DEFORMABLE NET METHOD TO BE USED FOR RHEOLOGICAL IDENTIFICATION OF SPINAL SOFT TISSUES

[3] Martin Otáhal, [1]Ondřej Holub, [1]Tomáš Mareš, [1]Miroslav Sochor and [2]Stanislav Otáhal

[1]Laboratory of biomechanics, CTU in Prague, Faculty of Mechanical Eng.

[2]Laboratory of extreme loads, Charles University, Faculty of Physical education and sport.

[3] Laboratory of biomechanics, CTU in Prague, Faculty of Mechanical Eng.; email: otahal@biomed.fsid.cvut.cz,

INTRODUCTION

For a study of the options for developing a mathematical and physical model of spinal segments, it was necessary to obtain detailed information about the rheological characteristics of the spinal segment components. A testing apparatus called the µTester, which combines the principles of standard tensile testing and microscopy, was developed for this purpose. The test itself is executed in two phases. First, markers are applied to the specimen, and then in the second phase, a standard tensile test, the position of the specimen is detected using a microscope. In this way, information is obtained about the internal properties of the specimen, in the course of loading.

METHODS

Basic information about the visco-elastic characteristics of soft tissues can be obtained by means of a standard tensile test and a cyclic tensile test, using a precisely defined loading regime. However, this was insufficient for our purposes, since soft tissue is neither isotropic nor homogeneous. Consequently, a more precise material description and more complex measurements of the characteristics of the structures need to be executed.

The method applied here for identifying the visco-elastic characteristics and for describing the behavior of these structures is based on monitoring the markers attached to the observed specimen. The way in which these markers are attached to the specimen accentuates the tissue structure. It is therefore possible to monitor the tissue deformations in detail at various points in the specimen.

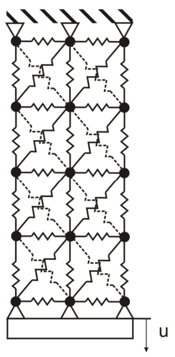

Figure 1: Rheological model of soft tissue

The rheological model in Fig. 1 describes the visco-elastic tissue behavior between the individual nodes. These nodes coincide with the observed markers, and create a rectangular grid. The nodes then create a net that simulates the real structure of the investigated tissue.

Using the data obtained after completely loading the specimen, assessing the complete deformation of the specimen and the local deformations between the individual markers, a setting can be obtained for elastic or visco-elastic specimen models. Such models then correspond to the tissue that has been measured.

An Olympus SZX-12 microscope, adapted for fluorescent and polarization microscopy, was used for observing the deformation of the markers. The specimen loading is then generated by the loading device of the µTester (Fig.2).

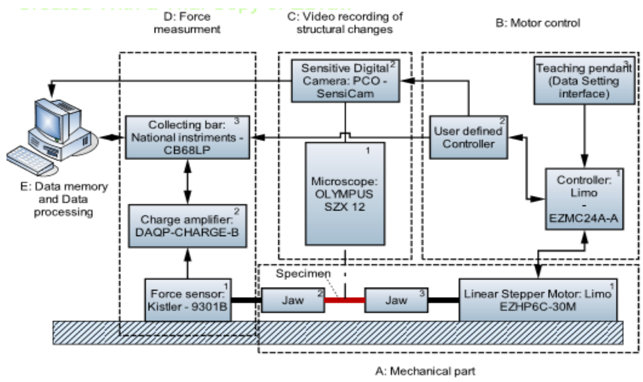

Figure 2: µTester flow chart

RESULTS AND DISCUSSION

The method presented here has been theoretically verified. Individual ligaments of the intervertebral articulation have been tested, using animal specimens.

CONCLUSIONS

The basic methodology for detailed identification of the rheological characteristics and deformation of the soft tissue specimen structure has been developed. This methodology is suitable for spine ligament measurements, and can also be applied for other soft tissues. The method still has some limitations, e.g., concerning specimen sizes, as it is necessary to provide specimens of a size suitable for applying the markers.

ACKNOWLEDGEMENTS

This project is supported by grant MPO Czech Republic No. FT-TA3/131 and by grant MSMT Czech Republic No. MSM6840770012.

REFERENCES

1. Otáhal M, et al. *J Biomechanics 41, suplement 1* ,S354. 2008.
2. Adams M, et al., *The biomechanics of back pain.* Elsevier, London, UK,, 2006.
3. Cowin SC, et al. *ISB Tissue mechanics*, Springer, New york, USA, 2007.