Chapter for upcoming book by Erik Dalton

Fascia as a Sensory Organ:
A Target of Myofascial Manipulation

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Introduction

The body-wide network of fascia is assumed to play an essential role in our posture and movement organization. It is frequently referred to as our *organ of form* (Varela and Frenk 1987, Garfin 1981). While many manual therapy approaches focus their treatment on fascial tissues, they claim to alter the density, tonus, viscosity or arrangement of fascia through the application of manual pressure (Barnes 1990, Cantu and Grodin 1992, Chaitow 1980, Paoletti 1998, Rolf 1977, Ward 1993). It is also assumed that these changes are not merely temporary, i.e., that they last longer than a few minutes after the immediate application. The given explanations of the involved mechanisms usually refer to the ability of fascia to adapt to physical stress. How exactly the practitioner understands the nature of this particular responsiveness of fascia does of course influence the treatment. Unfortunately, fascia is often referred to in terms of its passive mechanical properties alone. In contrast, this article attempts to explore the neural dynamics behind fascial plasticity, thereby offering a more dynamic explanation for myofascial treatment methods.

Thixotropy, or the gel-to-sol hypothesis

Many of the current training schools of myofascial manipulation have been profoundly influenced by Ida Rolf (Rolf 1977). In her hands-on work Rolf applied considerable manual or elbow pressure to fascial structures in order to change their density and arrangement. Rolf proposed the theory that connective tissue is a *colloid substance* in which the ground substance can be influenced by the application of energy (heat or mechanical pressure) to change its aggregate form from a more dense *"gel"* state to a more fluid *"sol"* state. Typical examples of this are common gelatin or butter, which get softer by heating or mechanical pressure. This gel-to-sol transformation, also called *thixotropy* (Juhan 1987), has in fact been demonstrated in connective tissues as a result of the application of long-term mechanical stress (Twomey and Taylor 1982).

However, the question arises: is this model also useful in explaining the immediate *short-term* plasticity of fascia? In other words, what actually happens when a myofascial practitioner claims to feel a tissue release under the working hand? In most systems of myofascial manipulation, the duration of a particular "stroke" on a particular spot of tissue ranges between a few seconds and two minutes. Yet often the practitioners report sensing a palpable tissue release within a particular "stroke". Such rapid tissue transformation – i.e. in under two minutes - appears to be more difficult to explain with the thixotropy theory. As will be specified later, studies on the subject of "*time and force dependency"* of connective tissue plasticity suggest that either much longer amounts of time or significantly more force are required for permanent deformation of dense connective tissues (Currier and Nelson 1992).

Furthermore, the problem of reversibility arises: in colloidal substances the thixotropic effect lasts only as long as the pressure or heat is applied. Within minutes after the heat or force application, the substance returns to its original gel state – just think of the butter in the kitchen. This is definitely not an attractive implication of this theory for the practitioner.

Piezoelectricity: fascia as a liquid crystal

Oschman and others have added *piezoelectricity* as an intriguing explanation for fascial plasticity (Oschman 2000, Athenstaedt 1974). Piezoelectricity exists in crystals in which the electric centers of neutrality on the inside of the crystal lattice are temporarily separated via mechanical pressure from the outside and a small electric charge can be detected on the surface. Since connective tissue can be seen to behave like a “liquid crystal” (Juhan 1998), these authors propose that the cells that produce and digest collagen fibers (fibroblasts) might be responsive to such electric charges. To put it simply: pressure from the outside creates a higher electric charge, which then stimulates the fibroblasts to alter their metabolic activity in that area. However, the processes involved seem to require time as an important factor. The half-life span of non-traumatized collagen has been reported to be 300-500 days, and that of ground substance 1.7 - 7 days (Cantu and Grodin 1992). While it is definitely conceivable that the production of both materials could be influenced by piezoelectricity, both life cycles appear too slow to account for immediate tissue changes that are significant enough to be palpated by the working practitioner.

Fascial plasticity: traditional explanations insufficient

Both models, thixotropy and piezoelectricity, are appealing explanations for long-term tissue changes. Nevertheless, it seems that they are not sufficient to account for the short-term plasticity of fascial tissues. Laboratory studies on the subject of time- and force-dependency of connective tissue plasticity (*in vitro* as well as *in vivo*) have shown the following results: in order to achieve a plastic elongation of dense connective tissues, one needs to apply *either* an extremely forceful stretch of 3 to 8 per cent fiber elongation, which will result in tissue tearing along with inflammation and other side effects that are usually seen as undesirable in a myofascial session. E.g.: for an 18-mm wide distal iliotibial band such permanent elongation starts at 60 kg (Threlkeld 1992). *Or* it takes more than an hour (which can be taken at several intervals) with a less brutal 1 to 1.5 per cent fiber elongation, if one wants to achieve permanent deformation without tearing and inflammation (Currier and Nelson 1992, Threlkeld 1992).

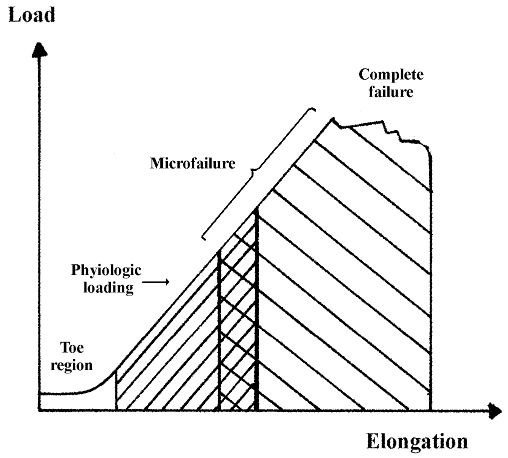

Fig. 1
Stress-strain curve of dense connective tissue. Most forces generated during daily life load the tissue in the linear region of the curve and do not produce any permanent elongation. Microfailure with permanent elongation happens at extreme loads only, and is accompanied by tearing and inflammation. The region of overlap of the microfailure zone with the physiologic loading zone varies with the density and composition of the tissue, yet for most dense connective tissues it would be well above a 20 kg loading. (Drawing based on Threlkeld 1992).

Fig. 1 illustrates the typical relationships for short-term strain applications. Microfailure is seen as the breaking of some individual collagen fibers and of some fiber bundles, resulting in a permanent (plastic) elongation of the tissue structure. This is usually followed by a cycle of tissue inflammation and repair. Based on measurements with different kinds of paraspinal tissues, Threlkeld calculates that microfailure of most dense connective tissues occurs at around 224 to 1,136 N, which equals 24-115 kg (Threlkeld 1992). While high velocity thrust techniques might create forces within that range, it seems clear that the slower soft tissue manipulation techniques are hardly strong enough to create the described tissue response. These propositions have recently been supported by studies from Chaudhry et al., demonstrating that the “palpable sensations of tissue release that are often reported by osteopathic physicians and other manual therapists cannot be due to deformations produced in the firm tissues of plantar fascia and fascia lata. However, palpable tissue release could result from deformation in softer tissue such as the superficial nasal fascia” (Chaudhry 2008). In other words: the force/time dimensions used in myofascial release sessions are hardly sufficient to induce sustaining deformations in denser fascial sheets. They could be sufficient, however, to induce lasting deformations in softer connective tissues, such as in the areolar layer of the subcutis.

A simple thought experiment may be used for corroboration: During everyday life, the body is often exposed to loading magnitudes similar to the manual pressures in a myofascial treatment session. While body structure may adapt to long term furniture use, it is almost impossible to conceive that adaptations could occur so rapidly that any uneven load distribution in sitting (e.g., while reading this article) would permanently alter the shape of your pelvis within a minute. It seems essential therefore that we find additional explanations – besides the thixotropic and piezoelectric ones - to account for the palpable tissue changes that occur in a treatment session.

The nervous system as a rapid self-regulatory system

From an evolutionary perspective it makes sense that animals have a slowly adapting plasticity system in order to adjust to patterns of long-term use. In addition to this capacity they have also developed a more rapid system of adapting their form and local tissue density to temporary demands. This regulation system capable of adapting to how the animal *perceives* its interaction with the environment. It seems plausible that this ability to be more rapidly adaptable is mediated by - or at least connected to - a body system that is involved in the perception of our needs as well as of the environment. Traditionally, this body system has been called the nervous system.

It is therefore suggested that the self-regulatory qualities of the client’s nervous system must be included in an explanatory model of the dynamics of fascial plasticity in myofascial manipulations. The author’s own experiments in treating anaesthetized people (with very similar results to that noted when manually treating very fresh pieces of animal meat) have shown that without a proper neural connection, the tissues did not respond as they would under normal circumstances (Schleip 1989).

The inclusion of the nervous system in attempting to understand fascial responsiveness is hardly a new concept altogether, since Andrew Taylor Still, the founder of osteopathy, wrote more than a century ago:

"The soul of man with all the streams of pure living water seems to dwell in the fascia of his body. When you deal with the fascia, you deal and do business with the branch offices of the brain, and under the general corporation law, the same as the brain itself, and why not treat it with the same degree of respect." (Still 1899.)

Many people consider the human nervous system to be organized like an old-fashioned telephone switchboard system of the industrial age and therefore incapable of representing finer and more complex processes such as "life energy", intuitive insights, rapid movement refinements, or human empathy. The reader is cordially invited to consider this to be an outdated model. Current concepts in neurobiology see the brain more as a primarily *liquid system* in which fluid dynamics of a multitude of liquid and even gaseous neurotransmitters have come to the forefront. Transmission of impulses in our nervous system often happens via messenger substances that travel along neural pathways as well as through the blood, lymph, cerebrospinal fluid or ground substance (Kandel 1995). This global system for rapid body regulation is inseparably connected to the endocrinal and immune systems, and also works with complex feedforward system dynamics. Rather than picturing the nervous system as a hard-wired electric cable system (which in the view of many bodyworkers is then of course incapable of being involved in more subtle energetic phenomena), picture it in your mind's eye as a *wet tropical jungle* (Schleip 2000). This jungle, even in adults, is a self-regulatory field with an amazing amount of complexity, plasticity, and continuous reorganization.

The Golgi reflex arc

Unfortunately, the neural dynamics of fascia have rarely been explored in detail. Cottingham presented a milestone proposal when he suggested a neurophysiological concept (Cottingham 1985) that was readily adopted by other authors (Ward 1993, Schleip 1989) and which will be recapitulated here: Golgi receptors are said to be ubiquitous in dense connective tissues. They exist in ligaments (as *Golgi end organs*), in joint capsules, and around myotendinous junctions (as *Golgi tendon organs*). These sensory receptors respond to slow stretch by influencing associated alpha motor neurons via the spinal cord to lower their firing rates, i.e. to decrease the active muscle tone in related muscle fibers. Cottingham suggested that during soft tissue manipulation – as well as in Hatha yoga postures and slow active stretching – these Golgi receptors are stimulated, resulting in a lowered firing rate of specific alpha motor neurons, translating into a tonus decrease of the related tissues.

Unfortunately, the experimental research on Golgi tendon organs suggests that passive stretching of a myofascial tissue does NOT stimulate these tendon receptors (Jami 1992). These experiments, usually performed on laboratory animals, propose that such stimulation happens only when the muscle fibers are actively contracting. The reason for this lies in the arrangement of the Golgi tendon receptors. They are arranged in series with the muscle fibers, with the tendon having a much higher stiffness than relaxed muscle fibers. When the muscle is passively elongated, most of the stretch will be taken up or "swallowed" by a resulting elastic elongation of the muscle fibers. This is of course different in active client contractions, in which the

Golgi tendon organs function to provide feedback information about dynamic force changes during the contraction (Lederman 1997).

Does this mean that deep tissue work (in which the client often is passive) will not involve the Golgi reflex loop? Perhaps, but not necessarily. The *in vitro* studies examined by Jami and Lederman have been conducted using preparations in which muscles were surgically isolated, i.e. freed from their lateral myofascial adherences to surrounding structures. However, as shown by the extensive work of Huijing, et al., intact muscle tissues exhibit very different force transmission dynamics than isolated muscles (Huijing 2009). Furthermore, it is important to note that only *fewer than 10%* of the Golgi receptors are found wholly within tendon. The remaining 90% are located in the muscular portions of myotendinous junctions, in the attachment transitions of aponeuroses, in capsules, and in ligaments of peripheral joints (Burke and Gandeva 1990). Taking these considerations into account, it cannot be excluded that passive tissue stretch may be able to stimulate some Golgi receptors, particularly if the tissue is stretched in different directions than along the main muscle-tendon axis. However, the chance of eliciting such responses appears as much higher if the related muscle fibers are not in a state of complete relaxation, or if the strain application of the practitioner occurs with a relatively strong force magnitude.

Ruffini and Pacini corpuscles

Immunohistochemical examination of the human thoracolumbar fascia revealed that it is richly populated by *mechanoreceptors* (Yahia et al. 1992). The intrafascial receptors that they described may be divided into three groups. The first group consists of the large *Pacini* corpuscles plus the slightly smaller *Paciniform* corpuscles. The egg-shaped Pacini bodies respond to rapid changes in pressure (but not to constant unchanging pressure) and to vibration. A bit smaller are the *Paciniform* corpuscles, which have a similar function and sensitivity. The second group consists of the smaller and more longitudinal *Ruffini* organs, which do not adapt as quickly and therefore respond also to constant pressure. It seems likely that the Pacinian receptors are being stimulated only by high-velocity thrust manipulations and by vibratory or oscillatory techniques. In contrast, the Ruffini endings are activated by slow and deep “melting quality” soft tissue techniques as well.

Table 1:

Mechanoreceptors in Fascia

Receptor type	*Preferred location*	*Responsive to*	*Known results of stimulation*
Golgi Type Ib	• Myotendinous junctions • Attachment areas of aponeuroses • ligaments of peripheral joints • Joint capsules.	Golgi tendon organ: to muscular contraction. Other Golgi receptors: probably to **strong stretch** only	**Tonus decrease** in related striated motor fibers.
Pacini and **Paciniform** Type II	• Myotendinous junctions • deep capsular layers • spinal ligaments • **Investing muscular tissues.**	**Rapid pressure changes** and vibrations	Used as proprioceptive feedback for movement control **(sense of kinesthesia)**.
Ruffini Type II	• Ligaments of peripheral joints, • Dura mater • Outer capsular layers • and other tissues **associated with regular stretching**.	Like Pacini, but also to **sustained pressure**. Especially responsive to **tangential forces** (lateral stretch).	**Inhibition of sympathetic activity**.
Interstitial Types III and IV	• **Most abundant** receptor type. Found almost everywhere, even inside bones. • Highest density in periosteum.	Rapid as well as sustained pressure changes. 50% are **high-threshold** units, and 50% are **low-threshold** units	Changes in **vasodilation** Plus, apparently in **plasma extravasation.**

Both types of intrafascial mechanoreceptors, the Pacinian/Paciniform and the Ruffini bodies, are found in all types of dense connective tissue, i.e. in muscle fasciae, tendons, ligaments, aponeuroses, and joint capsules. In myotendinous junctions the Pacinian corpuscles are more concentrated in the tendinous portion (as opposed to the Golgi tendon organs, which are more concentrated in the muscular portion). They have also been shown to be more concentrated in the deeper portions of joint capsules; in deeper spinal ligaments; and in investing (or enveloping) muscular fasciae such as the antebrachial, crural, and abdominal fasciae; the fascia of the masseter; the lateral thigh; in plantar as well as palmar tissues; and in the peritoneum (Stilwell 1957). The Ruffini endings are particularly densely distributed in tissues associated with regular *stretching*, like the outer layer of joint capsules, the dura mater, the ligaments of peripheral joints, and the deep dorsal fascia of the hand. At the knee joint, the Ruffini endings are especially found at anterior and posterior ligamentous and capsular structures, whereas Pacinian bodies are more accumulated medially and laterally of the joint (van den Berg and Capri 1999).

Two aspects of Ruffini endings seem important: They are especially responsive to tangential forces and lateral stretch (Kruger 1987). In addition it has been shown that that stimulation of Ruffini receptors tends to induce a lowering of sympathetic nervous system activity (van den Berg and Capri 1999). This seems to fit to the common clinical finding, that slow deep tissue techniques tend to have a relaxing effect on local tissues as indeed on the whole organism.

In order to examine the potential neural dynamics of myofascial manipulation, it is suggested that the following scenario should be used as a reference point: Imagine a practitioner working slowly with the connective tissue around the lateral ankle, in an area with no striated muscle fibers. (Choosing this reference scenario allows us to focus on intrafascial dynamics only, and – for the purpose of this article – to ignore the stimulation of intramuscular mechanoreceptors and other effects that would be involved in the analysis of many other myofascial working situations.) If that practitioner reports a "tissue release", what has happened? Possibly the manual touch stimulated some Ruffini endings, which in turn triggered the central nervous system to change the tonus of some motor units in muscle tissue that is mechanically connected to the tissue under the practitioner's hand (Fig. 3).

Interstitial receptors

In order to discuss the third group of intrafascial mechanoreceptors described by Yahia, it is necessary to go on a short excursion. For many people it comes as a big surprise to learn that our richest and *largest sensory organ* is not the eyes, ears, skin, or vestibular system but is in fact our muscles, along with their related fasciae. Our central nervous system receives its greatest amount of sensory input from myofascial tissues. Yet the majority of these sensory neurons are so small that until recently little has been known about them (Engeln 1993).

If one studies a typical muscle nerve (e.g. the tibial nerve), it consists of almost three times more sensory fibers than motor fibers. This points to a fascinating principle, that sensory refinement seems to be much more important than motor organization. Let us not get distracted by this, however. While many of the nerve fibers in a typical motor nerve have a vasomotor function, regulating blood flow, the largest group of fibers is *sensory*. Now comes the really interesting point: of these sensory fibers only a small fraction, or 20%, belong to the well-known types I and II afferent fibers, which originate in muscle spindles, Golgi organs, Pacini corpuscles and Ruffini endings (see Fig. 2). The majority, or four times as many, belongs to an interesting group of types III and IV afferent fibers, which are hardly mentioned in most textbooks (Mitchell and Schmidt 1977).

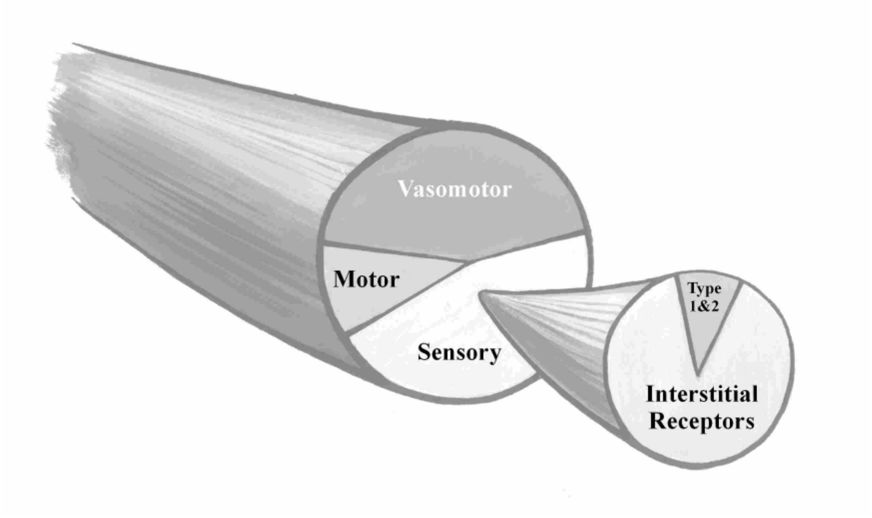

Fig.2: ***Within a typical muscle nerve there are almost three times as many sensory neurons as motor neurons. Note that only a small portion of the sensory information comes from the type 1 and 2 afferents originating in muscle spindles, Golgi receptors, Pacinian corpuscles and Ruffini endings. The majority of the sensory input comes from the group of type 3 and 4 afferents, or Interstitial Receptors, which are intimately linked with the Autonomic Nervous System***.

These hidden neurons are much smaller in diameter and are now commonly called *interstitial muscle receptors.* A better name would be *interstitial myofascial tissue receptors* since they also exist abundantly in fascia. A minority of these fibers are covered by a very thin myelin sheath (type III, also called A-delta fibers), but 90% of them are unmyelinated (type IV or C fibers). These interstitial receptors are slower than the types I and II afferent fibers and most of them originate in *free nerve endings*.

In the past it was assumed that these nerve endings are mostly pain receptors. Some have also been shown to be involved in thermo- or chemoception. While many of these receptors are multimodal, research has shown that the majority of interstitial receptors do in fact function as *mechanoreceptors*, which means that they respond to mechanical tension and/or pressure (Mitchell and Schmitt 1977).

While the type III and type IV fibers exhibit some important differences in some physiological aspects, they do express common features regarding their mechanoreceptor functions. The large group of interstitial mechanoreceptors can be subdivided into two groups of equal size: low-threshold pressure units (LTP units) and high-threshold units (HTP). A study of cat Achilles tendon revealed that about half of the types III and IV endings encountered were LTP units and responded to light touch, even to touch as light as *"with a painter's brush"* (Mitchell and Schmidt 1977). Based on this latter finding, doesn't it seem possible – if not probable - that soft tissue manipulation might involve stimulation of these type III and type IV receptors?

Naturally this raises the question of the natural functional role of interstitial mechanoreceptors in the body. What regular consequences or reactions have been associated with an excitation of this hidden and rich sensory network? Of course some of them function as pain receptors. But a Japanese study revealed as early as 1974 that the type III and type IV receptors in the fasciae of the temporalis, masseter and infrahyoid muscles show "responses to the mandibular movement and the stretching of the fascia and the skin", and it was therefore suggested that these nerve endings are concerned “with the sensation of position and movement of the mandible” (Sakada 1974).

Furthermore, the majority of these type III and type IV mechanoreceptors have been shown to have *autonomic functions*, i.e., stimulation of their sensory endings leads to a change in heart rate, blood pressure, respiration, etc. Stimulation of type IV receptors tends to increase arterial blood pressure (Coote JH and Pérez-Gonzáles 1970) whereas stimulation of type III receptors can both increase and decrease blood pressure. Several studies have shown that an increase of static pressure on muscles tends to lower arterial blood pressure (Mitchell and Schmitt 1977). It seems that a major function of this intricate network of interstitial tissue receptors is to fine-tune the nervous system’s regulation of blood flow according to local demands, and that this is done via very close connections with the autonomic nervous system.

Research on the stimulatory effects of touch manipulation

Based on this research, it should not come as a surprise that slow deep pressure on the soft tissue of cats has been shown to lead to a reduction in muscle tonus as measured by EMG activity (Johansson 1962), and that slow stroking of the back in cats produces a reduction in skin temperature as well as signs of inhibition of the gamma motor system (von Euler and Soderberg 1958).

Furthermore, it has been demonstrated that deep mechanical pressure to the human *abdominal region* (Folkow 1962), or sustained pressure to the *pelvis* (Koizumi and Brooks 1972) produce parasympathetic reflex responses, including synchronous cortical EEG patterns, increased activity in vagal fibers, and decreased EMG activity.

According to the model of hypothalamic tuning states developed by Ernst Gellhorn, an increase in vagal tone does not only trigger changes in the autonomic nervous system and related inner organs, but also tends to activate the anterior lobe of the hypothalamus. Such a “*trophotropic tuning”* of the hypothalamus then induces a lower overall muscle tonus, more quiet emotional activity, and an increase in synchronous cortical activity, both in cats as well as in humans (Gellhorn 1967). It therefore appears that deep manual pressure – specifically if it is slow or steady - stimulates interstitial and Ruffini mechanoreceptors, which results in an increase of vagal activity, which then induces an alteration not only in local fluid dynamics and tissue metabolism, but also results in global muscle relaxation, as well as a more peaceful mind and less emotional arousal.

On the other hand, sudden deep tactile pressure, or pinching, or other types of strong and rapid manipulations have been shown to induce a general contraction of skeletal muscles (Eble 1960), particularly of “genetic flexor muscles” (Schleip 1993), which are innervated via a ventral primary ramus from the spinal cord.

Mechanoreceptors have been found abundantly in visceral ligaments as well as in the dura mater of the spinal cord and cranium. It seems quite plausible that most of the effects of visceral or craniosacral osteopathy could be sufficiently explained by a stimulation of mechanoreceptors, with resulting profound autonomic changes, and might therefore not need to rely on more *esoteric* assumptions (Arbuckle 1994).

Recent discoveries concerning the richness of the *enteric nervous system* (Gershon 1999) have taught us that our “belly brain” contains more than 100 million neurons and works largely independently of the cortical brain. It is interesting to note that the limited connection between these two brains of only a few thousand neurons consists of nine times as many neurons involved in processes in which the lower brain tells the upper one what to do, compared with the number of neurons involved in the top-down direction. Many of the sensory neurons of the enteric brain are mechanoreceptors, which - if activated – trigger, among other responses, important *neuroendocrine* changes. These include a change in the production of *serotonin* – an important cortical neurotransmitter of which 90% is created in the belly – as well as other neuropeptides, such as the substance *histamine* (which increases inflammatory processes).

Fascial mechanoreceptors: an entry for changing skeletal muscle tone

Let us carefully apply these findings to the practical hands-on work (see Fig. 3). Myofascial manipulation can be assumed to involve stimulation of intrafascial mechanoreceptors. Their stimulation can lead to an altered proprioceptive input to the central nervous system, which can easily result in a changed tonus regulation of motor units associated with this tissue. In the case of a slow deep pressure, the related mechanoreceptors are most likely the slowly adapting Ruffini endings and some of the interstitial receptors, though additional receptors might also be involved (e.g., spindle receptors in affected muscle fibers nearby, or possibly some intrafascial Golgi receptors).

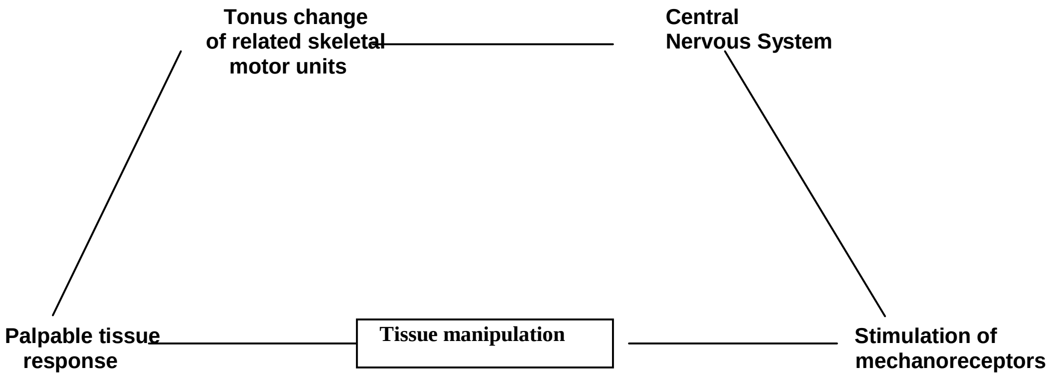

Fig 3: The "Central Nervous System Loop" *(inspired by Cottingham).*
Stimulation of mechanoreceptors leads to a lowered tonus of skeletal motor units, which are mechanically linked to the tissue under the practitioner's hand. The involved intrafascial mechanoreceptors are most likely Ruffini endings, Pacinian corpuscles (with more rapid manipulations), some of the interstitial receptors, plus possibly some intrafascial Golgi receptors.

Measurements of the mechanoreceptors of knee joint ligaments have shown that their stimulation leads to only weak effects in alpha motor neurons, but to powerful changes in gamma motor neurons. That means that these ligamentous mechanoreceptors are probably used as proprioceptive feedback for preparatory regulation (preprogramming) of muscle tonus around this joint (Johansson 1991). For myofascial practitioners this is fascinating news, as it suggests that simulation of fascial mechanoreceptors may lead primarily to changes in gamma motor tone regulation. While the alpha and gamma motor systems are usually coactivated, there are some important differences between them. The alpha system originates primarily in the cortex, and it is particularly involved in volitional and precise movements of the extremities; whereas the gamma system originates in older brain stem structures and plays a strong role in the more global and unconscious postural organization of antigravity-extensor muscles and chronic musculo-emotional attitudes (Glaser 1980, Henatsch 1976, Juhan 1987).

Muscles are not functional units

When discussing any changes in motor organization, it is important to realize that the central nervous system does not operate "in muscles", i.e., a muscle is never activated as a whole. The functional units of the motor system are the so-called *motor units*, of which we have several million in our body - much like a school of fish that have learned to swim together. Depending on the quality of sensory feedback, these millions of motor units can be individually regulated (Basmajian 1985). Based on this background, we can now apply these details to our reference scenario, in which a practitioner is working on the connective tissue around the lateral ankle. When the practitioner reports a tissue release, it may be that it is caused by a lowered firing rate of only a few fish (motor units) in the vicinity, and that this movement is transmitted to the tissue under the practitioner's hand. If the practitioner then feels the change and responds in a supportive way toward these particular fish, other fish may soon follow the new direction, which of course leads to additional "release sensations" for the practitioner, and so on. Fig 4.

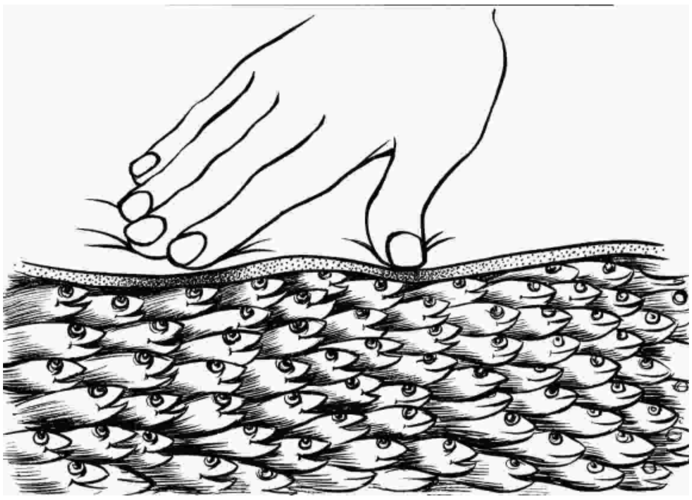

Fig.4
Myofascial tissue as a school of fish.
A practitioner working with myofascial tissue may feel several of the motor units responding to the touch. If the practitioner then responds supportively to their new behavior, the working hand will soon feel other fish joining, and so forth.

Influencing local fluid dynamics

However, there are probably additional feedback loops involved. Let's remember that it is the large group of interstitial receptors that makes up the majority of sensory input from myofascial tissue. Their activation triggers the autonomic nervous system to change the local pressure in fascial arterioles and capillaries. Additionally, stimulation of Ruffini endings is reported to have a similar effect in terms of a lowering of sympathetic activity (van den Berg and Capri 1999).

According to Kruger many of the interstitial fibers – if strongly stimulated - can apparently also influence *plasma extravasation*, i.e. the extrusion of plasma from blood vessels into the interstitial fluid matrix (Kruger 1987). Such a change of local fluid dynamics means a change in the viscosity of the extracellular matrix. This harks back to Ida Rolf’s originally proposed gel-to-sol concept (Rolf 1977), but this time with the inclusion of the client’s nervous system. It also supports the proposal of Mark F. Barnes that myofascial manipulation might involve a change of the *system of ground regulation*, which, according to Pischinger, is defined as a functional unit of final vascular pathways, connective tissue cells and final vegetative neurons (Barnes 1997, Pischinger 1991). With an increased renewal speed in the ground substance, it also appears more likely that the piezoelectric model that was explored in the early part of this chapter might play a role in immediate tissue plasticity.

Given that a myofascial manipulation then affects both the local blood supply and the local tissue viscosity, it is quite conceivable that these tissue changes could be rapid and significant enough to be felt by the listening hand of a sensitive practitioner. Fig. 5 illustrates this first autonomic feedback loop – here called “*Intrafascial Circulation Loop”* – which is based on the work of Mitchell and Schmidt (1977).

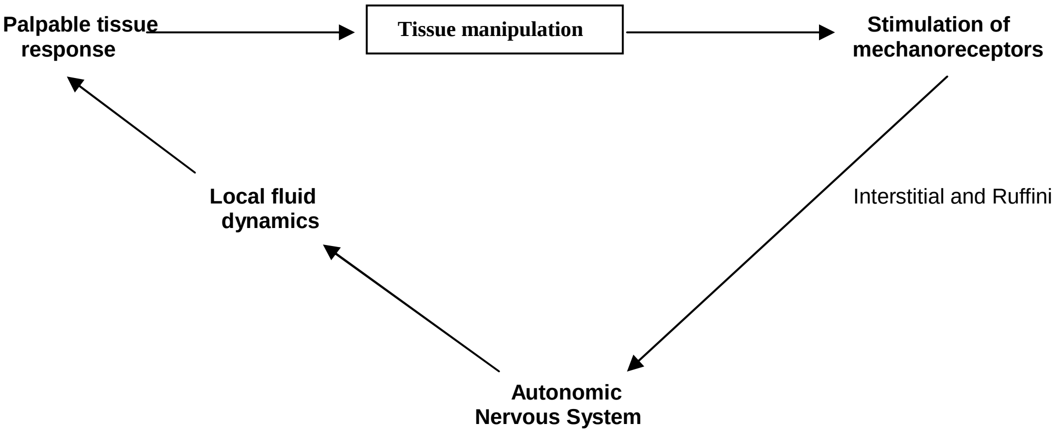

Fig. 5: The “Intrafascial Circulation Loop” *(based on Mitchell and Schmid 1977).*
Fascia is densely innervated by interstitial tissue receptors. The autonomic nervous system uses their input (plus that of some Ruffini endings) to regulate local fluid dynamics in terms of an altered blood pressure in local arterioles and capillaries, plus plasma extravasation and local tissue viscosity. This change might then be felt by the hand of a sensitive practitioner.

Hypothalamic tuning

In addition there is at least one more autonomic feedback loop. The interstitial mechanoreceptors can trigger an increase in *vagal tone*, which leads towards more *trophotropic* tuning of the hypothalamus. According to the previously discussed findings of Gellhorn, this results in global neuromuscular, emotional, cortical and endocrinal changes that are associated with deep and healthy relaxation (Gellhorn 1967). This *“Hypothalamus Loop“* is illustrated in Fig 6.

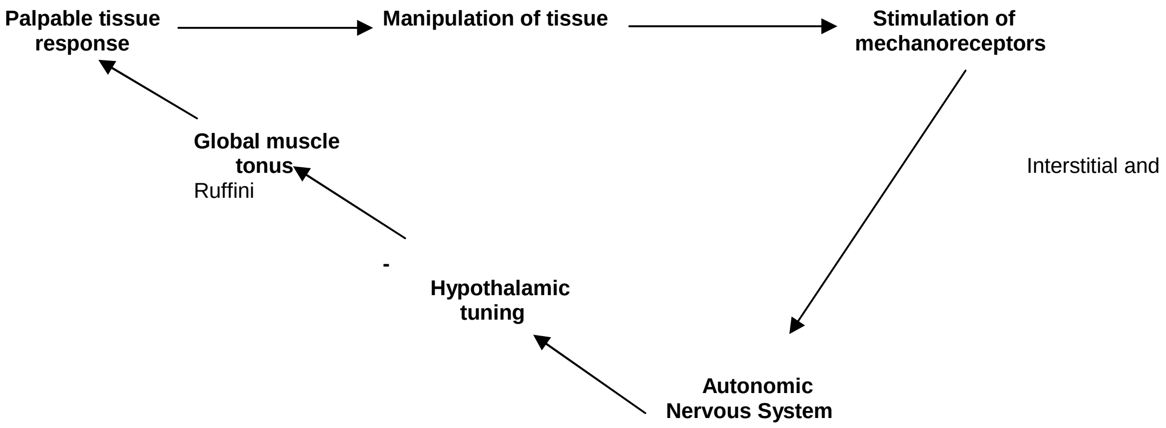

Fig.6…**The "Hypothalamus Loop"** based on Gellhorn.

Note that slow deep pressure usually leads to a more parasympathetic state. This activates the more trophotropic anterior lobe of the hypothalamus to lower the overall tonus of the body musculature.

Working with the whole Italian family

For a simplified analogy, Fig.7 illustrates a cartoon version of some of the clinically important features of the four types of fascial mechanoreceptors. The bodybuilder image of Signor Golgi illustrates one proposed working style for addressing Signor Golgi, who is the oldest of the three Italian brothers. A Golgi receptor likes it if he can be muscularly active; he likes strong work, and when he gets addressed that way he gets very relaxed.

His brother, Signor Pacini, on the other hand, needs constant stimulation. Like a person with attention deficit disorder, it is difficult for him to pay attention to you if your touch is too slow, steady or monotonous. On the other side, if you entertain him with constant changes and stimulation, he rewards you with vivid attention.

Finally let's look at the third of the three Italian brothers, at Signor Ruffini. He is not the fast cappuccino guy, but an old-fashioned pipe smoker with a beard. He likes it slow. And he prefers to address an issue at an angle, not in straightforward attacks. If you approach him in a slow manner and at the right tangential angle, he likes it a lot, and he will disperse some nice relaxing smoke that will have global effects throughout the whole body.

However, the power of the three brothers is well matched - or even surpassed – by that of their numerous little sisters. Some of these tiny nerve endings can have witch-like properties, evoking both temporary and long-term pain sensitization processes in their neighborhood. However, others can have angel-like healing properties, if addressed in the right manner.

While many practitioners may have a favorite working style, possibly primarily affecting only one of the four described mechanoreceptors, it is advisable to address the remaining receptor types as well, at least once a while. As in family systems therapy, it is suggested that ignoring some members may be less efficient than giving at least some attention to all.

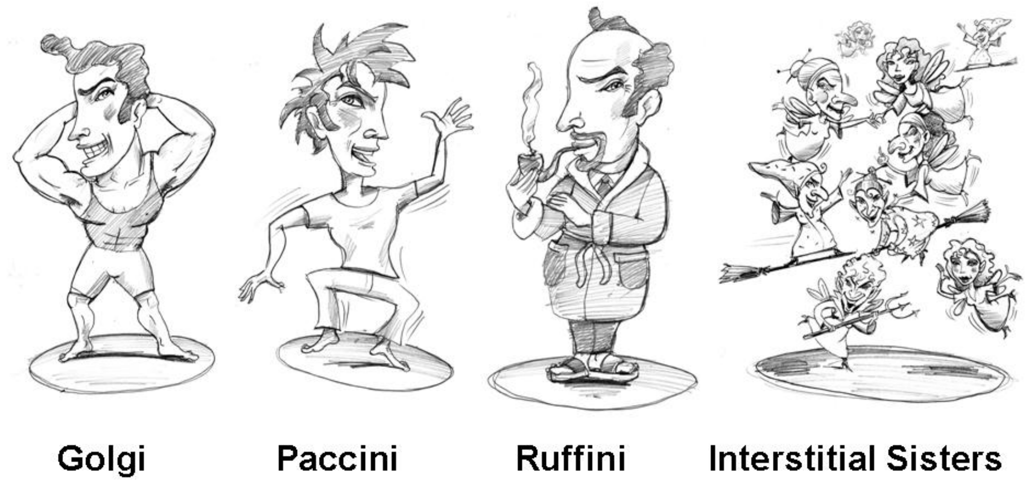

Fig. 7: A simplified cartoon model of the four fascial mechanoreceptors. This Italian family consists of three older brothers and their little sisters. Signor Golgi prefers to be muscularly active and likes it strong. When addressed that way, he is a jolly good fellow. His brother Signor Pacini on the other side needs constant stimulation, which he then rewards with vivid attention. Signor Ruffini appreciates it when you go slowly, which he then rewards by inducing a global relaxation (smoke). Finally, the numerous little sisters, representing the interstitial receptors, can have witch-like properties as well as angel-like healing properties.

Specific instructions on how to optimally address each of the depicted mechanoreceptors are best taught in the setting of a hands-on instruction class. As an example, working approaches for addressing the Ruffini receptors are usually attractive to practitioners who already love a melting touch quality, in which the hand carefully listens to the tissue at which exact tangential angle it tends to respond most. This myofascial working approach correlates well with important elements in traditional Rolfing, and also with slow-melting approaches in fascia-directed osteopathy.

Working with the interstitial receptors in the periosteum might recall Chua Ka, the traditional bone massage with which Mongolian warriors reportedly freed their body from fear before going into battle. Here the pressure or shear of the practitioner on the periosteum is slowly increased until a slight sympathetic activation, along with a minimal orienting motor response, can be noticed. These reactions may include a slight widening of the pupils, an increase or extension of a respiratory inhalation movement, a tiny watering of the eye, a slight blushing of the face, or a minimal turn of the head towards the practitioner. However any motor expression of a withdrawal response, however small it may be, should alert the practitioner to back off (e.g. narrowing of the eye, neck preparation to turning away from the practitioner, tightening of lips, a more angular breathing movement of the lower belly wall, etc.). Ideally the client supports the periosteal work with active movement participations from the inside, thereby increasing the pressure or shear at the working site in a moderated manner. While such periosteum work should not be done on inflamed myofascial tissues or other areas with heightened pain sensitivity, it usually works very well in those periosteal areas that are located close to pain areas but which have already normal pressure sensitivity. If preceded by respective training to extend ones tactile sensitivity into a well-crafted hand tool, some practitioners profit from using a wooden or metal tool in the hand to direct the periosteal pressure with more precision.

Early indications for fascial contractility

We have learned that fascia is more “alive” than has previously been understood in Western medicine. This aliveness includes not only the sensory dimension, which we have just addressed, but also a motor dimension; i.e., fascia is not an inert tissue that only responds to outside forces. From what we know today, fascia also has the ability to change its tonus autonomously, independent of outside muscular forces. Let’s explore this in more detail.

Yahia and his team in Montreal – after doing the study on the sensory innervation of fascia discussed before – also conducted a fascinating examination on the viscoelastic properties of the lumbodorsal fascia (Yahia 1993). Performing various repeated tests with dynamic and static traction loading on fresh pieces of lumbodorsal fascia from cadavers, their findings supported the well-known force- and time-dependent viscoelastic phenomena that have already been described by other researchers: creep, hysteresis, and stress relaxation (Chaitow and DeLany 2000). But they also described a new phenomenon for the first time, which they termed *ligament contraction*. When stretched and held at a constant length repeatedly, the tissues started to slowly increase their resistance.

Since nobody had described such spontaneous contraction of connective tissue before, they performed repeated tests involving different temperatures, solutions, and humidity, all with similar results. After very carefully ruling out the possibility of an experimental artifact, Yahia and associates finally concluded:

> *A possible explanation for the contraction of fascia held under isometric conditions could be the existence of cells with muscle like contractile properties in the lumbodorsal fascia. Indeed, many visceral muscles possess the ability to contract spontaneously. Price et al (Price 1981) demonstrated that strained and isometrically held intestinal muscles undergo relaxation followed by contraction. In order to test these specimens in a relaxed state (without spontaneous contraction), they used diverse techniques to suppress spontaneous activity, amongst them the use of epinephrine. A histological study of lumbodorsal fascia would therefore be desirable to evaluate whether muscles play a role in the contraction observed. (Yahia 1993).*

A few years later, in 1996, Staubesand, a German anatomy professor, published an exciting new paper. He and his Chinese co-worker Li studied the fascia cruris in humans over several years using electron photomicroscopy, and found *smooth muscle-like cells* embedded within the collagen fibers (Staubesand and Li 1996; fig.8).

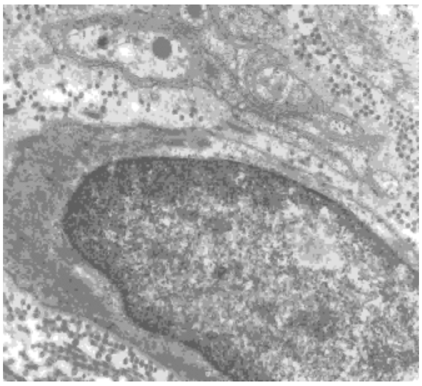

Fig. 8

Electron photomicrograph of a typical smooth muscle-like cell within the Fascia cruris. Above it may be seen the terminal portion of a type-IV (unmyelinated) sensory neuron. (Photo reproduced with kind permission of J. Staubesand).

Staubesand also described a rich intrafascial supply of autonomic nerve tissue and sensory nerve endings. Based on his findings, he concluded that it is likely that these fascial smooth muscle cells enable the autonomic nervous system to regulate a fascial *pre-tension* independent of the muscular tonus (Staubesand and Li 1997, Staubesand, et al. 1997). He therefore postulated that this new understanding of fascia as an actively adapting organ gives fascia in general a much higher functional importance, and that the close links between fascia and autonomics may have far-reaching clinical implications.

Recent evidence for fascial tonicity

Inspired by the combined findings of Yahia and Staubesand, our group conducted a histological examination of fascial tissues from different anatomical locations in 32 human donors (ages 17-91). We demonstrated the existence of "myofibroblasts" in all of these fascial tissues (Schleip 2006). Fascial myofibroblasts can be seen as a phenotype of fibroblast with very high contractile properties. It has long been known that fibroblasts often transform into *myofibroblasts*, which stress fiber bundles containing smooth muscle actin and can therefore actively contract in a smooth muscle-like manner. This happens in pathologies such as Dupuytren's contracture, liver cirrhosis, rheumatic arthritis and frozen shoulder. But it is also a productive element of early wound healing; and myofibroblasts are found regularly in healthy skin, and in the spleen, uterus, ovaries, circulatory vessels, periodontal ligaments and pulmonary septa (van den Berg and Cabri 1999).

With *in vitro* examinations we also explored the contractile capacity of rat lumbar fasciae in response to chemical stimulation. We were able to elicit contractile responses, which were large enough to predict a palpable tissue response, when applied to the anatomical properties of the human body. However, our original hypothesis, that autonomic nervous system neurotransmitters (such as epinephrine, norepineprhine – also called adrenaline, noradrenaline - or acetylcholine) might be able to elicit such responses, was thwarted. On the other hand, substances that are associated with the regulation of wound healing and inflammation, such as thromboxane and mepyramine, were able to trigger long-lasting tissue contractions.

Does this mean that the proposed sympathetic regulation of fascial tonicity, as suggested by Staubesand, has little substance in reality? Recent findings from the field of psychoneuroimmunology have uncovered confirmation for Staubesand's model. While it has been known for some time that sympathetic activation leads to altered activity in the immune system, particularly to the deployment of regulatory T-cells in the body's lymph nodes, the exact transfer mechanism by which the sympathetic nervous system stimulates these cells remained enigmatic. A new study has elucidated the missing link in that transmission: it is TGF-beta-1, a well-known multipotent cellular growth factor in the human body (Bhowmick 2009). This study demonstrates that an increase in sympathetic activation uses an increase in TGF-beta-1 to elicit the expression of specific T-regulatory cells in lymph nodes.

Interestingly, this same messenger substance is also known as the most reliable and most potent physiological stimulator for contractility by myofibroblasts. As shown by the work of Tomasek, an increase in TGF-beta-1 can induce tissue contracture mediated by myofibroblasts (Tomasek 2002). Fig. 9 and Fig. 10 therefore illustrate our proposed connections between the autonomic nervous system and fascial tonicity.

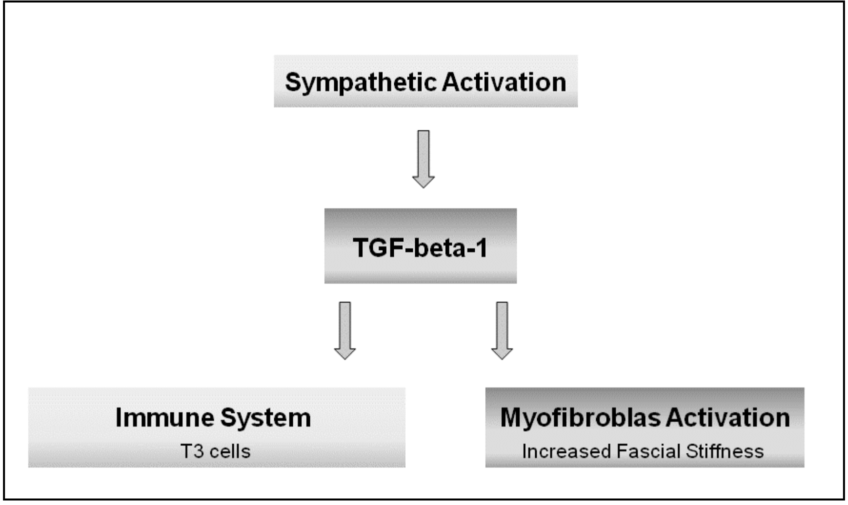

***Fig 9: How stress can influence fascial stiffness**. An increase of sympathetic activation leads to alterations of the immune system. A potent cytokine and well-known specific growth factor, TGF-beta-1, has now been shown to serve as a bridge for that transmission. However, TGF-beta-1 is also known to increase tissue stiffness via activation of the contractile behavior of myofibroblasts.*

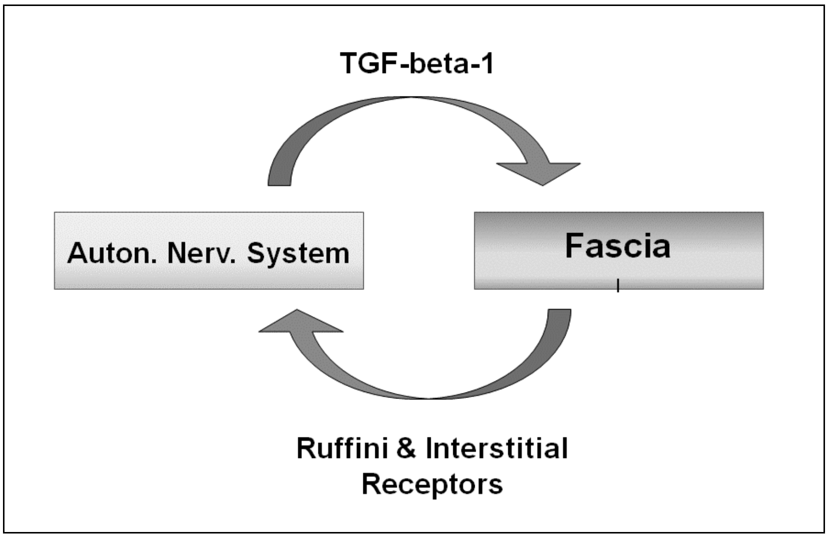

***Fig. 10: Interactions between the ANS and fascia.** An increase in sympathetic activation can increase fascial stiffness via the stimulatory action of TGF-beta-1 on fascial myofibroblasts. A therapeutic stimulation of fascial mechanoreceptors, particularly of Ruffini endings or interstitial receptors, may reduce stiffness by inducing changes in the state of the ANS.*

In addition, the work of Pipelzadeh suggests that alterations in the pH level of the cellular environment can impact myofibroblast contractility (Pipelzadeh 1998). Pain can induce a shift in the pH level of the ground substance (Steen 1996). The same is true for nutrition as well as for chronic hyperventilation (Chaitow 2002). Therefore all these factors - in addition to the state of the ANS as well as mechanostimulation - may influence the regulation of fascial stiffness.

Acupuncture meridians and fascia

Electron photomicroscopy studies of the Fascia cruris showed that there are numerous perforations of the superficial fascia layer that are all characterized by a perforating triad of vein, artery and nerve (Fig. 11). Staubesand could ascertain that most of the perforating nerves in these triads are unmyelinated sympathetic nerves (Staubesand 1997, Staubesand and Li 1997).

A study by Heine around the same time also documented the existence of these triad perforation points in the superficial fascia. Heine found that the majority (82%) of these perforation points are topographically identical with traditional Chinese acupuncture points (Heine 1995).

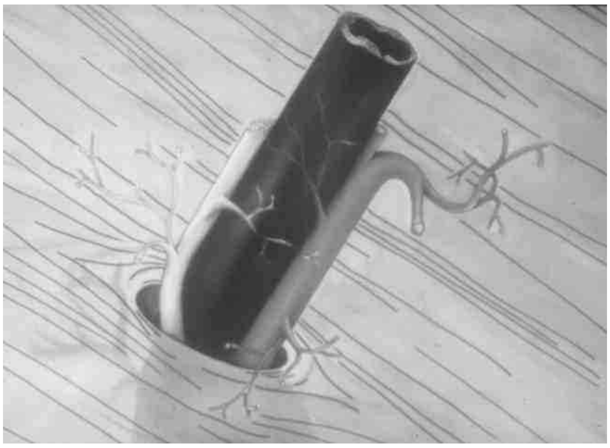

Fig. 11
***The superficial fascia is perforated at specific points by a triad of nerve (left), vein (large body in middle) and artery**. According to Heine, most of these perforation points are topographically identical with traditional Chinese acupuncture points.*

This stimulated a German surgeon to conduct a clinical study together with Heine. When studying these fascial perforation points in patients suffering from chronic shoulder-neck or shoulder-arm pain, they found that the perforation points in these patients showed a peculiar anomaly. The perforating vessels were “strangled” together by an unusually thick *ring of collagen fibers* around them, directly on top of the perforation hole. The surgeon then treated these points with microsurgery in order to loosen the strangulations and to achieve a *freer exit* of those vessels. This resulted in a significant improvement for the patients (Bauer and Heine 1998).

While many took this as clear evidence of a new mechanical explanatory model for pain in relation to acupuncture points, only a year later a back pain researcher from Spain published a study that seems to question some of Bauer and Heine’s assumptions - and which adds an exciting new dimension (Kovacs 1997). Using a well-orchestrated double-blind study design with patients suffering from chronic low back pain, *surgical staples* were implanted under their skin. An interesting point was that the location of the implants was defined by their segmental innervation, and was carefully chosen not to coincide with Chinese acupuncture points. The result: Kovacs’ treatment led to a clear pain reduction in the majority of his patients, with improvements at least statistically similar to those that Bauer and Heine had had with their patients.

Kovacs suggested the following explanation: most likely a class of liquid *neuropeptides*, called enkephalins, are released by both treatments, which then counteract the release of substance P, bradykinin and other neuropeptides associated with pain and which support the activation of nociceptive fibers. In other words: the stimulation of certain noci- and/or mechanoreceptors under the skin stimulates the release of specific neuropeptides that help to depolarize already activated pain receptors which have been instrumental in the maintenance of chronic pain (Kovacs FM 1997).

A dynamic systems approach

The beauty of Kovacs' approach lies in his view of the nervous system as "a wet tropical jungle", i.e. in his inclusion of the liquid aspects of the nervous system. Compared to the more mechanically-oriented treatment approach of Bauer and Heine, Kovacs sees the body as a *cybernetic system* in which an intervention stimulates complex internal self-regulatory processes.

Cybernetic approaches often work with *flow charts* as useful simplifications for complex dynamic interdependencies. Fig.12 can be seen as a first attempt towards an analysis of some of the neural factors behind immediate fascial plasticity. It includes several different feedback loops described earlier in this article. This flow chart does not include any neuroendocrine aspects, although it is very likely that they are significantly involved in myofascial manipulation.

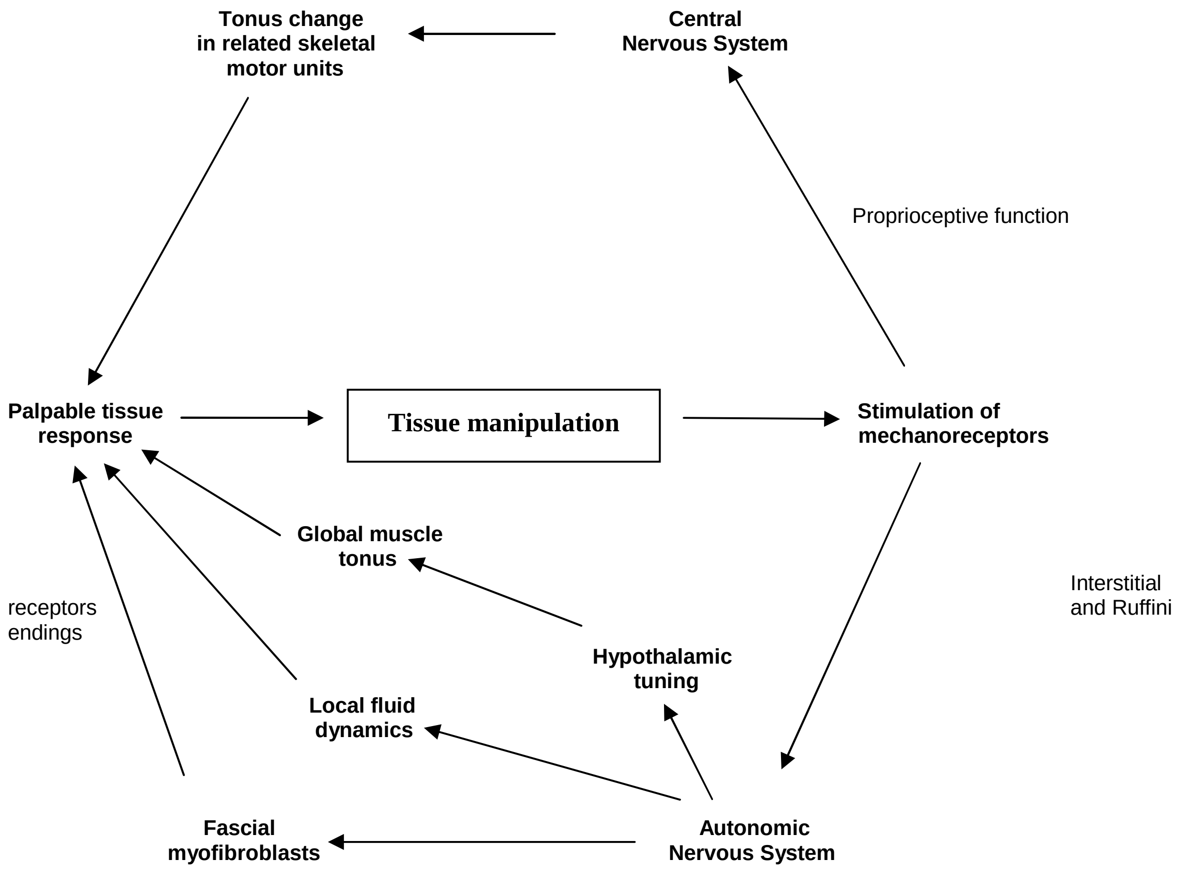

***Fig.12 Flow chart of several processes involved in the neural dynamics of immediate tissue plasticity in myofascial manipulation**. This chart includes the four different feedback loops that were discussed in Part One of this article series. The practitioner's manipulation stimulates intrafascial mechanoreceptors, which are then processed by the central nervous system and the autonomic nervous system. The response of the central nervous system changes the tonus of some related striated muscle fibers. The autonomic nervous system response includes an altered global muscle tonus, a change in local vasodilation and tissue viscosity, and a lowered tonus of intrafascial smooth muscle cells.*

Shifting models: from hero technician to humble midwife

It seems clear that in order to better understand and to utilize fascial plasticity, we need to include the self-regulatory dynamics of the nervous system. This includes an attitudinal shift in the practitioner. If we are willing to move from a mechanical view of the body to one that includes the neuroendocrine system, we do well to train ourselves to think more in terms of nonlinear system dynamics. The self-regulatory complexity of the nervous system can readily be compared with that of a rainforest or a metropolitan city. According to Senge and others, in dealing with such complex systems it usually does not work very well to assume the role of an expert or *master* who heroically intervenes from the outside and who believes himself able to predict his results with certainty. While often yielding positive short-term effects, such linear interventions lend themselves to producing unforeseen long-term reactions that are detrimental (Senge 1990).

TABLE 2:

Classical Concept: **THE BODY AS A MECHANICAL OBJECT**	New Neurobiological Model: **THE BODY AS A SELF-REGULATORY PROCESS**
The body is seen as a perfect or imperfect **machine,** governed mainly by classical Newtonian physics.	The body is seen as a self-regulating (SR) **biological organism**, involving nonlinear system dynamics, complexity and autopoiesis.
Typical "**industrial age"** viewpoint	Typical "**information age"** viewpoint
Clear distinction between **structure and function**	No clear distinction between structure and function
Less focus on nervous system	Strong inclusion of **nervous system**
Subject/object separation ("principles of **intervention**")	Subject-object connection ("**interaction**" instead of intervention)
Problem solving attitude	Focus on **enhancing** already existing SR
A machine has a limited number of variables. An inner sense of absolute **certainty** in the practitioner is therefore seen as achievable and as desirable	The system has high degree of complexity with almost unlimited variables. Practitioner personality needs to be comfortable operating with **uncertainty** principles
Local **"precision**" is important and admired	Good **timing and gradation** (dosage) are becoming at least as important
"Master Technician" as idol	"**Facilitator**" or "**Midwife"** as idols
Typical work example: Direct mobilization of a precise "**spinal fixation"** or sacral torsion by the practitioner.	Typical work example: Inclusion of facilitated active client **micromovements** during the hands-on work.

Usually it works better to assume the more humble role of a *facilitator*, who is curiously interested in learning and whose personality is more comfortable dealing with uncertainty principles. In the context of a bodywork session, practitioner and client then work together as *"a learning team"* (Petersen 2000).

Table 2 shows some of the consequences of this shift. Rather than seeing practitioner and client as clearly separable entities (subject and object) and discussing different "principles of intervention" in manual therapy in which the practitioner performs a number of skilled techniques on a mostly passive client, it is suggested that there is benefit to be gained by involving the client as an active partner in an "interaction" process, for example with specific micromovements during the fascial manipulations.

Note that the common distinction between structure (e.g. bones and connective tissue) and function (neuromuscular organization) is no longer useful within such a picture. The Nobel laureate Ludwig von Bertalanffy puts it this way:

> The antithesis of structure and function, morphology and physiology, is based upon a static conception of the organism. In a machine there is a fixed arrangement that can be set in motion but can also be at rest. In a similar way the pre-established structure of, say, the heart is distinguished from its function, namely, rhythmical contraction. Actually, this separation between a pre-established structure and processes occurring in that structure does not apply to the living organism. For the organism is the expression of an everlasting, orderly process, though, on the other hand, this process is sustained by underlying structures and organized forms. What is described in morphology as organic forms and structures is in reality a momentary cross section through a spatio-temporal pattern.
> What are called structures are slow processes of long duration, functions are quick processes of short duration. If we say that a function such as the contraction of a muscle is performed by a structure, it means that a quick and short process is superimposed on a long-lasting and slowly running wave.
> (von Bertalannfy 1952).

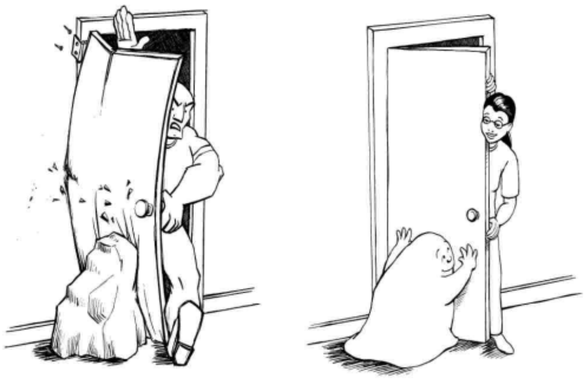

Fig. 13
A door blocked by a rock requires a different approach than if one deals with an animated obstacle. *Similarly a blocked joint or immobile tissue can be understood in purely mechanical terms or as an active self-regulatory system. The choice of approach depends largely on whether the practitioner sees any neural dynamics involved in the specific situation on the client’s side. This article makes a point of seeing fascia as innervated and alive, and therefore suggests treating it more with the second approach.*

The role of a “master technician” in Table 2 can best be described by the following story: The heating system of a big steamboat was broken and for several days nobody could fix it. Finally a master technician was called in. He just walked around and looked at everything and finally took out a little hammer from his pocket and hit a little valve, which immediately fixed the problem and the machine started working again. When his bill of $1000 arrived, the captain didn’t want to believe such a high sum for such little work, so he asked for an itemized bill. The next day the new bill arrived, it said:

“For adjusting a little valve: $ 0.01.
For knowing where: $ 999.99”.

Many bodywork practitioners still worship this story as an ideal of *mastery* in their work, although it clearly belongs in the realm of dealing with a mechanical universe. If one is willing to deal with fascia in a dynamic systems perspective, it is more appropriate to assume the role of a *midwife* or *facilitator* who is skillfully assisting a self-regulatory process of the organism. This ideal is expressed in the Chinese saying:

> "Give a man a fish, and you feed him for a day.
>
> Teach him how to fish, and you feed him for a lifetime".

Active Client Participation

A groundbreaking study by Moseley demonstrated that skillful mechanostimulation on the hand can be used as very effective treatment for complex regional pain syndrome. However the effectiveness of the treatment depended on the cortical attention of the patients. If the patients were asked to accompany each touch with detailed attention via a perceptual discrimination task, the treatment was highly effective; whereas the exact same type of mechanostimulation showed zero effectiveness when the patients were allowed to read the newspaper and were not required to give detailed attention to each stimulation (Moseley 2008). The proposed mechanism for the effectiveness of the treatment included a remapping of the respective body part representation in the somatomotor cortex. While such cortical remapping may not have the same importance in all other musculoskeletal dysfunctions, most body therapists would probably agree to the notion that the ultimate sustainability question (How long do the session changes last?) depends to a large degree on how much the client "owns" or "embodies" the newly gained relationships in their internal body schema and psychological body image.

How can we engage the client to pay curious attention to each detail of our fascial manipulation? Working at the edge of pain does work well with most clients. The same goes for the perception/projection of charisma/status on the practitioner, for an atmosphere of magic, or the setting of appropriately timed pauses after each intervention. Another and even more reliable tool, which is also easily teachable, is the engagement of the client's participation with active micromovements during the hands-on work. Fig. 14 shows a typical example of using active micromovement participation in a sitting client. Refined verbal and tactile guidance from the practitioner serve to facilitate subtle slow motion participations of the client such that the nervous system is more deeply involved in the coordination around a specific joint or area. Inspired by the Continuum Movement work of Emilie Conrad and Susan Harper, the smaller and slower the movements can be orchestrated, the more nurturing the perceptual involvement becomes (Conrad 2008).

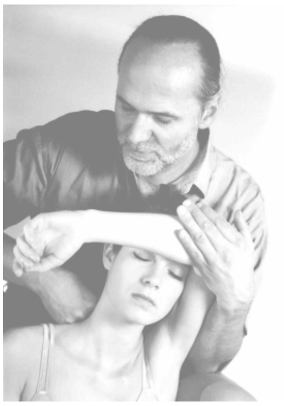

Fig.14
***Example of the use of AMPs (active movement participation) of the client in a Rolfing®** structural integration session. While deeply melting with one hand into the tissue and specific joints of the upper thorax, the author guides the client to support his myofascial work with subtle and non-habitual slow motion participations. Here the client performs a lateral bending movement of the thorax combined with a cranially directed extension (following the elbow) in order to increase an opening of the thoracic vertebral joints. (Photo reproduced with kind permission of European Rolfing Association).*

Conclusion

Fascia is alive. The practitioner working with fascial tissue should understand that it is innervated by four different kinds of mechanoreceptors. Without an inclusion of their responsiveness to various kinds of touch, the immediate tissue release effects in myofascial manipulation cannot be adequately explained. Manual stimulation of these sensory endings probably leads to tonus changes in the motor units that are mechanically linked to the tissue under the practitioner's hand. At least some of these responses are primarily regulated by a change in gamma motor tone. Of particular interest are the Ruffini organs (with their high responsiveness to tangential pressure) and the very rich network of interstitial receptors, since stimulation of both of these receptors can trigger profound changes in the autonomic nervous system. There are strong links between fascia and the autonomic nervous system that affect fascial tonus and local tissue viscosity. A shift from a mechanically-oriented "technician" point of view towards an inclusion of the self-regulation dynamics of the client's nervous system is therefore advocated.

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