



Oral presentation by Robert Schleip on Nov 13 2004 to the 5th Interdisciplinary World Congress on Low Back & Pelvic Pain in Melbourne, Australia.

Dr. Andry Vleeming (Programm Chairman):

I like to introduce to you Robert Schleip, who is doing a VERY interesting study on movements of contraction in the thoracolumbar fascia. That is of interest to all of us. Can we get a contraction in connective tissue? I am specifically interested since we did a study in 1995 in 'Spine' on the biomechanics of the thoracolumbar fascia; and I really like to hear your story.

Active contraction of the thoracolumbar fascia

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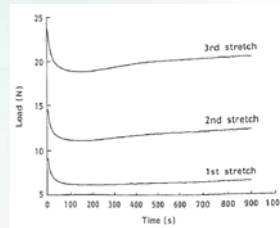


TEXT OF ORAL PRESENTATION

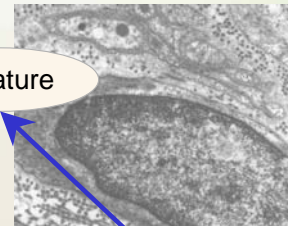
The thoracolumbar fascia, shown in this picture, is an important element in low back stability. In a classic paper on its viscoelastic properties in 1993, a surprising fascial behaviour was reported.

Active fascial contraction?

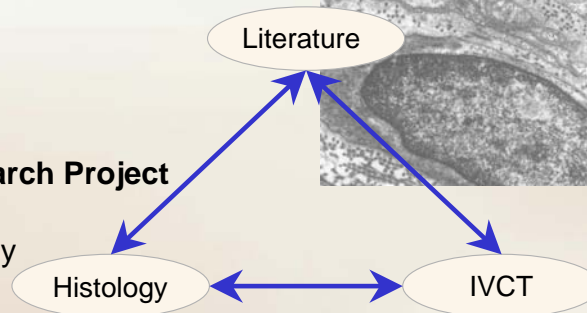
1. **Unexpected ligament contraction of TLF**
Yahia 1993



2. **SM-like cells in crural fascia**
Staubesand 1996



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When strips of tissue were stretched at a constant length over a period of 15 minutes, their resistance force declined, as was expected. Yet when the tissue was stretched again, after half an hour of rest, the resistance had increased. After a second period of rest, there was another increase in resistance. The authors proposed, that this behaviour was probably due to the existence of smooth-muscle-like cells in the fascia, and they suggested a histological study for these cells.

3 years later the German anatomist Staubesand reported his discovery of smooth muscle cells in the fascia of the lower leg. He documented this with electronmicroscopy. Here is an example of one of the cells.

These two studies motivated our group to start a special research project, to examine whether the lumbar fascia can actively contract. We followed 3 major approaches: First - a literature review on what is already known in this field. Secondly - a histological search for contractile cells in human lumbar fascia. And finally, in vitro contraction tests with fascia.

In vivo contractures of fascia

Hand:

palmar fibromatosis & knuckle pads



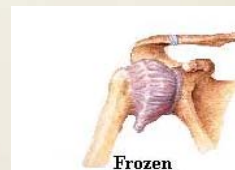
Foot:

plantar fibromatosis & club foot



Shoulder:

frozen shoulder

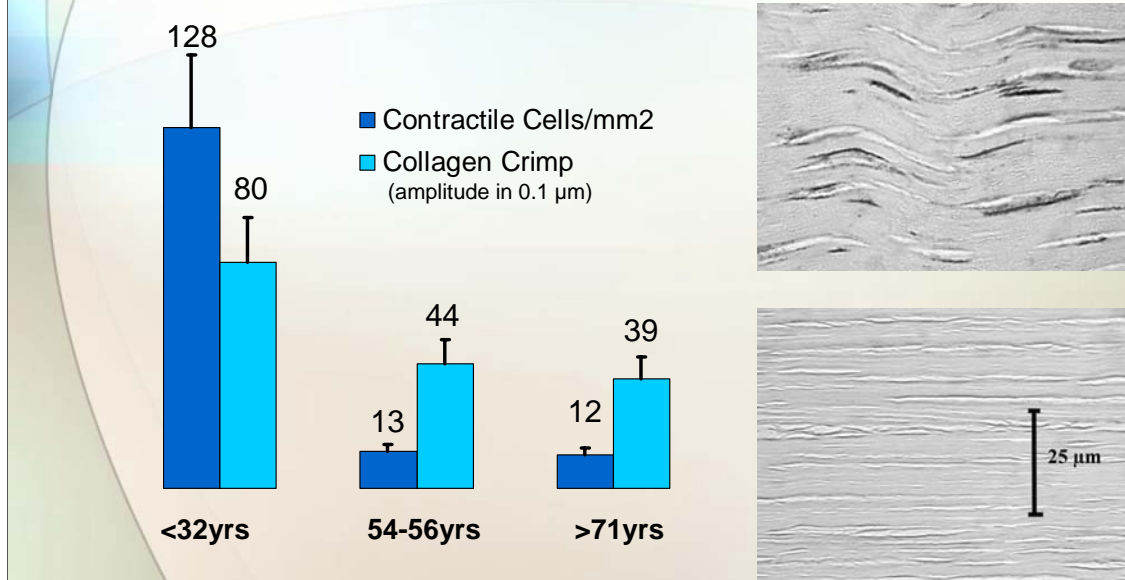


In the literature review we found many examples of tissue contractions caused by connective tissue cells called myofibroblasts. This happens naturally in wound healing, but also in several chronic fascial contractures. In the hand, it presents as palmar fibromatosis, also known as Dupuytren contracture, or as a pad like thickening of the knuckles. In the foot the same process as Dupuytren is called plantar fibromatosis; here ((pointing at illustration)) you can see the tissue hardening on the sole . And in club foot, the myofibroblasts contraction is focused on the medial side. In frozen shoulder, the contraction happens in the shoulder capsule. These are just 3 examples.

Now, considering the existence of pathological fascial contractures, it seems likely that there may be lesser degrees of fascial contractions in normal people which may influence biomechanical behavior.

Immunohistochemical analysis of human lumbar fascia


for cells containing α -SM Actin SEM for n=12



In our second approach, the histological studies, we collected pieces of the lumbar fascia from human cadavers and treated them with an antibody for smooth-muscle-actin stress fibers. Cells containing these fibers are assumed to be either smooth muscle cells or contractile myofibroblasts. We found these contractile cells in all of them.

But as you see on this diagram, there was a significantly higher density in the younger age group than in the two older groups. And interestingly, the density correlates with the crimp amplitude of the collagen fibers. In the upper right picture of a sample from a 19 year old man, there are plenty of darkly stained contractile cells and also extensive crimping or wave formation. With the 76 year old donor below, there is neither crimp formation nor contractile cells.

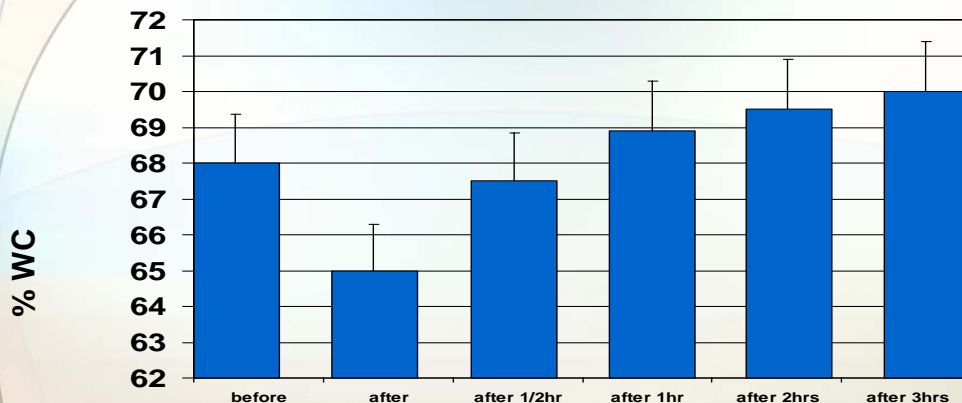
In vitro contraction tests with porcine lumbar fascia

Adrenaline n=6	no effect	
Acetylcholine n=4	no effect	
Nifedipine n=4	no effect	

In our in vitro tests, we take pieces of fresh porcine lumbar fascia, and suspend thin strips in an organ bath. This allows us to add specific drugs to the bath and measure the tensional response with a force transducer. Based on Staubesand's suggestion, that the contractile cells in fascia might behave similar to smooth muscle cells, we started with adrenaline and acetylcholine, at different dosages. There was no response. Then we used the vasodilator substance nifedipine, again without any clear response.

That was when we began to question whether there may be other factors aside from cellular contraction, which may explain the reported tissue hardening in repeated stretches.

Changes in water content



	WC	Stiffness (Mpa)
Dist. Water n=6	↑	+42%
Sucrose n=6	↓	-27%



Based on the work of Pischinger and Oschman we looked at the water binding qualities of the ground substance. We took strips of porcine lumbar fascia and measured the water content at various stages. Before the stretch, the average water content was 68%. Immediately after a 15-minute stretch, the water content was significantly lower. Within approximately 30 minutes, the water content had returned to the original level. Then we had a real surprise. We discovered that if the strain was strong enough and the rest period long enough, the water content would continue to rise to an even higher value than before the stretch.

In order to understand what effect this might have on the elastic stiffness, we increased the tissue hydration by putting distilled water in the bath. Here we measured the elastic stiffness in mega-Pascal compared with the effects of a sucrose solution, which dehydrates the tissue. The results were quite clear: an increase in water content increased the elastic stiffness of the tissues. This led us to the following conclusion. When the fascia is stretched, there are longitudinal relaxation changes in the collagen fibers and the water is squeezed out. Within a few minutes the collagen fibers recover their original state. Meanwhile, water continues flooding into the tissue to an even higher percentage than before, substantially increasing the elastic stiffness. This ground substance response reminded us of how a jellyfish is able to shrink and expand by changing its water content.

Induction of tension changes in normal fascia

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Glyceroltrinitrate	Relaxation	Mouse lumbar F.
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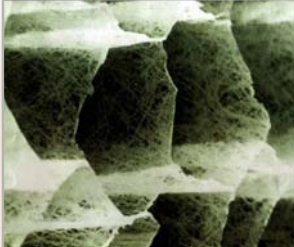
Univ. of Bradford

Calcium chloride	Contraction	Rat lumbar F.
Potassium chlorid	Relaxation	Rat lumbar F.
Mepyramine	Contraction	Rat lumbar F.

While this may not be regarded as an active contraction process, we finally had some success with our in vitro contraction experiments. When we applied glyceroltrinitrate – a powerful NO-donator, which works a little like Viagra - and applied that to the lumbar fascia of mice, we got a clear and significant relaxation response.

We also found, that Dr. Ian Naylor and colleagues at the university of Bradford in the U.K. had recently reported positive results with a number of additional substances. This group, which we are now collaborating with, is interested in the pharmaceutical regulation of wound healing and Dupuytren contracture. They have also started to conduct tests with normal uninjured fascia. Using the lumbar fascia from rats, they reported a clear contraction response with calcium ions and mepyramine, and a relaxation with potassium ions.

Potential contraction force

	Lamina only 3.6 x 10 ³ mm ³	0.8 N
	With perimysium & endomysium 2.2 x 10 ⁵ mm ³	36 N

If we take the strongest measured contraction response from the Bradford studies and apply that to the size of the superficial lamina of the posterior layer of the thoracolumbar fascia, we calculated there would be a resulting force of only 0.8 Newton. Which is not much.

Yet, if we include the many intrinsic fascial layers of the perimysium and of the endomysium –which is shown in this beautiful picture - then 20% of the muscle mass consists of fascia. If we include these layers of the lumbar erectors, then we get a resulting contraction force of 36 Newton, which could be strong enough to cause a paraspinal compartment syndrome or to help stabilize the lumbar spine at rest.

Next steps

- In vitro contraction tests with human fascia
- Water content measurements with repeated loading
- Immunohistology for SM-actin & vimentin with human donors of different ages:
 - Plantar fascia
 - Fascia lata



Our next steps:

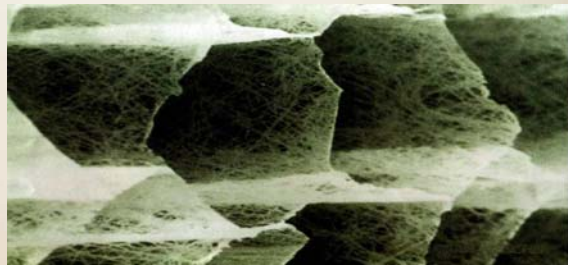
The in vitro lab team in the upper picture is preparing to apply the Bradford mepyramine protocol with human surgical fascia lata.

We plan to extend our water content measurements with repeated loadings.

And finally our histological team – greeting you from Munich in the picture below – they will conduct further tissue studies with antibodies against both smooth-muscle-actin and the smooth-muscle-protein vimentin with human lumbar fascia, plantar fascia and fascia lata.

Conclusions

1. **Chronic fascial contractures are common adaptations to stress.**
2. **Dynamic changes in its water content allow fascia to respond to loading in a smooth-muscle-like manner.**



To summarize our conclusions to date:

Chronic contractures of frequently loaded tissues are common adaptations, driven by cellular contraction within fascia.

Fascia is capable of performing smooth-muscle-like, slow contractions, through a surprising regulation of its water content. Since dehydration is an intrinsic aspect of aging, specific stretching routines or manual therapies may be worthwhile study projects in anti-aging.

Conclusions



- 3. Preliminary indications tend to support the concept of active tissue contractility of fascia.**


If verified, this could have relevance for the understanding of low back pain and of myofascial release therapies.

- 5. Further research is indicated and promising.**

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Although only two teams so far have independently measured a cellularly driven fascial contraction, preliminary results do indicate, that a short term active contractility, happening over minutes, may exist in vivo. If verified in future studies – and it does need verification -, this may have important implications for the understanding of back stability, as well as for deep tissue therapies such as Rolfing and myofascial release.

Certainly, fascia deserves more attention, and warrants further investigation.



Thank you for your attention!

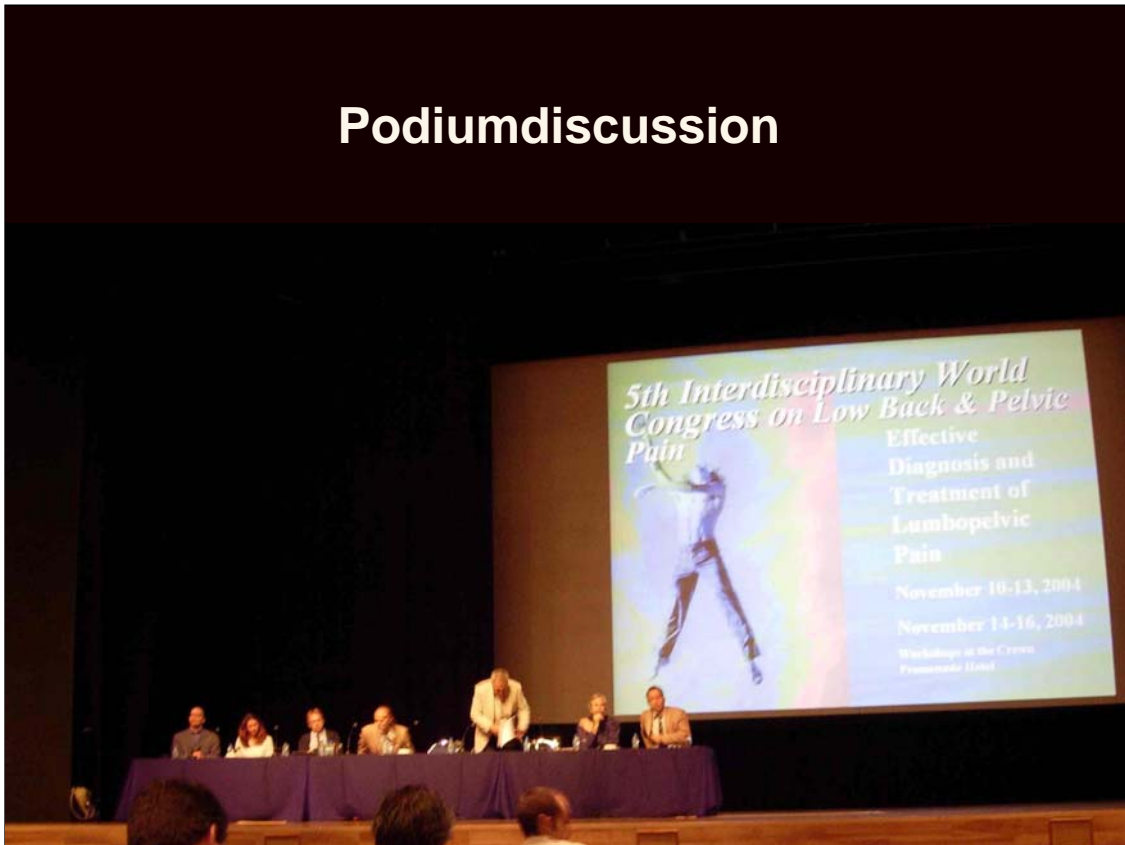
Special thanks to:

European Rolwing Association
Rolf Institute of Structural Integration

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And in the name of our research group - and the two institutions who supported us - I thank you very much for your attention; or as we say in Germany "Vielen Dank".

Podiumdiscussion



Dr. Vleeming: Very good, very interesting. Thank you. That is really new information, an exciting information.

Cameron Olson from Queensland: I am intrigued with your findings on the fascial tightening with progressive loading, and would like get your comments of the implications of that for the treatment of conditions such as frozen shoulder where you have a restricted capsule.

Schleip: I would like to know that myself ... Nevertheless there were two avenues. One was the water content. And there it would mean, if you come with the right timing of tension, either manipulative or with stretching, you could IN-crease the tonus. That would be maybe an application for hypotone tissue – if that is right.

The other thing is, that deep tissue practitioners, that's the field I am coming from, we know the feeling if you lean with slow deep pressure on a very hard connective tissue, it often relaxes under your hands. And actually with frozen shoulder, I haven't had that much success. Yet with other tight places, there was much more success.

Cameron Olsen: Thanks, that's actually a great field to study.

Vleeming: I am very interested in the study. I have a question. Maybe you are familiar with the work of Professor Frank Willard. He is working in an osteopathic college in Boston. He made a remark, that thoracolumbar fascia, supraspinous ligament, interspinous ligament, and flavum ligament could be connected with one another. Do you think for the future, because that would be hugely interesting, if you would be able in your porcine experiments to try to take out the combination of the thoracolumbar fascia connected with the supraspinous ligament, interspinous and flavum ligament and test if you find the same contractile structures?

Schleip: That is a good idea. I am not sure, because the lumbar fascia looks different in the quadruped. It is more longitudinal and most of the fibers go into the tail. I didn't find the typical diagonal arrangement as in humans. But I think it could be done. What we did is, we tried to find regional differences between L2 and L4. And there we haven't found any differences yet. But we need to do more quantitative analyses.

Vleeming: Ok. But did you do any testing of the supraspinous ligament, maybe then isolated, and check for contractive elements?

Schleip: No, we only took the superficial layer of the lumbar fascia.

Vleeming: but that's ...

Schleip: We'll certainly do it. Thank you for that suggestion.