Injuries

David McQuillan

Forces which may lead to Injury

There are five primary forces which affect the musculo-skeletal system and may contribute to injury. Injury occurs when the force applied overcomes the resistance of the structure that it is applied to.

Compression

Compressive forces act to push surfaces which the forces are acting on together. They tend to lead to crushing injuries - bruising of soft-tissue, and compression fractures of bone.

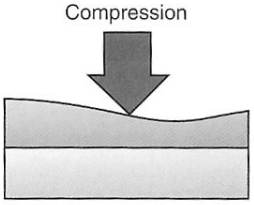

Fig 1. Compression
(Fritz, 2004)

Stretching

Stretching forces (also called strain forces) act to pull surfaces which the forces are acting on apart. They tend to lead to injuries such as muscular strains.

Shearing

Shearing forces occur when the forces applied are parallel to the surface on which they are applied. The effect of these forces are typically to twist the structure which they are applied to. In the body, the layering of body tissues tends to convert shearing forces to the body into stretching forces on individual tissues.

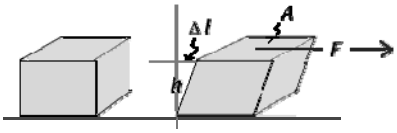

Fig 2. Shear forces
(Effects of Stress and Shear on Materials, 2007)

Torsion

Torsion forces are really a type of shearing force, but they occur when soft-tissue is twisted around the central axis of the bone. Torsion forces may also act through bone.

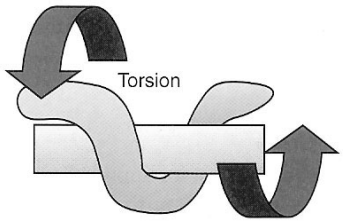

Fig 3. Torsion forces
(Fritz, 2004)

Bending

Bending forces affect bone. They occur when both ends of the bone are fixed, and a force is applied to the middle of the bone. Bending forces may lead to fracture if the force is overly strong.

Fig 4. Bending forces
(Stress and Strain, 2007)

Types of Injury

Strain	A stretch injury resulting in tearing of either muscle or tendon
Sprain	An overstretch injury to the ligaments surrounding a joint
Dislocation	Injury that occurs when the joint is moved out of it's normal alignment. Often associated with other types of injuries.
Fracture	Any variety of broken bone.

Injuries typically occur because of overload or trauma.

This overload may be caused by new activities to which the body is not accustomed, weekend warrior activities where the body is temporarily pushed behind it's limits for a short but intense period, or repetitive activities. Constrained postures may overload the body's ability to process metabolic waste. When repetitive activities are combined with constrained postures (e.g. computer data entry), their effects compound. It's not surprising that O.O.S./R.S.I. is often associated with computer work.

The Injury Healing Process

The healing of tearing or breaking injuries occurs via the inflammatory process. Blood flow to the area is increased to facilitate healing. Blood flow out of the area is decreased to limit the spread of inflammatory agents.

Massage therapy can be a very useful modality to aid effective injury healing. However it's important that massage therapists understand what occurs in each phase of the injury healing process so that they can safely interact with the healing tissues. Improper techniques at incorrect times can easily cause more damage than good.

Phases of the Injury Healing Process

The injury healing process is composed the acute phase and the sub-acute phase.

NOTE: The following descriptions apply to muscle tissue in an average person.

Acute Phase

The acute phase is characterised by two inter-related processes the inflammatory process and the fibroplastic process.

The **inflammatory process** describes the process of inflammation that is associated with wound healing. During this process, mast cells release histamine causing short-term vasodilation. As a result blood flow increases to the injury site causing the symptoms of heat and redness which are associated with injury healing. The increase in intercellular fluid compresses nerve endings causing pain. Blood-borne phagocytes remove debris & foreign antigens from the wound site. The process of phagocytosis produces hydrogen peroxide, ascorbic acid and lactic acid which chemically irritate nerve endings also causing pain.

The **fibroplastic process** describes the actions of fibroblasts in wound healing. Fibroblasts are the main drivers of *re-epitheliasation*, *fibrosis* and *wound contraction*.

If the wound has broken the skin, the epidermis must be reestablished across the surface of the wound. This process is called *re-epethiliasation*, and occurs for most wounds within forty-eight hours. The same process may take several weeks to be completed for larger wounds.

The repair of collagen collagen fibres occurs via a process called *fibrosis*. In normal muscle & fascial tissue collagen fibres are aligned along the line of stress forces. Fibrosis causes collagen fibres to be laid out haphazardly. The diagram to the right shows the formation of fibrotic scar-tissue in muscle tissue.

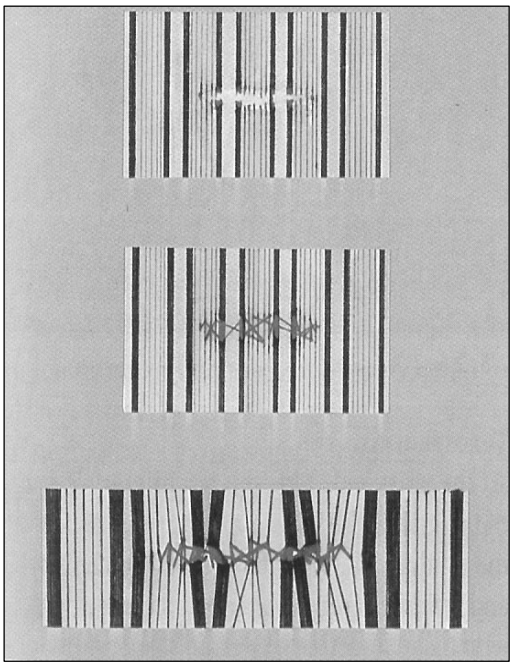

Fig 5. Scar-tissue formation
(Cyriax, 1983)

As a wound heals, it's edges are drawn together. This process is called *wound contraction*, and helps to prevents infection by closing the boundaries of the wound to external antigens. *Scar contracture* occurs in fibrotic tissue, resultings in hardening of the scar, and deformation of the structures involved. The distortion is illustrated in fig. X (opposite).

Any inflammation and swelling should have cleared up by the end of the acute phase of injury healing.

Sub-acute Phases

The sub-acute phases of injury healing are characterised by remodelling of the existing scar-tissue. Bio-mechanical stresses to the injury site act to break down the adhesions between functionally separate structures and to indicate where new collagen fibres should be laid down. New collagen is created along the lines of stress. This remodelling process acts to strengthen the integrity of the newly healed area and to reduce the negative effects of the scar-tissue. If adequate stimulus does not occur for some reason (e.g. pain, inability, plaster-cast, etc.), the collagen fibres cause adhesion between muscle fibres or other structures in the vicinity of the injury site.

The scar typically stops increasing in size by the end of the fibroplastic stage (day twenty-one).

Throughout the *consolidation stage* fibroblast's numbers and vascularity drop until at day forty-two the vascularity is equal to normal tissue. Throughout the consolidation stage fibroblasts are quite active in remodelling scar-tissue.

The *maturation stage* is characteristed by a marked reduction in remodelling. Remodelling activity still remains fairly high through the third and fourth months, then gradually drops off. Between six months to a year few changes occur, and the scar becomes more and more tendon-like. Intra-collagen bonding becomes stronger over this time resulting in a gradual increase in scar strength.

Variation in Tissue Healing Times

The time periods mentioned in the above description of the phases of injury healing are based on muscle tissue in an average person. Tissue healing times are affected by vascularity, the age of client, etc. Tendons have a reduced blood supply. As a result tendon injuries will take longer to progress through the stages of healing. Children's muscular injuries will typically progress through these same stages more quickly than the model suggests due to their more rapid healing processes.

Elevated cortisol levels which are associated with chronic stress weaken connective tissue. In addition to this cortisol has anti-inflammatory qualities which inhibit the healing response. Another effect which may be associated with chronic stress is a reduction in the production of growth hormone. Growth hormone is related to collagen formation (Caperna, et al., 1994), and is produced during restful sleep. Chronic stress may interefere with natural sleeping cycles. If an injured client is suffering from stress, management of this sterss should be a priority.

Muscular Strains

A strain is a stretch injury resulting in tearing of the musculo-tendinous unit that may affect muscle tissue, tendon tissue, or a combination of the two. Strains may occur due to a stretch force that is overly strong, but are more likely to occur as a result of repetitive overuse (Werner, 2005).

Strains are most common in the lower back and neck, the hamstrings, adductor longus, iliopsoas and rectus femoris muscles (Premkumar, 2000). Tears are most likely to occur at the myo-tendinous junction, although they can also occur at the teno-periostial junction or within the muscle belly (Whiting, Zernicke, 1998).

If there is noticeable swelling, bruising, pain or dysfunction, the client should immediately be referred to a doctor or physiotherapist.

Assessment of Muscular Strain

- Occasionally a 'snap' or 'crack' is heard as muscle tears.
- Pain, swelling, tenderness and stiffness of the affected area.
- There may be associated muscle spasm if the strain is mild.
- Pain is reproduced over tear site on active contraction or passive stretch. **Note:** further damage may be caused to the muscle by the masseur incorrectly & unsafely trying to reproduce the pain by passively stretching or contracting the muscle (muscle strength test). **Only reproduce slight pain & do not hold for long!**

Classification of Muscular Strain

Grade 1: Minor strain of a few fibres with minimal bleeding. Client complains of soreness during activity which increases with continuing activity.

Grade 2: More severe injury with tearing of a moderate to large number of muscle fibres. Sharp pain during activity causing client to stop.

Grade 3: Complete muscle tear. There is a palpable gap in the muscle. Seek immediate medical attention.

Treatment of Muscular Strain

Massage is an extremely valuable treatment modality in the rehabilitation of muscular strains. However the massage therapist must be aware of the current phase of the healing process if they are to avoid further harm to the client.

As well as treating the injury site, the therapist should also be aware of adhesions that may develop between tissues in the area.

Treatment and the Acute phase

The key sign of the acute phase of injury healing is inflammation. The R.I.C.E. protocol is generally used to minimise swelling and re-injury. Massage, heat, exercise & alcohol should be avoided during the acute period.

R = Rest	Prevents further damage
I = Ice	Cryotherapy reduces local blood flow & therefore haemorrhage; decreases the inflammatory response & therefore oedema; increases pain threshold & reduces muscle spasm by providing analgesia. Ice is best applied immediately following injury as crushed ice in a moistened towel or towelling bag & moulded to the contour of injured region. Ice & water baths are ideal for peripheral limb injuries.
C = Compression	Apply stretch bandage (only slight tension) to minimize bleeding & continued between ice application, with/without interposed cotton wool. For compression around joints such as ankle, fill in spaces with cotton wool then wrap with even pressure from joint below injury to above.
E = Elevation	Elevation reduces blood flow to & assists venous return from the injured region.

Careful massage can be a useful supportive modality in this stage. Circulatory massage can improve nutrition to the area, and improve lymphatic drainage from the area. Both of these actions will enhance healing. If muscle tension is a factor in the strain, massage aimed at removing trigger points and lengthening the muscle may be beneficial. General relaxation massage can be useful towards the end of the day can help to facilitate restorative sleep particularly if the client is having trouble sleeping. Restorative sleep will increase the availability of growth hormone, which is essential in the tissue repair process. Extreme care must be taken during the application of massage techniques to avoid any strokes that pull the lesion apart, which can cause reinjury.

Rhythmic traction may act to relieve pain, and may therefore be a useful modality at this stage.

Gentle pain-free exercise will act to reduce edema and will also provide the stimulus for correctly aligned collagen formation. It's important that the exercise does not overly stress the injury site. Again too much stress will cause reinjury.

Treatment and the Consolidation Stage

The aim of treatment in the consolidation stage is to limit the development of fibrotic tissue, and to provide the appropriate stimulus for the creation of correctly aligned collagen fibres. This is the phase in which the application of massage is most effective.

Friction massage is very useful at this stage to break up fibrotic adhesions. The diagram to the right shows the effect of the application of cross-fibre friction to a fibrotic injury. Cross-fibre frictions are recommended in the consolidation stage over other friction techniques because strokes in a cross-fibre direction are least likely to cause damage to the injury site. During this stage the healing tissues are still fairly soft and weak (especially in the earlier part of the consolidation stage). Frictions should be applied initially with a relatively light pressure. This pressure should be increased as the consolidation stage progresses and the tissues become more firm. Cross-fibre frictions are particularly valuable as a modality because they provide a type of stress which cannot be easily provided by movement. For more information about the application of cross-fibre friction see the section following (Deep Transverse Friction).

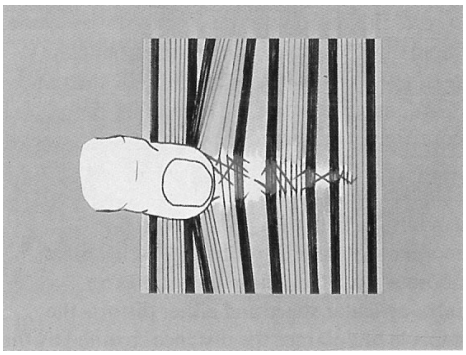

Fig 6. Cross-fibre friction
(Cyriax, 1983)

Circulatory massage can still be useful in this stage to improve nutrition to the area, and increase lymphatic drainage from the area. Care should be taken with longitudinal strokes away from the lesion especially in the earlier stages of the consolidation stage. This kind of stroke applied with too much pressure may lead to re-injury.

Exercise at this stage can progress to gentle active and passive stretching techniques which may gradually become more intense as the scar tissue matures.

Treatment and the Maturation Stage

From day 60 onwards the scar-tissue increases in firmness, and becomes increasingly resistant to change.

The application of frictions must be increasingly aggressive. Multi-directional friction may be used in this stage, although cross-fibre frictions will still be the strokes that are most effective in breaking up adhesions within the musculo-tendinous unit.

Stretching exercises should also become more aggressive, and a programme to strengthen any atrophies muscles may be instigated.

Phases of Injury Healing (Muscular)

Phase	Period	Characteristics	Massage Suggestions	Complementary Treatment
Acute				
Inflammatory Process	Day 1 – Day 14	Inflammation • Redness • Heat • Swelling • Pain • Impairment of function	Circulatory massage • Improve drainage • Improve nutrition General relaxation massage at the end of the day • Restorative sleep → increased availability of Growth Hormone → Improved tissue repair Reduce tension in strained muscles **CAUTION** - Avoid strokes that pull the lesion apart	R.I.C.E. Gentle pain-free exercise for edema reduction & correct collagen formation stimulus Rhythmic traction for pain inhibition
Fibroplastic Process	Day 1 – Day 21	Re-epitheliasation Fibrosis Wound contraction		
Subacute/Remodelling Phase				
Consolidation Stage	Day 21 – Day 60	Scar-tissue remodelling Gradual reduction of vascularity and fibroblast activity	Circulatory massage to improve nutrition & drainage Cross-fibre frictions to break up adhesions gradually becoming firmer as scar tissue matures Be very careful when using longitudinal strokes away from the lesion	Gentle active and passive stretching techniques gradually becoming more intense as scar tissue matures
Maturation Stage	Day 60 – Day 360	Hardening of scar-tissue Limited remodelling	Aggressive multi-directional friction massage to break up scar tissue	Stretching to break up adhesions (active & passive) Strengthening of atrophied muscles.

Fig 7. Phases of injury healing (Muscular)

NOTE: The above descriptions of the period of each injury healing phase are based on the healing of muscle tissue in an average person.

Ligamentous Sprains

Sprains occur when a joint is forced beyond it's normal range of movement. This results in a tearing injury to the ligaments which support that joint.

Ligament sprains are more serious than muscular strains because ligaments once stretched do not naturally regain their original tonus.

The swelling associated with a sprain is more pronounced than that of a muscular strain. This is an attempt by the body to compensate for the the lower circulation that ligaments have.

Assessment of Ligament Sprain

Typical features are-

- Tenderness over ligament on palpation.
- Pain when joint is moved or stressed.
- Bleeding causing swelling & bruising around the joint (more than with muscle tear).
- Joint instability depending on grade of sprain.

Classification of Ligament Sprain

- Grade 1 sprain: Damage to a small number of fibres. Joint is stable.
- Grade 2 sprain: Damage to a larger number of fibres. Localized pain on stressing joint.
- Grade 3 sprain: Complete rupture involving all fibres. Seek immediate medical attention.

Note: Masseurs tend to see more Grade 1 tears & sprains than 2 & 3. Grade 3 are uncommon (you may however see the chronic result of).

Treatment of Ligament Sprains

Ligaments sprains heal via the same process as muscular strains. Ligamentous injury can be treated by friction in the same manner as muscular strains (see previous section – Treatment of Muscular Strain), however the ligament healing process typically takes longer than the muscular healing process due to the reduced circulation to ligamentous structures.

Deep Transverse Friction

The development of deep transverse friction (DTF) is often attributed to Cyriax. While cross fibre friction existed before Cyriax, he as one of the most influential figures in orthopaedic medicine was instrumental in popularisation of the technique.

Cross-fibre friction is used to break up misaligned scar tissue, and fibrotic adhesions between adjacent structures. Cross-fibre frictions minimise the longitudinal stresses through the tissue, thus minimising the chance of reinjury while maximising the therapeutic effect of the massage strokes.

DTF may be used as an alternative to corticosteroid injections. DTF typically takes approximately 6 weeks of regular application to have it's full effect, compared to 1-2 weeks for corticosteroids. The use of DTF however does not have the negative side-effects of corticosteroid application namely weakening of connective tissue, and anti-inflammatory pain reduction (which may lead the client to feeling that they are able to perform actions that they perhaps should not). (Grisanti, 2006)

Preparation for DTF

When applying this technique to muscular tissue the muscle must be placed in a relaxed state. When applying the technique to tendon or ligament the structure must be placed in a stretch position so that it is taut.

Application of DTF

The skin should be moved over the underlying lesion in a cross fibre direction back and forth 2-3 times per second. The movement should cover the entire area of the lesion. If it is not possible to do this with one movement several frictions can be applied to cover the area.

This is a repetitive movement. To prevent blistering of the skin, tension in the skin at the end of each movement should be minimal, and fingernails must be trimmed.

DTF is applied in cycles. At the start of each cycle the pressure applied should be increased until a moderate level of discomfort is felt. It's important that the discomfort does not stimulate an increase in muscular tension (i.e. "Good pain". Client can still relax). Pressure should be maintained at this level for 1-2 minutes. After 1-2 minutes this technique will stimulate the release of enkephalins and endorphins and the pain should reduce considerably.

This cycle should be repeated from 3 to 7 times depending on the stage of injury healing

Time from Injury	Number of cycles	Approximate time
3 weeks out	3	< 6 minutes
4 weeks out	4	< 8 minutes
5 weeks out	5	< 10 minutes
6-7 weeks out	6	< 13 minutes
8+ weeks out	7	< 15 minutes

Fig 9. Application of Deep transverse friction

If the client experiences pain at the injury site or with movement and if the pain is a result of the injury, DTF applied correctly should cause a reduction of pain. If no decrease in pain is felt by the client it is likely that either you are not applying DTF to the site of injury, or the injury is not the cause of the pain.

If tenderness increases or does not decrease this treatment mode should be stopped. Either

- The initial pressure may have been excessive OR
- You may not have been working directly over the primary lesion

Contraindications for DTF (Keun, 2007)

Calcification of soft-tissues
Rheumatoid-type tendinous lesion
Local sepsis – Infection of the blood
Skin disease

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