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Fascia:

The Tensional Network of the Human Body

The science and clinical applications in manual and movement therapy

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Chapter 7.17 Surgery and scarring.

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1. Introduction.

Nature provides us with a means of survival by restoring tissue integrity via granulation scar tissue in response to damage. While non-surgical insults such as infection, chemotherapy, radiation and cancer may damage tissue and initiate the healing cascade, a common trigger to tissue healing and scarring is still injury and surgery. Maintenance of our well-being depends on the body's ability to guide the insult through an appropriate sequence of repair without complications.

For open wounds (including surgery) and severe internal tears (ruptured tendon or ligament) wound closure and tissue strength are critical and a certain amount of scarring is necessary and inevitable. Scars differentiate and attempt to become quasi-tissue specific in response to internal and external influences. Filling defects in loose, flexible tissue, scar tissue will change to duplicate the same tissue characteristics as far as possible in the final stages of healing. Impaired mobility of soft tissues can contribute to chronic pain and tissue stiffness as well as abnormal movement patterns within the musculoskeletal system (Bouffard et al 2008).

Although all wounds pass through the same mechanism of repair towards full recovery, the final cosmetic and functional result may differ markedly. The ideal is for a scar to firstly close the wound and establish tissue stability and secondly to blend cosmetically with surrounding tissue, allowing pre-injury function.

1.1. The extent of the problem.

Successful healing does not automatically correlate with return to full function. If for example, a repaired tendon develops normal tensile strength but does not glide, it is a functional failure. Postsurgical adhesions result from injured tissue (following incision, cauterisation, suturing or other means of trauma) fusing together to create abnormal connections between two normally separate surfaces of the body (Ergul and Korukluogla 2008). Outcomes differ depending on the injured tissue, type of injury, genetic factors, and the presence of systemic disease.

Alterations in the normal healing response could be associated with severe after-effects either as a failure to heal (wound failure), or excessive repair including hypertrophic scarring, keloids, contracture and adhesions (Occleston et al 2008). For most patients adhesions have little effect while others may develop considerable clinical consequences, for example:

- After laparotomy, almost 95% of patients are shown to have adhesions at later surgery (Ellis et al 1999). Intestinal obstruction, chronic abdominal and pelvic pain, female infertility and difficult reoperation with bigger risk are also reported (Ergul and Korukluoglu 2008, Salim et al 2008).

- Even minimally invasive surgical procedures (e.g. arthroscopy) are reported as contributing to increased risk in developing knee osteoarthritis (Ogilvie-Harris and Choi 2000). This can be associated with surgical difficulties and postoperative complications in primary total knee arthroplasty (Piedade et al 2009).

- Previous abdominal surgery has been shown to be a factor in low backache, myofascial pain syndromes (Lewit and Olsanska, 2004), and in compromised vascular anatomy of the abdominal wall (Rozen et al in press).
- Adhesions, tissue fibrosis and loss of tissue glide between structures can be identified as the source of pain and restriction of movement and function in up to 72% of patients after surgery for breast cancer (Lee et al, 2009).

1.2. Understand fascial relationships.

Fascia plays an important role in the body's musculoskeletal dynamics (Stecco & Stecco 2009). This includes tension transfer across the epimysium (the fibrous envelope surrounding a muscle), and between muscles (Huijing, 2007). It further contributes to the development of muscle force (Aspden, 1990) and functions as a responsive, dynamic and complex mechanosensitive system for coordinated movement (Schleip et al, 2006). Fascia controls the ***quality*** of movement while keeping the bony levers and spacers within a specific functional configuration.

A full understanding of fascial arrangements and its behaviour under load are needed to understand how fascial restrictions can contribute to pain and dysfunction.

Anatomy of tissue layers.

The body is arranged in several layers from superficial to deep (from Stecco & Stecco 2009):

- The skin formed by the epidermis and dermis.
- The superficial fascia consisting of two or more adipose, loose connective tissue layers separated by a membranous layer(s) of collagen and elastic fibres.
- The deep fascia that envelops the large muscles of the trunk and forms fascial sleeves in the limbs.
    - In the trunk, the deep fascia is subdivided into three laminae. Each lamina is in turn bilaminated to accommodate superficial, intermediate or deep muscles in the trunk and neck. Thin layers of loose adipose tissue separate the various fascial laminae, allowing gliding between layers.
    - Deep fascia in the limbs mostly glides over the muscles.
- The epimysial fascia beneath the deep fascia of the limbs. This interface consists of three distinct layers: the deep fascia, the fibrous envelope of the muscle (epimysium) and a loose areolar tissue layer between the deep fascia and epimysium (McCombe et al 2001). The deep fascia of the trunk is often fused with and becomes the epimysial fascia for the muscles.

The superficial fascia allows muscles to slide beneath the skin as they contract, while the deep fascia synchronises motor activity in order to produce smooth, resistance-free economical movements (Stecco & Stecco 2009).

2. Surgery.

The body's response to injury, either surgically or traumatically induced, is immediate. It signals repair to begin. Three dominant phases can be described: the inflammatory phase preparing the area for healing, the fibroplastic phase rebuilding the structure and the remodelling phase providing the final form. One process is stimulated to begin, and its completion in turn signals another cellular response until the wound is bridged by scar. Different tissues heal at different rates. One wound can show various areas in different stages of healing. All surgery carries a risk of adhesions between tissues resulting in dysfunction in the form of restricted tissue glide, muscle imbalances, weakness or loss of flexibility (**figure 1a & 1b)**. Disturbed patterns may even become evident some distance from the scar.

Inflammation is crucial to the healing response. It continues throughout all healing phases, stimulating and coordinating the functions of wound repair. Inflammatory mediators regulate all aspects of tissue healing and remodelling, whether planned (as in development) or unplanned (as in tissue repair after injury). One mediator, the cytokine Transforming Growth Factor beta 1 (TGF-β1) is unique in its widespread actions; from enhancing the deposition of extracellular matrix to acting as a potent regulator of repair by coordinating or suppressing the actions of other growth factors, cytokines and mediators (Henry and Garner 2003).

A prolonged inflammatory phase after surgery may result in proliferative scarring and increased fibrosis within the damaged area. Fibrosis represents a pathologic excess of normal tissue repair. Excessive or sustained production of TGF-β1 is a key molecular mediator of tissue fibrosis. It consistently and powerfully acts on cells to encourage the deposition of extracellular matrix.

The connective tissue response to the internal (inflammatory mediators and growth factors) and external (motion and directional strain) stresses applied will determine how the scar matures. Thus the scar can become either dense and unyielding **(figure 2)** or pliable and mobile. Remodelling is not restricted to the injured area only. Neighbouring, non-injured tissue also changes its collagen production rate in response to inflammation

Every normal movement is accompanied by stretching, gliding and/or shifting within the surrounding soft tissue. Compromised soft tissue mobility may therefore impair motor function. Distortion of surrounding myofascial relationships can alter synergistic and antagonistic muscle balances and proprioception (Stecco & Stecco 2009). Adaptive patterns to complete or execute a movement and straining to overcome tissue resistance to produce movement are energy expensive and run the risk of producing further tissue damage (Manheim 2001). The ultimate outcome could be global dysfunction. Damaged tissues and structures need repair before the system can function efficiently again.

3. Treatment.

Rehabilitation concerns the continuum of repair to full function while guiding the wound to return as close to pre-surgery architecture as possible.

The treatment and management of surgical scarring falls into two main categories:

1. Early management to guide the healing tissue to return as close to pre-surgery architecture as possible.
2. Late treatment to address dysfunction that may have developed due to scarring and adhesions.

Vigorous therapy used too early can stimulate inflammation and oedema, prolong the inflammatory phase, or disrupt the wound. Forceful mobilisation aimed at breaking established scar tissue may create a new inflammatory response, ultimately causing further scar formation. A secondarily inflamed wound results in additional collagen deposition, compounding existing morbidity.

3.1. Therapeutic intention.

With the cytokine TGF-β responsible for the secretion of collagen by fibroblasts, controlling and limiting inflammation is important in early wound care. Overstimulation of TGF-β may be implicated in the overproduction of new collagen resulting in hypertrophic scarring and tissue fibrosis. Apart from drug and gene approaches to wound healing, the role of manual therapy also needs acknowledgment.

Scars are treated for largely two reasons:

- To aid in controlling the inflammation and swelling in the early stages of wound healing.
- To restore tissue function and gliding.

In a laboratory model, Bouffard et al (2008) used treatment sessions of stretching surgically induced scar tissue for 10 minutes twice daily for 7 days by applying a stretch that lengthened the damaged tissue area by 20 to 30%. They concluded that brief, moderate amplitude stretching (at 20-30% strain) of connective tissue decreases both TGF-β and collagen synthesis, thus reducing cross-binding adhesions between tissue layers. *In vitro* studies by Yang et al (2005) showed that repetitive stretching of tendons at small amplitude (≤4%) seemed to be anti-inflammatory and restoring tendon homeostasis while large amplitude stretching seemed to be pro-inflammatory in nature. Benjamin (2008) remarks that if these findings also prove to be applicable in vivo, it can then be assumed that regulated movement at moderate intensity may be beneficial for reducing inflammation. With less fibrosis and better tissue glide less effort will be needed to produce normal movement and overcome tissue resistance. Reduced internal strain decreases treatment pain with better compliance to prescribed exercises. By being gentle early, rehabilitation can progress faster at later stages.

3.2. Before we start:

The barrier phenomenon

Similar to joints, soft tissue has a specified range of available movement that can be divided into a physiologic and an anatomic range of movement.

- Physiologic range is necessary for smooth, unrestricted movement of underlying structures during normal movement (active range of movement).

- Anatomic range refers to where tissue can be stretched beyond the physiologic range and before coming to a stop without discomfort or pain (passive range of movement).

- The distance between physiologic and anatomic limits constitutes a "safety" zone protecting the body from damage should external forces be applied.

As in joints, there is a range within which minimal resistance to stretch or shift is encountered. When resistance is met the anatomic barrier is reached. Under normal conditions the barrier has a soft, elastic end-feel and can be moved easily accompanied by a sensation that no unnecessary tension is present in the target tissue.

In a ***pathological*** barrier, the anatomic (passive) tissue range is reached prematurely. This barrier characteristically has a tense, restrictive feel, with an abrupt, hard or leathery end-feel. Normal physiologic movement may still be present with no apparent movement restriction, but there will be reduced protection when the tissue is strained.

Depth and grading of touch.

An advantage of manual techniques is that the hand is a sensitive instrument which establishes a feedback relationship with the manipulated tissue. When treating wounds and scarring, the therapist should be clear of how deep and firmly to work. A grading scale of 1 to 10 could be used (Fourie & Robb 2009).

- Grade 1 to 3: Very light, mild and non-irritating. It feels like moving the eyelid on the eyeball without irritating the eye. No discomfort.

- Grade 4 to 6: Moderate to firm. This is where most massage techniques are performed. There may be mild discomfort, but no damage to tissue.

- Grade 7 and 8: Firm, deep and uncomfortable pressure with discomfort, but tolerable. There is a potential for tissue bruising. Trigger point work would be performed at this level.

- Grade 9 and 10: Deep, very uncomfortable or painful with a good potential for tissue damage. It is often described as "surgery without anaesthesia". An example of this grade would be deep transverse friction.

3.3. Evaluation

Scar evaluation aims to determine the **quality, extent and depth** of the "premature or pathologic" tissue barrier.

- Quality refers to the perceived **end-feel** - a normal soft, elastic or an abnormal solid, abrupt end-feel.
- The extent of the barrier refers to **where** in the available range resistance is encountered, and how large an area is involved.

- The depth of the tissue barrier may be subjective but an attempt should be made to distinguish between **which tissue layers** restrictions are felt – superficial between dermis and deep fascia, deep restrictions between muscles, organs or between a tendon and its sheath.

Three layers of fascial glide need assessment:

- Skin and superficial fascia – manually glide the skin ON the deep fascia. Move hand and skin as a unit to the end of available tissue glide using a pressure grading of 2 to 3.
- Deep fascia and myofascial interfaces – move one deep structure ON another. Change hand or finger position accordingly and glide tissue at a firm pressure grading of 4 to 6.
- Deep muscle and soft tissue on bone interfaces - modify hand and/or finger position to test for specific directional restrictions with fingertip or thumb pressure at a pressure grade of 6 to 8. This may be experienced as discomfort by the patient and should be done with care.

This is an assessment of tissue **movement**, not of painful areas within the soft tissue. Palpation is for tissue mobility, flexibility and freedom of tissue glide. The position and direction of tight, hypomobile or inflexible tissue should be documented.

Four directions of scar movement need assessment:

- Longitudinal along the length of the scar.
- Transverse across the long axis of the scar.
- Rotation clockwise and anti-clockwise.
- Lifting the scar vertically away from deeper layers.

3.4. Treatment.

Both the source of a restriction and extent of the resultant dysfunction guides treatment. Primary treatment is directed at the restricted tissue glide (local source of the problem) before rehabilitating the abnormal condition that the patient presents with (the dysfunction). There must be clarity about the depth, site and extent of restricted tissue gliding.

3.4.1. Principles:

- Treatment is directed at the mechanical restriction identified by evaluation.
- The goal is to move the tissue barrier towards a normal end-feel and amplitude.
- Approach treatment in a layered fashion- clearing one layer or compartment of restrictions before moving to a deeper or adjacent layer.
- Techniques are performed at or just before the palpable tissue barrier at varying angles to the restriction.
- Use gentle touch grading during the early stages. For mature, chronically adhered scars more forceful treatment may be necessary.

3.5.2. How to treat

The use of gentle treatment in the early stages of healing safeguards against causing wound breakdown and increasing inflammation. For longstanding scars and adhesions higher touch grades can be used. Care must however be taken to avoid triggering a **new** inflammatory response.

Approaches to engage and move the tissue barrier (Lewit and Olsanska, 2004):

- Engage the barrier directly and wait with a sustained pressure until the tissue releases and the barrier shifts after a short delay.
- Use a sustained stretch of the scarred tissue. Stretch could be uni- or multidirectional.
- Apply slow rhythmic mobilisations towards and into the tissue barrier. Movement direction could be perpendicular to, at an angle to, or away from the tissue barrier.

3.5.3. Basic techniques:

Gross stretch (figures 3a & 3b):
This is the most superficial and least painful scar technique. By using finger or full hand contact, take up all the tissue slack and apply a gentle stretch along the length of the scar. Hold, wait for release and stretch again. Change hand position and repeat the stretch perpendicular to the original stretch. Repeat the stretch sequence diagonal to the previous position. Continue to stretch across the scar in a radiating pattern until no further stretch is possible.

Gentle circles (figure 4d):
With this technique, the fingers move the skin ON the deep fascia. Tissue movement is of an engaged shearing nature. Rest the fingers on the part to be treated (next to the scar). The heel of the hand may also rest on the body. Starting at 6 o'clock, push the skin around in a circle with the middle three fingers as if following the arms of a clock. Slowly move the skin towards the scar to engage and shear the tissue barrier while keeping the circle round and the pressure and pace even.

Change hand position, repeat the circle and release. Treat the full length of the scar and repeat several times in a session if needed. Alternatively, start the circle at 12 o' clock and pull down and stretch the skin and scar.

Firm upside down "J" stroke (figure 4c):
This technique is very similar to the previous in starting position and depth. The stroke is directed towards the scar from about an inch (2,5cm) away. Movement is slow and deliberate into the tissue barrier. When the barrier is engaged, the fingers shear away towards the left or right and the tissue is allowed to return to its non-stretched position. Repeat gently until the tissue barrier has moved, or discomfort subsides.

Vertical lifts (figures Figures 5a, 5b, 6a & 6b):
Vertical lifts are used to treat any scar that can be gripped between thumb and fingers. Grip an area of the scar and gently, but firmly apply a vertical stretch. Hold, wait for release and increase the

stretch. When no further stretch is available, change the angle of stretch while maintaining the vertical lift. Repeat the lift sequence from different angles until no further stretch is available.

Regardless of the modality used, an impairment-based approach is recommended for treatment of restrictive scars and adhesions. The selection of technique, direction and depth are based on the level of dysfunction revealed during the assessment. This approach gives the therapist the flexibility to adapt treatment to the person, rather than treating the “diagnosis”. Further, based on the treatment response, treatment can be modified in line with the patient’s improvement or lack of progress (Fourie & Robb 2009).

When understanding the basic layered arrangement of tissue, the wound healing process and how to grade touch, any manual therapy or massage technique can be modified to achieve the aims of restoring tissue mobility glide and flexibility.

Treatment is discontinued when the release has been completed in all directions and layers. This may not happen in a single treatment and may even take several months – especially in longstanding chronic scars. Care should be taken not to create wound breakdown or an inflammatory response to tissue mobilisation.

3.5.4. Conclusion:

In many cases the problem may be irreversible with scars becoming so fixed and strong that only surgery will release the adhesion. In established fixed scars, where no tissue gliding is possible by manual means, treatment is aimed at creating more soft tissue space and flexibility in the surrounding tissue. In many cases adhesive scarring may affect quality of life adversely; however open, positive discussion with adequate explanation and intervention may vastly diminish the patient's anxiety, suffering and disability.

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Legends of figures:

Figure 1a: A surgical scar in the deltoid muscle after an open reduction with internal fixation of a fracture of the humerus head.

Figure 1b: Attempted external rotation of the arm. Note the adherence of the scar to deeper tissue layers.

Figure 2a: An X-ray of the same shoulder showing the bony components held in place with screws.

Figure 2b: An extended field of view ultrasound image of the same shoulder showing the extent and depth of soft tissue scarring and adhesions. Note the destruction of superficial fascia continuity between the arrowheads.

Figure 3a: Gross stretch with full hand contact. Longitudinal, transverse or in opposite directions.

Figure 3b: Gross stretch with full hand contact - longitudinal

Figure 4a: Direct engagement and shifting of the tissue barrier.

Figure 4b: Transverse into or away from the scar.

Figure 4c: The upside down “J” stroke.

Figure 4d: Gentle circles. Next to, or on the scar.

Figure 5a and b: Sliding towards and “under” the scar.

Figure 6a and b: Vertical lifts.

Figure 7a, b and c: Skin rolling.

Images:

Figure 1a

Figure 1b

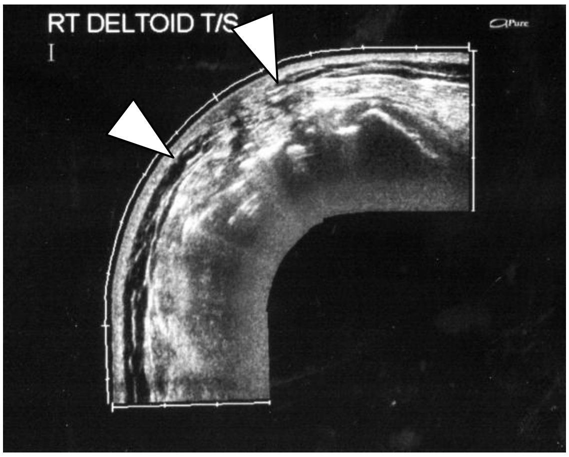

Figure 2

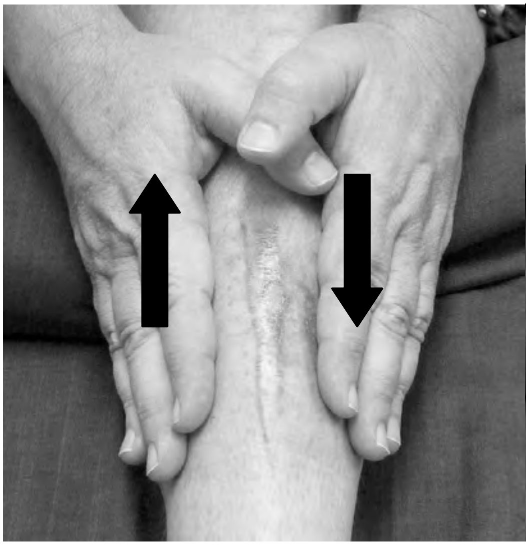

Figure 3a

Figure 3b

Figure 4a

Figure 4b

Figure 4c

Figure 4d

Figure 5a

Figure 5b

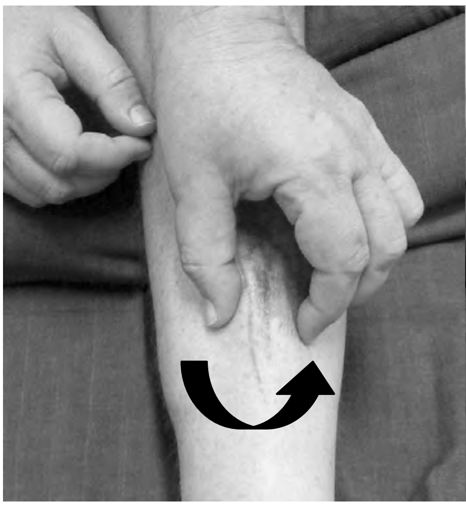

Figure 6a

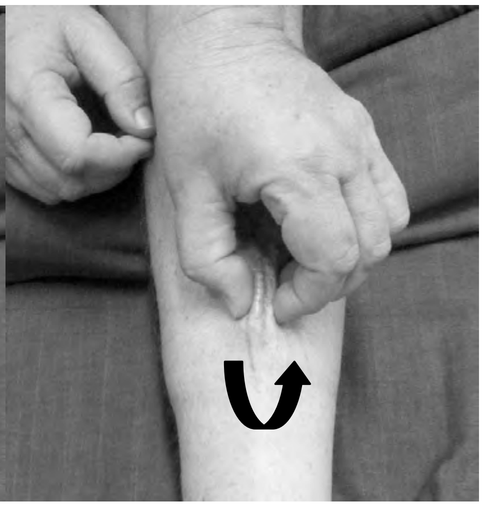

Figure 6b

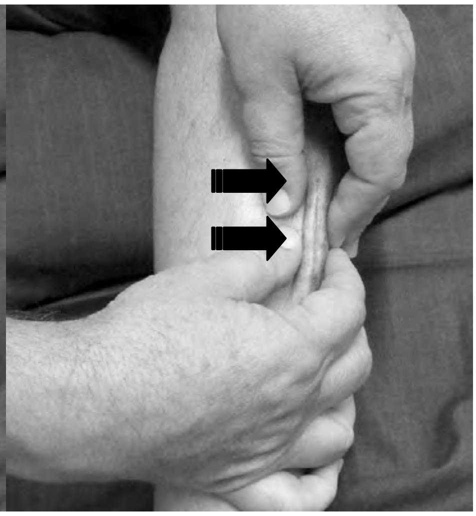

Figure 7a

Figure 7b

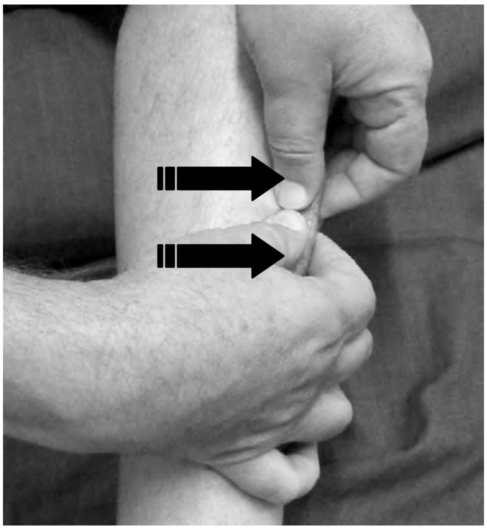

Figure 7c