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SPECIAL MINIATURE TRANSDUCER FOR IN VIVO OF BONE MEASUREMENT

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Abstract - This paper attends to new special transducer for measuring the stress field in the bone. This transducer is designed as hole that into bone is placed. Paper described design of this transducer, its properties, results of measurement in simulation conditions and its calibration.

Keywords: transducer, stress field, bone

1. INTRODUCTION

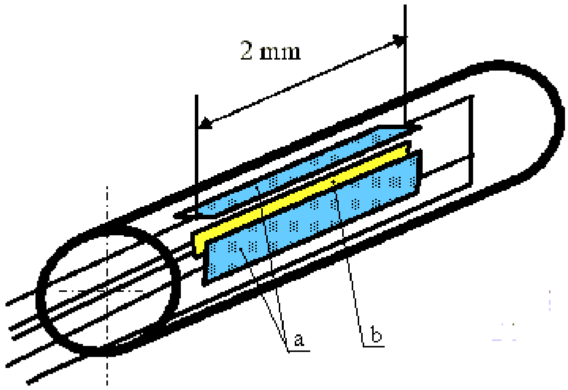
Parts of skeleton are changing their qualities during their life. These changes are joint with remodelling of the structure which influence the stress field in the material of the bone. The only possibility how to estimate them is to use transducers.

2. 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 (potential 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 2,5 mm, wall thickness 0,2 mm, total length according to medical demand was 6 mm (Fig. 1). As it was not possible to apply train gages in the circumferential direction the only chance was to apply semiconductive strain gages orientated axially (Fig. 1). Together with strain gages one resistive thermometer are placed. Thermometer is determined for measurement of temperature for accuracy compensation of strain gages temperature dependence.

First tests and computer simulation were done with semiconductive gages available on market which had greater length (3 mm) than we needed. These tests proved great sensitivity to unsymmetric positioning of the transducer and to added bending out of plane.



a – strain gages, b – resistive thermometer

Fig. 1 Scheme of hole transducer

This paper describe calibration of the transducer in original debris piggish bone by known loading in special preparation (see Fig. 5). The output voltage signal was measured.placed. Thermometer is determined for measurement of temperature for accuracy compensation of strain gages temperature dependence.

Measure bridge Scout 55 of firm Hottinger Baldvin Messtechnik was used for verification of function.

Function verification was make by computation of transducer contact with its surrounding, that table of loaded preparation presented. Theoretical signal values of strange gauges sensors, that setting of transducer diameter until 1,5 mm. parameters corresponded to measure bone stress, let us say to material of loading model.

On Fig. 2 are draw axis deformation courses along of surfaces by angle. From these courses it flows, that length of used strain gauge slightly intervene out area of constant value of axis extension. So us requirement arose to strain gauge producer at next application, that it was possible strain gauge shorter upon 1 until 1.5 mm. This requirement follow from dependencies , showed on Fig. 3.

Measurement of load response for step loading upon original transducer was made (see Fig.4). The load response has linear character. (correlation coefficient R^2 = 0,997). This results very good corresponding with theoretical hypothesis. Measure was made by temperature 25,5 °C.

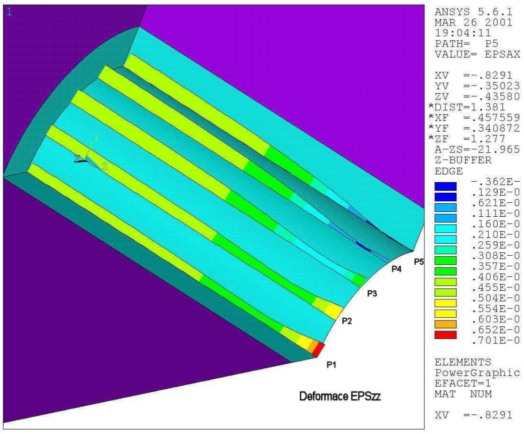
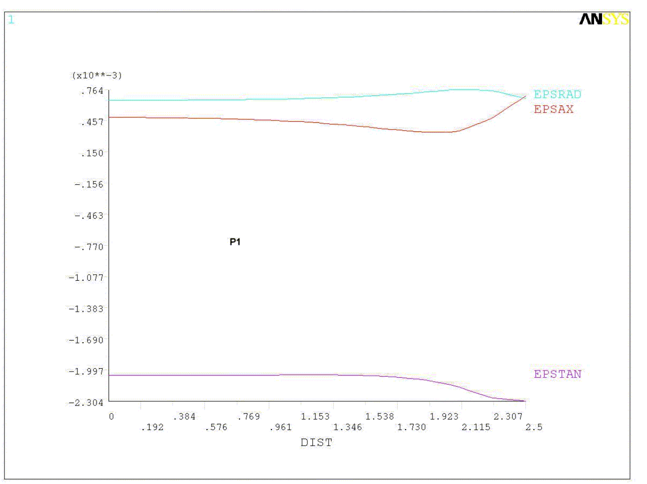


Fig. 2 Axis deformation

According to our wish the domestic producer VTS/SGT prepared for us shorter base of the strain gage (in this time are finish and tested 1,5 mm) and applied one pair of the above mentioned gages on the inner surface in a half-bridge resistance at sterilisation by temperature, chemistry or radiation.

Special attention was given to strain gage isolation which has to fulfil requirements of biokompatibility as well as resistance at sterilisation by temperature, chemistry or radiation.



Epsrad ε in radial direction
Epsax ε in axial direction
Epstan ε in tangential direction

Fig. 3 Elongation course in direction P1

3. CONCLUSION

The load response has linear character. (correlation coefficient R^2 = 0,997). Measure was made by temperature 25,5 °C.A good agreement between numerically simulated results and experimental ones was found.

Figures, diagrams and data in more detail will be presented in the symposium.

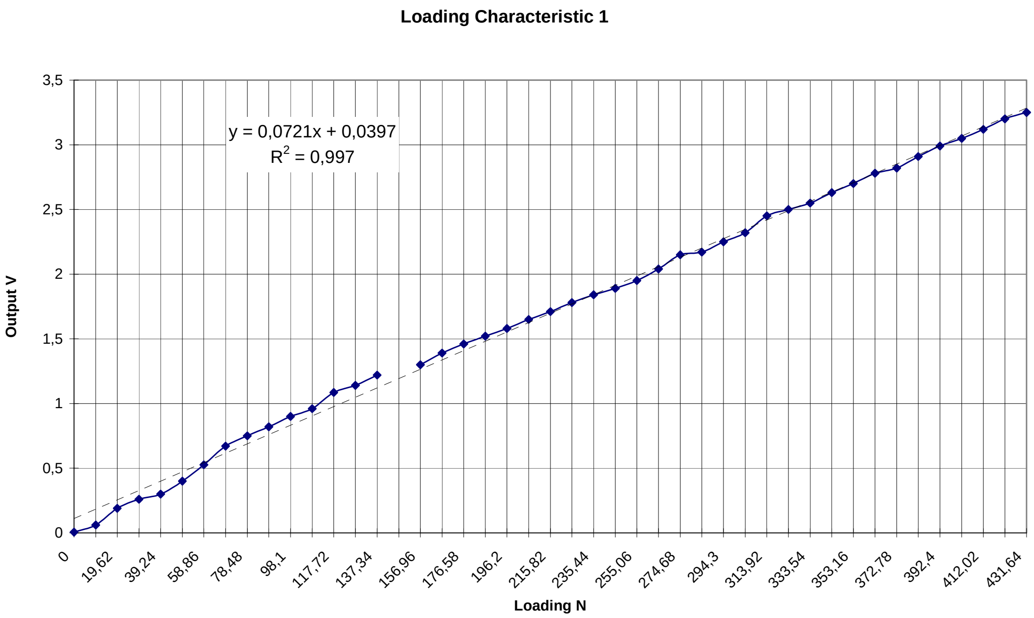


Fig. 4 Load response

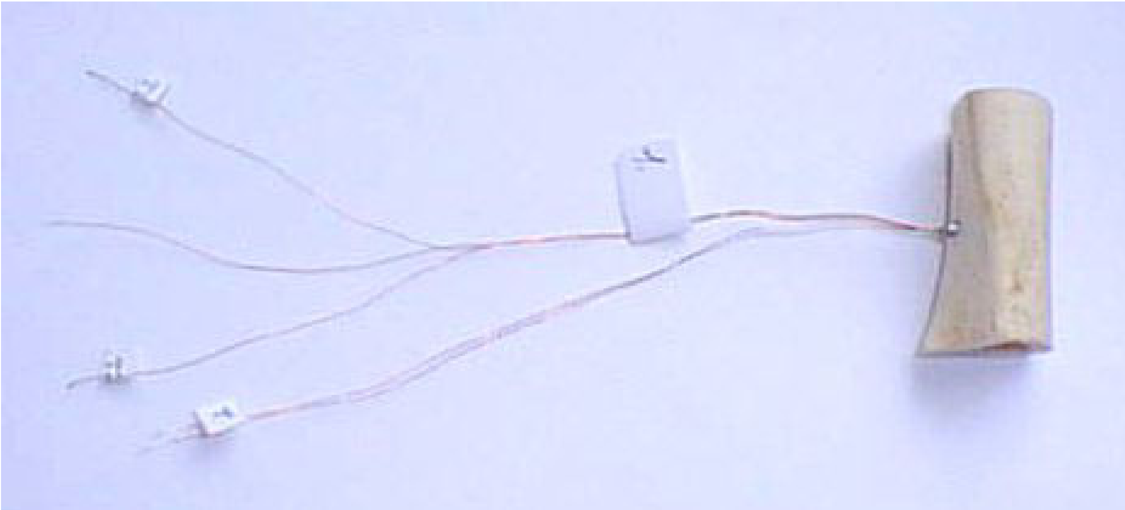


Fig. 5 The real transducer placed in piggish femur

VTS/SGT producer is preparing new types of semiconductive strain gages with the total length 1,5 mm that can be applied on the inner surface in the circumferential direction. More over there will be applied one miniature semiconductive thermometer near to the measuring strain gage what enable measurement by single strain gages and the influence of temperature shall be compensated as every strain gage will have its own temperature characteristic.

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