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FASCIA CONGRESS ABSTRACT

# Visco-elastic mechanical properties of human abdominal fascia

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## Background

Q2 Abdominal fascia is a dense fibrous connective tissue membrane forming a sheath around the abdomen. It is a highly complex tissue, which visco-elastic material properties reflect its composition and structure. The changes of its mechanical properties contribute to a development of different types of hernia according to localization.

The review of literature sources on experimental investigations of abdominal fascia showed that the information about visco-elastic properties of human abdominal fascia is missing. The aim of this work was to contribute to the visco-elastic mechanical properties of human abdominal fascia and their variations with the direction of loading and localization.

## Methods

The investigation included 20 specimens taken from 8 donors. The average age of the subjects was 64.5 years in the range of 46–83 years. All available samples were harvested from non-herniated subjects. Ten strips were extracted from posterior wall of inguinal canal and another ten strips from umbilical region. From each localization five samples were oriented and cut parallel to the main fibers direction (L1) and five perpendicular to it (L2 direction). Relaxation tests on specimens in longitudinal (L1) and transversal (L2) directions were performed using a computer-controlled Instron type testing device FU1000E with load cell 500 N, minimal value of the load of 0.2 N and minimal value of the displacement of 0.1 mm. Testing was performed immediately after excision and less than 36 h after death, in order to avoid postmortem changes. The experiments were conducted at an ambient temperature of $20 \pm 2\,^{\circ}$C.

The specimens were subjected to few cycles of loading and unloading until repeatable mechanical performance was obtained. Thus we reached a steady state known as a "preconditioned state". The preconditioned specimens were loaded at 6% of their initial length. The experiments were performed at a rate of elongation 1.26 mm/s in the longitudinal and transverse directions. The extension of the specimen was kept constant 600 s during relaxation tests while the load was recorded. Then the sample was left to rest for 15 min. A second preconditioning and relaxation at the same strain were then performed. The experimental data were represented as Lagrangian stress–time relationships. Lagrangian stress $T_L$ was calculated as the load $F$ divided by the undeformed initial cross-sectional area of the specimen $S_0$.

## Results

The relaxation behavior of human abdominal fascia from inguinal region – fascia transversalis (FT) and from

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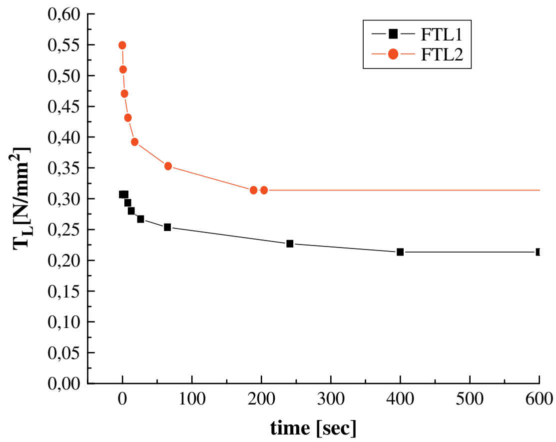


**Figure 1** Mean relaxation curves ($n = 5$) for fascia transversalis FT for longitudinal direction L1 and transversal direction L2.

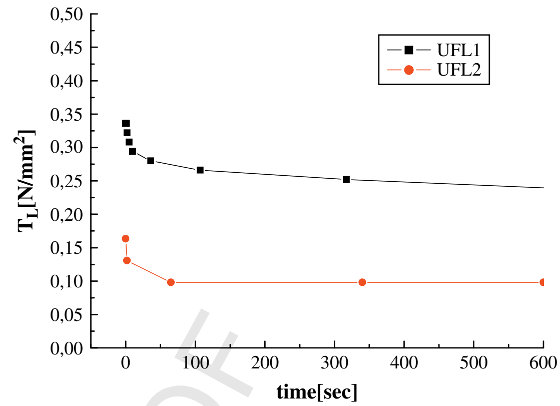


**Figure 2** Mean relaxation curves ($n = 5$) for umbilical fascia UF for longitudinal direction L1 and transversal direction L2.

umbilical region — umbilical fascia (UF) in longitudinal and transversal directions was investigated. The main reason for this choice is the fact that inguinal hernia is the most frequently performed operation concerning men, while the umbilical hernia is wide spread among women.

The mean curves which described the relaxation behavior of the fasciae, were obtained from five experimental curves, using nonparametric median test. The results are presented in Figures 1 and 2. They showed that the relaxation curves had a decaying form with time which can be divided as: initial part of fast relaxation, second part of slow relaxation and third part of fully relaxed tissue. The mechanical behavior of investigated abdominal fascia led to the conclusion that relaxation process depended on direction of loading and type of fascia. Initial part lasted up to 8.5 s for FTL2. The process of slow relaxation varied between 2.2 s for UFL2 and 400 s for FTL1 and depended probably not only on localization and direction of loading but also on structure of the material. The relaxation process in some of the strips continued more than 600 s (Figure 2, UFL1). The third part of relaxation curves corresponded to the minimal stress achieved.

Both investigated materials revealed orthotropic mechanical properties (Figures. 1 and 2), which proved the conclusion that the relaxation process depended on the direction of loading. The stress during the relaxation process was higher for FTL2 than for FTL1 but for umbilical fascia the situation is inversed. The above-mentioned fact revealed that the relaxation process depended on localization as well.

It was noted that load bearing properties of FT in L2 direction were better than load bearing properties of UF in the same direction L2. This means that mean stress in the FT strips loaded in transversal direction is higher than mean stress in UF strips loaded in the same direction. This behavior however is reversed for longitudinal direction and could be explained with different arrangement and contents of the fascia layers.

## Conclusion

Although the results presented in this work are preliminary, it is evident that the visco-elastic mechanical response of abdominal fascia depends on localization. Both fasciae revealed orthotropic mechanical properties. Further investigation of mechanical properties of human abdominal fascia is necessary in order to demonstrate the above observations. The obtained results will be used for mathematical modeling of the visco-elastic properties of human abdominal fascia. Q1



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