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MEASURING OF STRESS TENSORS IN VIVO BONE
MĚŘENÍ NAPĚTÍ V ŽIVÉ KOSTI

Stanislav HOLÝ, Marie BLÁHOVÁ, Ladislav HRUBANT*, Karel VÍTEK, Jaromír VOLF

Sumary: *The exact determination of stress state in the bone of living subjects has great importance in biomedical research (remodelling of bones) as well in practical branches as orthopedics, reumatology and osteology. Designed type of transducer for implatation into the bone will be presented.*

Obsah: *Určení napěťového stavu kosti živých subjektů je závažný pro biomedicinský výzkum (remodelace kosti) stejně jako pro praktické obory jako jsou ortopedie, reumatologie a osteologie. Je navržen a zkoušen miniaturní snímač tlaku.*

Key words: *pressure transducer, semicoductive strain gage, stress state modelling, phooelasticity*
Klíčová slova: *snímač tlaku, polovodivý tenzometr, modelování napjatosti, fotoelasticimetrie*

Introduction

Parts of skeleton are changing their qualities during their life. These changes are joint with remodelling of the structure which influence the stress field in the material of the bone. The only possibility how to estimate them is to use transducers.

Transducer for measuring the stress field in the bone

Principal of the transducer is given by the distribution of stress field round cylindrical hole. As it is not possible to measure these stresses directly a transducer has to be inserted into the examined bone. But the rigidity of the embedded transducer must not influence considerably the stress field. From the medical reasons outer diameter of the hole cannot be greater than 3 mm.

Problems of biological compatibility and aseptic treatment (potentional application of the transducer in the bone is 6 – 8 months) have predetermined material used for injection needle. Theoretic and numerical calculation were performed so that we receive optimal distribution of the examined stress field in the bone. The outer diameter of the elastic body of the transducer is 2,8 mm, wall thickness 0,2 mm, total length according to medical demand was 5 mm (Fig. 1).

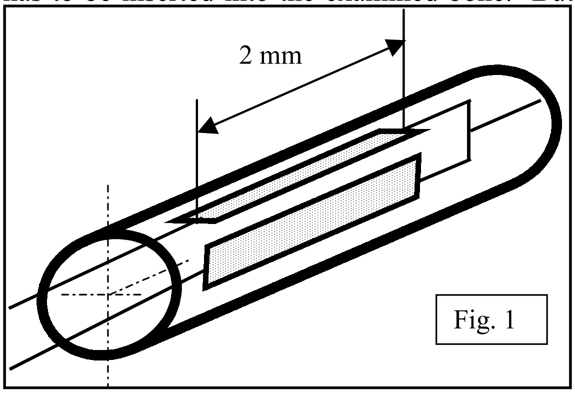

Fig. 1

As it was not possible to apply strain gages in the circumferential direction the only chance was to apply semiconductive strain gages orientated axially (Fig. 1) as they have several ten times higher sensitivity than metal one and thus they give sufficient signal. First tests were done with semiconductive gages available on market which had greater length (3 mm) than we needed. These tests proved great sensitivity to non-symmetric positioning of the transducer and to added bending out of plane. These tests were carried out in the photoelasic model (Fig. 2) and numerical simulation.

Czech Technical University in Prague, Faculty of Mechanical Engineering, Technická 4, 166 07 Praha 6
**) VTS/SGT – Strain Gages and Transducers Zlín – Associated Manufacturers, 760 01 Zlín, Czech Republic*
e-mail: holys@fsid.cvut.cz

According to our wish the domestic producer of semiconductive strain gages - the company VTS/SGT Zlín prepared for us shorter base of the strain gage (2 mm) and applied one pair of the above mentioned gages on the inner surface in a half-bridge connection. (Fig. 1). This transducer does not suffer from not only additional influences (non-symmetry, bending, but also from temperature shifting).

Special attention was given to strain gage isolation which has to fulfil requirements of biocompatibility as well as resistance during sterilization by temperature, chemistry or radiation. Problems of glues for bonding is solved separately.

VTS/SGT producer prepared new types of semiconductive strain gages with the total length 2 mm and with the connecting wires leading to one side. It is prepared production of the semiconductive strain gage of the length 1,5 mm.

As in the living bone it may be expected temperature changes that intensively influence the signal relevant to pressure it is necessary to add semiconductive temperature. that gives relevant signal to temperature and by SW elimination of temperature can be carried out. In this way it is possible to use single strain gage in one circumferential position.

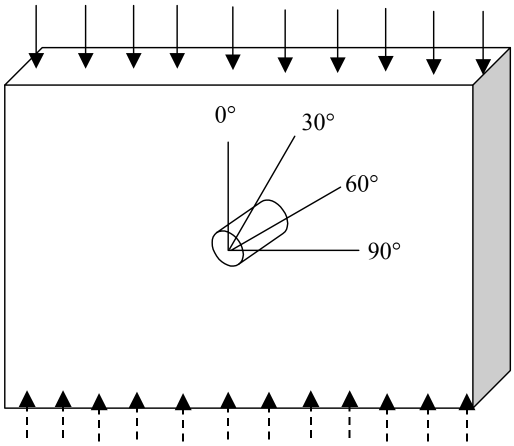

Fig. 2

Numerical simulation of application [2] into a bone has been done and the experiment on bone is prepared. First on animal, later human one

Conclusion

During tests linearity of the signal due to the applied loading as well as sensitivity to angular orientation were performed by means of photoelastic model (Fig. 2). A good agreement between numerically simulated results and experimental ones was found.

Figures, diagrams and data [1] in more detail will be presented in the Conference.

Literature

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