Fascial plasticity – a new neurobiological explanation Part 2

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Abstract Part 1 of this two part article showed that immediate fascial responsiveness to manipulation cannot be explained by its mechanical properties alone. Fascia is densely innervated by mechanoreceptors which are responsive to myofascial manipulation. They are intimately connected with the central nervous system and specially with the autonomic nervous system. Part 2 of the article shows how stimulation of these receptors can trigger viscosity changes in the ground substance. The discovery and implications of the existence of fascial smooth muscle cells are of special interest in relation to fibromyalgia, amongst other conditions. An attitudinal shift is suggested, from a mechanical body concept towards a cybernetic model, in which the practitioner's intervention are seen as stimulation for self-regulatory processes within the client's organism. Practical implications of this approach in myofascial manipulation will be explored.
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Introduction

Part 1 of this article showed that fascial responsiveness cannot be explained by its mechanical properties alone. Fascia is populated by a dense network of mechanoreceptors. The majority of fascial sensory nerve endings which are stimulated by fascial manipulation are interstitial receptors (type III & IV) which have been shown to induce a change in local vasodilation. The additional group of Pacinian receptors seem to be involved in high-velocity manipulation, while Ruffini endings are mostly stimulated by slow deep pressure techniques, specially if they involve tangential forces, i.e. lateral stretch (Kruger 1987). Stimulation of fascial mechanoreceptors leads to changes in muscle tonus which come primarily from a resetting of the gamma motor system, rather than the more volitional alpha motor coordination. Additionally, stimulation of Ruffini organs as well as of many of the interstitial receptors effects the autonomic nervous system, which can result in a lowering of sympathetic tone, or in changes in local vasodilation. Part 2 of this article will explore further implications and practical applications of this neurobiological orientation.

Mechanoreceptors influence local fluid dynamics

Let us now look at some of the other effects of myofascial work. It is the large group of interstitial receptors that make 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 appears to have a similar effect in terms of a lowering of sympathetic activity (van den Berg & Cabri 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), yet this time with the inclusion of the client's nervous system. It also supports the assumption 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 (Pischinger 1991, Barnes 1997). With an increased renewal speed in the ground substance it also appears more likely that the piezoelectric model which was explored in Part 1 might play a role in immediate tissue plasticity.

If myofascial manipulation affects both the local blood supply as well as 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 sensitive practitioners. This first autonomic feedback loop – here called '*Intrafascial Circulation Loop*' – is based on the work of Mitchell and Schmidt (1977) and is illustrated in Fig. 1.

Changes in hypothalamic tuning

And there is a second autonomic feedback loop. The interstitial mechanoreceptors can trigger an

increase in *vagal tone* which leads towards more *trophotropic* tuning of the hypothalamus. Based on Gellhorn (1967) this results in global neuromuscular, emotional, cortical and endocrinal changes that are associated with deep and healthy relaxation (see the paragraph '*Touch research with cats and humans*' in Part 1). This *Hypothalamus-Loop* is illustrated in Fig. 2.

Fascia is capable of spontaneous contraction

Yahia and her team in Montreal – after doing the study on the sensory innervation of fascia which was discussed in Part 1 – also conducted a fascinating study on the viscoelastic properties of the lumbodorsal fascia (Yahia et al. 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 which have already been described by other researchers: creep, hysteresis, and stress relaxation (Chaitow & DeLany 2000). Yet they also
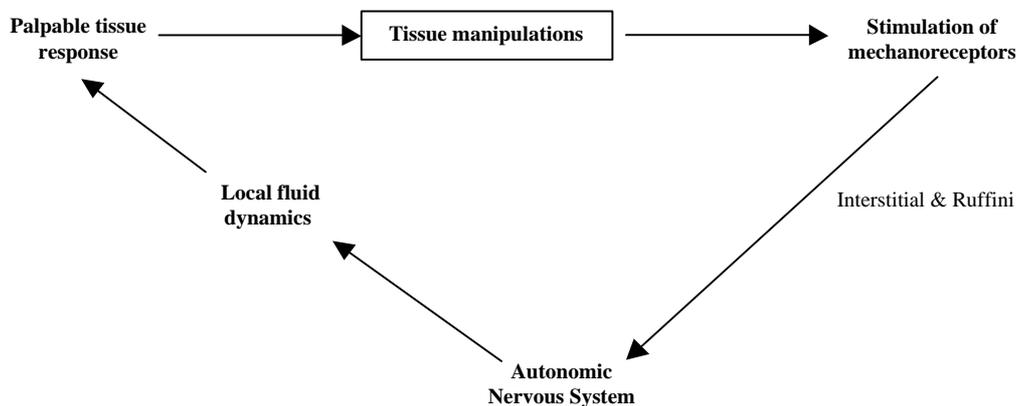

Fig. 1 The '*Intrafascial Circulation Loop*' (based on Mitchell & Schmid 1977). Fascia is densely innervated by interstitial tissue receptors. The autonomic nervous system uses their input (plus that of some Ruffini endings) to regulate local fluid dynamics in terms of an altered blood pressure in local arterioles and capillaries plus in plasma extravasation and local tissue viscosity. This change might then be felt by the hand of a sensitive practitioner.
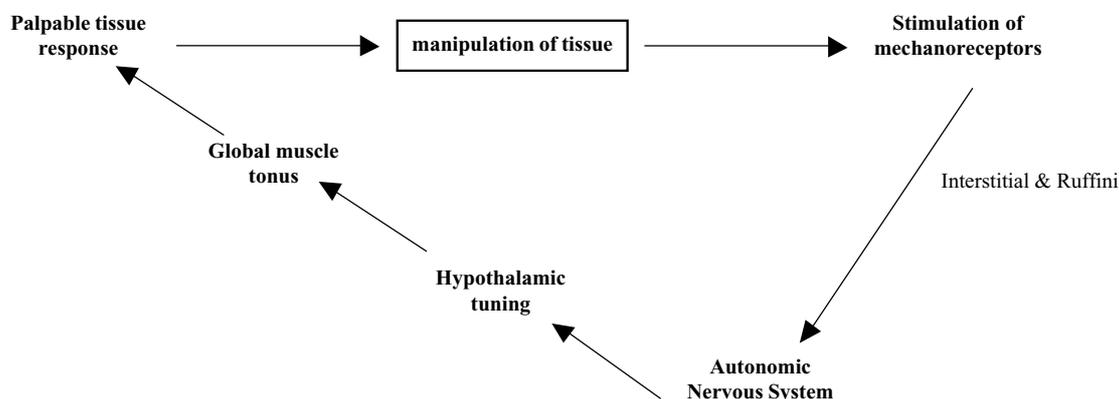
Fig. 2 The '*Hypothalamus-Loop*' based on Gellhorn (1967). Note that slow deep pressure usually leads to a more parasympathetic state. This activates the more trophotropic anterior lobe of the hypothalamus to lower the overall tonus of the body musculature.

Table 1 Fascial mechanoreceptors in myofascial manipulation		
	Responsiveness to manipulation	**Results of stimulation**
Golgi	Probably only responsive to muscular contraction or to very **strong** manipulation.	**Tonus decrease** in related striated motor fibers.
Pacini	Only responsive to **high velocity** or vibratory techniques	• Increased local **proprioceptive attention**
Ruffini	Specially responsive to **lateral stretch**	• Increased local **proprioceptive attention** • **Inhibition of sympathetic** activity
Interstitial	• 50% of these are **high** threshold pressure units (HTP) • Other 50% are sensitive to **low pressure** (LTP)	• Increased local **proprioceptive attention** • Increase in **vasodilation** and respiration • Stimulation of HTP may produce **pain** and increase plasma **extravasation**

described for the first time a new phenomenon, which they termed *ligament contraction*. When stretched and held at a constant length repeatedly the tissues started to slowly increase their resistance (Table 1).

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 intrusion of muscle fibers in the

lumbodorsal fascia. Indeed, many visceral muscles possess the ability to contract spontaneously. Price et al. (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. An histological study of lumbodorsal fascia would therefore be desirable to evaluate whether muscles play a role in the contraction observed (Yahia et al. 1993).

The discovery of fascial smooth muscle cells

A few years later, in 1996, a German anatomy professor, Staubesand published an exciting new paper. He and his Chinese co-worker Li studied the fascia cruris in humans with electron photomicroscopy for several years and found *smooth muscle cells* embedded within the collagen fibers (Staubesand & Li 1996) (Fig. 3). For a more detailed description of this discovery see Box 1 'Fascia is alive!'

Interestingly, this article also reported – similar to Yahia's innervation study – the widespread existence of intrafascial nerves. Staubesand describes a rich intrafascial supply of capillaries, autonomic nerves 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* independently of the muscular tonus (Staubesand & Li 1997, Staubesand et al. 1997). He therefore postulates 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.

Unfortunately, Staubesand was unaware that Yahia's research had already demonstrated that fascia has the ability to actively contract and to do so with measurable and significant effects. But Yahia could not isolate or identify the related muscle cells. Staubesand on the other hand had been able to identify and to photograph the related muscle cells, but he himself had no proof at that time that they are powerful enough to have any functional importance. Nevertheless it seems justified to say that both studies taken together show that there are smooth muscle cells embedded within fascia, and that it is highly probable that they are involved in the regulation of an intrafascial pre-tension.
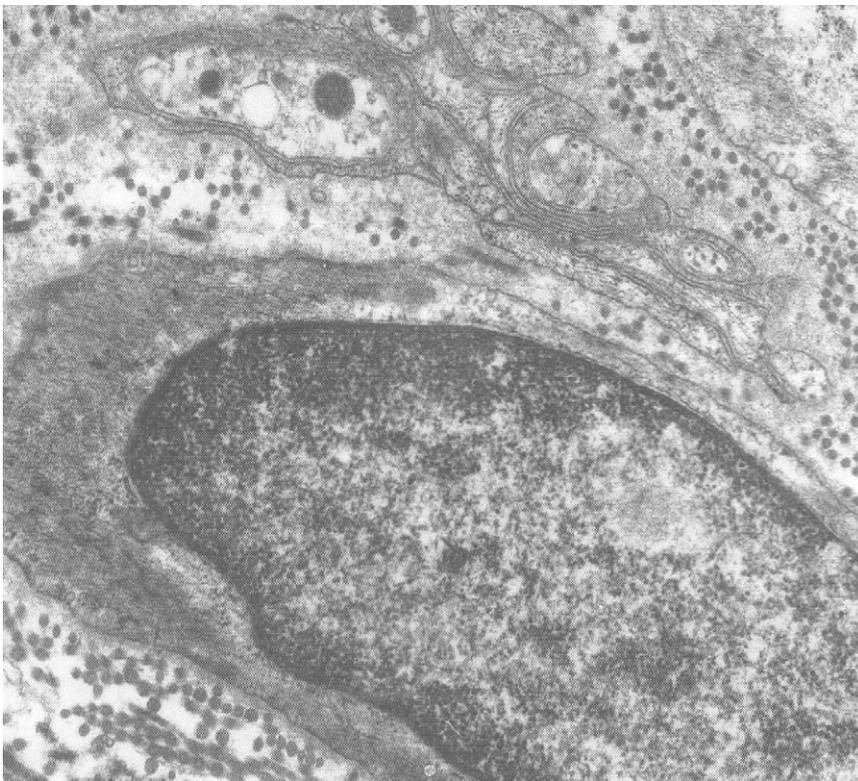
Myofibroblasts and tissue contractility

Compared with striated muscle cells, smooth muscle cells offer a more efficient transformation of chemical energy into mechanical strength. It has long been known that fibroblasts often transform into *myofibroblasts* which contain smooth muscle actin fibers and can therefore actively contract. This happens in pathological situations like Dupuytren's contracture, liver cirrhosis, in rheumatic arthritis and a few other inflammatory processes. Yet it is also a productive element of early wound healing, and myofibroblasts are found regularly in healthy skin, in the spleen, uterus, ovaries, circulatory vessels, periodontal ligaments and pulmonary septa (van den Berg & Cabri 1999).

Fig. 3 Electron photomicroscopy of a typical smooth muscle cell within the Fascia cruris. Above it is the terminal portion of a type IV (unmyelated) sensory neuron. (Photo reproduced with kind permission of Springer Verlag, first published in Staubesand 1996.)

Box 1 Fascia is alive!

The following is an excerpt of an interview from the author with J. Staubesand, now emeritus professor of anatomy at the University of Freiburg, Germany

The complete version is available at www.somatics.de

Staubesand: We did some electron photomicrograph studies of the Fascia cruris, which is the connective tissue covering the lower leg in humans. Rather surprisingly we found isolated smooth muscle cells within the fascia. Additionally, we found some intrafascial nerve fibers and sensory nerve endings which have not been reported previously.

Do you think these smooth muscle cells have any functional significance?

That is indeed possible, although at this time one cannot say for sure. Because of the microscopically thin layers of tissue that we examined in our electron photomicrographic studies, we are not yet able to say anything about the relative three-dimensional density of the smooth muscle cells within fascia. Yet it appears likely that these smooth muscle cells are there for a functional reason. Based on our findings it seems quite possible that the body is able to regulate a fascial pre-tension via those smooth muscle cells, in order to adjust to different muscular tonus demands. This function would also explain the amazingly widespread presence of autonomic nerves and capillaries which we found in fascia.

It is true that such a function puts fascia into a very different picture than in the past, where it was believed that fascia would only adjust passively to short-term changes in tensional demands. This new picture of fascia as an actively adapting organ; and the widespread existence of various intrafascial neural receptors, gives fascia a much higher functional importance.

What kind of nerve supply did you find in the fascial sheets that you studied? Were they sympathetic fibers?

This we can't say with certainty. Further studies are necessary to clarify this question. Yet what we can say is that there are myelinated, as well as unmyelinated nerve fibers in fascia. The myelinated axons are generally regarded as sensory. The unmyelinated nerve fibers could have motor functions as the efferent nerves of the autonomic nervous system to the smooth muscle fibers, or they could also serve other autonomic nervous system functions. Based on studies from Heppelman and others (Heppelman 1995) on pain receptors in the joint capsule of the knee in cats and due to striking similarities with our observations we can assume that there are also pain receptors in the fascial tissues that we examined in humans.

In our studies we found that what had previously been described as perforations of the superficial fascial layer by the venae perforantes, are regularly created by a triade of vein, artery and nerve. And these perforations are quite numerous. For example, in humans there are about 150 such triad perforations in each leg.

In your publications you also mentioned a possible relevance for the understanding and treatment of fibromyalgia

With fibromyalgia the main understanding has been that the pain receptors are in the muscle tissue. Yet now we know that there are many sensory receptors, including pain receptors in fascia, which points our attention in fibromyalgia, as well as in many other kinds of soft-tissue pain syndromes to a much higher value of therapeutic interventions in the fascia itself.

What is the most relevant aspect of your research for manual therapists?

I believe that the most important aspect of our findings for your work relates to the innervation of fascia. The receptors that we found in the lower leg fascia in humans could be responsible for several types of myofascial pain sensations. If you could influence these fascial receptors with your manipulation this could be of significant importance.

Another aspect is the innervation and direct connection of fascia with the autonomic nervous system. It now appears that the fascial tonus might be influenced and regulated by the state of the autonomic nervous system. Plus – and this should have ramifications for your work – any intervention in the fascial system may have an effect on the autonomic nervous system in general and on all the organs which are directly affected by the autonomic nervous system. To put it more simply: any intervention on the fascia is also an intervention on the autonomic system.

From a teleological perspective it makes sense that an interspersing of smooth muscle cells into fascial sheets equips the organism with an accessory tension system to increase muscular tonus and offers an evolutionary survival advantage in fight/flight survival situations. Staubesand's study had demonstrated a *scissor-like* configuration of the collagen fibers in the epimysium. This arrangement makes perfect sense as it allows a small quantity of intrafascial smooth muscle cells to effect a relatively large lattice network.

An interspersing of smooth muscle cells into fascial envelopes would also explain the following observation: The fascial lining of many organs consists mostly of collagen fibers, whose small range of elasticity allows for minute length changes only. Yet the spleen can shrink to half size within a few minutes (which has been shown to happen in dogs when their blood supply in the spleen is needed due to strenuous activity). The most likely explanation for this are smooth muscle cells embedded within that organ capsule.

Fascial tonus, breathing, and fibromyalgia

Tonus regulation of fascial smooth muscle cells is most likely achieved via the sympathetic nervous system as well as vasoconstrictor substances such as CO_2. The discovery of fascial muscle cells therefore opens a doorway for exciting speculations about a direct link between fascial behavior and the pH of the body, which is directly linked to breathing function and CO_2 levels. As Chaitow, Bradley and Gilbert showed (Chaitow et al. 2002) there is already a clear link between smooth muscle contraction and depleted levels of CO_2 such as occurs in relative respiratory alkalinity. When there is a shift toward increased alkalinity due to – for example – hyperventilation – vasoconstriction is automatic and dramatic. Possibly, at this same time fascial smooth muscle cells contract and increase overall fascial tension. The implications for such changes in conditions such as fibromyalgia and chronic fatigue are enormous, since a common clinical finding is that most people with FMS and CFS are frank or borderline hyperventilators.

One can also speculate about the possible effect of increased serotonin levels on fascial smooth muscle cells. Serotonin has been known to be an enhancing agonist for smooth muscle contractions such as peristaltic activity or vasoconstriction in large pulmonary vessels. Unusually high levels of serotonin have recently been found in the cerebrospinal fluid of fibromyalgia patients (Pongratz & Späth 2001). A possible connection between fibromyalgia and serotonin-mediated hypertonicity of fascial smooth muscle cells might be a worthwhile investigation. On the other hand, serotonin has been shown to decrease the pain threshold of group IV receptors (Mitchell & Schmidt 1977), which could mean that the increased pain sensitivity of those receptors in fibromyalgia might be less of a motor dysfunction (fascial smooth muscle cell hypertonicity) but more of a sensory regulation dysfunction.

Based on Yahia and Staubesand, Fig. 4 illustrates a third autonomic feedback loop – which I call '*Fascial Contraction Loop*' as a potential factor behind short-term fascial plasticity. Leaving aside the possible interactions of chemical vasoconstrictor substances for the moment, this 'loop' focuses on neural network dynamics alone. To put it simply: Stimulation of intrafascial mechanoreceptors (in this case mostly free nerve endings) triggers the autonomic nervous system to alter the tonus of intrafascial smooth muscle cells.

How about visceral ligaments?

In visceral osteopathy it is often claimed that gentle manipulation of a visceral ligament can induce an immediate and palpable release within that ligament (Barral & Mercier 1988). Similar concepts have also been suggested for osteopathic work with skeletal ligaments (Barral & Croibier 2000, Crow et al. 2001). Since ligaments can be seen as special arrangements of fascia – often ligaments are nothing but local thickenings within larger fascial sheets – the question arises: how is this possible? As was shown in Part 1, that in order to create an immediate yet permanent lengthening of any substantial fascial structure with mechanical means, much larger amounts of force and/or time are required than are usually applied in gentle non-thrust manipulations.

Fascial smooth muscle cells and active fascial contractility have only been reported from large fascial sheets. This is also where the scissor-like fiber arrangement makes it possible for a relatively small amount of interspersed contractile cells to effect the whole fascial lattice network. It therefore seems unlikely that intra-ligamentous smooth muscle cells might be the basis of this reported osteopathic phenomenon.
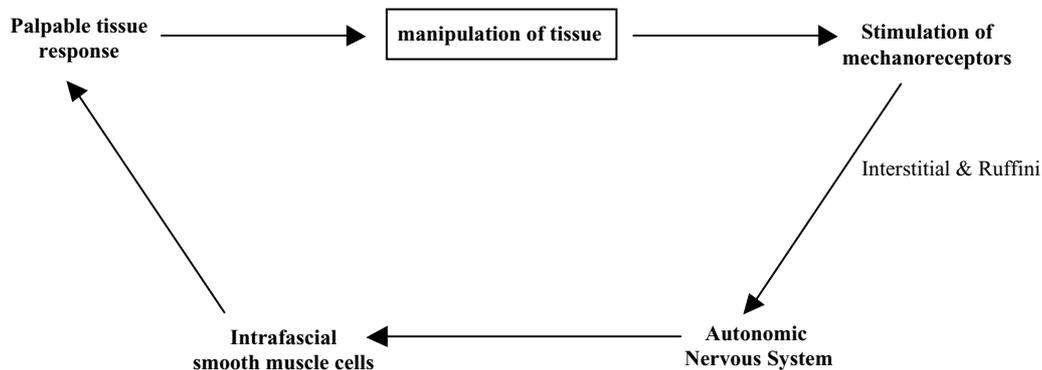

Fig. 4 The '*Fascial Contraction Loop*' (based on Yahia and on Staubesand). Embedded between the collagen fibers of fascia are smooth muscle cells, which are regulated by the autonomic nervous system. Their activation can cause an active intrafascial tissue contraction.

It seems more likely that the osteopathic soft tissue manipulation stimulates mechanoreceptors within the treated ligament, which then induces a relaxation of related (smooth or striated) muscle fibers; and this is felt as a 'ligament relaxation' by the practitioner. Additionally, it is quite possible – particularly with stimulation of visceral ligaments – that specific metabolic ground substance changes and physiologic organ function changes might be triggered in the neighborhood, which could also be palpable. Yet the actual length of the ligament would not be altered. If true, this explanation would challenge – or modify – some of the current assumptions in osteopathy and would lead to several different practical consequences in that work.

Fig. 5 The superficial fascia is perforated at specific points by a triad of nerve (left), vein (large body in middle) and artery. Based on Heine most of these perforation points are topographically identical with traditional Chinese acupuncture points. The perforating nerves usually innervate Pacinian and Meissner corpuscles under the skin.

Acupuncture points and fascia

As we learned in Part 1 of this article, an electron photomicroscopy study of the Fascia cruris (Staubesand 1997, Staubesand & Li 1997) 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. 5). Staubesand could identify that most of the perforating nerves in these triads are unmyelated autonomic nerves.

A study by Heine around the same time also documented the existence of these triad perforation points in the superficial fascia. Heine, a German researcher who has been involved in the study of acupuncture and other complimentary health disciplines, found that the majority (82%) of these perforation points are topographically identical with the 361 classical acupuncture points in traditional Chinese acupuncture (Heine 1995).
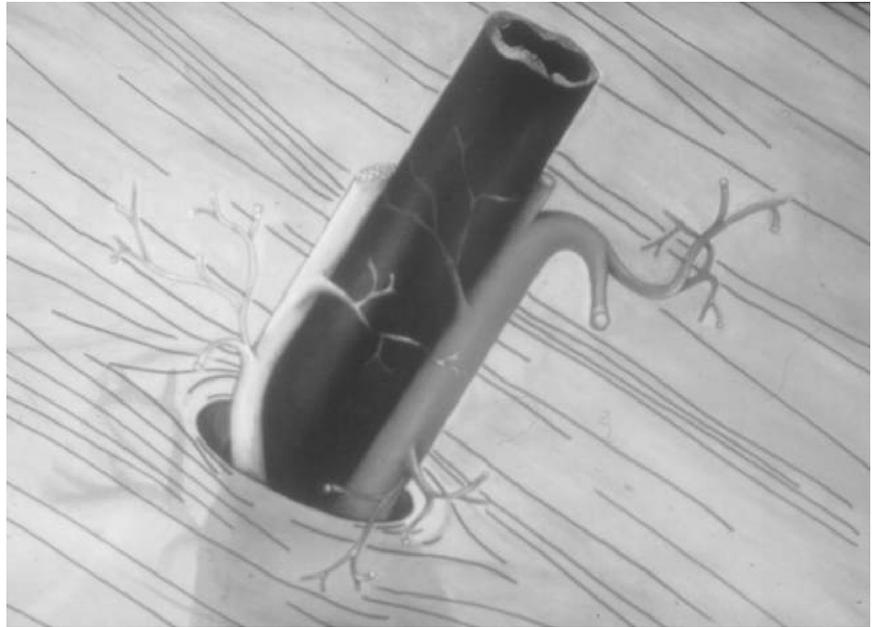
This stimulated a German surgeon to conduct a clinical study together with Heine. They studied these fascial perforation points in patients suffering from chronic shoulder–neck or shoulder–arm pain. They found that the perforation points in these patients showed a peculiar anomaly. The perforating vessels 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 & Heine 1998).

Many took this as clear evidence of a new mechanical explanation model for pain in relation to acupuncture points. Yet just a year later a back pain researcher from Spain published a study which seems to question some of Bauer and Heine's assumptions and which adds an exciting new dimension (Kovacs et al. 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 innervation (as trigger points) 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 at least a similar statistical improvements to those that Bauer and Heine had with their patients.

Kovacs' suggested the following explanation: most likely a class of *neuropeptides*, called enkephalins, are released by both treatments, which then counteract the release of substance P and other neuropeptides which are 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 deactivate pain receptors which are instrumental in the maintenance of chronic pain (Kovacs et al. 1997).

A dynamic systems approach

The beauty of Kovac's 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, Kovac looks at the body as a *cybernetic system* in which an

intervention is seen as stimulation for complex internal self-regulatory processes.

Cybernetic approaches often work with *flow charts* as useful simplifications for complex dynamic interdependencies. Figure 6 can be seen as a first attempt toward an analysis of some of the neural factors behind immediate fascial plasticity. It includes the four 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. Following Kovac's example, it would be useful for future research to explore whether deep tissue work triggers a release of

specific neuropeptides, which might explain some of the profound short term as well as long-term effects of this work.

From hero technician to a humble midwife

It seems clear that in order to better understand and to use fascial plasticity, we need to include the self-regulatory dynamics of the nervous system. This will include an attitudinal shift in the practitioner. If we are willing to move from a mechanical view of the body towards an inclusion of the neuroendocrine system, we are doing well to prepare our brain (and guts) to think in nonlinear system
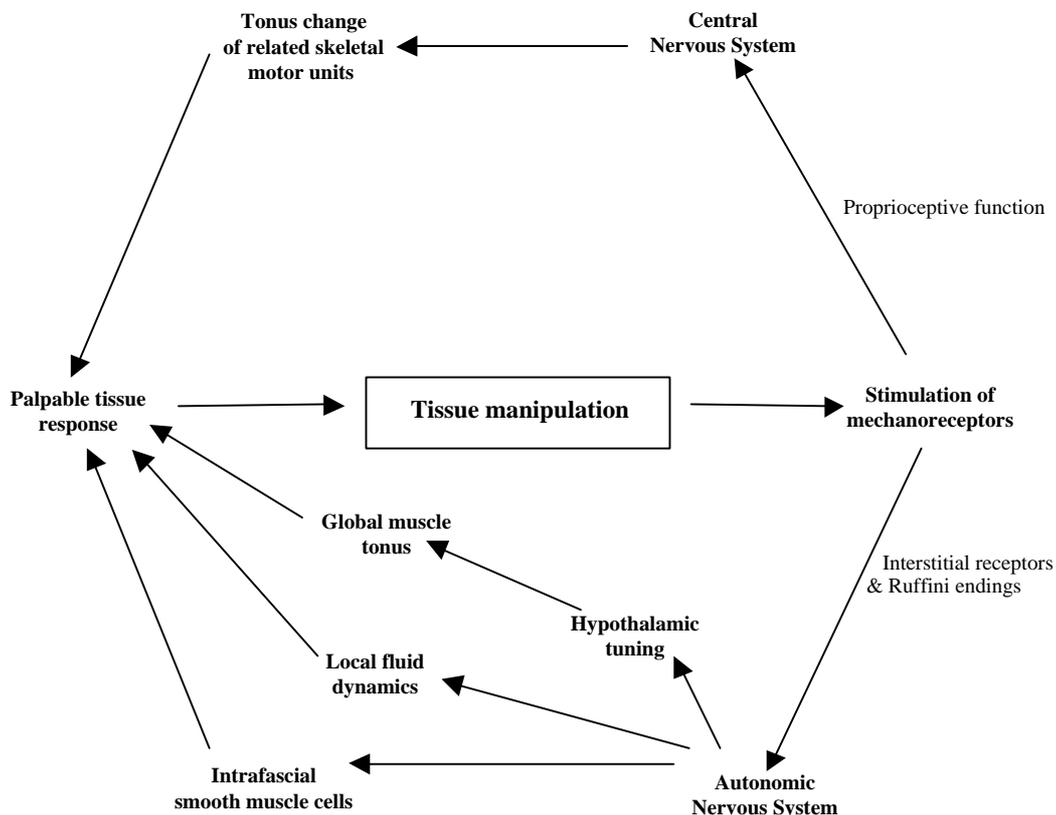

Fig. 6 Flow chart of several processes involved in the neural dynamics of immediate tissue plasticity in myofascial manipulation. This chart includes the four different feedback loops which were discussed in part one of this article series. The practitioner's manipulation stimulates intrafascial mechanoreceptors, 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.

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 getting 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

dynamics. The self-regulatory complexity of the nervous system could 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 a *master* who interferes from the outside with heroic interventions and who believes to be able to predict his results with certainty. More often than not such linear interventions produce unforeseen long-term reactions which are counterproductive (Senge 1990).

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 to deal 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 active 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
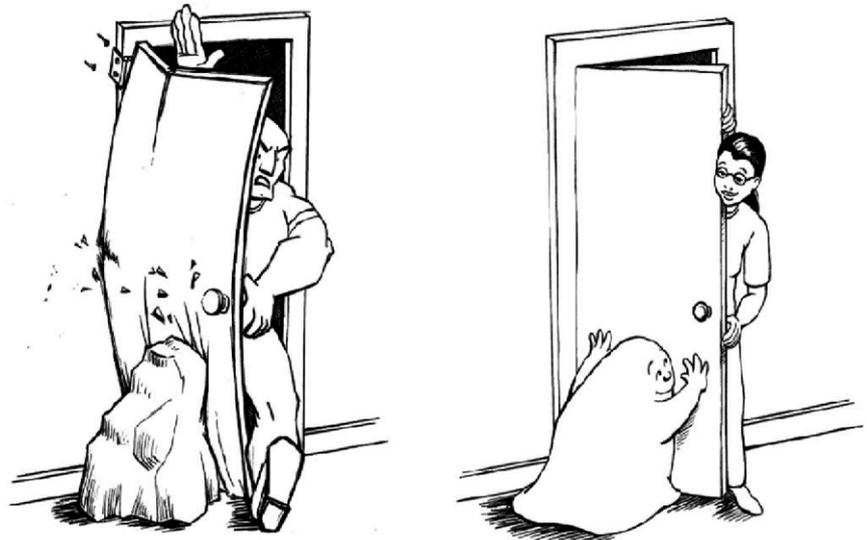
Fig. 7 A door blocked by a rock requires a different approach than if one deals with an animated obstacle. Similarly, a blocked joint or immobile tissue can be understood in purely mechanical terms or as an active self-regulatory system. The choice of approach depends largely on whether the practitioner sees any neural dynamics involved in the specific situation on the client's side. This article makes a point to see fascia as enervated and as alive, and therefore suggests to treat fascia more with the second approach.

(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).

A different role model

The role of a 'master technician' in Table 2 can best be described by the following story: The heating system of a big steam boat 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 a more specified 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* that is skillfully assisting a self-regulatory process of the

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Table 3 Practical applications

WHERE TO WORK:
1. *Short and tight tissues*
   Bring attention to the primary (inappropriately) shortened and hypertoned myofascial tissues.
2. *Include antagonists*
   Include bringing attention to the antagonistic muscle fibers of the related joint.
3. *Respect receptor density*
   Give extra time and attention to those tissues that have an usually high density with mechanoreceptors (suboccipital muscles, periosteum, palmar and plantar fascia, myotendinous junctions, ligaments).
4. *Face and Hands*
   Give high attention to those myofascial fibers that move the face or hands
5. *Abdomen and Pelvis*
   Deep pressure on visceral nerves as well as sustained pressure on the pelvis have been proven to increase vagal tonus

HOW TO WORK:
6. *Timing*
   For tonus decrease: slow and melting to induce parasympathetic state and to avoid myotatic stretch reflex
   For focusing attention: stimulating, calling attention, more rapid changes, but never boring.
7. *Ruffini-angle*
   Tangential pressure (lateral stretch) is ideal to stimulate Ruffini organs, which tend to lower sympathetic tone.
8. *Attention to ANS*
   Pay great attention to the state of the autonomic nervous system
   (which influences the body's overall tonus regulation).
9. *Unusual sensations*
   Create unusual body sensations that are most likely to be interpreted as 'significant' by the filtering action of the reticular formation of the central nervous system; i.e.:
   (a) unusually **strong** stretch of those fibers
   (b) unusually **subtle** stimulation ('whispering effect')
   (c) unusually **specific** stimulation
   (d) sensations that are always slightly **changing/moving** in a not precisely predictable manner
10. *Immediate feedback inclusion*
    As soon as you sense the beginning of a tonus change, mirror this back with your touch in some way to the tissue. The more precise, immediate and refined your feedback inclusion is, the more effective your interaction will be.
11. *Animistic Thinking*
    A motherly caring attitude towards lots of little gnomish entities inhabiting the tissue triggers usually the highest 'sensory acuity' in the practitioner's (mammalian) nervous system.

CLIENT PARTICIPATION
12. *AMPs*
    Engage the client in active micromovement participation (AMP). The slower and more refined they are and the more attention they demand, the better.
13. Ask and allow for a *deepening of proprioception*.
14. *Relate body perceptions* and movements to functional activities and include the external space orientation as well as the social meaning aspects of altered body expressions.

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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 life time".

Where to work

Table 3 gives some recommendations for the practical work. Since myofascial work seems to be more focused on softening or *release* of tight tissues (Rolf 1977, Barnes 1990) rather than on an increase of tonification, it usually includes work on those myofascial tissues which appear as unnecessarily short and tight (see rule 1 in Table 3). Yet if one includes the self-regulatory system dynamics of the client's motor coordination, it is also useful to include work on the antagonists of those hypertonic tissues (rule 2). For example if the client shows a chronic anterior pelvic tilt (not only in standing and walking but also in supine and prone position on the table) and the Modified Thomas Test (Tunnel 1998) has revealed that one or several hip flexor muscles are short, it is often helpful to work with the upper hamstrings and gluteals (rule 2) in addition to direct work with the shortened hip flexors (rule 1).

The basis for rule 2 rests primarily on the clinical experience of the author. Nevertheless, the following theoretical explanation might be applicable: Agonists and antagonists of a specific skeletal joint are neurologically closely connected via a complex network of spinal and supraspinal reflexes and feedback loops (Kandel 1995). Any tonus change in the agonists will tend to also trigger changes in the related antagonists, and vice versa. Bringing attention to the antagonistic fibers of the primarily shortened myofascial tissue might therefore provide an additional input for the

nervous system regulation around this joint. Giving this additional invitation for the nervous system to *'please re-evaluate your tonus regulation around this joint'* might therefore be more efficient than only repeating the same access road (via the shortened agonistic tissues) again and again. Nevertheless, usually more work should be done on the shortened agonistic tissues than on their opposing antagonists.

An understanding of the 'inner anatomy' of the client, i.e. of the client's body scheme organization within the cortex, supports rule 4, i.e. to give extra attention to the myofascial tissues which are involved in movements of the face

and hands. Together both representational areas make up about two-thirds of the 'inner body organization' in the brain. In the cortex, there is a general tendency for local spreading: the excitement of a local cortical area will tend to influence surrounding areas in its neighborhood. E.g. if the practitioner achieves a healthy tonus change in previously tightened hand – and face muscles within 15 minutes of myofascial work, it is more likely that this change – involving two-thirds of the clients internal body image organization – will spread to the rest of the body, compared to if the practitioner works for an hour on the trunk only (which makes up
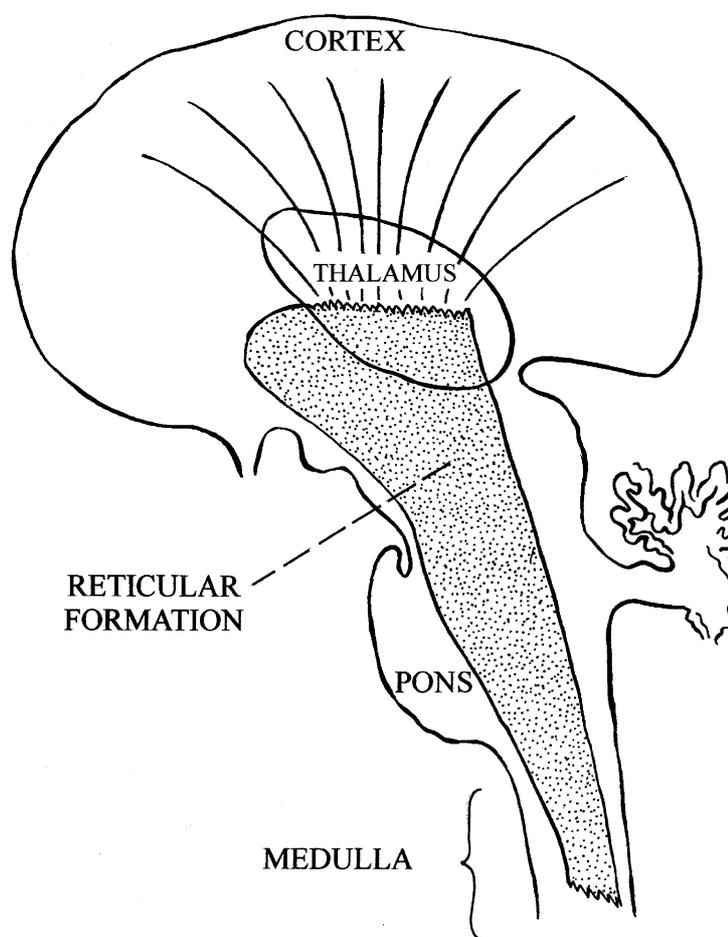

Fig. 8 The manual practitioner needs to understand the filtering action of *Reticular formation* in the spinal cord and brain stem. Only if this system interprets the practitioner's touch as significant or interesting, will it allow this input to reach higher areas of the clients body organization.

only a minor portion of the somatomotor cortex).

Rule 5 rests on the research which was discussed in Part 1 of this article (Folkow 1962, Koizumi & Brooks 1972).

How to work

The basis for rule 7 has been explored in Part 1, same for rule 8 which relates to Gellhorn's research on trophotropic and ergotropic tuning states (Gellhorn 1967).

Rule 9 acknowledges the fact that the reticular formation (see Fig. 8) usually filters out all manual input which is interpreted as nonsignificant by the clients central nervous system. An example: while probably sitting and reading this article, the reader's underwear and other pieces of clothes are touching the body, sometimes with an amount of pressure comparable to very fine craniosacral bodywork. Also the ischial tuberosities may be exposed to pressure comparable to strong myofascial work. Yet both inputs are readily ignored in everyday life and do not lead to significant short-term changes.

Rules 10 and 11 underline the importance of palpatory sensitivity. Imagine the school of fish which we used as an analogy in Part 1 for the hundreds of motor units under the practitioner's hand or elbow. If lets say one or two of those fish (motor units) start changing their tonus and if the practitioner's hand is able to perceive this, it can mirror this change back to the tissue and might influence other fish to flow in the same direction. Whereas if the practitioner's hand or elbow is not sensitive enough to perceive this change, this chance might be lost. The question then comes up: How can we increase the sensory acuity? The author's own teaching experience supports the observation,

that our own (mammalian) nervous system tends to work at it's highest sensory acuity if we are engaged in a motherly bonding relationship context. Imagining dozens of baby like gnomish entities inhabiting the fascial tissue therefore usually works better than imagining nerves,

collagen fibers or other images from dissections or anatomy books.

Active client participation

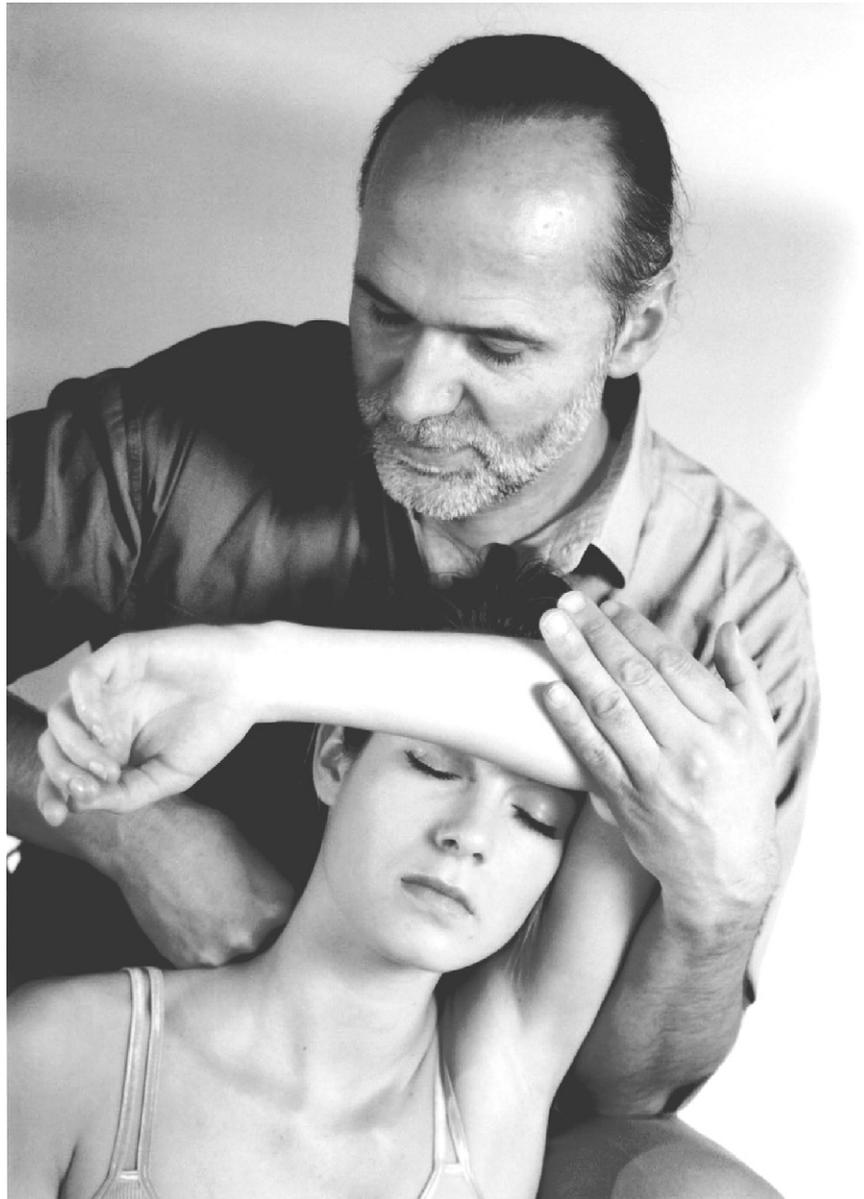If it is true that myofascial manipulation includes the

Fig. 9 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 nonhabitual 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.)

self-regulation dynamics of the client's nervous system, then it makes sense to involve the client more actively in the session. Figure 9 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.

Recent insights into the organization of the motor cortex have shown that it is less organized around topographical body parts but rather around complex elementary movements towards specific spacial end-point directions (Graziano et al. 2002). Rule 14 takes this insight even further, by preferring movement participations with a clear functional intention (e.g. reaching for something, or pushing something away) which involve the client's nervous system more fully than mere mechanically/ geometrically described movements (Reed 1996).

Conclusion

Fascia is alive. Practitioners working with this truly fascinating 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. Fascia has been shown to contain smooth muscle cells which seem to be responsible for its ability of active 'ligament contraction'. There are strong links between fascia and the autonomic nervous system which effect fascial tonus, local tissue viscosity, and possible fibromyalgia. A shift from a mechanically oriented

'technician' point of view towards an inclusion of the self-regulation dynamics of the clients nervous system is therefore advocated. Rather than seeing the practitioner as the expert technician, client and practitioner work together as a learning team in order to open new options for movement and posture organization.

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