistance to stress while the last allows for stretch. There are more than ten types of collagen.

Fibrillar collagen types I and III are the most relevant here, being found in tendon, skin, ligament and skin vessels. These types have the greatest stiffness (see below). The ground substance is composed of water and organic molecules, predominantly glycosaminoglycans (GAGs). These molecules have water-binding properties and are responsible for the amount of water present in the tissue. This gives them a role in the diffusion of molecules through the tissue, notably incoming nutrients and outgoing metabolites. They are also important for communication between cells and for their adhesion to collagen. Their structure makes them springy and so able to absorb shock. This mechanism is enhanced by their being held under tension by the surrounding collagen fibres. In a specialised connective tissue such as cartilage, this springiness allows compression when weight-bearing and restoration of shape when the weight is removed. In the superficial tissues, these molecules allow take-up or removal of liquid, which appears to be partly under hormonal control. Skin, therefore, can be 'dry' or well hydrated, terms that refer to the skin itself rather than its surface. This can be palpated as a change in consistency and loss of compliancy of skin and is different from the presence of fluid in the tissue spaces, which gives the skin a 'spongy' feel. Hyaluranon has a role in hydration and enables gliding movement within the tissue (Culav et al 1999).

The cells of connective tissue are:

- Fibroblasts: synthesise collagen and reticulin, important in repair;
- Macrophages: phagocytic;
- Plasma cells: produce antibodies, present in large numbers in pathological states;
- Mast cells: in loose connective tissue, release inflammatory agents of histamine, serotonin, heparin;
- Fat cells: mobilisation of the contained fat is under nervous, hormonal and chemical control; and
- Pigment cells (chromatophores): in the corium, contain melanin.

Biomechanics of connective tissue

The main constituent of connective tissue is the protein collagen, the function of which is to resist axial tension and which has been shown to exhibit standard stress–strain behaviour. Collagen is derived from its precursor procollagen, synthesised by the fibroblast. Procollagen becomes tropocollagen, which in turn forms microfibrils. Under the electron microscope, collagen fibres are seen to be arranged in bundles and have a crimped appearance, thought to be due to molecular attachment. There are several types of collagen. Type I collagen (in dermis and fascia) consists of three polypeptide chains, coiled in a left-handed helix; these helical chains are coiled together in a right-handed helix. This type gives resistance to tension and provides filtration and support. The basal lamina of epithelia contains type IV collagen, which synthesises epithelial cells. Hydrogen cross-links are formed between chains, and also between molecules, giving stability at fibril level and between fibrils, assisting in the formation of collagen fibres. They allow the tissue to function under mechanical stress.

The orientation of fibres depends on the stresses to which the fibre is subjected. Connective tissue needs to be pliable yet very strong. The stress–strain behaviour of biological materials may be demonstrated by a *stress–strain curve* (Fig. 2.4). These have been plotted for various types and constituents of connective tissue, the exact behaviour differing slightly in each:

- Stress = force applied per unit area; and
- Strain = proportional elongation.

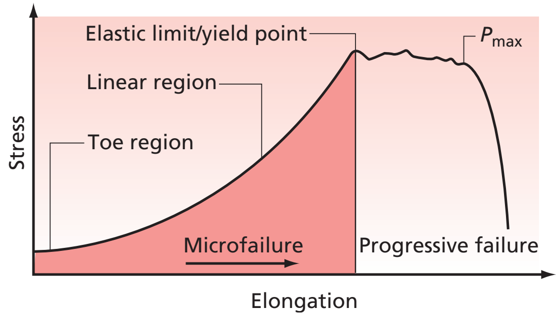

Figure 2.4 • Typical stress–strain curve for connective tissue. Stress = force applied per unit area; strain = proportional elongation; P_{max} = maximum load point.

When longitudinal stress is applied, the tissue responds firstly by elongation. This occurs in the *toe region* of the curve and is thought to be due to a straightening out of the crimping in the fibres. It may also be due to some interfibrillar sliding and shear of ground substance which flows between the fibres. Stress and strain are linearly proportional up to the *proportionality limit*. Elongation that occurs in this region will not be permanent. The *elastic limit* is the point to which maximum stress may be applied without permanent deformation. As the loading continues, a greater force is required to increase elongation. This is due to the fact that the tissue becomes stiffer.

Schliep, Klingler and Lehman-Horn (2005) have found that, during an initial isometric stretch, fluid is extruded which returns when the stretch is removed. This will affect the apparent stiffness of the tissue and also indicates that tissue fluid is refreshed and renewed during massage.

The next part of the curve is the *linear region*. Microfailure begins to occur in some of the fibre bundles, but the tissue retains its external appearance of continuity. The end of the linear region is known as the *yield point* of the tissue. Here, elongation (or yielding) can occur without a corresponding increase in load. Once beyond this point, major failure of fibre bundles occurs. The external appearance changes, and the smooth outline is lost; this is termed 'necking'. The same effect is seen, for example, when an elastic band is overstretched or becomes overused and its width changes and appears uneven. It loses strength but still has gross continuity. When the *maximum load point* is reached at P_{max}, complete rupture occurs. Its position on the curve designates the rupture strength.

Most changes that occur as a result of massage are in the toe region of the curve. The therapist should take care not to overstretch the tissues, thereby causing damage to the internal structure of connective tissue fibres. Each massage student should learn to be sensitive to the 'end-feel' of the tissues (see Chapter 5). Any permanent deformation is termed *plastic* and occurs with microfailure—breakage of cross-bridges. These are molecular bonds which bind adjacent fibres together. When lengthening occurs, the bonds are broken; they then re-form further along the fibres, enabling the fibres to reposition themselves in relation to each other, resulting in increased length of the tissue. The undamaged fibres absorb a greater proportion of the load as a new length is established, which reflects the balance between elastic recoil and the resistance of the water and GAGs to compression.

Biological materials also have viscosity, a property of fluids of resistance to flow, and elasticity, a property of solids. They are therefore said to be *visco-elastic*. The response is dependent on how quickly the load is applied or removed (regardless of the size of the strain). The quicker the repetitive loading and unloading occurs, the stiffer the material becomes, as there is less chance for the ground substance to flow between fibres. This continuous loading and unloading causes friction and a rise in temperature, as energy is dissipated as heat when the tissue is returned to its original length. This quality is known as *hysteresis*. Consideration should be given to the speed at which massage is undertaken and the therapist should be sensitive to how stiff the tissues feel. If an increase in tissue mobility is aimed at, the progression of treatment should be partly dictated by this stiffness and the rate at which any lengthening is felt to occur.

If a low constant or repetitive *load* is maintained over a long period, the elongation is by *creep*, whereas if the *length* is held constant, elongation occurs by *relaxation*. Excess fluid in the tissues which remains for a long period of time, for example in chronic oedema or lymphoedema, will stretch and produce a creep effect on the surrounding tissues and they will not be restored to their original shape following removal of the fluid. This is important as connective tissue helps to maintain the fluid pressure in the tissue spaces. If the pressure reduces, due to stretching of connective tissue as a result of creep, the pressure within the vessels may be comparatively greater and external pressure must be applied to prevent swelling. For example, pressure stockings or sleeves may be worn to maintain the beneficial effects of oedema massage.

Massage produces low repetitive load over the medium term and may cause a non-permanent creep response. Biomechanical study of connective tissue indicates that the quicker tissue is loaded, the stiffer it becomes owing to its visco-elastic properties. Dry tissue produces more friction, and is known to lose compliance, elongating less readily than when the tissue has good water content. Thus, the rate of massage should be suitable for the type and condition of the tissue.

It is known that connective tissue initially responds to stretch with an increased stiffness (Yahia et al 1993) thought to be due to the presence of contractile cells, but this response has not been fully understood until recently. Schleip et al (2005) found this to be due to changes in matrix hydration. Myofibroblasts have recently been found in fascia (Schliep et al 2006). These are contractile and it has been demonstrated experimentally that they respond to pharmacological agents, notably mepyramine (a antihistamine), whose effects can last for up to two hours. Histamine and oxytocin have a lesser effect in that the contractile response is shorter lasting. A nitric oxide donator triggered brief relaxation in some tissue samples. The same research team found that approximately 50% of the tissue bundle samples exhibited a stronger resistance force in response to 5% isometric strain and this lasted for up to 45 minutes (Schliep et al 2005, 2006). These findings are of considerable interest in explaining some of the phenomena felt by the therapist when handling tissues.

Goldfarb et al (2001) compared the effects of low- and high-force rehabilitation on collagen synthesis and extracellular matrix maturation in sutured intrasynovial flexor tendons in dogs. They found that higher force rehabilitation did not accelerate healing, as no changes were seen in the biomechanical composition of the healing tendon over a period of 6 weeks. This suggests that there is no advantage in applying heavy stresses to the tissues in relation to healing speed.

The implications of tissue biomechanics in the different phases of healing are discussed later.

Fluid system dynamics

The therapist must be able to recognise subtle changes in the fluid content of the tissues. One of the first things she notices when performing any form of deep massage in the tissues is that the fluid balance between the circulation and the tissue spaces changes, sometimes rapidly. To understand how the squeezing, pulling and stretching manipulations affect the tissue fluid, it is necessary first to examine tissue fluid dynamics.

The fluid of the body serves to transmit nutrients and to bathe structures, ensuring that the correct chemical and electrolyte balance is maintained around the cells. In some instances this is crucial—around the heart, for example, which cannot function correctly without its muscle cells being bathed in a perfect balance of electrolytes. It may appear, simply, that newly oxygenated blood is pumped from the heart and carried in the arteries, arterioles and capillaries (in order of descending size) and, when deoxygenated, returns for replenishment via the capillaries, venules and veins. However, the mechanism by which specific components of the blood flow into and out of the tissues, and maintenance of the delicate balance of fluid inside and outside the tissue spaces, warrant closer examination.

Fluid movement occurs either by diffusion or osmosis along concentration gradients or by flow along pressure gradients. In diffusion or flow, water flows down the gradient, from an area of high concentration or pressure to one of lower concentration or pressure. However, in osmosis, water flows up the gradient, towards the side of the most concentrated solute. This physiological concept of functional gradient is an attempt by the body to achieve balance and uniformity. So, when two non-uniform areas exist, in either concentration or pressure, fluid will move to try to level them out.

After fluid has been filtered by the capillaries, it returns to the circulation by the venous end of the capillary loop. A small proportion is returned via the lymphatics. There are two key areas involved in maintenance of tissue fluid balance: the capillary loop and its surrounding environment, and the lymphatic vessel. The capillary loop has an arteriolar end and a venule end. This demonstrates that both sections of the blood vessel network are, in fact, continuous and the moment at which blood *coming from* the heart becomes blood *going to* the heart depends on a subtle pressure change.

The important mechanism by which equilibrium of fluid within the blood vessels and tissue spaces is maintained was first described by Starling. It is the mechanism by which the inherent leakiness of the capillaries through their semipermeable membranes is counteracted to maintain the volume of circulating plasma.

To understand these pressure changes, it is necessary to examine the blood, which is composed of plasma (clear liquid containing substances in solution or suspension), red and white cells, and plasma proteins (such as prothrombin and fibrinogen). Nutrients, for example oxygen, enter the tissue spaces from the bloodstream by diffusion, until concentration gradients are equal on both sides of the capillary wall. Plasma proteins are too large to leak out of the tiny pores in the capillary vessel walls and therefore create a pressure (known as osmotic pressure) inside the vessel. If you imagine liquid flowing into an empty vessel, its ease of passage will depend on the relationship between the quantity of liquid and the size of the vessel. If the vessel contains large particles, this effectively reduces the space available for the liquid to occupy and increases the pressure inside the vessel. This is exactly the effect of the plasma proteins. In some situations, they are able to leak out into the tissue spaces when the vessels dilate, which causes the pores in the vessel walls to increase in size. Adipose tissue contains type I capillaries which have uninterrupted membranes with 'pores' in them. The pressure from the fluid itself is known as the hydrostatic pressure. It is slight outside the vessel, but greater inside owing to the pumping of the heart. This pressure is opposed by the osmotic (or colloid osmotic, or oncotic) pressure, which is a reabsorption pressure resulting from the fluid itself which forces fluid back in the vessel. If the osmotic pressure inside the vessel and the hydrostatic pressure outside the vessel are equal, then fluid flow will not occur. In reality, at the arterial end of the capillary loop, the net result of these different pressures tends to produce an outward force, moving fluid into the tissue spaces. However, at the venous end of the capillary the net pressure tends to move fluid into the capillary, thus maintaining normal balance (Fig. 2.5). The development of oedema and its implications will be discussed subsequently. These pressures can be influenced by compression or movement of the tissue, as in massage, and natural pumping mechanisms can be enhanced mechanically in this way.

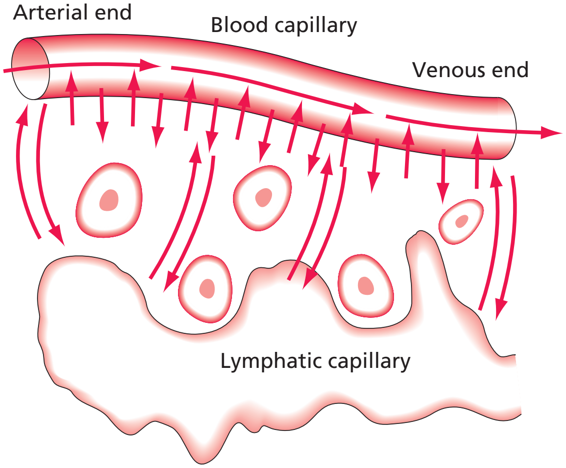

Figure 2.5 • Diffusion of fluid and dissolved substances between the capillary and interstitial fluid spaces. Reprinted from *Textbook of Medical Physiology 8e*, Guyton (1991) with permission from Elsevier.

The lymphatics

The pressure in loose subcutaneous tissue is negative, maintained at −3 mmHg as a result of the pumping action of the lymphatics. One-tenth of fluid is removed via the lymphatics rather than the venous end of the capillary. Proteins and other substances of higher molecular size that leak into the interstitial spaces cannot return into the capillaries because of the adverse concentration gradient, and must return via a different route—the lymphatic system. If massage is to enhance this effect and improve this system, it needs to be employed in the correct way; thus an understanding of the lymphatics is necessary for successful massage.

The lymph system mirrors the vascular system in structure. Tiny lymph capillaries have blind endings in the tissue spaces which drain into veins. They form a mesh-like system in the tissue spaces, and are slightly larger than vascular capillaries. They are composed of a single layer of endothelial cells, the basement membrane often being absent. The capillaries unite to form larger vessels and have a coating of connective tissue outside the endothelium. The larger collecting trunks resemble small veins structurally, with smooth muscle present in their walls, which is important for the transmission of fluid. Unidirectional flow is maintained by the presence of semilunar, paired, one-way valves, which are found in higher numbers here than in veins (Fig. 2.6).

The movement of lymph occurs via the following chain of events. Filtration pressure in the tissue spaces is caused by filtration of fluid from the vascular capillaries. The surrounding muscle pump effect compresses lymph vessels and lymph moves as directed by the valves. Flow is enhanced by respiratory movements, particularly inspiration, creating a

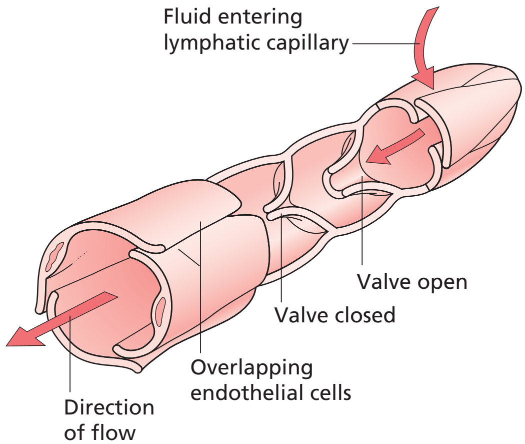

Figure 2.6 • Structure of a typical lymphatic capillary. Reprinted from *Anatomy and Physiology 6e*, Thibodeau & Patton (2007) with permission from Elsevier.

negative pressure in the brachiocephalic veins, the pumping effect of muscle contraction and possibly arterial pulsing. Sympathetic stimulation causes contraction of the smooth muscle in the vessel walls, particularly near the valves. The endothelial cells of the lymphatic capillaries are attached, by anchoring filaments, to the surrounding connective tissue. When fluid enters the tissues they swell and the anchoring filaments pull the capillary open, allowing fluid to flow between the cells. This effect can also result from the mechanical deformation that occurs during massage. The overlapping cells produce a valve-like effect by which fluid can flow in, but not out, as the back-pressure closes the flap. The rate of flow is determined by the interstitial fluid pressure and lymphatic pump activity.

The factors increasing lymphatic flow are:

- Increased capillary pressure;
- Reduced plasma osmotic pressure;
- Increased interstitial fluid pressure; and
- Increased capillary permeability.

When interstitial fluid pressure reaches a little above atmospheric pressure (0 mmHg), lymph flow fails to continue rising, probably due to fluid compressing the outer surfaces of the larger lymph vessels, impeding flow (this is why massage should be directed proximally). The lymphatic capillaries empty into collecting lymphatics. The vessel stretches with increased volume of fluid, and the smooth muscle in the walls of the vessels contracts (Starling's law). This effect is particularly marked immediately proximal to the valves, and so pumps fluid through the proximal valve. Thus, pumping is increased by the compression of the vessel (Guyton 1991). A pumping action is also exerted by actomyosin in the capillary end cells.

The lymph nodes are small oval structures composed of a collagenous capsule and an interior trabecula. Within this framework is a fine reticulum within which many lymphocytes are embedded, with fewer macrophages and reticular cells (littoral cells). Blood vessels and the efferent lymph vessel enter and leave the node at the hilum, while afferent lymph vessels enter it around the periphery. Points at which the reticulum is loose, relatively cell free, and where lymph flows freely are termed lymph sinuses. Within the cortex, collections of cells are termed lymphatic follicles, or nodules, and contain germinal centres.

Lymphatic fluid is transported from the tissue spaces to the nodes where it passes in close proximity to a range of phagocytic cells. The large surface area of the node's interior ensures that numerous cells are available. Micro-organisms and foreign bodies are removed from the bloodstream here, to be processed by the lymph glands, and certain cells and proteins are returned via the lymphatics. The lymphatics assist in reducing the threat of toxic spread throughout the bloodstream; however, they also provide a channel for the spread of infection or malignancy.

Fluid eventually returns to the bloodstream via the thoracic duct, which extends from the twelfth thoracic vertebra to the root of the neck. It passes through the diaphragm and travels on the posterior mediastinum to the neck, where it drains into the left subclavian and internal jugular veins. At the base of this duct is the cysterna chyli, which extends down to the first lumbar vertebra. It receives the right and left lumbar and intestinal lymphatic trunks, which in turn drain the lower limbs, pelvis and abdomen, respectively. In addition, drainage from the intercostal trunks, the left jugular trunk draining head and face, and the left subclavian trunk draining the upper limb, join the thoracic duct. The right lymphatic duct receives drainage from the right jugular trunk, the right subclavian trunk and the right bronchomediastinal trunk. Most drainage from the head and neck enters the deep cervical (superior and inferior) group of nodes, which in turn drain into the jugular trunk. There are also minor groups draining particular areas. Figure 2.7 gives a summary of drainage and shows the position of the nodes.

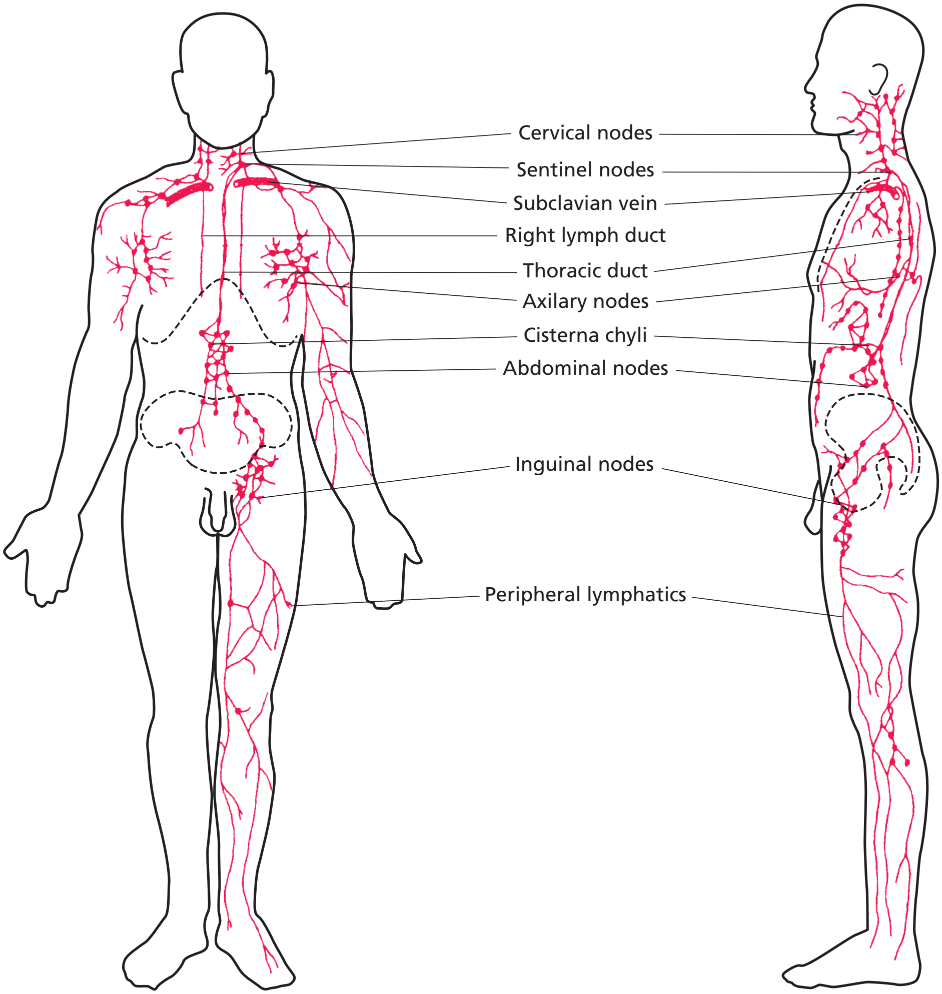

Figure 2.7 • Main lymphatic channels and glands. Reprinted from *Textbook of Medical Physiology 8e*, Guyton (1991) with permission from Elsevier.

Lymph drainage from the skin occurs by a system of overlapping skin areas. The tiniest vessels are known as precollectors; they drain from several skin areas into a collector in the hypodermis. The skin area of one collector is a strip of skin—a 'skin zone'. The zones of a single lymph vessel bundle have been termed a territory (Kubik & Manneston 1984). The borders of these territories are known as lymphatic watersheds as there is normally no functional connection across watersheds, although they anastomose with each other.

As lymph drains into a single duct in a proximal direction, it is important that any attempt to increase this drainage mechanically occurs in the same proximal direction. A lymphatic system that is blocked with fluid anywhere on its course will necessitate that extra mechanical drainage occurs in the trunk, to clear an area into which the more distal fluid can drain. This is discussed in more depth in Chapter 11.

Muscle tone

Massage can also affect skeletal muscle. A healthy muscle is always in a certain amount of resting tone, which is a response of the muscle fibres to nervous activity; this maintains the muscle in a state of slight, normally imperceptible, contraction. Tone can be increased, especially in postural muscles, by factors such as stress or cold. This is probably, in part, due to the fact that muscle spindles have a sympathetic innervation (Barker & Saito 1981). Tone is dependent on interaction between the muscle spindle (sensitive to length and rate of change in length of muscle) and the central nervous system. Stretching a muscle will stimulate the spindle and cause reflex muscle contraction, while reflex inhibition of the antagonist occurs. Massage can add an external stimulus to sensory organs and either increase tone by stimulation or reduce it, probably by facilitating an accommodation of the spindle, causing it to 'reset' at a lowered threshold of excitability. The sympathetic supply to muscle spindles means that any influence on the autonomic nervous system will affect muscle responses. Massage techniques which have a general relaxation effect, as well as local massage, will therefore change muscle tone.

Conclusion

It is important for the massage therapist to understand the effects of massage on the different body systems. The structure and function of the skin, how it is nourished with blood and the way in which fluid and fibres behave must be understood before the effects of massage can be explored. The mechanisms by which muscle tone is maintained and influenced are pertinent, as are the transmission and interpretation of touch and other types of sensation. Only by a full understanding of these factors can the therapist work autonomously and make effective and informed clinical decisions.

Key points

- Horizontal arteriovenous plexi lie at the skin interfaces and can be influenced by massage.
- The dermis gives a mobility to the skin which can be maintained or restored by massage.
- Fibres in the tissues can be overstretched beyond their elastic limit, causing damage.
- Failure of fibre bundles occurs beyond their yield point. This can be prevented by not stretching tissue beyond its end-feel.
- Massage principally works within the elastic limit of the stress–strain curve.
- Massage provides a low repetitive load over the medium term and may create a non-permanent creep response by which the tissue is temporarily elongated.
- Massage should not be done too quickly, to avoid a stiffening of connective tissue, as a result of its visco-elastic properties.
- 'Dry' tissue should be massaged more slowly as more friction will be produced between collagen fibres.
- The effectiveness of the venous system can be enhanced, to aid removal of excess tissue fluid, by increasing its pumping effects with massage.
- Lymphatic drainage can be increased by a pumping effect and a pulling on the filaments, which open the gaps between cells in the walls of lymphatic vessels.
- The muscle spindle can be stimulated or caused to accommodate by massage, producing a change in muscle tone.

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Therapeutic and reflex effects

3

CHAPTER CONTENTS

It is clear that people like massage. The frequency with which individuals casually touch each other, their children and their pets demonstrates that touch is comforting and is an automatic reaction to another's distress. It is also clear from the increasing willingness of large numbers of people to pay for massage regularly, and their response when receiving it, that it is perceived to be valuable by many individual recipients. Identifying with authority the specific therapeutic effects attributable to massage itself is, however, difficult. There are many postulated effects which are widely believed and documented throughout the massage literature. Unfortunately, not many have yet been substantiated scientifically.

The aim of this chapter is to discuss the accepted effects, passed on through the oral tradition and literature of physiotherapy and, more latterly, of massage therapy, and examine them in the light of the underlying pathophysiology and available research findings.

An interesting starting point is the widespread popular belief that massage can 'break down' fat tissue and reduce its bulk. Perhaps, as therapeutic massage becomes more popular, this belief is becoming less well promulgated as there is neither convincing evidence nor a plausible theoretical basis for it. Fat is stored as triglycerides in liquid form and held in globules within the cells themselves (Guyton 1991). It is liberated into the bloodstream by enzymatic activity in response to energy demands, to be utilised as a metabolic and biochemical event. A passive mechanical manipulation of the storage area cannot affect the cells in the same way. The fat cells are collected together and compartmentalised by fibrous septa, each compartment having its own blood supply (Williams et al 1989). If the fluid balance within this tissue alters and the collagen fibres become tight, the subcutaneous tissue loses smoothness in outline and takes on a characteristic 'cellulite' appearance. It appears to worsen under the influence of the autonomic nervous system (ANS). It may be unevenly distributed, for example where there is nerve root irritation.

Manipulation which alters the fluid balance in this layer and restores mobility and length to the fibrous tissue may change its appearance, but this is in no way due to reduced fat *content*, rather a surface smoothing-out effect. Possibly, toxins are removed as the tissue fluid is replaced with new protein-free fluid fresh from the bloodstream. Clinical experience shows that massage can indeed improve the appearance and mobility of the subcutaneous tissues as the circulation is improved and mobility restored, especially techniques such as manual lymphatic drainage and connective tissue massage. However, clients should not be misled into believing that massage can replace a reducing diet, should they wish to lose weight.

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There have been many effects claimed for massage, and examination of massage texts reveals that authors vary somewhat in their opinions, and few rigorously support the claimed effects with research findings. It is necessary, then, to examine which of these effects are likely, in the light of the previous chapter on the pathophysiology underpinning therapeutic massage, in order to progress thinking and debate in this therapeutic area. We start by logically following through the layers of tissue as they are affected by massage, before summarising the likely effects; these are later compared with research findings.

Events in the tissues

The first events begin on the surface of the skin, when it is touched. It is now widely accepted that human touch is a prerequisite for the healthy functioning of the individual. At the same time, in the area of health care, prolific technological advances are decreasing our opportunities for physical intervention. In addition, Western culture is largely moving away from physical activity towards seated activities, such as those involving computers or performing arts entertainment with the result that many are losing the ability to integrate body and mind, suffering consequently from a lack of sensory unity. Touching and being touched is a basic human need but there is little opportunity outside of families to express or receive feelings of care by touching. This situation is magnified for many elderly people and those residing in an institutional care environment. Massage can offer valid human contact to counterbalance the potentially dehumanising effects of tactile deprivation.

The anatomy and physiology of touch receptors and their interaction with the central nervous system (CNS) were discussed in Chapter 2. We know and understand a great deal about the mechanisms of touch; what is less clear is how the physical phenomenon of touch affects our moods, emotions and levels of autonomic, cortical and behavioural arousal. Knowledge of this would enable us to predict the responses that might occur as a result of any tactile intervention.

The sense of touch is one of the earliest senses to develop. The human embryo has been observed to withdraw reflexly from stroking stimuli at 6 weeks after conception (Montagu 1978). Preterm infants have been observed not to tolerate massage but to prefer 'containment', that is, holding or cuddling, which is thought not to stimulate developmentally uninhibited reflexes (Hartelius et al 1992). Containment may be perceived by the infant as a similar stimulus to the pressure exerted by amniotic fluid in the uterus. However, a later study (Field et al 1986) found that not only did preterm infants tolerate massage, but they showed increased weight, alertness and maturity. Further work by this team (Diego et al 2007) has shown that massaging preterm infants results in short-term increased vagal activity and gastric motility which could explain the increased weight gain. Mendes and Procianoy (2008) found that massage given by mothers four times each day reduced length of hospital stay. The babies were, however, also given passive limb movements. An earlier systematic review by Vickers et al (2001) of studies in larger babies had shown that work conducted before this on pre-term and low birth-weight infants was inconclusive as the positive effects were small and therefore of low clinical significance.

Observations on young animals have provided some information about their response to touch, the implications of which may be transferable to humans. Among many mammals tactile rituals occur after birth which serve physiological functions and may promote normal emotional development. There is a relationship between the stroking of young animals by humans and a reduction in the animal's physiological response to stress, demonstrated by a decreased output of adrenocorticotrophic hormone (ACTH) (Seyle 1950) and reduction in blood pressure and heart rate (Lund et al 1999). Young animals that are handled also show greater development of the cortex and subcortex of the brain; they learn faster and have a more advanced stage of neural development than non-handled animals (Ruegammer et al 1954). Resistance to infection later in life may also be influenced beneficially by cutaneous stimulation experienced by the infant animal (Soloman & Moos 1964).

It is thus probable that cutaneous stimulation during critical periods of a human infant's development will promote similar normal organic and behavioural growth. After the age of about 3 months, the infant begins to utilise his/her sense of touch to learn about the immediate environment. Deprivation of this primary learning process may compromise later social and learning responses, and adversely affect the way the adult utilises tactile information (Frank 1957, Mason 1985).

Touch

Throughout our lives, contact with the environment ensures that our skin receives continual stimulation. We receive tactile messages from, for example, the clothes we wear, from the water we wash in, from the rubbing of lotions on our skin, and from people and animals we touch or are touched by. Depending on the quality of tactile stimulation perceived, we can feel such emotions as pleasure, pain, fear or revulsion. Similar feelings are engendered by the type of human contact we experience, which is often tempered by integration with other somatic senses. Contrast, for example, the feelings experienced by the touch of a warm hand or a cold one; the sense of smell may influence our response; auditory and visual information may also influence our response to touch. Usually we permit touch when we perceive it as safe or desirable but avoid physical contact with people whom we dislike. The subjective experience of the touch determines our neural and hormonal responses, which in turn influence our integrated response to the touch. As massage necessarily involves touch, the therapist needs to consider not only the mechanical and physiological effects but also the emotional responses likely to result. This careful thought will begin before the massage, while taking the client's medical history and during the assessment.

Therapeutic considerations

The first fact to be established is whether the client has given permission to be touched. A major factor will be how the patient perceives the therapist and the environment. The variables may include the way the therapist presents herself, the degree of privacy involved, and whether the environment is perceived to be safe. Careful attention should be given to differentiating between verbal permission and any non-verbal indicators to the contrary. Some individuals involuntarily interpret touch as threatening, and the sympathetic nervous system may be aroused as a result; these individuals are described as being 'tactually defensive'.

An explanation should be given of the method of massage to be used; a patient who has previously experienced only a pleasant skin rub with essential oils may be unprepared for deep tissue manipulations. The quality of touch which is conveyed to the patient may be predetermined by the therapist's intention and may vary through caring, sensitive and professionally based to cold, hasty and clumsy. Invasion of the body surface by unwelcome types of touch will be perceived as threatening or undesirable, and is likely to produce an unwanted effect. Conversely, the effects of appropriate touch will enhance the rapport between patient and therapist, thus enabling further therapeutic intervention. Constant monitoring of the patient is required throughout treatment to ensure that changes in technique are made when appropriate.

As professional therapists, we are concerned with *all* the effects our massage may produce. When administering a massage the main objective is often to have a mechanical effect with the aim of restoring normal function. However, we should not neglect the fact that there may be other stimuli, extrinsic or intrinsic to the massage, which are capable of producing undesirable effects. Such factors as the environment, the temperature of the environment, the degree of privacy and background noise will all affect the response of the client; similarly, the various sensations provoked by the quality of touch can produce a variety of responses. Our responsibility as therapists is to ensure that all the effects of our treatment are desirable and none detract from our aims. In this respect the therapist should have an understanding of autonomic and emotional arousal.

Stressors

The main centres of ANS activation are in the spinal cord, brainstem and hypothalamus, with control also being influenced by the limbic cortex. Visceral functions such as arterial pressure, heart rate, gastrointestinal motility and secretion, temperature and sweating are controlled. When the system is working optimally, there is a state of homoeostatic equilibrium. The ANS is also influenced through visceral reflexes, sensory signals that trigger reflex responses of the visceral organs. Change of function can be rapid: the heart rate can increase to twice its normal level in 3–5 seconds, and arterial pressure can double in under 15 seconds or conversely, arterial pressure may increase to 50% of normal in 10 to 40 seconds (Guyton & Hall, 2006). (See Thibodeau et al (2007), pp 842–3, Figs. 22.2–22.4.)

Any agent that provokes sympathetic arousal is termed a 'stressor'. Stressors may be physical, psychological or sociocultural (Seyle 1982). One current theory of stress is that it is cognitively controlled;

that is, an individual's response to a stressor is dependent upon that particular individual's previous experience of similar stessors, and his/her present ability to cope with the stressor. While a moderate level of sympathetic arousal is desirable to facilitate most everyday activities—it keeps us mentally and physically alert—prolonged exposure to a stressor that produces a high level of autonomic arousal can have undesirable physiological effects, resulting in, for example, decreased immunity, and increases in hypertension and vascular disorders (Willard 1995).

Current concepts of stress take account of the neuroendocrine changes in the body in response to a stimulus (see Fig. 10.1, which summarises some of the current concepts of stress responses).

An emotion is an expression of subjective feeling accompanied by neural and hormonal activity; emotions are determined by learned, cognitive and biological factors. The systems that control autonomic and emotional activity are interactive, being linked by neural impulses and hormones. A therapist who has a good understanding of the integration between these systems will work holistically with clients, thus ensuring that the whole person benefits from her intervention.

The tissue layers

Changes can actually be seen on the surface of the skin during vigorous massage, when some reddening occurs. The amount depends to some extent on the reactivity of the skin, which is determined by skin type, although vasodilatory reactions in the skin are common. Fundamentally, it is as a result of release of histamine from the mast cells. Mast cells are found in connective tissue and contain histamine, heparin and hyaluronic acid and it is known that cells respond to mechanical signals (Banes et al 1995). Cell deformation may activate calcium ion channels and influence calcium transport. Mechanical stress has specifically been found to activate mast cell secretion (Theoharides 1996). It is unclear why this mechanical irritation and its resulting vasodilatation should occur, and to what purpose. Further reddening seen in the skin may be due to shear forces acting on the endothelium of blood vessels, causing release of the vasodilator nitric oxide (Noris et al 1995), which is angioprotective. Vasodilatation is accompanied by an increase in capillary permeability and it is likely that the tissue fluid released from these capillaries has a flushing effect on the tissues, both removing irritants and allowing protective chemicals to be brought to the area via the bloodstream. The reddening may increase if the hands glide over the surface of the skin, particularly with speed as this increases friction. Reddening can be reduced by massaging more slowly and by using an oily medium.

When a hand is held over the surface of another person's skin, heat can be felt. If the hand is placed on skin and held in a stationary position, this heat can be felt to increase. Rubbing over the surface of the skin causes friction and this increases heat even further. Heat is a form of energy and some schools of massage, particularly those grounded in Eastern practices, base their approach on a belief that an energy field exists around the body. There is, however, no evidence for this aura, as it is known, and the Kirlian photography used to measure it has been found to be scientifically invalid. Some therapies are based on a belief in energy fields running through the body along specific pathways known as meridians. These principles are utilised in orthodox health care systems through acupuncture (mainly used by physiotherapists and doctors), reflex therapy (used by physiotherapists) and therapeutic touch (popular with nurses in the USA). Therapeutic touch, non-contact therapeutic touch and other energetic forms of massage use this principle to varying degrees as they attempt to normalise the energy fields, promoting healing and well being. Within biomedicine, it is often interpreted as ANS activity, as discussed below.

With a slight increase in pressure, layers of tissue are moved *with* the hands, rather than the hands gliding lightly *over* the skin surface. A very light glide necessitates some movement of the epidermis. If there is friction between the therapist's hand and the patient's skin, the epidermis moves with the therapist's hands and is gently stretched. As this layer is so thin, the dermis must move simultaneously because of traction between the dermis and epidermis which results from natural adherence between the layers. The application of slightly more pressure with friction (but note the massage still feels very light) and a traction effect occurs between the dermis and subcutis. Resistance or tension is felt when this traction reaches its limit and all layers are stretched. This is referred to as the *end-feel* of the stroke and at this point, if the hands glide or continue to push into the resistance, the massage is deepened as traction occurs at the next interface down.

So far, we have recognised that massage involves an interaction of energy between the patient and therapist; that it utilises the effects of touch to induce relaxation, communication and a sense of well being; and that it produces movement of the tissues in subsequent layers as a result of traction at tissue interfaces. In addition, a complete variety of strokes lifts, pulls, squeezes and twists the skin, connective tissue, tendons, ligaments, muscles, blood vessels and nerves. Sensory and autonomic nerves are stimulated, inducing changes in the nervous and circulatory systems, and movement is effected in abnormal tissue, for example scar tissue or where layers are adherent.

The therapist should be aware that whilst it is possible to target a specific structure, the surrounding tissues will also be influenced due to their interconnectedness, particularly those in superficial layers.

Circulatory effects

The pressure of the massage itself increases pressure in the tissues. Pressure gradients are created between the tissue spaces and vessels as discussed in Chapter 2. As the hands are moved, so the area of increased pressure is moved, creating a *fluctuating* pressure difference between one area of tissue and another. Thus fluid moves constantly from tissues to vessels and back again, as it flows from areas of high to low pressure. This can occur in two ways: if pressure is increased only in the tissue space and not in the vessel, fluid will move from the tissue into the vessel. Slightly more pressure, however, also increases the pressure in the vessel, so there may be a tendency for fluid to move out of the vessel into tissue space which is at lower pressure. If the vessel is compressed and this pressure moves longitudinally along its course, as in effleurage, then the fluid is pushed proximally along the vessel, leaving the collapsed vessel behind the hand to fill again rapidly. This refilling or milking effect can push fluid towards the heart. If it occurs in veins, a suction-like effect will take place, aided by the valves which prevent back-flow. In addition, manipulation of the tissues at a careful depth will cause a pull on the filaments, which are connected to the flaps in the walls of lymphatic vessels, allowing larger plasma proteins to be removed from the tissue spaces, thus restoring a normal osmotic pressure to the extracellular fluid.

While there appear to be several ways in which fluid balance in the tissues is influenced, the mechanisms are probably more complex than the theoretical supposition described here. It is not possible for the therapist to know exactly where the smaller vessels lie as their exact positions are subject to individual variation. The deep vessels cannot be palpated if they are normal and healthy. The massage manipulations themselves are complex and involve a combination of squeezing, stretching, pulling and traction forces, with movement occurring in different directions and in different tissue planes: for example, kneading consists of circular movements, skin rolling produces transverse movements, stroking and effleurage produce longitudinal forces. Consequently, there are complex repetitive pressure changes occurring in varying directions and at different depths. This is likely to have an effect on fluid *interchange*, whereby fluid is pushed from the tissue spaces into the vessel, towards the lymph nodes and heart, and new fluid is pushed or drawn into the spaces. Generally, it seems less logical to assume that massage will reduce the amount of fluid in the spaces when it is more likely to replenish it.

This flushing effect in the tissues is important. New circulation is brought to the area, bringing with it fresh nutrition, and the stasis by which inflammatory products, chemical irritants and toxins linger in the tissues is corrected. The local environment is therefore changed for the better. The mechanism by which chemical irritants in the tissues can cause an undesirable plasticity in the spinal cord, lowering the threshold to pain within a whole neuronal pool, is discussed further in Chapter 4. Replenishing tissue fluid and removing inflammatory products will reduce this effect, possibly preventing or reducing some types of chronic pain. Removing metabolites and chemicals such as potassium from muscles by releasing them from muscle cells and 'flushing' the muscle tissue with new circulation will reduce muscle soreness following exercise. This effect will reduce pain in situations where metabolites have built up due to prolonged muscle spasm, increased tone (for example, where there is excessive anxiety or tension) and conditions such as fibromyalgia. Indirectly, massage can promote healing by bringing new circulation to the area. Occasionally, in a chronically swollen limb or when fluid is trapped in a tissue space (as in the hand or around the ankle, for example), or where there is fibrous swelling, massage can soften and release the swelling, facilitating its removal.

A much-cited study into massage and blood flow was carried out by Wakim et al in 1949. This team measured blood flow by plethysmography and spirometry in the forearms and hands and in the lower legs. In a group of 15 asymptomatic subjects they found that arm massage increased blood flow to significant levels in 11 of 12 observations and that leg massage increased it to significant levels in 11 of 14 observations. This increase was maintained 30 minutes after the cessation of the massage. The massage given in this instance was a vigorous type involving deep stroking, deep forceful kneading and friction. After a modified Hoffa type of massage, which included stroking and deep kneading, 16 of 32 readings on the upper limbs showed insignificant results while 10 of 32 showed an increase and 6 of 32 a decrease in blood flow. Lower limb readings were insignificant in 15 of 24 subjects, with 5 of 24 showing an increase and 4 of 24 a decrease. In paralysed limbs, 4 of 6 had a significant increase and 3 of 5 limbs with spastic paralysis showed an increase. Rheumatoid limbs showed readings fairly evenly distributed across the significant increase, non-significant increase and reduced flow categories. Of further interest is the fact that, following two sessions in two patients with poliomyelopathy, all observations were significant. This research was conducted some time ago and plethysmography has been criticised by Hansen and Kristensen (1973) as a technique which only measures blood flow in the skin. Significance levels were arbitrarily set at 15% and improvement was measured in percentages. There was no statistical analysis, so it is not a statistical significance referred to here. There was no account taken of probability in the calculations; the results are of clinical significance only if the pattern of results occurs more frequently than they would by chance, which is why statistical analysis is important. The stimulating massage that produced better results is unlikely to be carried out frequently in a real clinical situation, and the trauma and irritation of such a massage would be expected to increase blood flow in skin, but with a limited therapeutic value. The results of this study are of interest but should be treated with caution, as little convincing scientific evidence is offered.

A further attempt to measure the effects of massage on blood flow was made by Hansen and Kristensen (1973) by the more sophisticated ^{133}Xe clearance technique. This substance was injected into the calf muscles and measured with scintillation detectors during and after massage. The 'centripetal effleurage' was conducted for 5 minutes in the legs of two women and 10 men, aged 20–32 years. The mean disappearance rate during massage was statistically significant, with the significance reducing 0–2 minutes after the massage. The results show a slight effect, with none in avascular subcutaneous tissues. Unfortunately, little detail was given concerning the massage itself, for example the amount of pressure used. Also, some traditional principles of circulatory massage were not respected, namely, massaging proximal areas before distal ones and using an assortment of techniques. In addition, differences in amounts of massage time were not monitored. This research supports the assertion that massage increases blood flow in muscles but missed the opportunity to increase its impact by informing us more about types of massage and lengths of treatment. The study was, in fact, designed to compare the effects of massage with those of shortwave diathermy and ultrasound (found to be not significant) and therefore did not examine massage in particular detail. As the blood flow effects were short-lived, this would suggest that these effects are as a result of *mechanical* stimulation of blood vessels rather than chemical or reflex responses.

The following year produced a publication which to some extent substantiated these findings (Hovind & Nielsen 1974). Blood flow was measured in the brachioradialis and vastus lateralis muscles of nine volunteers aged 22–32 years, following intramuscular injection of saline and ^{133}Xe. The results showed that, following tapotement, blood flow rose significantly for 10 minutes after cessation of the technique, but petrissage results were inconsistent, short-lasting and not statistically significant. As the tapotement results were similar to those found during active isometric muscle contractions, it is probable that this technique (described by the authors as 'unpleasant to the experimental volunteers') stimulated reflex muscle contractions, which increased the blood flow.

Shoemaker et al (1997) studied the effect of massage to the forearm flexor muscle and the quadriceps on blood flow (mean blood velocity (MBV)). Blood flow was measured by pulsed Doppler ultrasound and vessel diameter by echo Doppler ultrasound. Ten subjects were studied, with readings of MBV taken prior to treatment and at 5, 10, 20 seconds and 5 minutes following the onset of massage. Vessel diameter readings were taken before and after massage. Massage did not significantly increase blood flow in either muscle group, whereas light exercise *did* elevate blood flow from rest. This is a sound study in which the massage was conducted by a registered massage therapist. It is not indicated whether the massage was superficial (with the hands gliding over the skin, using an oily medium) or whether it was deep. It is logical to assume the effects on blood flow of deep and superficial massage would differ and a comparison of different depths would make an interesting study.

In normal limbs, then, there appears to be some increase in blood flow, either in the skin or intramuscularly, during massage, particularly effleurage, although this is not universally substantiated by all studies. Small sample sizes and inconsistent methodologies leave results inconclusive. Increases in circulation occurring during, but not following, massage suggest that it results from the mechanical, rather than the reflex or chemical effects of massage, although it has been asserted for many years (Carrier 1922) that vasodilatation during fairly vigorous massage occurs as a result of stimulating the axon reflex, observed as a reddening of the skin. Massage has, in fact, been shown to increase the effect of a vasodilator substance in the skin following superficial massage and in muscles following deep massage (Severini & Venerando 1967). As physiological compensating mechanisms are extremely efficient in healthy tissues, any alteration in local blood flow will be compensated for by autoregulatory processes; these researchers are perhaps limiting their results by using subjects with normal circulatory systems. Severini and Venerando also found, surprisingly, that deep and superficial massage *decreased* skin temperature. Deep massage demonstrated 'appreciable' increases in blood flow in both the massaged and non-massaged legs; increases in cardiac stroke volume; and decreases in heart rate and systolic and diastolic arterial pressure. Unfortunately, only the abstract is available in the English language.

Morhenn (2000) found that massaging the cheeks of the face increased skin temperature in seven out of eight human subjects, which plateaued after 40 minutes of massage. It was accompanied by erythema. The effect was blocked by pre-treatment of capsaicin, a chemical which causes release of substance P by peripheral nerve endings which suggests that the raised temperature effect can be partly controlled by substance P. A point of less relevance than interest is that the researchers conclude that social grooming in animals may be necessary because of the survival effect of neurotransmitter release. Zoologists, however, have conducted much research into this subject and their explanations for animal grooming vary from stress reduction, care of the coat/feathers, parasite control, communication and the spread of chemicals (such as pheromones in bees), depending on the species.

Cambron et al (2006) missed an opportunity to measure changes in blood pressure following massage. They studied the effects of massage on 150 clients, but utilised different types of massage for different clients. Unsurprisingly, the painful treatments caused a rise in blood pressure whilst some clients undergoing other forms of massage experienced a drop in blood pressure. The findings of this study should be interpreted with caution.

In 1988, Flowers compared massage with string wrapping and a combination of the two in 56 upper limb digits in 10 women and 4 men aged 24–61 years. They used a retrograde 'milking' massage along the whole length of the digit and monitored its effectiveness by measuring the distal interphalangeal joint girth with a tape measure. Using sound statistical tests, they found that neither the string wrap nor the massage alone demonstrated significant results but, when combined, results were significant. Continuous stroking was better than intermittent stroking. This is interesting, as the combined effect would operate at a much deeper level in the tissues than manual lymphatic drainage, which is the current treatment of choice for *protein-rich* oedema. Presumably, the swelling in this study was more acute and was possibly trapped in the tissue spaces, needing mechanical assistance to return back into the bloodstream. The string wrapping maximised the principle of pressure gradient-induced fluid dynamics, and the massage mechanically aided the process. It is illuminating that a combination of these two modalities produced good results. This indicates that the pumping effect of rhythmical effleurage may be important in oedema removal and that the constant pressure produced by the string wrapping ensured the swelling did not return to the tissues through leaky capillaries. This points to the need to combine oedema massage with some form of pressure to maintain its effects between treatments.

While the results of different studies can appear confusing, it seems that general massage, arbitrarily used, can produce erroneous results. When massage is more specific, however, and carried out sensitively, is anatomically correct and applied at a precise depth, specific strokes can indeed achieve a specific purpose. Clinical experience suggests that a positive effect on physiological parameters is more likely in the presence of pathology. Trubetskoy et al (1997) conducted research which showed that gentle manual massage for 5 minutes increased absorption of subcutaneously injected substances from the tissues into the lymphatics. Effleurage and manual lymphatic drainage can mechanically produce a milking effect or open lymphatic flaps for the removal of proteins. A rhythmical pumping effect can then be achieved. The choice of technique or combination of techniques should therefore be selected carefully, the selection being informed by relevant pathophysiology.

Blood constituent readings following massage can offer further elucidation on the mechanism by which massage works. Arkko et al (1983) conducted research in which vigorous conventional whole body massage, using oil as a lubricant, was carried out for 1 hour in nine healthy male volunteers. Stroking, kneading, friction and shaking were applied by an experienced therapist. Blood samples were taken before, immediately after and at 2, 24 and 48 hours later. A variety of blood and serum constituents were measured and results showed wide individual variation, none reaching statistically significant levels. The results did, however, substantiate the findings of Bork et al (1971) that serum levels of creatine kinase (CK) and lactate dehydrogenase (LDH) were raised. These are enzymes that can be examined for skeletal muscle specificity. Bork and co-workers suggested that LDH was liberated by muscle cells, probably as a result of the mechanical trauma of the massage. This work was not in agreement with the claim by Wood and Becker (1981) that haemoglobin levels and erythrocyte count are raised. Unfortunately, there was no check on the activity levels of the subjects earlier in the day. This group of volunteers was not compared with a control group which did not receive massage. Nine is too small a number to conduct the statistical tests used here with confidence (such as the one-tailed paired *t* test). A larger group may have shown more (or, indeed, less) significant results and, in comparison with controls, would have increased the validity of this study.

Ernst et al (1987), in a group of normal subjects, found that a standard 20-minute massage treatment reduced the haematocrit, blood and plasma viscosity. The suggestion here is that the fluid immediately surrounding poorly perfused vessels has low viscosity owing to its lack of cells and that the vasodilatation caused by massage nearby creates a need for these almost dormant vessels to be recruited. This may be useful where it is desirable to increase local circulation, for example to promote healing. It can also be a help to athletes whose performance would benefit from increased recruitment of blood vessels. In addition, the mechanical effect of the massage causes a removal of the low-viscosity tissue fluid into the circulation. The study offers further evidence that massage produces a flushing and mechanical effect on the circulation, as the local effects here were detected within the bloodstream.

Research has shown that massage can reduce the incidence of deep vein thrombosis (DVT). Sabri et al (1971) found that the incidence of DVT was reduced by 82% in the massaged limb when compared with the non-massaged limb. Knight and Dawson (1976) demonstrated that the occurrence of DVT in the leg can be reduced by massage of the arm. Both these studies, however, used pneumatic compression devices which simply squeeze the whole limb in a rhythmical manner. This does not mirror a manual massage; rather it mirrors the effect of rhythmical muscle contraction on the muscle pump, which increases venous return. This does not indicate that the reduced incidence of DVT on these occasions was due to massage causing reduced blood viscosity, nor that pneumatic compression devices are superior to regular muscle-pumping exercises in anyone confined to bed or undergoing surgery. A comparative study would be helpful for clarification.

Effects on muscle

It is claimed that the circulatory effect of massage can reduce muscle soreness and thus aid conditions that cause muscle soreness, muscle injury or post-exercise recovery. Danneskiold-Samsoe et al published important research in 1982. Thirteen women aged 24–55 years with muscle pain and tension in the shoulder region and back had ten 30- to 45-minute massages over 4 weeks. The index of fibrositis was taken, based on scores attached to the size of tension areas. Venous blood samples were taken before and at 1, 2, 3, 4, 5 and 6 hours following massage at the first treatment, and then before and at 1 and 2 hours after massage. Levels of myoglobin, a protein found only in muscle tissue and associated with oxygen transport in the blood, were measured. The results were statistically significant. There was a peak value of myoglobin within 3 hours of the massage. Gradually, the level of significance fell between treatments. The fibrositis index scores fell between the fourth and seventh treatments, and there was no difference in either myoglobin levels or index scores between treatments 7 and 10. LDH levels showed no change (giving no support to Arkko and colleagues' (1983) suggestion that this was raised as a result of mechanical trauma of the massage itself) and serum creatine concentration rose slowly during 6 hours to double its normal value. The fact that myoglobin levels gradually declined in the blood samples until there was no difference between treatments 7 and 10 showed that this was not, in this case, due to mechanical damage produced by the massage. These results also offer an indicator to treatment length. There was a significant difference between the group and controls after treatments 1 and 4. According to these findings, treatment programmes for this condition should ideally consist of seven sessions.

Further effects of massage on muscle can be divided into effects on tone and performance, as influenced by discomfort. Muscle tone ensures that skeletal muscles remain in a mild state of contraction. It is maintained by a complex interaction between stimulating impulses from the muscle spindle (stretch receptor) and inhibitory impulses from the Golgi tendon organs (Fig. 3.1).

The anterior horn cells in the spinal cord receive these impulses, and activity in these cord cells is further mediated by descending brain activity. Various factors affect muscle tone in situations where functioning of the CNS is normal. This is little understood, but varies from local spasm in response to injury (for example, near a recently fractured bone) to increased muscular tension around the neck and shoulder area and to myofascial trigger spots.

It seems that spasm occurs in response to pain, in an attempt to prevent movement and further damage. This can be useful in indicating potentially serious underlying damage which warrants further investigation. More frequently, however, the cause is unknown, has resolved or cannot be alleviated; therefore the spasm or, more likely, the muscle shortening itself becomes the problem and the cause of further pain (Fig. 3.2). It has long been assumed that ultimately, a situation can exist where spasm itself becomes the overriding symptomatic factor. Changes then occur in the muscles as their blood supply becomes compromised, resulting in oedema, adhesions and muscle shortening. Massage has been advocated for relieving this cycle (Jacobs 1960). However, Mense et al (2001) remind us that not all painful muscles which feel tense are in spasm and may sometimes show no increased electromyographical activity, and that not all muscle spasm is painful.

Where this situation exists, however, massage is also said to reduce tone in muscles that are tense or in spasm, and to reduce the soreness and tenderness of tense or over-exercised muscles. Certainly, muscles can be felt to 'soften' during massage, an effect which is followed by a reduction in pain. Further investigation of the pathophysiology is clearly indicated. Massage can also prepare muscle for exercise and is also sometimes used to temporarily reduce hypertonus in spastic muscles.

It is thought that muscles which maintain excess tone or static contraction for prolonged periods of time work beyond their oxidative capacity and an algesic substance, possibly potassium, is released

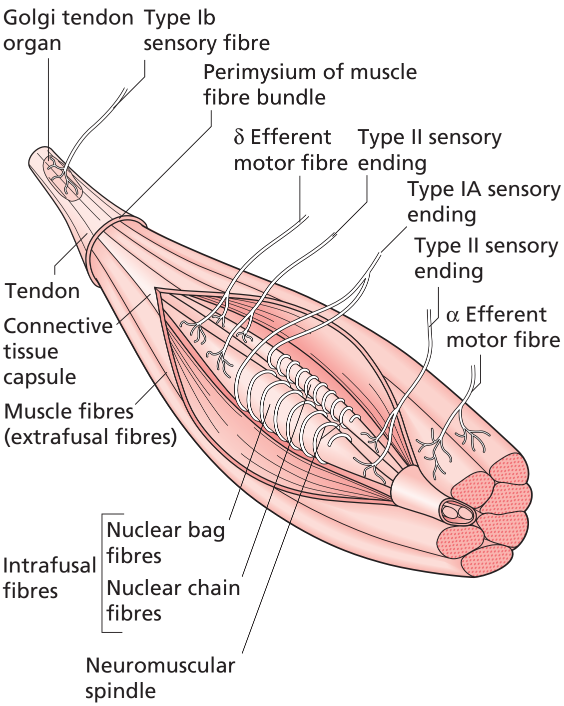

Figure 3.1 • Sensory receptors in muscle—proprioceptors. Reprinted from *Anatomy and Physiology 6e*, Thibodeau & Patton (2007) with permission from Elsevier.

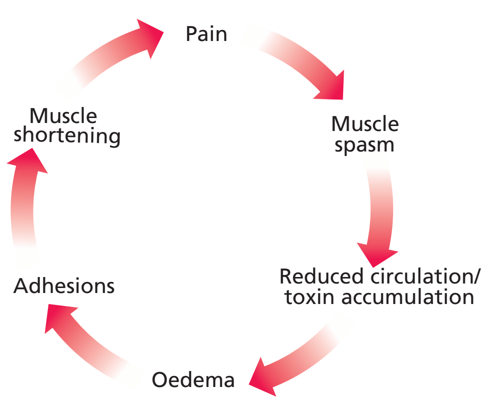

Figure 3.2 • Self-perpetuating muscle spasm cycle.

(Jones & Round 1990). Discomfort reduces as its cause is removed by circulating blood. A cycle of excess (for example, postural or occupational) tone causing release of algesic substances producing pain, which increases tone, causing further toxin release and an increase in pain, may be produced. This probably explains the discomfort experienced around the neck and shoulder girdle region in tense individuals or those with poor posture. Posture can also be influenced by emotions or body language, hence the typical clinical picture of a very controlled individual who is 'cool in a crisis', holding her/his emotional tension in the muscles of the upper back and neck. Massage appears to soften the tissues, reducing tone, liberating fluid from the muscle tissue and flushing out the algesic substance as new circulation is brought to the area. Often the muscles of the back, particularly paraspinal muscles, are felt to be 'ropey'; that is, they feel as if they have rolled tissue, like thin ropes, in them. This is thought to be due to spasm of muscular fascicles as a result of increased sensitivity in the spindles which control them (Yates 1990).

Exercise that works the muscles eccentrically, or which generates high forces in muscle, produces delayed-onset soreness and a feeling of stiffness. It is thought that this is due to swelling in the muscle and inflammation of the connective tissue which sensitises mechanoreceptors (Jones & Round 1990). Once the initial tenderness has passed, or before it develops, massage can help to limit the painful episode. It is also claimed that massage can help to prevent subsequent post-exercise pain, in a way similar to increased training. Sports physiotherapists describe regularly massaged muscles as being more pliable and less hard. It is possible that the stretching manipulations increase extensibility and strength in the connective tissue. It may also reduce oedema in the muscle tissue and produce a flushing effect, removing algesic substances. More recent work has found that calcium leakage leading to destructive enzyme release is likely to be responsible for exhaustion, muscle soreness and damage during and following strenuous exercise and in cardiac pathology (Bellinger et al 2008).

The work of Danneskiold-Samsoe et al (1982), discussed earlier, substantiates the assertion that massage can reduce muscle discomfort. They assumed that, because myoglobin levels in plasma correlated with a reduction in pain (indicated by the fibrositis index), the regional pain and tension in fibrositis is associated with muscle, rather than connective tissue, damage. They also measured levels of CK and LDH, which are muscle enzymes, and found that CK rose twofold during the 6 hours following massage, with no significant increase in LDH. Pain has been found to occur on activity in muscles if the metabolic demands of the muscle cannot be met. This is thought to be due to the release of algesic substances (for example, potassium). Delayed-onset pain is experienced after the exercise has stopped and is caused mainly by exercising with the muscles in a lengthened position or by eccentric (isotonic lengthening) muscle work. The muscles also feel stiff, tight and tender, and may be oedematous. This type of pain is thought to be due to connective tissue inflammation rather than muscle damage, which may explain why it occurs when the muscle is exercised in a lengthened position. Massage may assist the performance of muscle by increasing pliability in the connective tissue around the muscle fasciculi. It will maintain mobility between the interfaces within the muscle and will flush this relatively avascular tissue. It will also stretch any fibrous adhesions or scarring in the tissue, which may be particularly troublesome when they occur between the connective and muscle tissue, binding them together. Positive effects on healthy tissue are less clear.

Muscle tension can sometimes produce symptoms elsewhere. A well-known example is that of tension headache. Puustjarvi et al (1990) studied the effects of 10 sessions of deep-tissue upper body massage in 21 women suffering from chronic tension headaches. It was found that the range of neck movements (measured with a Myrin goniometer), surface electromyographic (EMG) activity on the frontalis muscle, pain scores on the visual analogue scale (severity) and scores on the Finnish Pain Questionnaire all improved significantly, together with the incidence of neck pain, at 2 weeks, 3 and 6 months of follow-up. Beck Depression Inventory scores also improved but surface EMG recordings from the trapezius muscle were not significantly changed. The authors suggest that the headaches reduced as a result of a relief of 'cephalic spasm' (Poznick-Patewitz 1976) and endorphin release.

Later research, based on a series of cadaveric dissections, found a fascial connection between the rectus capitis posterior minor muscle and the posterior atlanto-occipital membrane which is attached to the dura mater layer of the spinal meninges (Hack et al 1995). The researchers postulate that contraction of the muscle exerts tension on the dura through the fascia and atlanto-occipital membrane. The dura is known to be richly innervated with sensory nerve endings and the authors suggest that this is a common mechanism for tension headaches. Massage techniques along and below the occipital ridge, which reduce tone in this muscle, should therefore reduce the pain of headache. Any underlying cause should of course be investigated and treated to prevent recurrence. If the cause is muscular tension arising from stress, then massage and relaxation techniques as part of a stress management programme should benefit the patient considerably.

Interest has been shown in the effects of massage on the H (Hoffman) reflex, which indicates the excitability in α-motoneurons, or anterior horn cells. Goldberg et al (1992) investigated the effectiveness of two different depths of massage on depression of spinal motoneurone excitability. The subjects were 20 neurologically healthy volunteers, 10 women and 10 men, aged less than 40 years. They were controlled for activity, caffeine and alcohol intake. One-handed petrissage was performed at both deep and superficial levels. The decision regarding what constituted deep and superficial was subjective but the therapist was trained to standardise massage to the agreed depth. The massage was interspersed between control periods and the order of deep or superficial was allocated randomly. Deep massage showed a 49% reduction in H reflex activity and the light massage a 39% reduction. The order of massage or gender of the subjects produced no differences in result, indicating that gender-based placebo effects did not influence the results. It was concluded that influencing cutaneous mechanoreceptors and pressure receptors reduces H reflex activity. Comparable results were found when the study was repeated on patients with spinal cord injury (Goldberg et al 1994).

In a study conducted by Sullivan and co-workers (1993), 16 subjects (8 women and 8 men aged 21.9–61.3 years) received effleurage over triceps surae and the hamstring muscles at a standardised rate of 0.5 Hz. Recordings of peak-to-peak H reflex activity demonstrated stability during control periods and significant falls in activity during periods of massage. This was a well-controlled study which utilised sound statistical tests and demonstrated a reduction in α-motoneurone excitability of the massaged muscles. This substantiated the work of Morelli et al (1990), who conducted a similar study in the triceps surae muscles of 2 men and 7 women. The H reflex peak-to-peak amplitude was measured at 10-second intervals during two pretreatment control periods, a massage period and two post-treatment control periods. The massage was found to produce a significant reduction in spinal motoneurone excitability during, but not after, massage. Morelli et al did further work in 1998 to determine whether the H reflex, diminished in amplitude by massage, is really due to decreased motoneuronal excitability or to another cause. This study showed that motoneuronal excitability is reduced as peak-to-peak mean amplitude of the gastrocnemius muscle H reflex was reduced when the soleus muscle was massaged for 3 minutes. As this close synergic muscle was also affected, this suggests that the effect must be due to reduced α-motoneuronal excitability.

These findings were unsubstantiated by the work of Newham and Lederman (1997). In their study, 5 minutes of massage to the quadriceps muscle was found not to affect the quadriceps reflex peak-to-peak amplitude in 20 healthy volunteers (age range 18–64 years).

Similarly, Dishman and Bulbulian (2001) found that massage did not reduce the amplitude of the tibial nerve H reflex when the massage was done locally or paraspinally. Spinal manipulation, however, produced a transient reduction in amplitude.

The suggestion (Goldberg et al 1992) that the effects of massage on H reflex excitability may be due to its influence on cutaneous mechanoreceptors has been tested by Morelli et al (1999). Massage was conducted both with and without the application of a topical anaesthetic and no difference was found between the two groups, but there was significant difference in result between the two experimental groups and the control group. The authors concluded that deep, rather than superficial mechanoreceptors were likely to be influenced by massage.

The positive reports of massage reducing α-motoneurone excitability have involved measurements taken *during* the massage. The studies reporting negative findings, however, took measurements *after* the massage. This area of research would suggest that massage reduces H reflex amplitude during massage, but there is no sustained effect after the cessation of massage.

Nordschow and Bierman (1962), in an earlier, less sophisticated, study of 25 healthy subjects (22 women and 3 men aged 20–35 years), found that, following Swedish massage to the back and Hoffa massage to the back and leg, fingertip-to-floor measurements with a tape measure increased in all subjects, with a mean increase of 1.35 inches. Tests for statistical significance were not carried out but results showed a trend towards an immediate greater increased flexibility after massage than after rest.

Effects on pain and sensation

Many of the effects discussed above would contribute to a reduction in pain and have already been examined in relation to muscle soreness. Pain can be reduced by massage as a primary intervention or as a secondary effect if massage removes the cause of the pain. Ueda et al (1993) demonstrated that massage has a sensory effect. They compared two groups of 16 patients who had had minor obstetric or gynaecological surgery under a lidocaine (lignocaine) epidural block. One group received 30 minutes of gentle massage of the epigastric area, and the proximal extent of the sensory analgesia was monitored before the massage and at 0 and 30 minutes after massage (i.e. every 30 minutes). The analgesic boundary changed in the controls from T9 (before massage) to T10 (at 0 minutes) and T10 (at 30 minutes), whereas that in the massage group progressed by two segments every 30 minutes: T9 (before), T11 (at 0 minutes) and L1 (at 30 minutes). This study suggests that mild sensory stimulation can facilitate regression of sensory analgesia, with possible implications for sensory recovery in other situations.

The effects of massage on levels of pain perception have been studied by Carreck (1994). She compared a minimum of 20 subjects who had painful stimulation (by transcutaneous nerve stimulation) before and 15 minutes after Swedish massage of the leg. The massage was substituted by rest in the control group. Pain threshold was raised to significantly higher levels in the massage group, although individuality of response was seen. Massage can therefore be used to manage pain or reduce treatment soreness, but care should be taken if other modalities in which pain levels are an important guide for effective or safe application are also used. A non-statistically significant trend towards an increase in pain threshold by massage was shown by Kessler et al (2006). Massage increased pain threshold in comparison to static touch and baseline and was therefore shown to produce non-significant hypoalgesic effects on experimental (cold-induced) pain on healthy volunteers.

Massage has been shown to contribute to a reduction in pain in various situations. Massage and unspecified physiotherapy decreased post-thoracotomy pain as measured by a visual analogue scale in a study of 116 patients (Marin et al 1991). A randomised controlled trial by Mitchinson et al (2007), also on post-surgical pain, compared routine care with 20 minutes of individualised attention and up to five sessions of back massage. Patients in the massage group reported short-term decreases in pain intensity, pain unpleasantness and anxiety with the rate of decrease in pain intensity occurring faster in the massaged group. Massage had no impact on long-term anxiety, analgesia use or length of stay. Less clear was the work of Weinrich and Weinrich (1990), who studied cancer pain in 28 patients who were randomly assigned to either a control or a massage group. Patients in the massage group received a 10-minute back massage, while the others received a visit for the same amount of time, to take into account the effect of one-to-one contact and attention. Pain levels in men decreased significantly immediately following the massage. This measure was not significant in women; neither were reductions of pain levels significant for either group 1 or 2 hours after massage. The age range of these patients was 36–78 years, which is wide for a relatively small study. Also, the levels of pain were actually higher in the experimental group than in the control patients. This study could have been more elucidating had the authors compared homogeneous groups and identified particular patients who may have benefited from massage. The difference in the sex-specific responses contradicted the findings of Goldberg et al (1992), which demonstrated no sex differences in the effect of massage, although this may reflect a difference in the way patients and healthy volunteers respond. Seers et al (2008) randomised 101 chronic pain patients to a control group (15-minute talk about their pain) or a group which was given a single 15-minute massage by a nurse. The massaged group experienced a short-term reduction in pain and anxiety, lasting less than 2 hours after the massage.

Massage causes traction to occur at tissue interfaces. Horizontal plexi lie at interfaces in the tissues, and gentle pulling on these vessels may stimulate the accompanying sympathetics which supply the mechanoreceptors. These receptors are distorted by the manipulation and there is therefore a dual effect in which mechanoreceptor sensitivity might be lowered, reducing pain and tenderness. If delayed-onset pain in muscle is caused more by connective tissue inflammation than by metabolic build-up in the muscle, as previously supposed, the flushing effect in the surrounding fluids, removing inflammatory mediators, may increase the speed at which the inflammation resolves. Substance P, for example, is known to play a role in chronic inflammation and pain (Harrison & Geppetti 2001). Promoting the flushing of the tissues through massage will inevitably reduce such irritants and therefore contribute to an alleviation of pain.

Effects on connective tissue

It is necessary to examine the purely mechanical effects of massage on the non-contractile or vascular tissues. Connective tissue is primarily composed of collagen fibres held together by fibrous cross-bridges. Following injury or disease processes, inflammation causes increased vascular permeability, which allows fluid to seep into the tissues in the form of oedema. This oedema contains plasma proteins, in particular fibrin-secreting fibrinogen, responsible for fibrous tissue. Adhesions thus form within the tissues, binding tissue interfaces or individual fibres together. These adhesions appear to increase the cross-bridge effect between pairs of fibres, preventing normal glide of fibres upon each other and also reducing the ability of the fibres to spread apart.

It has been asserted that massage will stretch tissues that have become short, tight or adhered. Some authors (Cassar & Maxwell-Hudson 2004, Wood & Becker 1981, Ylinen & Cash 1988) describe the 'breaking down' of adhesions, which suggests a vigorous, destructive response. The adhesions, however, become part of the tissue; such a violent effect would be destructive to the surrounding tissue as the technique cannot differentiate between adjacent structures and the normal, more vascular and sensitive, surrounding tissue, which may also yield. This would cause further inflammation and pain, and would precipitate more extensive fibrin deposition.

In speculating about what does actually happen, we know that petrissage manipulations stretch and pull the tissues in all possible directions, thus mobilising adjacent connective tissue fibres. The molecular cross-bridges between fibrils will be influenced and plastic changes may occur, and their length maintained or increased due to elongation or 'creep' (see Chapter 2). Mobility will be increased biomechanically at the fibrous cross-bridges, between fibres and where there are adhesions, by stretching connections between the fibres. This will promote width, spread and glide at tissue interfaces, and longitudinal elongation which will increase flexibility. These effects can be observed and palpated readily in scar tissue. Following surgery or accidental laceration, scars can become bound down to the underlying tissue, and massage will mobilise and soften by means of increased fluid exchange, elongation and creep.

Collagen fibres align themselves along the lines of stress; thus they are not found to lie in parallel formation in many muscles and tendons, as the directional forces on the intramuscular septum or ligament vary with changing range of motion. Techniques that stretch the fibres and adhesions in different directions will eventually restore their mobility, promoting remodelling along the lines of their normal stresses. The stretching and pulling may ensure that the connective tissue maintains its pliability and length, and could account for the subjective observations of sports therapists that regularly massaged muscles feel softer and more pliable, despite intensive training. Local flexibility contributes to general flexibility, and structures that regain their full length after injury are less likely to be reinjured during sudden stretching movements. Massage may be important, therefore, in optimising the functional recovery of a structure and preventing reinjury, by ensuring mobility at interfaces both inside and outside the structure. It cannot replace prolonged, accurate, controlled, longitudinal stretching exercises but the two complement each other well.

There is currently much interest in the way components of the body are interconnected through the connective tissue levels. Elements of the cytoskeleton connect, across the cell surface membrane, with the extracellular matrix. Theories based on the belief that effects on one part of this system can spread throughout have been developed (Oschman 2000a, b, 2003). As connective tissue is influenced, the effects can occur on both the micro and the macro level and can be generalised throughout the body. Connective tissue may, therefore, contribute to the quality of movement, mood and general well being. Some bodyworkers believe it is the 'underlying determinant' of these functions (Schultz & Feitis 1996). One explanation for how widespread influence can be achieved by localised manipulation of connective tissue is the piezo-electrical effect. Some molecules operate as liquid crystals. Stretch or compression creates an electrical field and sets up pulsations and oscillations in the crystal. This represents the movement created in the tissue and the information is transmitted through the tissue electrically and electronically. This mechanism forms the basis of realignment of structure and is the way in which weight-bearing stimulates bone remodelling (Oschman 2000a). Connective tissue can be visualised as being a continuous fascial network supported by struts. This allows tensegrity (Kassolik et al 2009) whereby the body can absorb impacts, which functions more efficiently if the network is flexible and balanced. Mechanical energy, whether in the form of manual therapy or harsher physical impacts (such as in sport or falls), will be more readily transmitted through a mechanically healthy network as information rather than damage (Lederman 1997).

A particularly specific technique for mobilising scar tissue is that of deep friction (Cyriax 1984). Carried out with the force applied at 90° to the fibres being targeted, it provides a specific stretch and separation between individual fibres. Aimed at creating movement and reactive hyperaemia (Chamberlain 1982), frictions are thought to stretch cross-bridges between fibres and to stretch adhesions within the structure. This also restores the sideways spread that occurs in muscles during contraction. Adhesions are stretched between, for example, a tendon and its synovial sheath. Fibrous scarring in skin, muscle, ligament and adhesions within a tissue or at interfaces can become more pliable. Frictions also cause a temporary numbing of the area. Deep transverse frictions are commonly used in the treatment of soft tissue injuries (Ombregt et al 1995) but research evidence for their effectiveness is patchy (Fig. 3.3). Brosseau et al (2002) undertook a Cochrane systematic review on the efficacy of deep transverse friction (DTF) in the treatment of tendinitis. No benefit was shown in the included randomised controlled trials of DTFs combined with other modalities for pain relief, increased grip strength and function status. The reviewers found methodological issues in the studies, which compromised the findings.

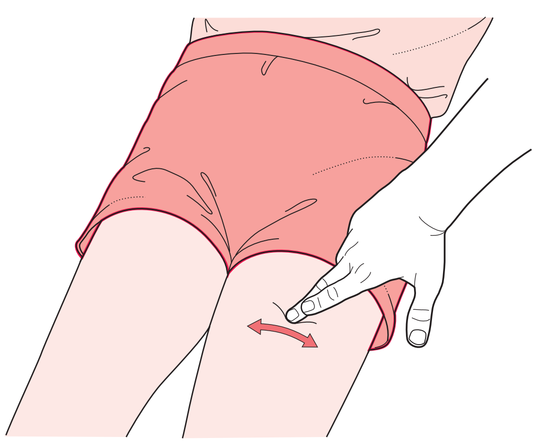

Figure 3.3 • Deep transverse friction technique to a lesion in rectus femoris muscle.

Pellechia et al (1994) compared iontophoresis of dexamethasone and lidocaine (lignocaine) with a protocol of moist heat, friction massage, phonophoresis of 10% hydrocortisone and cold therapy, in a group of patients diagnosed as having patellar tendinitis. If symptomatic after six treatments, the patients were changed to the other treatment group. The age range was 14–43 years and the duration of symptoms varied from 3 days to 10 years. Exercise programmes were added on an individual basis, and not controlled. The iontophoresis appeared to be more effective than the mixed protocol, but both groups showed significant improvement on the number of pain-free step-ups. There are, however, too many variables for this study to contribute to our knowledge of the effectiveness of friction massage. Troisier (1991) monitored deep friction massage on the extensor carpi radialis longus tendon below the elbow in 131 cases of tennis elbow. Good and excellent results were demonstrated in 63% of cases. Unfortunately, little detailed data analysis is available in the English language, so the study cannot be evaluated and must be taken at face value. Walker (1984) studied the effects of friction massage on the healing of minor sprains in the medial collateral ligaments of 18 rabbits. Examination of stained tissue samples could not distinguish between sprained and unsprained ligaments, nor between treated and untreated ligaments. The injury was experimentally induced and therefore acute, but surprisingly the earliest the ligaments were examined microscopically was at 11 days. This study obviously had too many methodological problems to inform our understanding. De Bruijn (1984) suggested that the analgesic effect of frictions is due to a noxious counterirritant effect and described results in 13 patients with a variety of soft tissue injuries, 11 of which were tenoperiosteal lesions. Friction massage for a mean of 2.1 minutes produced 0.3–48 hours of post-massage analgesia in five patients. While these results are interesting, little experimental or data analysis detail is given, so this study cannot be evaluated.

Massage is thought to cause elongation in the toe region of the stress–strain curve. It should be noted that the effects of massage on the tissues is multidirectional. Regular stretching and exercise can maintain this elongation effect but stretching exercises tend to be unidirectional. Utilising spiral stretches, such as those of yoga, can produce a more functional stretch, as many muscle and collagen fibres lie in a spiral arrangement. This would enhance the biomechanical effects of stretch more effectively than unidirectional stretching but a combination of multidirectional massage and spiral stretching exercise would be the most effective method of elongating tissues.

Reflexes and autonomic reflexes

Some practitioners of therapeutic massage work solely on the principle that they are producing reflex effects, rather than working mechanically. Some therapists may specialise in reflexology, for example, and work only on the feet. Other therapists work within an Eastern framework and use the meridians to direct their strokes. Thus, therapists may work to their own individual philosophical base. A more biomedically oriented therapist will acknowledge the contribution of physiological reflexes and use them to produce specific therapeutic effects. In practice, it is not possible completely to divide the reflex from the mechanical, as manipulation of the tissues will produce a dual effect, but one may be used more than the other, so the emphasis of treatment and clinical reasoning may differ. An understanding of both effects, therefore, will enable the therapist planning treatment to choose whether both will be utilised equally, or whether consideration of one should predominate. This is an area widely supported by clinicians, but discussion of it requires a more eclectic viewpoint than some of the preceding subject matter.

Reflexes

There are many types of physiological reflex, defined in *Mosby's Medical, Nursing and Allied Health Dictionary* (1998) as a reflected action, particularly an involuntary action or movement. Through this mechanism, motor responses can be produced in skeletal or visceral muscle. For example, in the heart, the strength of contraction of the muscle depends on the amount of blood entering its chambers. This phenomenon occurs by a reflex mechanism known as Starling's law: when blood enters the heart, the muscle is stretched by the volume of blood, and contracts accordingly; the more the muscle is stretched (by increased venous return), the more strongly it contracts. A different type of reflex response is the flexor withdrawal mechanism. If the sensory endings in the skin detect damage (burning of the hand, for example, or pricking with a pin), the flexor muscle groups in the limb immediately contract and the hand is withdrawn from the source of danger. The essence of a reflex is that it is involuntary, and therefore outside conscious control, and in normal circumstances not overridden. It is an *automatic* response to a given stimulus. There are permanent reflex states in the body. The intrafusal fibres of the muscle spindle relay signals which ultimately influence the amount of tone in the extrafusal fibres. This can be overridden to initiate movement, but there is no voluntary control of the resting state, which is purely reflex.

The reflexes pertinent to massage are predominantly those that occur in the skin or are triggered via the skin. They are of the cutaneous autonomic variety and are often named somatovisceral or cutaneovisceral.

Autonomic reflexes

The axon reflex, triggered by a scratch or fairly vigorous massage in normally responding skin and which produces a response in the capillary bed, has been referred to earlier. In fact, there are various ways in which the ANS is triggered. The gut, which operates solely under autonomic control, actually has its own nervous system, the enteric nervous system, which can function without any other neural influence (Gershon 1981). Its simplest form of operation is via viscerovisceral reflexes in which the stimulus is provided from within the gut and the gut itself responds, peristalsis being stimulated when the walls of the gut are stretched by food. Slightly more complex are the segmental autonomic reflexes. These occur within the same spinal segment. *Suprasegmental* reflexes involve the brain and are therefore more complex. To examine these more closely, we need to look at how the ANS is structured and how it functions. It is also necessary to examine a spinal segment.

The autonomic nervous system

The ANS is the part of the nervous system not under conscious control. It controls the functions vital for life, such as respiration and circulation. It is structured in two parts, the sympathetic and parasympathetic nervous systems. The sympathetic nervous system deals with active involuntary motor functions. It increases the rate and strength of the heart beat, constricts blood vessels in the gut and dilates blood vessels in muscles, thus redistributing the circulation to prepare for dynamic activity. It also dilates the bronchi, stimulates sweating, stimulates the release of glucose from the liver and decreases gut activity (Fig. 3.4). Its primary neurotransmitter is adrenaline (epinephrine). The sympathetic system leaves the spinal cord via the thoracolumbar outflow, its ganglia running alongside the spinal cord (positioned close to the costovertebral joints) at T1–L3 segments. It can be thought of as the part of the system that is predominant during physical activity.

In contrast, the parasympathetic nervous system (Fig. 3.5) stimulates gut and bladder activity via stimulation of smooth muscle contraction and therefore controls peristalsis and slows heart rate. Its primary neurotransmitter is noradrenaline (norepinephrine). It leaves the spinal cord through the craniosacral outflow (cranial nerves III, II, IX and X and segments S2–S4) and is dominant during the eating and digestion of food.

In normal circumstances, both systems operate in balance, the dominance of each reciprocally modifying in response to external situations. Thus, when one becomes dominant, the other becomes proportionately quiescent. At all other times, they should be in optimum balance. In pathological states, activity can be prolonged locally, and in suboptimal states of health the entire system of one can predominate inappropriately, being manifest as autonomic imbalance. The effect of cutaneous manipulation

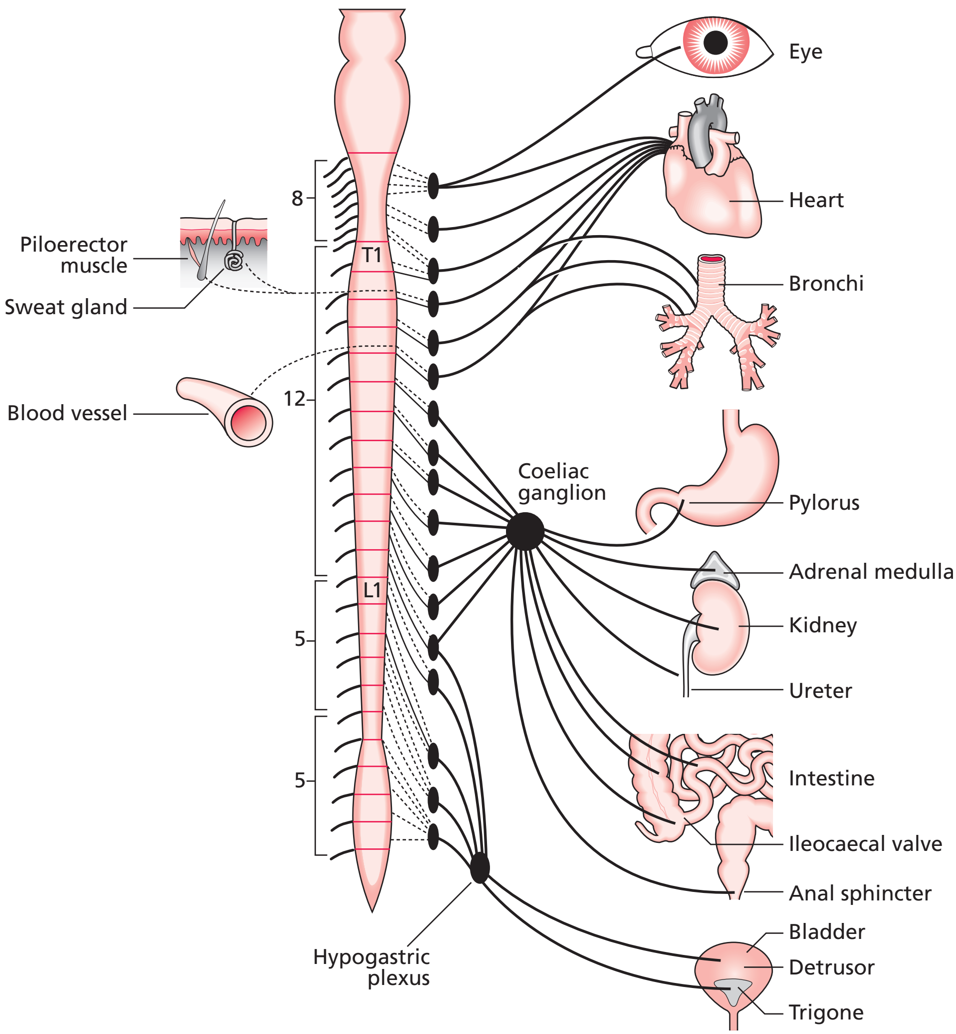

Figure 3.4 • The sympathetic nervous system. Reprinted from *Textbook of Medical Physiology 8e*, Guyton (1991) with permission from Elsevier.

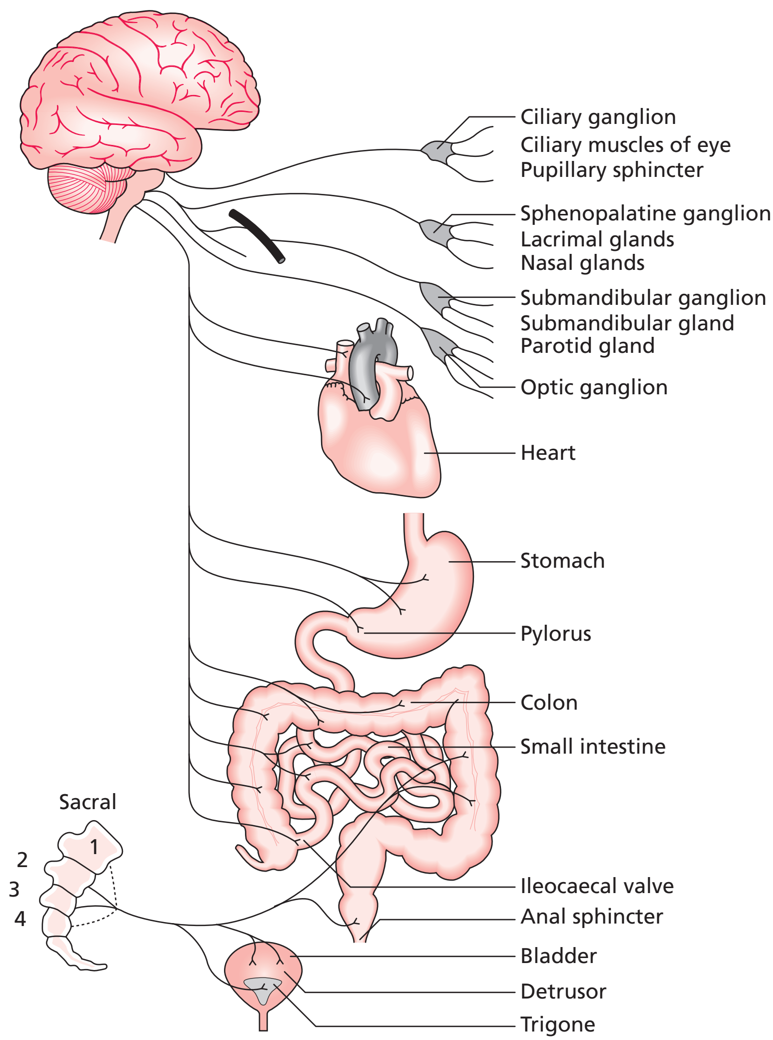

Figure 3.5 • The parasympathetic nervous system. Reprinted from *Textbook of Medical Physiology 8e*, Guyton (1991) with permission from Elsevier.

on internal functioning has been studied by researchers, who demonstrated that mechanical and thermal stimulation of the skin of cats produced reflex responses in the bladder, even though the cats were anaesthetised. These reflexes and their scientific evidence are discussed in some detail by Sato (1975), Koizumi and Brooks (1972) and Sato et al (1997). In addition, Kurosawa et al (1995) found that stroking the abdomen of a rat lowered blood pressure and Hotta et al (1999) were able to demonstrate that uterine contraction and blood flow can be influenced by cutaneous mechanical sensory stimulation in anaesthetised rats. This shows the segmental reflex operating via the parasympathetic nervous system.

It has been shown experimentally that strong autonomic reflexes exist segmentally and that there are suprasegmental reflexes which are weaker. The segmental reflexes produce a sympathetic response when skin of the same spinal segment is stimulated. This reflex reaction is integrated in the spinal cord. In the suprasegmental type, responses are elicited in segments distant from the point of cutaneous stimulation, the organisation occurring primarily in the medulla (Sato & Schmidt 1971). Type II and III fibres of cutaneous, visceral and motor nerves contribute to supraspinal reflexes that are integrated at medullary and supramedullary levels, whereas fibre types IV contribute to segmental and suprasegmental reflexes, reaching only as far as the medulla (Sato et al 1969, Sato & Schmidt 1971).

Thus, certain types of skin stimulation can have an autonomic effect. It has also been found that, following somatic afferent stimulation, a silent period in the sympathetic reflex occurs which appears to result from a descending inhibition from the medulla. Polosa (1967) found that repetitive stimuli produce a longer silent period and Koizumi & Sato (1972) demonstrated that a repetitive rate of 10 per second produced a dominant inhibitory effect. There is also an autonomic influence on the receptor mechanism. Merkel's discs are the exteroreceptors that detect shear force in tissue. They are supplied directly by the sympathetic nervous system (Barker & Saito 1981), so sympathetic tone will influence their sensitivity. Sympathetic stimuli and directly applied adrenaline (epinephrine) has been found to modulate the action of cutaneous mechanoreceptors of frog skin *in vitro* (Loewenstein 1956, Loewenstein & Altamirano-Orrego 1956).

There is, then, a connection between skin stimulation and autonomic function, whereby activity in the ANS can be modified by skin stimulation; there is also a converse connection operating in the opposite direction between autonomic output and the structure and functioning of the skin. To summarise, the sympathetic nervous system controls smooth muscle in blood vessel walls. If sympathetic activity increases, the muscles will constrict, causing, among other things, vasoconstriction and altering fluid balance. Sympathetic activity may also alter the threshold of mechanoreceptors causing them to be stimulated more readily, or even to be stimulated by the sympathetic nervous system itself, as in sympathetically maintained pain (Roberts 1986), which occurs in complex regional pain syndrome (reflex sympathetic dystrophy). The concept of autonomic reflexes involving the skin is well accepted but relatively little is known and its relevance to manual therapy is, at present, only postulated. A helpful conceptual model is that of Korr's facilitated segment (Korr 1979).

The facilitated segment

A spinal cord segment is an anatomical and functional unit which includes a spinal nerve, its root and the section of spinal cord to which it is attached (Bogduk 1989). The spinal nerves form parts of mixed peripheral nerves which contain sensory, motor and autonomic fibres. Sensory stimulation enters the spinal cord via the dorsal horn and motor output leaves via the ventral horn. Convergence of sensory, motor and autonomic impulses occurs in lamina V of the dorsal horn at the wide dynamic range neurones. The segment therefore receives afferent stimuli from sensory fibres, provides electrical supply to muscles via motor nerves and innervates tissues and viscera via autonomic nerves (Fig. 3.6). Each segment connects to neighbouring ones and to other parts of the CNS via longitudinal connections in the fibre tracts of the spinal cord.

According to Korr's theory, all neuronal components within a single vertebral segment may become 'facilitated' by abnormal activity or irritation in any of the individual components. Facilitation in this context refers to synapses that are easily triggered, probably due to loss of inhibitory factors. In other words, it is 'more easily activated by a stimulus than is necessary in order to provide optimal service to the total organism' (Upledger 1989), a phenomena well understood in the field of physiology where it is described as a lower synaptic threshold. This causes it to fire off a more rapid volley of nervous activity

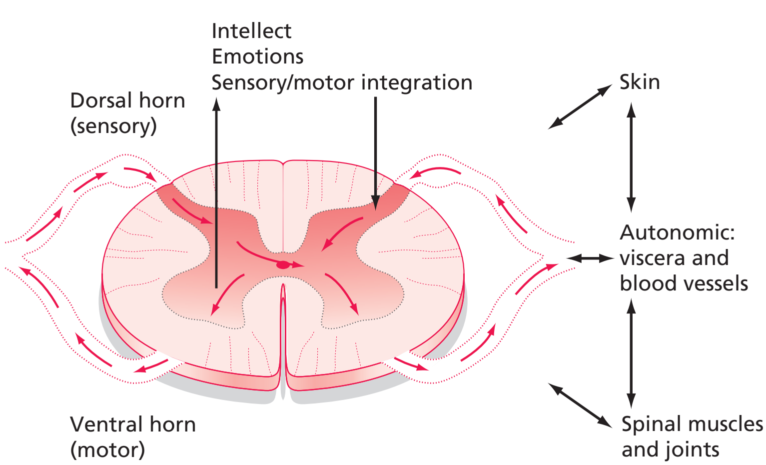

Figure 3.6 • The facilitated segment.

than is warranted by the strength of the incoming stimulus and these are able to pass more easily across the synapses. With reference to pain impulses, for example, the 'gate' is opened. It is thought that, eventually, this facilitation spreads to all nervous tissue throughout the segment, and possibly to neighbouring segments, through neuronal pools. Changes will be seen and felt by the therapist and experienced by the patient in skin, muscle, circulation and viscera. So, the therapist may feel tight, dry or sweaty skin, thickened connective tissue, reduced circulation and increased muscle tone, whereas the patient may feel tightness and soreness for example, between the shoulder blades with visceral symptoms such as an irritated stomach or gallbladder, depending on the spinal segments involved. Normal stimuli can trigger discomfort in an irritated structure and a minor strain, for example in a muscle, will trigger symptoms in a segmentally associated organ.

Eventually, the whole segment can be irritated and abnormal responses of the microcirculation can result. It should be understood that the effects may be extremely subtle, the tissue changes being detectable only by a therapist with very sensitively trained hands. The visceral discomfort may be a slight discomfort or irritation, rather than pain. It is believed that it is possible to desensitise the segment by applying altered neuronal programming, by changing the local chemical environment, improving circulation, reducing the muscle spasm, removing the focus of irritation (by stretching a scar, for example, or manipulating a joint) or modifying the diet to 'rest' an inflamed gallbladder.

Clearly, it is preferable to remove the cause of the facilitation but sometimes this is not possible if the problem is a chronically degenerated joint or an ongoing stress response such as a stomach ulcer. Once a state of facilitation exists, it can be 'damped' by treating any part of the segment, to have a reflex reprogramming effect. Massaging the skin, changing the circulation and local fluid balance, reducing muscle spasm and stretching tightened connective tissue will affect sensory, autonomic and motor nerves, and should eventually have an effect through the whole segment. In chronic states, when the facilitation itself has outlived the initial primary problem, this sort of treatment may reduce and prevent symptoms altogether (Upledger 1989).

So, theoretically, stimulus of muscle, skin and viscera can produce responses in the other structures supplied by the same segment; the effect can be positive (if used therapeutically) or negative (if this results in hyperactivity and irritation). This situation should dictate whether intervention should be stimulatory or sedative. A muscle problem may require massage but, if it occurs in association with an area of autonomic tissue change or facilitation, the intervention should ultimately be sedatory and care should be taken not to over-treat.

Reflex effects can also be utilised more specifically through reflex points in the skin and superficial tissues. Myofascial trigger points are not included in this discussion as they fit into this category only loosely, and so are considered elsewhere. The examples chosen for inclusion here are connective tissue zones (Head's zones), Chapman's neurolymphatic reflexes and Bennet's neurovascular points. The therapy associated with the first, Bindegewebsmassage (BGM), or connective tissue manipulation (CTM), has its origins in European physiotherapy (it was developed in Germany), whereas the latter are grounded in osteopathy.

Connective tissue zones (Fig. 3.7) are found on the surface of the body, in the skin and connective tissue (Holey 1995a). They exist in anatomical areas which have a clear, identifiable segmental relationship, occurring in the dermatome which shares the sympathetic supply of the corresponding visceral organ (stomach, for example) or function (such as venous circulation to the legs). They are found between the dermis and hypodermis when acute, and between the hypodermis and fascia when chronic. Zones appear as tight indrawn areas, often with oedema around their edges. On palpation, the tissues feel dry, adherent, with increased tension and/or thickenings, or can be very oedematous (Dicke et al 1978, Ebner 1980). Agreement between therapists in recognising the presence of active zones has been demonstrated (Holey & Watson 1995). Dermal-visceral zones have also been identified by measurement of their electrical impedance and they have been found to correlate with certain disease states (Zimlichman et al 2005). Stretching the tissue interface to produce a 'cutting' sensation normalises the tension in the tissue, reflexly increases the circulation throughout the area that corresponds to the zone and improves visceral function. Working on the sacral and buttock areas, for example, can reduce local pain, increase peripheral circulation and improve bowel and bladder function. CTM may also promote balance within the ANS in patients who present as being sympathetically or parasympathetically dominant (Holey 1995b). This technique has been found to be more effective than

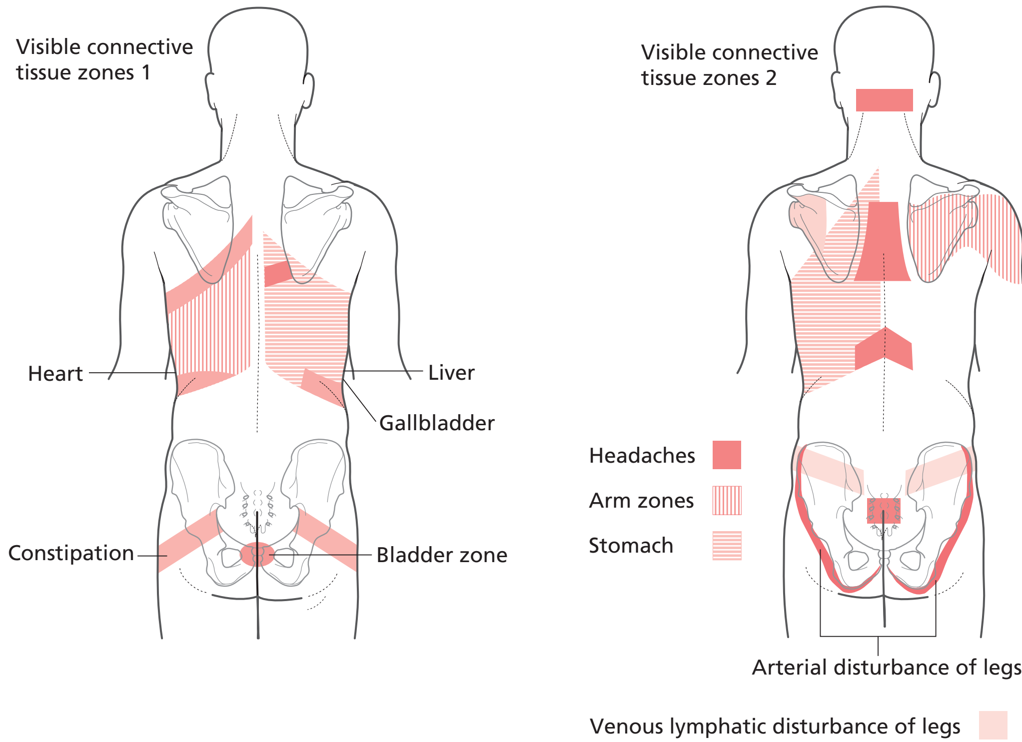

Figure 3.7 • Connective tissue zones. After Ebner (1962).

abdominal massage in improving bowel function in a single case (Holey & Lawler 1995) and as effective as an epidural injection for pain relief (Fraser 1978). It has also shown a trend towards relieving anxiety symptoms (McKechnie et al 1983). Kaada and Torsteinbo (1989) found an increase in plasma beta-endorphins following CTM, demonstrating the stimulation of suprasegmental reflexes. Positive results have been reported for its use in fibromyalgia (Citak et al 2001); fibromyalgia combined with therapeutic ultrasound (Citak-Karakaya et al 2006); and when used alone (Brattberg 1999), but one study showed it to be less effective than manual lymphatic drainage under this condition (Ekici et al 2009). Positive effects have also been found in treating tension headaches (Akbayrak et al 2002), migraines (Akbayrak et al 2001), Raynaud's disease (Ekici et al 2008), reflex sympathetic dystrophy (Taspinar & Aslan 2008, Van Schie 1993) and back pain (Sanchez 2007). Not all of these papers are available in English.

Chapman's reflexes are described as being specific points in deep fascia, palpable as thickenings smaller than the size of a large bean. They assist diagnosis and, when manipulated, alter local fluid drainage and stimulate somatovisceral reflexes. Bennet's neurovascular points are palpated as contraction or induration of the tissues. They are relieved by slight pressure, which is most effective when applied with a fingertip in between two adjacent fingertips, which exert a slight stretch to the skin by drawing away from each other. Bennet believed that this stretch may be followed by a palpable arteriolar pulsing (Chaitow 1987).

Unless the therapist is using a general massage technique such as classical massage, or is following a particular approach such as shiatsu or segment-massage, she is faced with a bewildering array of reflex points and their postulated effects. Chaitow's solution is to use neuromuscular technique (NMT), in which all the tissues are systematically palpated and treated by specific stroking movements of the finger or thumb tips. These are applied at two depths: the first is a superficial stroke aimed at palpating and identifying a problem area; this is then treated by a deeper stroke which is often sufficient to alleviate the problem. The palpable areas are treated as they are encountered and Chaitow advocates the use of NMT in combination with any other technique necessary, such as stretch and pressure (Chaitow 1987). CTM, however, should not be mixed in the same treatment with other modalities as the therapist needs to control potentially strong autonomic effects. Most reflex points identified in soft tissue therapy approaches have yet to be identified and explained scientifically. The exception to this are Head's connective tissue zones—see Chapter 9.

Conclusion

Several claims have been made for massage. Some have been demonstrated scientifically but, unfortunately, many of the studies are flawed, some in the light of more recent knowledge and some owing to poor research design (Ernst & Fialka 1994). Massage remains both under-researched and difficult to research. Many of the suggested effects for massage can be explained and understood in the context of sound scientific principles, but it is desirable that these beliefs are supported by research evidence. Claims should be regarded sceptically, at least until a convincing explanation has been given, and the therapist should be clear about which parts of our understanding are based on biological explanations rather than scientific validation.

Key points

- The fat content of tissues cannot be reduced by massage.
- Touching can provoke various responses.
- Massage can influence fluid exchange in tissues without necessarily changing the volume of fluid present.
- Massage can reduce swelling; this effect is considerably enhanced by the use of continuous pressure between sets of strokes and treatment sessions.
- Increased fluid exchange can 'flush' the tissues, clearing the area of chemical irritants and toxins.
- Massage has been shown to increase circulation in immobile limbs.
- The circulation is not increased beyond muscle pump effects in healthy volunteers.
- Vasodilatation caused by massage possibly creates a need for dormant vessels to be recruited.
- Massage has been found to reduce the discomfort of fibrositis, with seven treatments being the optimum number.
- Massage can reduce spasm in muscle fascicles, thought to be due to increased sensitivity in muscle spindles.
- Massage reduces muscle tone, increasing the range of joint movement and reducing associated pain.
- Massage reduces the H reflex, the deep effect being greater than superficial effect.
- Massage increases general flexibility.
- Sensory recovery can occur more quickly with massage.
- Remodelling of connective tissue during the healing process can be facilitated by massage.
- Autonomic reflexes are stimulated by massage; these are the axon and cutaneovisceral reflexes.
- The spinal neuronal segment is said to be facilitated when all its components are hyperactive and the whole is triggered by any one component.
- Reflex points on a patient's skin may be connective tissue zones, Chapman's neurolymphatic reflexes or Bennet's neurovascular points.

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4

Pathological principles

CHAPTER CONTENTS

When massage is applied therapeutically for specific physical problems, the therapist should be guided by knowledge of not only the underlying pathological process, but also the stage of healing. Almost all diseases or traumatic states involve a process of inflammation and repair, and the stages in this process must inform decision-making in the planning, progression and modification of treatment. In addition, massage should be applied in the context of the patient's well-being as a whole: the influence of massage on other physical problems must be clearly thought through *before* treatment begins as they may indicate modification of, or even contraindicate, the preferred treatment. Psychological and emotional factors must also be considered carefully to ensure that the psychological effects will be positive and that the massage is appropriate to the patient.

Physical considerations

Pathological factors to consider are both local and general.

Local factors

Inflammation (Fig. 4.1)

Inflammation may have an acute and a chronic stage. Acute inflammation is the response of the tissues to injury. It is a common process which occurs following mechanical or chemical trauma, infection, extremes of temperature, ischaemia, bacterial invasion and faulty immune reactions (Box 4.1). It is a necessary and positive event, being an important defensive mechanism essential for adequate healing to occur. It can, however, be induced or maintained inappropriately, in which case it may cause severe tissue damage, pain, deformity and loss of function in the affected parts.

Immediately after injury to the tissues, damaged blood vessels constrict under the influence of noradrenaline (norepinephrine) to slow blood loss should that be occurring. During acute inflammation the tissues then undergo sequential change, which begins with arteriolar dilatation, induced by local chemical mediators, including histamine, released from Mast cells and bradykinins, causing relaxation of the smooth muscle in the vessel walls. There is a consequent increase in blood flow. This means that the capillaries become dilated with the increased volume of blood entering them from the arterioles, which is seen and felt as a reddening of the skin in the affected area.

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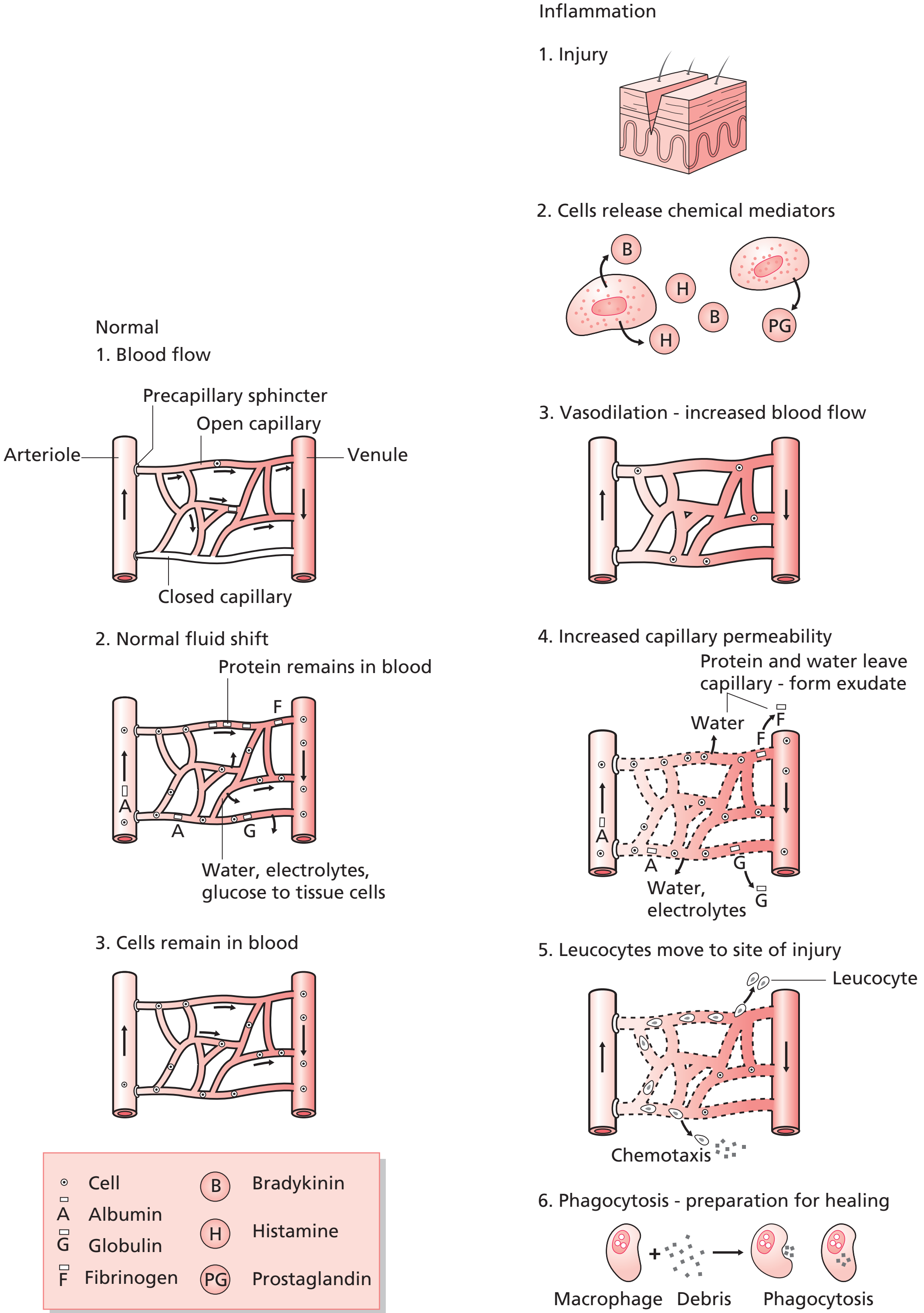

Figure 4.1 • Inflammation: a comparison of normal capillary exchange and inflammatory response.

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Box 4.1

Stages of acute inflammation

- *Transient phase*: mild injury, caused by histamine, lasts approximately 15 minutes.
- *Delayed persistent phase*: delayed response in which swelling may take up to 24 hours to reach a maximum because of endothelial cell damage.
- *Immediate persistent response*: may last for several days until damaged endothelial cells are replaced.

Note that massage is contraindicated over an area of acute inflammation.

There follows an increase in capillary permeability, which allows leakage of plasma into the tissue spaces. The intercellular gaps in the endothelium increase in size due to contraction of the endothelial cells, which contain contractile filaments. Fluid is forced out of the capillary into the extravascular tissue spaces by an increase in hydrostatic pressure within the vessel, created by the extra blood which has flowed into the area. Proteins are also lost from the vessel, as they can escape through the enlarged intercellular gaps; this causes decreased intravessel osmotic pressure and increased osmotic pressure in the tissues. The fluid is seen and felt as a swelling, or oedema, in the affected and surrounding tissues. It is thought that oedema dilutes any toxins that may be present in the tissues and carries important substances which assist in phagocytosis. The fluid is known as inflammatory exudate and the process by which it moves into the tissues is termed transudation.

White cells line and adhere to the venule walls (margination) immediately the inflammatory process begins. Once fluid and proteins have leaked into the tissues, blood flow diminishes and blood viscosity increases, with red cells undertaking rouleaux formation in which they are stacked together.

Outside the vessels, white phagocytic cells, mainly neutrophils, migrate to the area. They are attracted by chemotaxis and leave the blood vessels by pushing between the endothelial cells, forcing through their pseudopodia between the cells. They are followed by large numbers of macrophages. The exudate is now a cellular aggregate and is viscous in consistency and appearance. Phagocytosis then removes unwanted material from the damaged area. The target cells are coated with protein—antibodies or complement—in the process of opsonisation, which allows them to be engulfed by the phagocyte. The material is then ingested, requiring much lysosomal activity.

Once the causative factor has been dealt with and inflammation has slowed, the tissues must return to normal by resolution. The inflammatory debris (including fibrinogen) is removed by macrophages, plasmin and lysosomal enzymes. The exudate and its proteins are removed by the lymphatics. If, however, any exudate persists it must undergo the process of organisation. Macrophages, fibroblasts and new capillaries invade the area. The macrophages remove the remains of the exudate while the fibroblasts secrete fibrin, which eventually results in collagen formation (a process expanded upon later in this chapter). The new capillaries withdraw and the collagenous tissue shortens, forming a *scar*. If tissue has been lost and the damaged cells are able to reproduce, regeneration next occurs.

The subacute phase lasts from 2 to 4 weeks after injury and is the period when resolution becomes complete and symptoms gradually subside (Kloth et al 1990).

Chronic inflammation

Inflammation that persists for months or more is termed chronic. It results from a breakdown in the normal process of acute inflammation, caused, for example, by a persistent irritant, inadequate circulation or a failure of exudate, pus or bacterial removal. It may also be caused by an autoimmune response. The presence of increased numbers of macrophages in the tissues will attract collagen-producing fibroblasts, which aim to encapsulate the affected site to prevent the spread of pathogens. Thus, prolonged inflammation will produce excess scar tissue, which can have significant functional consequences.

Inflammation occurs in all damaged tissues; recognition and assessment of the presence and severity of the symptoms will inform accurate clinical decision-making concerning massage.

The symptoms of inflammation (see Box 4.2) are known as the four cardinal signs. *Redness* is caused by the capillary vasodilatation and increased blood flow; *swelling* is caused by the inflammatory exudate in the tissues, enhanced by a reduction in lymphatic drainage in the area due to fibrinogen clots; *heat* is due to increased blood flow; and *pain* results from the former events, particularly the distension of tissues, pressure exerted by the oedema in limited tissue space and chemical irritation from inflammatory mediators.

Box 4.2

Symptoms of inflammation

- Redness
- Swelling
- Heat
- Pain

Healing (Fig. 4.2)

The next process to consider is that of wound healing. The process is essentially the same in soft tissues whether the wound is caused by a scalpel, a crush or blow, a tear, or non-mechanical trauma. Inflammation is an inherent part of healing as the initial inflammatory process serves to contain the damage, preventing bacterial spread, for example. The other phases of healing must also be considered as they should dictate the type and timing of different massage manipulations. During this process, the tissues show a diversity of the various stages of healing. Ongoing inflammation occurs alongside other healing processes and possibly pathologies, for example inflammatory exudate, scar tissue and tissue necrosis.

There are two types of healing, the distinction being whether there is tissue loss. If the wound is a neat incision (a cut with a knife, for example) there is no tissue loss, whereas in the case of a skin graze, or a blow leaving crushed muscle fibres which die, tissue loss leaves a gap. Wounds without tissue loss heal by 'first intention' and those with tissue loss heal with 'second intention' (Fig. 4.2).

In either case, granulation tissue is formed, this process beginning 38–72 hours after injury. The area contains large numbers of macrophages for debris removal; fibroblasts and surrounding capillaries 'bud' into the area, forming new growth to provide nutrition. Collagen, hyaluronic acid and fibronectin (a glycoprotein which enhances cellular adhesion and migration) surround these new leaky capillaries and newly formed lymphatics. This tissue is termed granulation tissue, as its new capillaries give it a red granular appearance.

Meanwhile, a few hours after injury, epidermal cells begin to migrate. The surrounding epidermal cells break their desmosomal attachment with neighbouring cells and produce actin filaments at the edges of their cytoplasm which give them the capacity to move more easily by reaching out with pseudopodia. The cells either roll over the top of each other in a continuous line until the gap is filled, or slide along in a chain until the lead cell reaches the other side of the wound. The surrounding epithelial cells also reproduce, until a thin covering of cells seals the wound surface, and the wound is then closed from the edges inwards, growing progressively smaller in diameter. It is thought that these events can occur because the natural inhibitors of tissue growth—chalones—are absent from the area of tissue loss and are therefore unable to prevent cell division, and because epidermal growth factor is present.

At this stage the connections between the cells are fragile and delicate, and manipulation may damage them, causing breakdown of the new tissue which delays healing. However, good nutrition via the bloodstream is essential for successful tissue repair and careful massage of the surrounding area may be beneficial, particularly where the circulation is poor.

The next visible occurrence is wound contraction. This begins before substantial collagen synthesis in the first 2 weeks after injury; it is thought to be due to the contractile abilities in the actin-containing fibroblast, the myofibroblast. These cells extend pseudopodia, attach to the collagen fibrous network and retract, reducing the surface area of the wound if the conditions are favourable, and if the number of cells is appropriate for the size of collagenous matrix.

Once cell migration is complete, a collagenous basement membrane is laid down and the cells form connections. In scar formation, cytokines stimulate fibroblasts which form collagen, and polypeptide chains aggregate into a triple helix to become procollagen, at which stage it is released from the fibroblast. Parts of the molecule are lost, leaving tropocollagen, and intramolecular and intermolecular cross-bridges are formed to give tensile strength to what is not yet a structural fibril. At this point, the collagen resembles type III collagen, which is eventually replaced by type I collagen in response to mechanical stress. This stage is a major part of skin healing, as dermis contains predominantly connective tissue.

Mechanical stress is important at this stage for the remodelling of collagen (replacement of type III with type I collagen) and also for alignment along the lines of stress. This alignment is due to the piezo-electrical effect whereby electrical streaming potentials result from mechanical stress and dictate the remodelling process. This stress is usually produced internally by normal functional activity, for example when muscle contraction exerts a pull on a tendon or when

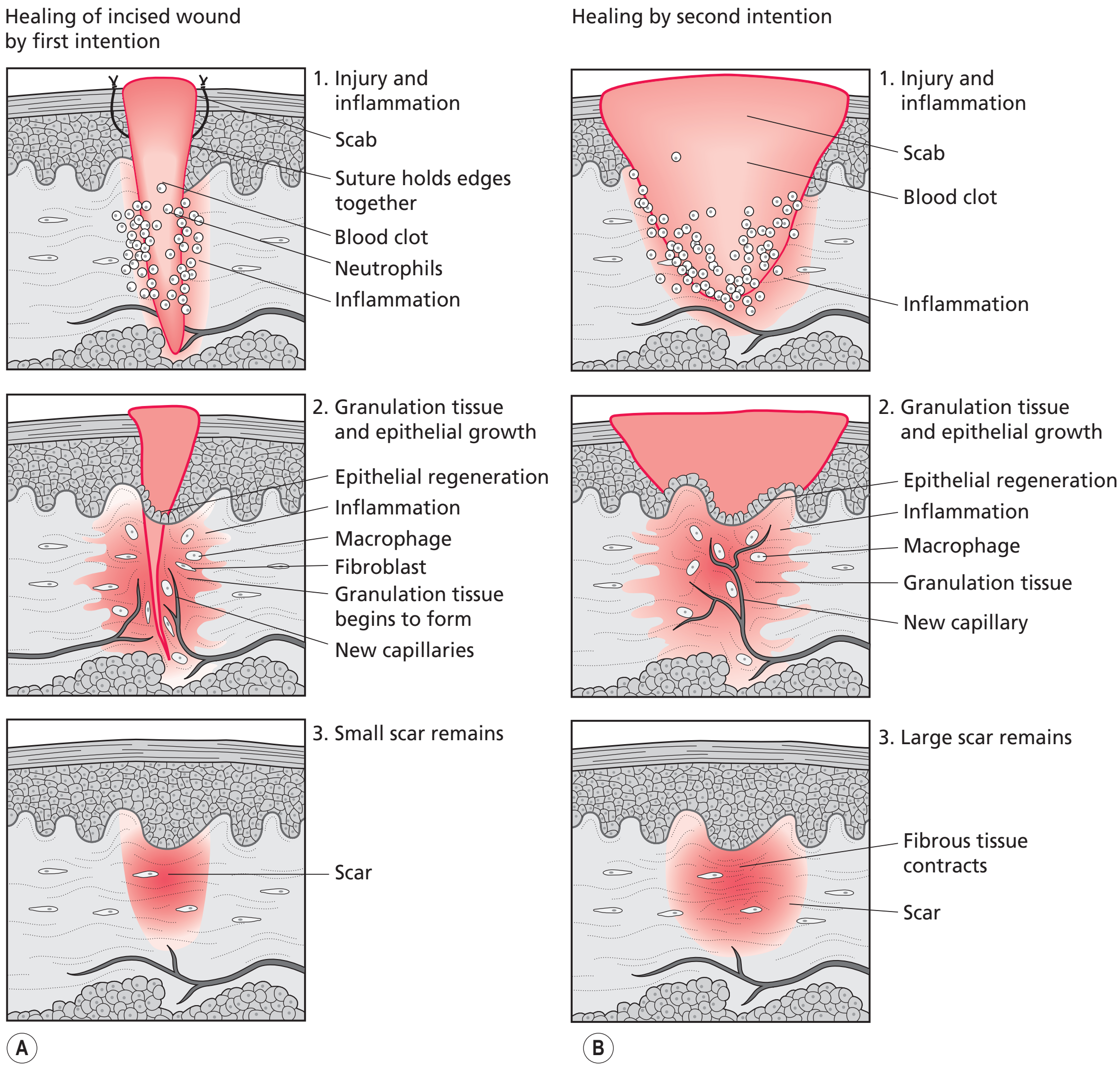

Figure 4.2 • The healing process. Reprinted from *Pathophysiology for the Health-related Professions*, Gould (1997) with permission from Elsevier.

joint movement applies forces to ligaments. The effect may be enhanced with artificial stress, applied externally by manipulation of the tissues. Massage, therefore, will promote remodelling and thereby increase the tensile strength of the tissues. This effect is particularly important where immobility, either local or general, has been enforced. The lack of movement will have resulted in reduced stress being exerted on the tissues which has a weakening effect, even in normal tissues, as demonstrated by research (Akeson et al 1973).

The remodelling occurs during the *maturation phase* of scar formation. The bonding within the intercollagenous molecules strengthens, converting from the weaker hydrogen type to the stronger covalent type of bond. Hydrogen bonding permits stretching in response to gentle stress, whereas mature collagen is more resistant. This is important, as at this stage stress that is correctly applied and not excessive will ensure that the wound or scar heals at optimum length; any shortening is difficult to correct once healing is complete, owing to the stronger covalent bonding in mature collagen.

Occasionally, this remodelling mechanism fails and the balance between collagen removal (or lysis) and deposition (or synthesis) is lost. If excess collagen deposition occurs within the boundaries of a skin wound, a *hypertrophic scar* results. If it extends beyond the wound, and encroaches on normal tissue, then a *keloid scar* results. Keloid scarring is prone to occur in burned skin and the use of pressure garments is common in treatment of the burned patient. These exert a continuous pressure (they must be worn for 24 hours a day), creating a piezo-electrical streaming potential to maximise connective tissue remodelling. They have been found to be extremely successful in reducing hypertrophic and keloid scarring.

Friction massage has been found not to influence the vascularity, pliability or height of hypertrophic scarring (as assessed by the Vancouver Burn Scar Assessment Scale) when it was given to 30 children for 10 minutes daily over a 3-month period (Patino et al 1999). The choice of frictions as a massage technique in this study can be questioned. It placed a high level of dynamic mechanical stimulation in tissues in which, in the case of hypertrophic scarring, the balance between the lysis and synthesis of collagen has been lost. It is perhaps unsurprising that this study yielded negative results when there is evidence that continuous pressure is effective in reducing the effects of hypertrophic scarring.

This account of the physiological events that occur during the inflammatory and healing processes may serve to inform our intervention during or following these events. Massage should be employed to:

- Enhance natural healing processes;
- Increase surrounding circulation, thereby increasing local blood flow;
- Increase venous and lymphatic drainage from the area, enhancing the removal of waste products and proteins;
- Promote remodelling of collagen;
- Soften scarring; and
- Mobilise tissue bound in scar formation.

First, it may be appropriate to increase circulation to the area. Blood flow may be compromised as a result of the patient's circumstances—confined to bed, for example, or immobilised for some other reason. The reduced mobility may be general if the patient is unable to function normally, or may be local if only the affected limb, or even joints above and/or below the injured area, is immobilised. Immobility may be of a more subtle nature, for example if pain, or a dressing, prevents normal gait or muscle action. This situation reduces muscle pump activity and consequently venous return, resulting in a reduction of general circulation and a gravitational pooling in the lower limb. Slight puffiness around distal joints, especially the ankles, in the absence of other possible factors (such as heart or kidney failure), indicates reduced muscle pump.

The circulation locally around the wound may need to be increased. If inflammation has reached a chronic stage and healing has been delayed for any reason, then the wound margins may be adherent and congested. Wound contraction may be compromised due to excess adherence of the margins to underlying tissue. Gentle circular kneadings around the edges, taking care not to touch any healing surfaces, or to disturb areas of healing, may bring nutrition to the area, mobilise the margins from adjacent layers of tissue and speed up wound contraction, and therefore healing.

As the wound heals beyond the cell adherence stage, gentle stress will facilitate remodelling of collagen and therefore maturation of the scar. At this stage, adherence and excessive contracture must be avoided. Massage can help to loosen the scar from underlying tissue, preventing or reducing adherence in a more chronic stage of healing. It can reduce contracture of the scar by repetitive stretching, facilitating a final optimum length of the collagen fibres.

At all times, the stage of healing must be considered—this guides the effectiveness and safety of the techniques. The timetable of healing is now well established and the summary in Table 4.1 provides a good basis for clinical decision-making and treatment planning.

We will return to the implications of the stages of the healing process in the clinical sections of this book, but from the preceding descriptions it is clear that in the early stages of healing, when the cell connections and collagen fibrils are delicate, manipulation should be avoided. The surrounding area can be massaged gently to increase circulation, an effect that may be enhanced by proximal massage. During the early stages of remodelling, *gentle* mechanical stress will facilitate healing at the optimum collagenous length and strength. As this period moves into consolidated healing, a stronger stress will correct any shortening and further strengthen the tissue.

Wound contracture is an essential part of the healing process, particularly where there is extensive tissue loss, and over time the scars tend to become smaller and paler in colour. However, occasionally this shrinkage occurs beyond a desirable level. This sometimes happens as healing occurs, but remodelling, stimulated by normal movement of the body part and stretching of the affected tissues, gradually restores the tissue to a more functional length. If local or general immobility reduces this normal

Table 4.1 Phases of wound healing

Phase	Onset	Peak	Duration	Pathophysiology	Wound strength	Management
Traumatic inflammation	0	12 hours	24–48 hours	Vascular response: bleeding, oedema Cellular (phagocytosis) response: leucocytes, macrophages	Negligible	Rest Elevation Ice
Proliferation of fibroblasts	12 hours	2–5 days	10 days	Fibroblasts proliferate, migrate and bridge wound edges by 5 days	Some	Rest Elevation
Collagen (fibroplasias)	5 days	3 months	6 months	Collagen fibrils: initially weak random fibrils, later strong flexible fibres depending on the stress placed upon them	Rapid rise	Splintage of the repaired tissue Exercise
Remodelling	1 month	→	2 years or more	Collagenase removes excess collagen, fibroblasts contract, and there is vascular and wound shrinkage	Continued gradual rise	Exercise and return of function

Adapted from *The Hand Fundamentals of Therapy*, Boscheinen-Morrin et al (1992), Butterworth-Heinemann, Oxford.

process, or if pathological factors such as infection increase fibrous tissue formation, it may be appropriate to assist in the establishment of tissue length; depending on which tissues are involved, reduction in tissue extensibility, even temporarily, compromises joint movement and function causing possible joint complications such as stiffness and loss of accessory movements, which may alter the biomechanics of the joint and reduce its range of movement. Complications such as this produce the difficulties experienced by a patient as *functional loss*. This may be considerable, for example if the damage has occurred in the hand, with potentially serious psychological, social and financial effects. Eventually, if left, the tissue may remodel in its newly shortened length and contracture may be permanent. Manipulations that stretch the tissue in all directions are important here.

The effects of excess tissue contracture will vary with the tissues involved. Ligament contracture, for example, will compromise the function of its joint. The effects will be exacerbated if adherence of the scar to underlying tissue has occurred. This will result in loss of excursion, not only of the superficial layers but of the deeper layers also, resulting in increased functional loss. Each time a normal movement places the tissue on a stretch, rather than yielding normally, a pull will be exerted at the point of adherence (and the tissue interface), causing pain. The patient will tend to stop the movement short of that point, to avoid further pain. Remodelling of the tissue will therefore occur in response to non-functional stimuli, resulting in shortened, and initially weaker, collagen because of the reduction in stress. If muscle tissue is involved, shortening and muscle imbalance could result. Where movement is less well controlled, there will be pull exerted at the end-point of mobility, creating an inflammatory reaction at the adherent interfaces. This will result in the formation of further fibrin and collagen, causing thickening and excess scarring. The result will be a permanent adherence and loss of function.

At this chronic stage, massage should be vigorous, focusing on prolonged stretching manipulations.

It is likely that the circulation will be compromised, as chronic inflammation may result in its attendant problems, and there may be involvement of nerve endings, resulting in neural tension in the skin.

Oedema

Oedema is present in many of the patients who consult or are referred for physical therapy. It must be controlled immediately it occurs, as chronic oedema can cause fibrosis, adhesions, resultant loss of joint movement and pain. The excess fluid itself causes pain as pressure is exerted on nociceptors; it further prevents cells from being bathed in fresh, newly nourished tissue fluid, and thus reduces normal cellular metabolism. Metabolic circulation may be reduced together with metabolites, and protein remains in the tissues. Prevention, containment and removal of swelling is the essential hierarchy of care for the tissues, regardless of cause, and massage can be a cornerstone of effective treatment, with skilful application of manual lymphatic drainage (MLD) being essential in the treatment of lymphoedema.

Control of oedema is a significant feature of the massage therapist's professional life. It is present in many of our patients' tissues for a variety of reasons and hence occurs in many forms. It is essential that we are able to recognise it and identify its type so that we can establish its causative factors. This will enable us to decide whether massage can assist its removal, which type of massage will be most effective, whether an alternative intervention is required or whether massage should be avoided altogether. Excess tissue fluid is present in many people, from the 'puffy ankles' of the shop assistant on a hot day or the holiday-maker at the end of a long flight, to more long-standing intractable oedema, as in lymphoedema. Normal fluid balance in the tissues is dependent on many factors, any of which, if operating suboptimally, can result in excess tissue fluid.

Fluid balance in the body

To maintain a perfect balance of fluid between the circulatory system and the tissues, the circulation must be operating normally, in both the structure of the carrying vessels and the constituents of the blood itself. The heart pumps arterial blood into the periphery of the body, through the arterial system, so the veins must operate an efficient system of return. They must be sufficiently pliable to be squeezed by contracting muscles, to pump the blood from the superficial veins into the deep veins and then upwards along the venous system, against gravity. Valves stop the back-flow of blood when the muscles relax, thus contributing to the pumping effect. A strong dynamic muscle pump will make this system extremely efficient, and weakened muscles or immobility will decrease its effectiveness. The volume being returned to the heart must match the volume being pumped by the heart, and a system of fluid balance maintenance must operate successfully at the arteriovenous capillary loop, through pressure equalisation between the tissues and vessels (see Chapter 2). Adequate tissue pressure around the muscles created by the fascial layers will give the muscles a firm covering to contract against, ensuring that good squeezing of the veins occurs.

Causes of oedema

There are several components to the circulatory system, and oedema can occur when any component operates at less than optimum efficiency:

- Inflammation, as in an acute injury or an allergic response in the skin, causes increased permeability of the capillaries, and excess fluid will leave the circulation for the tissues.
- If pressure is placed on any part of the circulatory system, as in pregnancy, varicosity or thrombosis in the veins, the increased hydrostatic pressure within the vessels will be in excess of that in the tissues, resulting in oedema.
- Pressure can be increased in the circulatory system by heart malfunction. Cor pulmonale results from pulmonary conditions in which the pressure in the pulmonary artery is increased, exerting a back pressure on the right ventricle, resulting in hypertrophy and reduced output by the insufficient heart musculature. The back pressure causes congestion in the veins of the periphery, raising the hydrostatic pressure in the venous blood with inevitable oedema.
- Insufficiency of the lymphatic system, for example congenital absence or damage to the lymph glands by radiotherapy or surgery, means that proteinous fluid accumulates in the tissues.
- Other medical conditions can create oedema in the tissues. Heart failure, which lowers cardiac output, leads to a lowered capillary pressure, which affects perfusion in the kidneys. Sodium and water are retained by the body, some of the fluid being pushed into the tissues. Primary renal disease invariably leads to a reduced filtration rate with excess retention of salts and fluid (Woolf 1988).
- If the veins lose their compliance and the valves become incompetent, then venular distension occurs due to an increased volume of blood. The resulting increased hydrostatic pressure in the veins will produce oedema in the tissues. Primary varicose veins can be severe enough to allow blood from the deep veins to flow back across the saphenofemoral junction down the long saphenous vein. The veins will be very distended after standing and often reduce in size quite drastically after lying down. Secondary varicosity often follows an undetected deep vein thrombosis, which may exist without producing symptoms of its own, for example after surgery or childbirth (Hurst 1987).

- In situations where oedema has been long standing, the fascia may become stretched and the muscle pump becomes less efficient, so the problem becomes self-perpetuating.
- Ascites is the name given to the accumulation of fluid in the peritoneal cavity and is seen where the hepatic venous outflow is restricted in liver disease or malignancy. It also occurs in nutritional oedema resulting from prolonged starvation (particularly kwashiorkor, the name given to protein undernutrition in children).

Tissue fluid is also determined by sympathetic control of the capillary bed. The amount of arteriolar constriction is dependent on sympathetic stimulus and occurs in response to local metabolic need, chemical and mechanical irritants, temperature, activity elsewhere in the body (redistribution effect) and psychological factors such as stress. Normal tissue fluid balance is maintained by a balance between the hydrostatic pressure (outwards force) and colloid osmotic pressure (inwards force) in the vessel and the hydrostatic and colloid osmotic pressure in the tissues.

Factors disturbing any of these pressures will disrupt the balance and result in oedema. Dilatation increases the size of the gaps between cells in the capillary walls, allowing more fluid to escape from the bloodstream. This typically occurs in an acute injury as an essential part of the healing process. It is thought that the fluid flushes the area of damaging substances and chemical irritants. Plasma proteins are released into the tissues and must then be removed by an efficient lymphatic pump as they are too large to re-enter the bloodstream any other way. If fluid is formed more rapidly than it can be removed, the balance is lost and oedema accumulates. As one of the plasma proteins is fibrinogen, fibrin is secreted in an attempt to 'wall off' destructive agents and stop them spreading through the tissues. Eventually, fibrous tissue is laid down and this may trap the swelling, preventing its removal, or it may form adhesions between adjacent structures (for example between tendon and sheath, or between fibres within a ligament, or between a nerve and the connective tissue of a surrounding muscle). Once formed, it has a tendency to collect in pockets behind the malleoli or between the metacarpals or metatarsals (for example, following local injury), or to become trapped around scars, or more extensively in dependent parts—the lower leg and ankle. It was speculated in 1952 by Ladd and co-workers that metabolic circulation is reduced by oedema as the circulation is separated from the cells and massage was suggested as being important in assisting in its removal.

The need for caution

Massage can indeed help in the removal of excess tissue fluid but there are also situations in which it is ineffective or could even exacerbate the swelling:

- Where the fluid is due to organic disease such as heart or kidney problems or nutritional factors.
- Swelling due to an acute injury. In the first 24 hours after a soft tissue injury, massage may increase the inflammation and swelling and disrupt the healing process. A system of:
    - **R**est—with controlled movement
    - **I**ce
    - **C**ompression
    - **E**levation

  is the treatment of choice here.
- In the presence of a deep vein thrombosis or phlebitis. Venous problems can lead to skin ulceration and the veins can become inflamed and thrombosed (superficial thrombophlebitis). Massage could possibly dislodge a thrombus, precipitating its movement throughout the bloodstream. This could result in it causing blockage of a smaller vessel and could be fatal should this occur in the lungs. The signs to look for are increased pain, swelling and local erythema occurring in an area of venous varicosity which could indicate phlebitis; in this case a medical opinion and subsequent treatment should be sought. Pain and swelling in the calf, often fairly severe, could indicate a deep vein thrombosis. Homans' test (Fig. 4.3) should be carried out and, if positive, the patient should be referred to a medical practitioner.

Massage for hydrostatic oedema

Aims

To force blood mechanically along the vessel, to reduce the internal hydrostatic pressure to less than the hydrostatic pressure in the tissues and to push fluid from the tissues into the vessel by increasing tissue pressure beyond that of the vessels.

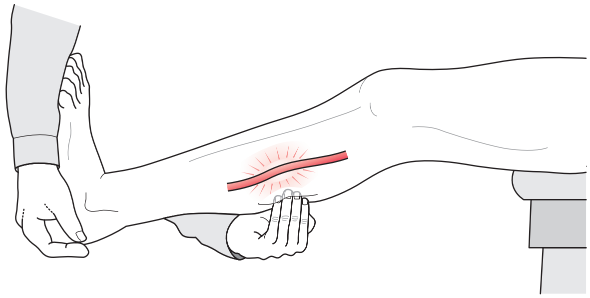

Figure 4.3 • Homans' test for deep vein thrombophlebitis.

Position

The limb should be elevated on pillows or a covered wedge, to utilise the effects of gravity. Care should be taken to ensure that the distal part of the limb is slightly higher than the proximal part but not raised so high the axillary tissues are stretched in the case of an arm, or the lymph nodes are not compressed in the groin in the case of a lower limb. An elevation of approximately 45° is suitable (Hollis 1987).

Media

The skin should be carefully inspected, as it is often dry and fragile, particularly if the oedema has been long standing; oil may be the medium of choice to protect and improve the skin.

Principles

The limb should be divided into sections and proximal areas should be worked before distal ones. As much of the procedure involves pushing the fluid mechanically towards the lymph glands, it is important that the way through is clear; therefore, the proximal sections must be drained to make room for fluid that has collected distally. Milking and pressure techniques will push blood along a vessel and push fluid from the tissues into the vessels. Effleurage may be done to coincide with static muscle contraction to increase the pressure on the vessels, or deep breaths to utilise this suction effect (Box 4.3).

Progression of treatment involves modifying the strokes as the tissues begin to feel different, increasing the size of each movement, for example. This will occur automatically as the tissues soften if they are worked to their end-feel. When the oedema has resolved, a general massage should be given to stretch and mobilise the tissue layers fully. In more acute injuries and in fibrous areas such as the soles of the feet, little soft pockets can be felt which seem to 'pop' and disappear when gentle pressure is put on them.

Self-care

The use of limb elevation, support stockings or bandages, breathing and circulatory exercises, and skin care as appropriate should be understood by the patient.

Box 4.3

Strokes

Whole limb:

- Effleurage (done slowly, as tissue fluid can be viscous) the whole limb

In section:

- Vibrations if the oedema is soft; omit if consolidated
- Deep kneading in box formation (hands on opposite aspects of limb)
- Effleurage
- Squeeze kneading for deeper tissues
- Effleurage

Whole limb:

- Effleurage

Repeat for each section.

In addition, when a joint is reached, finger and thumb kneading should be carried out around the joint line and ligaments specifically to mobilize these structures.

Tissue spaces – between the metacarpals and metatarsals, the dorsum of the foot and around the malleoli – should be effleuraged with the thumb, interspersed with finger kneading to release the fluid.

Massage for Venous Ulcers

If the massage is prescribed for an area of circulatory insufficiency, a venous ulcer may be present. This requires specific treatment which can be aided by massage. Hygiene is of the utmost importance and, if the ulcer is open, the therapist should wear medical gloves to prevent cross-infection. Latex gloves must not be worn if the patient has a latex allergy. If the massage causes discomfort or the ulcer haemorrhages, massage should be discontinued around this area (Whittaker 1987).

Aims

To increase the circulation to the surrounding tissues and mobilise the edges of the ulcer, promoting healing. As the ulcer heals and becomes smaller in diameter, massage aims to free the healed skin from the underlying layers and promote remodelling, thus increasing the tensile strength of the new skin.

Principles

The edges of the wound should be stretched and moved on underlying layers. Any open surface should not be touched. It is important to observe the wound surface during treatment to ensure that the areas of healing are not disturbed, as this may delay the healing process. The treatment should complement, not undermine, the dressing regimen and should preferably take place when a new dressing is due, so co-ordination with the nursing staff responsible may be essential. Extra changes of dressing which may disturb the healing process and introduce infection should be avoided.

Friction should be avoided where the circulation is poor. A record can be kept of the progress of healing, to monitor the rate at which the wound shrinks in size. A tracing of the wound can be taken on a double layer of sterile cellophane (the top layer, which is not in contact with the wound, is retained). This can remain as a purely visual record, or the wound area can be calculated after dividing the tracing into measured squares. Alternatively, an estimation can be made from a scale comprised of concentric circles (Fig. 4.4; Box 4.4).

Around the ulcer, where there is superficial oedema, the skin feels very soft and spongy. Where the ulcer is long standing, the skin will feel more solid and occasionally hard. The tissues may feel thickened and indurated. As the fluid reduces and circulation

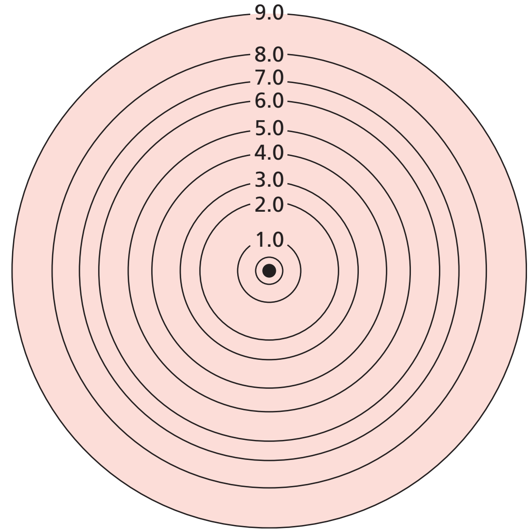

Figure 4.4 • Concentric circle grid for measuring wound diameter.

> **Box 4.4**
>
> **Strokes**
>
> **Around the edges of the wound:**
>
> - Finger kneading
> - Thumb kneading
> - Skin rolling

improves, solid areas and fibrous bands can often be felt which require treating in the usual way with deep circular finger kneading and friction techniques.

Self-care

The therapist should ensure that the patient understands good hygiene, skin care, support bandages, limb elevation, and breathing and circulatory exercises.

Massage should NOT be undertaken to the area around a decubitus ulcer (pressure sore). These are often found in tissues which have reduced nutrition due to poor circulation and/or generalised ill health where nutrient intake or absorption is reduced. There is often an infective element. Skin rubbing has long been advocated as part of nursing care, to improve circulation to areas which may be vulnerable to breakdown, although massage around decubitus ulcers has not been part of the tradition of physiotherapy because of the risk of damaging poor quality tissues (Pritchard & Mallett 1993).

A temporary drop in skin temperature may occur after massage (Tyler et al 1990), which may be clinically significant in this group of patients.

General factors

Adverse neural dynamics (Box 4.5)

This situation can occur in nervous tissue. Fibrous adhesions will produce tension at any interface—intraneurally or extraneurally. It is important that nervous tissue can glide in relation to the surrounding tissues, particularly when movement places a stretch on the nerve fibre. If not, stretch will increase the tension at the point of adherence, producing irritation. In severe cases, the nerve may be compressed by the adhesions. Injury involving the nervous tissue will produce this effect, but adjacent injury that produces inflammation and swelling may lead to compromise of the neural tissue (known as a subclinical entrapment) (Butler 1991).

Neural tension can lead to:

- Altered mechanics of the nerve and increased friction;
- Changes in the interior of the neurone which increases the irritability of the nerve;
- Abnormal chemosensitivity;
- Minor demyelination as a result of entrapment; and
- Increased autonomic sensitivity producing trophic changes (Gunn 1989).

If the nerve is irritated, a 'double crush' scenario may exist in which pathology in one part of the neurone (nerve roots, for example) may produce distal symptoms. Conversely a double crush may occur in which the pathology is distal and symptoms are proximal. According to Lundborg (1988), this is caused by reduced retrograde transport.

> **Box 4.5**
>
> **Complications of healing that may be helped by massage**
>
> **Contracture**
>
> This occurs when the tissue has healed in a shortened position. Sometimes this is necessary to prevent traction on the wound edges (for example, following tendon or nerve suture). Once healing is complete, passive and active stretching is necessary. The passive form can be applied longitudinally or transversely by massage.
>
> **Adherence**
>
> Healed tissue is often bound to the underlying layers of tissue by fibrous tissue. This must be freed by the loosening of the fibrous adhesions by vigorous massage. Adhesions can also occur between adjacent fibres in the same strata of tissue and will prevent the sideways spread necessary during contraction in a muscle or tension in a ligament. They can be loosened by a transverse friction technique.
>
> **Neural tension**
>
> The fibrous tissue produced in healing will inevitably involve any structures in the vicinity. Nerve endings may become involved in scars. This can affect the nerve by interfering with the conductivity, causing hypersensitivity. Where this occurs in autonomic nerves, it is believed that widespread effects can result throughout the autonomic nervous system (ANS). Thus, attempts to minimize the extent or effects of scarring may help to prevent neural tension occurring. Promotion of normal fluid balance, both intraneurally and extraneurally, will help to minimize fibrin formation. Mobilizing the tissues will prevent intraneural and extraneural contracture of fibrous tissue.

Pain

Most pathological changes result in varying degrees of pain. It has been found that, under normal conditions, pain is elicited by thermal, mechanical or chemical trauma. Furthermore, damage to the tissues causes chemical release which in turn may cause pain and damage the tissues even further. Substances such as potassium and bradykinin cause pain. In addition, there are various substances believed to have an indirect effect in producing pain. Acetylcholine, 5-hydroxytryptamine (5-HT), enzymes and prostaglandins can all have algogenic properties. There are situations in which chronic pain itself becomes the condition suffered by the patient, because it is disproportionate to the cause, or because it persists after the causative factor has been resolved. To explore how massage might be used to alleviate pain, pain mechanisms must first be described.

Pain mechanisms and the relief of pain

In the tissues

Any individual can identify two types of pain: fast and slow. The fast pain is experienced as sharp or pricking pain and typically occurs when one is pricked by a pin. The impulse travels so quickly that the reflex motor response by which the hand is sharply drawn away from the pin is already occurring as the pain becomes registered by the conscious mind. The slower type is of a more aching, throbbing variety. This phenomenon is accounted for by the different fibres in which the pain impulses are transmitted (Fig. 4.5). The painful stimulus is detected via nociceptors (pain receptors) and is transmitted along the large-diameter myelinated A-delta fibres at 15 ms^{-1} (or 35 miles per hour). Alternatively, it is picked up by the free nerve endings of polymodal C fibres which also detect chemical, thermal and mechanical stimuli. These use substance P as their neurotransmitter and, being unmyelinated and of small diameter, conduct impulses more slowly at 1.5 ms^{-1} (or 2.25 miles per hour) (Bowsher 1991). The impulse travels along the sensory nerve to enter the spinal cord at the dorsal horn.

Sensory nerve endings are also able to 'taste' the chemical environment in the tissues. These chemicals, which change following tissue damage, are transmitted antidromically through the axoplasm of the nerve fibre to the cell body. If chemical change persists, the presence of these chemicals within the nerve cell induces plastic changes in the neurone; for example, the cell becomes more sensitive, operating at a lower threshold. This is caused by the development of a subthreshold excitatory postsynaptic potential whereby the synapse becomes more likely to fire but a single stimulus is not sufficient to cause firing—several are needed. Normally, there is a balance between the excitatory postsynaptic potential and the descending inhibitory influences. The long-term effect of a *subthreshold* excitatory postynaptic potential increases the level of excitability and converts acute into chronic pain. In chronic states, this effect can spill over throughout a neuronal pool. This is probably why tenderness of the tissues occurs and why this area of tenderness extends over a wider area if a painful state lasts for any length of time. It is commonly experienced by patients suffering from chronic pain. Repetitive stimulus of C fibres lowers their threshold, which may be another source of tenderness. Prolonged excitation of nociceptors may be responsible for hypersensitivity and reflex responses. It is also known that bradykinin, for example, sensitises muscle nociceptors to mechanical stimuli such as weak local pressure. A recurring cycle can be produced in chronic pain states whereby algogenic substances cause altered local circulation. This increase of capillary permeability creates further biochemical disturbance which sensitises the cell bodies (for a review see Iggo et al 1984). This should be taken into account when massaging: tissues in this state should be massaged very gently. In chronic pain, the wide dynamic range (WDR) neurones in lamina V of the dorsal horn, at which convergence of sensory, motor and visceral impulses occurs, can become sensitised, causing abnormal responses to normal sensory stimuli throughout the segment.

In the periphery, massage can alleviate pain by removing waste products and chemical sensitisers from the tissues via the venous and lymphatic systems and by increasing blood flow, bringing fresh blood and plasma to the area. By stretching fibrous tissue and altering the pressures in the vessels and tissue spaces, massage releases fluid trapped in the tissue spaces and promotes transfer of fluid between the circulation and tissues. Thus, the local chemical environment can be altered and pain reduced. Removal of excess fluid from the tissues will lower pressure on nerves that may be causing pain. As fibrous tissue is stretched, this will relieve the pain-producing tension on nerve endings, including autonomic endings.

In the spinal cord

On arrival in the spinal cord, the A-delta and C fibres synapse. The point at which this occurs depends on the neuronal tract each fibre travels in to reach its final destination. Initially, the pain fibres ascend or descend several segments in Lissauer's tract before synapsing. Afferent A-delta fibres synapse in lamina I and lamina V, whereas C fibres mostly synapse in the substantia gelatinosa (lamina II), releasing excitatory chemicals, amino acids such as glutamate for fast transmission or neuropeptides (for example substance P, or vasoactive intestinal polypeptide) for a slower or modulating effect. Some fibres synapse in the ventral horn via interneurones and produce reflex motor activity, for example the flexor withdrawal response whereby a burned hand is rapidly withdrawn from the source of damage. They are also responsible for increased muscle tone in less acute pain states. If prolonged, this can lead to muscle spasm, a type of *reactive pain*. From the dorsal horn, the fast (A-delta) impulses are transmitted in the neospinothalamic tract of the opposite side after crossing in the spinal cord, to travel in the anterolateral fibre columns to the brain. Most of these fibres terminate in the thalamus but connect with the

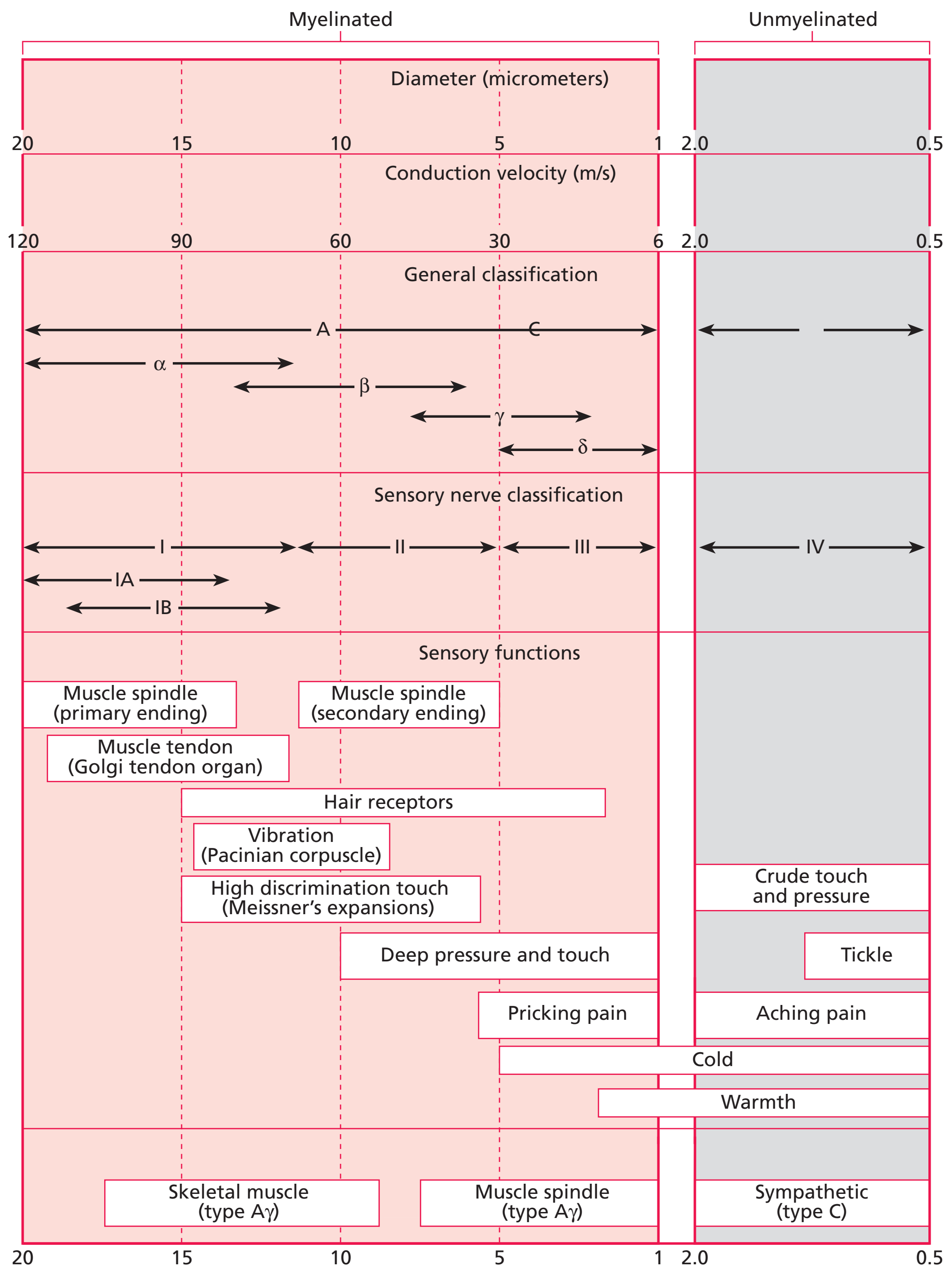

Figure 4.5 • Physiological classifications and functions of nerve fibres. Reprinted from *Textbook of Medical Physiology 8e*, Guyton (1991) with permission from Elsevier.

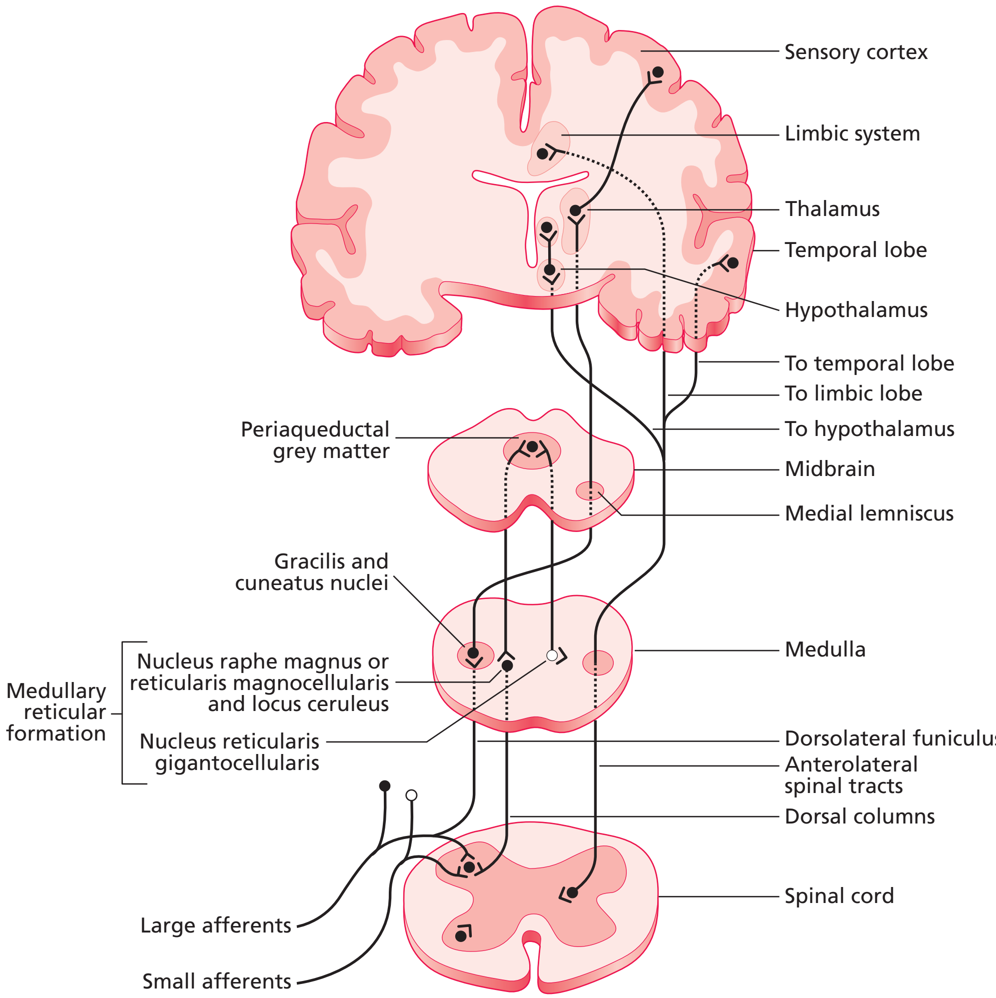

Figure 4.6 • Scheme of large- and small-fibre afferent systems and the ascending-descending inhibitory loop. Reproduced, with permission, from Hertling and Kessler (1990), p. 49.

periaqueductal grey area prior to this (Fig. 4.6). The A-beta impulses reach the cuneate and gracile nuclei of the same side without synapsing. The slower, chronic types of pain impulses are transmitted across a synapse in the substantia gelatinosa (lamina II) in the dorsal column before crossing to the opposite side to travel in the paleospinothalamic tract, eventually reaching the thalamus, and connecting with the reticular formation of the medulla. The reticular formation exerts an arousal response, the thalamus crudely interprets the stimulus as pain and has a localisation function, and the cerebral cortex, the final destination, is important for fine interpretation of the quality of pain and detailed spatial localisation. Communication occurs with the limbic system for emotional response to the pain. This is a highly significant factor as the emotional interpretation we place on a stimulus helps us to recognise it as unpleasant and damaging. The connections within the brain are more complex than described here and it is important to appreciate that reactions to pain are also complex. It is known that the hypothalamus is an important integrative area for various types of stimulus.

In addition to the ways in which massage may help to reduce pain by its effects in the tissues, as discussed earlier in this chapter, it is postulated here that massage may be able to interfere with the pain mechanism at the spinal cord level. A-beta fibres are mechanoreceptors which have a low threshold and therefore register mechanical stimuli very readily. As these fibres move from the dorsal horn, *en route* to the brain, they send a small collateral to the terminal of the C and A-delta fibres, partially exciting these terminals when they are transmitting impulses. If the dorsal horn is bombarded with A-beta fibre impulses, the stimulus in the collateral will block the C fibre synapse (by causing the terminal to be in a refractory state), ensuring that it cannot transmit further impulses. Thus, a repetitive mechanical stimulus may prevent pain impulses reaching the brain. It has been found that vibratory stimuli reduce pain (Lundeberg 1983); therefore massage techniques that have a vibratory effect in the tissues and probably other techniques that operate at the same frequency will have the same effect. This is the 'closed pain gate' of Melzack and Wall (1965). As it occurs before the synapse it is termed *presynaptic inhibition*.

Postsynaptic inhibition can occur by a descending mechanism. When the pain stimulus arrives in the raphe nucleus, the reticular formation and the periaqueductal grey area of the brain, it causes the release of endogenous opiates (endorphins, enkephalins) at these sites and in the substantia gelatinosa of the dorsal horn. These are substances released naturally by the body which act like morphine on opiate receptors (on the nerve cell membrane), causing relief of pain and a feeling of euphoria and well being. Stimuli that travel in the A-delta fibres, such as those from acupuncture, produce this effect. It is possible that a mechanical stimulus which occurs at the same frequency (two or three times a second) will have a similar effect. Massage may also produce postsynaptic inhibition because of the positive effects it has on the limbic system and cerebral cortex. Massage can produce relaxation and positive psychological effects, as discussed in Chapter 10. The patient may feel calmer, less anxious or stressed, may feel relaxed and cared for, and more in control of physical and emotional states. A *tonic* downflow of neural activity has been described in response to cultural, experiential and personality factors. A *phasic* downflow is more transient and is due to factors such as attention, anxiety and expectation. It is suggested that this influences the way each person responds to events and other forms of stimuli, emotional or physiological. As the experience of pain is a combined emotional and physiological event, these factors must influence the response to pain as it occurs in individuals and also as it occurs in each unique set of circumstances. Thus, any change in the client's emotions, as induced by massage, may alter this phasic downflow, helping him/her to cope with any pain that is occurring. In addition, this altered activity within the cortex and limbic system may cause release of endorphins, which could explain the feeling of well being that patients often report following massage.

In summary, massage is thought to assist in relieving pain both in the periphery and in the central nervous system in three ways:

1. The fluid exchange and increased circulation it causes will improve the local chemical environment.
2. It may produce presynaptic inhibition by closing the 'pain gate' in the dorsal horn of the spinal cord.
3. It may cause postsynaptic inhibition through its effect on the limbic system and cerebral cortex.

Contraindications

Finally, consideration of pathological factors must include discussion of contraindications to massage. Knowledge of what these are, understanding their relevance and the ability to recognise their existence are what makes massage safe, and safety is the baseline of competence. The approach taken in this book is that the therapist should understand the principles and be able to make informed choices about what is appropriate and when. Some contraindications are applicable in certain situations and they are not absolute in that they are not found in all circumstances, in every individual. Thus, headings and explanations, rather than long definitive lists, are given. This is different to approaches taken by other authors (Batavia 2004).

Some of the contraindications derive from theoretical understanding or common sense; some are speculative and unproven; and some are suggested as a result of reported occurrences. They can be divided into three types. The first type are absolute contraindications for all situations. The second type may not be absolute, and certain techniques in some of these circumstances may be safe. The third type require care and are more accurately regarded as dangers rather than contraindications in the true sense of the word.

To understand the contraindications, it is helpful first to explore the potential dangers of massage. The known effects of massage will prove to be a danger in any situation where those effects are deemed to be undesirable.

Dangers of massage

- Massage is thought to increase blood flow. However, increasing blood flow could be dangerous if a **thrombus** is attached to a vessel wall. Mechanical stimulation of the vessel and increased blood flow may cause the thrombus, or a small portion of it, to detach from the vessel wall to become an embolus. This can become lodged in the heart, lungs or brain to cause serious—potentially fatal—damage.
- It is possible that massage can disturb some **implants** in the body such as silicone implants or pacemakers. Kerr (1997) reported an incident which occurred in the accident and emergency department of a hospital. A ureteral double-J stent being used to treat ureteral stenosis and calculi was displaced by a session of Rolfing (manipulation of the fascial tissues). The patient was alerted to the problem by left flank pain during treatment. The resulting pain and incontinence resolved when the stent was repositioned.
- Massage increases lymphatic flow. Increased lymphatic flow may increase the rate at which **bacteria or metastases** are carried around the body.
- Massage creates compression and shear forces within the tissues. Mechanical manipulation over a **foreign body or sharp bony fragment** will cause damage to the surrounding soft tissues.
- Manipulation of the tissues involves manipulation of blood vessels. Damaged, leaking blood vessels will be further damaged, and bleeding will increase if they are manipulated. For example, bruising will increase in **recent muscle tears** (in the first 24–48 hours after injury) or **fragile blood vessels** will be disrupted by massage. Excess bleeding may occur in **haemophilia** if deep vigorous techniques are used.
- Manipulation of the tissues **too early in the healing process** will damage the delicate cellular and fibrinous network, delaying healing and even causing excess fibrous tissue to be produced.
- Massage stretches connective tissue and scar tissue. **Internal infection** can be spread if the fibrous tissue, which is produced in an attempt to encapsulate infective material, is damaged. Bacterial and fungal skin infections can be spread to non-infected areas through touch. Likewise, **infection** can be spread between patient and therapist, or between patients if a poor standard of hygiene is maintained.
- **Infection** can be introduced into an open wound if the surface is touched by a non-sterile object.
- Massage media can cause **allergies or irritations**. Schaller and Korting (1995) reported the case of a patient suffering from relapsing eczema which was resistant to therapy. Its distribution was generalised but occurred mostly on the scalp, neck and hands. Patch-testing revealed allergic airborne contact dermatitis from the use of oils in aromalamps. Despite having had previous exposure to lavender, the patient tested positive to jasmine and rosewood, laurel, eucalyptus and pomerance. Allergic contact dermatitis has occurred as a reaction to tea-tree oil (Khanna et al 2000) and lavender (Sugiura et al 2000). (See Chapter 7 for further discussion.)
- Any excess activity in the tissues (for example, **malignant growth, calcification**) can be exacerbated by mechanical stimulation, which may speed up local metabolism.

Absolute contraindications to massage

- Massage over an open wound surface;
- In the presence of inadequate circulation, thrombophlebitis or fragile blood vessels—look for petechiae or haemophilia;
- When haemorrhage is occurring;
- During the early stages of healing;
- When there is active bacterial or fungal infection (skin infections such as cellulitis, impetigo, ringworm or athlete's foot, abscesses, septicaemia);
- In febrile conditions (very high temperature, childhood diseases, influenza);
- Over areas of acute inflammation;
- Over active bone growth—a healing fracture site, in myositis ossificans or periostitis, such as Osgood-Schlatter disease;
- Directly over skin affected by conditions such as psoriasis;

- Undiagnosed cancer;
- In situations where increased blood or lymphatic flow is undesirable such as active malignancy, in the region of a tumour or deep venous thrombosis; and
- Over a foreign body or bony fragment.

Potential contraindications where caution must be applied

- *Malignant disease*: Manual lymphatic drainage or deep manipulations which stimulate the circulation or metabolic rate should be avoided over areas of active disease or in the vicinity of tumours.
- *Fragile skin*: Light pressure only should be used, with a suitable medium to reduce friction, or this type of skin may tear.
- *Collagenous weakening*: For example, in long-term steroid use or diabetes or advanced rheumatoid arthritis.
- *Patients with heart problems*: The anterior chest or neck must not be massaged and care should be taken between the shoulder blades, because of potential reflex effects. Grimes (1988) and Searle (1987) conducted research which showed that 10 minutes of effleurage (as a nursing back rub) in subjects who had undergone coronary artery bypass surgery produced an immediate rise in systolic and diastolic blood pressure, followed by a steady decrease in blood pressure. While the gradual drop in blood pressure may be of benefit to some cardiac patients, such as those who are post myocardial infarction, the initial blood pressure rise suggests that massage may be contraindicated in others. Patients unable to adapt to the initial rise, such as patients in the first 48 hours post surgery, should not be massaged (Labyak et al 1997).
- *Dermatomyositis*: It has been suggested by Bork et al (1971) that massage should be avoided in this condition as whole body massage has been shown to increase serum levels of gonadotrophin, creatinphosphokinase, lactate dehydrogenase and myokinase in a patient with this condition. As high levels of these enzymes indicate the severity of dermatomyositis, it should not be treated by massage.

When caution should be applied

Stationary pressure techniques

If using shiatsu or acupressure techniques, for example, excess pressure should be avoided and the underlying anatomy should be clearly understood. Herskovitz and co-workers (1992) described a situation in which degeneration of the recurrent thenar motor branch of the median nerve occurred as a result of direct pressure exerted during a shiatsu session. Although pressure was applied for only 30 seconds, it resulted in weakness of the abductor pollicis brevis muscle. A point of interest in this report is that the pressure caused ‘notable transient discomfort’. This could have indicated to the therapist that she was compressing a nerve fibre; this emphasises the fact that massage therapists should be aware of the effects any treatment is having on a patient, and that patients should be encouraged to describe any discomfort as it occurs. The therapist should act on this information immediately, modifying the technique to suit the individual. It is surprising in this particular case that a shiatsu pressure was sufficient to produce neuropraxia, as focal pressure on the tissues occurs as part of many daily activities. It may be that this particular massage was, as the authors suggest, ‘overzealous’ or there could possibly have been an underlying problem. The muscle did, however, recover fully. A similar case was reported by Giese and Hentz (1998) in which a neuropraxia of the posterior interosseous nerve was caused by deep tissue massage of the forearm, with static pressure. The patient presented with extensor paralysis of the metacarpophalangeal joints and an inability to abduct the thumb. This massage was kept within the patient’s pain threshold.

In the vicinity of endocrine glands

A case of destructive thyrotoxicosis which occurred following massage of the head and neck was reported by Tachi and colleagues (1990). The patient was diagnosed as having autoimmune thyroiditis (Hashimoto’s disease) 12 years previously, and severe symptoms of destructive thyrotoxicosis were found when the patient attended the doctor’s clinic 10 days after the massage. The authors suggest that the mechanical manipulation of the massage techniques injured the thyroid follicles, resulting in antigen release and antibody production. It seems surprising that massage could damage a gland as these structures are usually protected by a fibrous outer layer, although the malfunctioning thyroid is particularly susceptible to mechanical manipulation. Tachi et al based the suggestion on a study by Carney et al (1975), which found palpation thyroiditis to have occurred in 91% of a sample of 32 patients with thyroid disease. The massage therapist must know the patient's past medical history and massage should proceed with caution in the vicinity of active or remitting disease. A positive suggestion raised in Tachi et al's paper is that massage of the thyroid gland (Fig. 4.7) may promote altered hormonal secretion in a way that could be clinically significant.

Cancer

The early writers on massage placed little emphasis on cancer as a contraindication. It was not listed by Goodall-Copestake (1926) or Tidy (1932), although this omission could indicate the scant attention the disease received generally at that time. Hollis (1987) gives tumour as a contraindication and Tappan (1988) lists melanoma, as this type of cancer metastasises easily through lymphatic and blood vessels. Massage therapists with non-medical training are meeting this condition more frequently and the use of massage in people suffering from cancer has become a controversial point. In its traditional use, within orthodox medical care, massage has been regarded as being contraindicated for patients with active malignant disease. Physiotherapists, by taking a detailed medical history and having access to patients' medical records, have avoided techniques that may increase local metabolic rate or blood flow in the vicinity of active disease. This statement needs some clarification, as massage has been used to reduce local symptoms, or to aid relaxation in the patient at the later stages of the condition, when emphasis is being laid on comfort rather than cure.

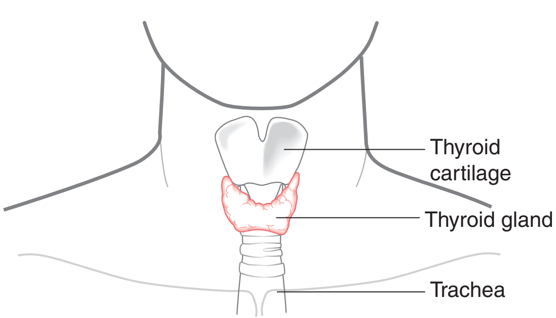

Figure 4.7 • Surface position of the thyroid gland.

It has also proved useful, for example, in spinal cancer which has produced uncomfortable sensory changes such as hyperaesthesia. This can be sufficiently severe to make touch uncomfortable to the point where washing becomes distressing. Gentle rhythmical stroking can prove useful to desensitise the skin, and the use of warm water to massage the skin gently (via gentle movements in a hydrotherapy pool, for example) may be helpful. Heavier stroking can be used as a counterirritant, acting through the pain gate to reduce pain. Further discussion of the use of massage in patients with cancer can be found in Chapter 11. Traditionally, massage has been taboo in the earlier active stages of the disease but acceptable at the later (including terminal) stages. After radical mastectomy, for example, patients have been given and taught oedema massage for the arm following removal of the lymph glands. Effleurage was the main treatment of choice; this has now largely been superseded by the more superficially applied manual lymphatic drainage.

Of course, patients with cancer have the right to treatment of other injuries and physical problems unrelated to the cancer. They also have the right to support for symptoms of stress, and help with coping mechanisms. Thus, as long as the tissues are not actively manipulated over any active disease site, increase in lymphatic and venous flow is avoided in patients with melanoma or Hodgkin's disease, and the lymph nodes are not directly stimulated mechanically, then gentle massage can be a useful adjunct to other therapies. Stationary and pressure techniques are probably the safest (holding, therapeutic touch, acupressure, shiatsu, for example); the more superficial techniques as used in gentle stroking, whole body sedative massage or through an oily medium would be the next treatment of choice from a safety viewpoint. It is unlikely that these techniques would be physiologically more stimulatory than the everyday activities of walking or housework. In relation to drug therapy, it has been suggested that massage may increase the rate at which chemotherapeutic agents flow around the body when administered into the bloodstream, that it increases the rate at which drugs enter the bloodstream when administered by other means, and that the dosage should be reduced accordingly (McNamara 1994). However, this has not yet been substantiated experimentally. Also, it has been suggested that massage increases the rate at which chemotherapy and its toxins will be lost from the body, although it should be recognised that we have insufficient experimental evidence to support these suppositions and the disease should always be treated with respect. Of course, as in all conditions, techniques and approaches should be modified to match the stage of disease.

A pertinent study was undertaken by McNamara (1994). She sent out questionnaires to 24 volunteer massage practitioners and asked for their views and knowledge on the use of massage for people with cancer. The main findings in relation to dangers and contraindications were that practitioners had often been taught or read that massage was contraindicated in the earlier stages of the disease but not in the terminal stages. There was obviously some concern about the lack of research evidence to support or refute this suggestion, but massage was generally being offered to people with cancer.

An *absolute contraindication* for massage is undiagnosed cancer. It is important that the massage therapist is alert to the possibility and that any patient experiencing symptoms which may relate to a serious condition should be urged to seek advice from a doctor immediately. Look for:

- Intractable pain—no relief on rest, significantly disturbed sleep (this may indicate inflammatory or malignant disease);
- Feeling of being generally unwell;
- Change in temperature;
- Inflammation and heat in the absence of trauma;
- Unexplained weight change;
- Any lump larger than 5 cm, especially if it is a recurrence of a previous lump or is deeper than fascia or is increasing in size (Grimer & Dalloway 1995); and
- Any suspicion that something is not quite right—if in doubt, refer to a medical practitioner.

Summary

This chapter has reiterated the message, emphasised throughout this book, that the therapist must take responsibility for her treatment decisions and that these should be based on sound theoretical knowledge. Decisions should be justified from a theoretical perspective, based on evaluation of research findings. If the therapist is unable to do this in any situation, then treatment of the condition must depend on the referral and advice of a medical practitioner. At all times, it is wise to err on the side of caution: patients rely on us not to make mistakes.

Key points

- Local areas of acute inflammation should not be massaged.
- Massage can help to reduce swelling, prevent adhesions and promote remodelling of fibrous tissue in chronic pathophysiological states.
- Massage used in the early stages of healing can disrupt delicate tissue but can assist healing in the later stages by improving circulation and tissue mobility.
- Massage can be used to improve general circulation at any stage.
- Massage can promote remodelling of connective tissue and can mobilise shortened, adherent scar tissue.
- Oedema can occur as a result of inflammation, pressure on part of the circulatory system (for example in pregnancy), heart malfunction, lymphatic insufficiency, venous problems or other medical conditions.
- Excess tissue fluid can reduce nutrition to the cells.
- Oedema leads to adhesions in the tissues.
- Massage should not be used when oedema is due to organic disease, acute injury or thrombosis.
- Swedish massage should be used for hydrostatic oedema; selected techniques applied around the edges of an ulcer or wound; and manual lymphatic drainage used for lymphoedema.
- The effects of massage in oedema are considerably enhanced if the patient wears a pressure garment or bandage between treatment sessions.
- Massage can reduce pain by flushing the tissues with new circulation, facilitating the removal of chemical irritants which can lead to chronic pain changes in the spinal cord.
- Massage can have a counterirritant effect.
- Stimulation of mechanoreceptors may close the pain gate.
- Absolute contraindications must always be followed.
- The therapist should understand the dangers of massage and be aware of cautions.

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