Contractile features of human lumbar fascia

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PURPOSE

To compare the mean density of contractile fibroblasts (myofibroblasts) in human lumbar fascia with other human fasciae, as well as with the lumbar fascia in quadrupeds. To calculate the potential contraction force of human lumbar fascia based on in vitro contraction tests with human fascia.

RELEVANCE

Human lumbar fascia has been shown to play a substantial role in force transmission of muscular forces influencing vertebral stability. Lumbar fascia stiffness can also contribute to lumbar compartment syndrome, a potential cause of low back pain.

Previous animal studies from our group suggested an ability of lumbar fascia to actively contract, due to the **presence of myofibroblasts.**

A better understanding of the potential impact of fascial tonicity on lower back biomechanics in humans would therefore be useful.

METHODS

We performed an **immunohistochemical analysis** for the myofibroblasts marker alpha-smooth muscle actin with tissue samples of lumbar fascia, fascia lata and plantar fascia from 32 human bodies, and with lumbar fascia tissue samples from rats (n=10), mice (n=4) and pigs (n=4).

Additionally **mechanographic force registrations** were conducted with biopsy pieces of human fascia lata. These were performed in a superfusion bath under isometric strain in response to stimulation with the myofibroblasts agonists mepyramine, histamine and thromboxane, as well as in response to the smooth muscle relaxant glyceryl trinitrate. Unviable fascia tissues were similarly investigated to elucidate the cellular contribution (Fig.1).

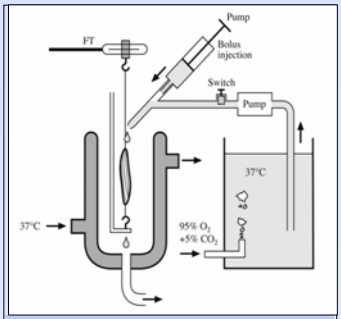

Fig. 1: Superfusion bath. The fascial tissue is pretretched and irrigated by a constant stream of aerated Krebs-Ringer solution, which is temporarily interrupted during bolus

ANALYSIS

Immunhistochemistry
Digital quantification of myofibroblasts density was performed based on the percentage of stained areas in 15 randomly chosen photomicroscopic images of each tissue sample (Fig.3).

Mechanography
Force differences between maximal tissue contraction and relaxation were hypothetically applied to the cross sectional area of all lumbar fascia at the level of L4/L5 in an average human body. The potential biomechanical impact was calculated with inclusion of intramuscular fasciae of paraspinal musculature.

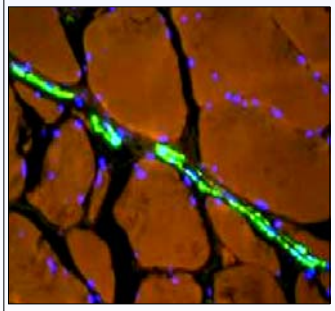

Fig. 2. Fluorescent stain for α-smooth muscle actin (green) and nuclei (blue). A surprising finding is that the perimysium (fascial layer surrounding groups of muscle fibers) contains a specially high density of contractile cells. Since tonic muscles contain more perimysium than phasic muscles, this finding offers interesting implications for the understanding of the tendency of tonic muscles to be affected by an increase in passive tissue stiffness (hypertonicity).

RESULTS

Immunohistochemistry
Human lumbar fascia revealed a higher myofibroblasts density than human plantar fascia or fascia lata ($p<0.05$). Myofibroblast density of lumbar fascia in humans was significantly higher than in rats (Fig. 3; $p<0.05$), and mean values of lumbar fascia in mice and pigs were also lower than in humans.

Mechanography
The max. observed force difference (3.6 mN/mm2) applied to the cross sectional area of lumbar fasciae predicts a total contraction force of 5 N. Higher values could be expected with in vitro tests from lumbar fascia, based on its higher MF density. Nevertheless, this force magnitude is already above the reported thresholds for mechanosensory stimulation and for influencing gamma-motor regulation.

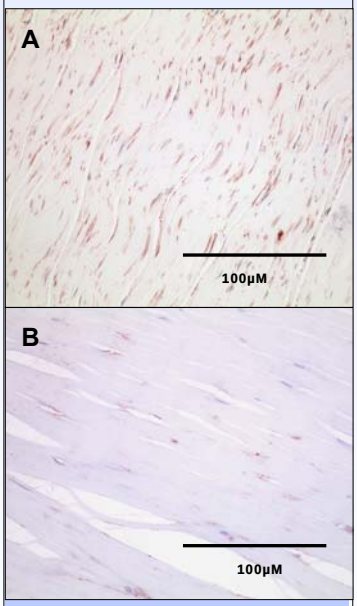

Fig. 3 : **Staining with the myofibroblast marker α-smooth muscle actin** (dark red)
A) Lumbar fascia from a person with a particularly high density of myofibroblasts.
B) Plantar fascia from another person (with average density of myofibroblasts).

This study has been supported by grants from the International Society of Biomechanics, the Rolf Institute of Structural Integration (USA), and by the Vladimir Janda Award for Musculoskeletal Medicine 2006.

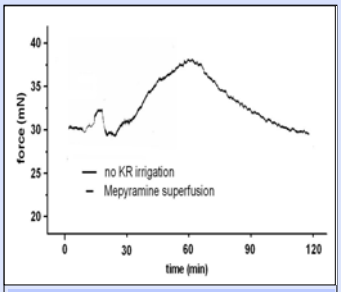

Fig. 4: Typical response curve of fascia to a contractile agonist. A bundle of rat lumbar fascia is exposed to 250 x 10^{-3}M mepyramine in a superfusion bath. To allow optimal tissue saturation with the substance, the constant Krebs-Ringer (KR) irrigation is interrupted 2 min before substance addition and restarted again 2 min afterwards. The brief initial force increase is due to temporary weight gain of the tissue due to the mepyramine solution, which is then quickly washed off. Note the slow and sustained duration of the reaction, a typical feature of fascial tissue response to our pharmacological stimulation.

Key References

(1) Yahia LH. et al. (1993) Viscoelastic properties of the human lumbodorsal fascia. J Biomed Eng 15: 425-429

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CONCLUSION

- The capacity for fascial contraction appears to be particularly expressed in human lumbar fascia, when compared with quadruped animals as well as with other human fasciae.
- The density of myofibroblasts in human lumbar fascia seems sufficient to allow an impact on musculoskeletal dynamics.

IMPLICATIONS

- Temporary or chronic changes in fascial tone may be able to influence low back stability in humans.
- Additional studies incorporating ultrasound based elastography are recommended to examine lumbar fascia stiffness in vivo.