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Determination of mechanical properties of the bone cement

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Abstract – The contribution deals with en experimental measurement of mechanical properties of the bone cement. Where bone cements (PALACOS R and SMARTSET HV) were mixed by two techniques (manual mixing and manual mixing in vacuum) and they were measured under different conditions (temperature, moisture). Measured data were evaluated by statistical analysis. Retrieved results were used for finite element material model of bone cement which is part of hip replacement study by finite element method.

Implantation of hip joint endoprosthesis is related with method of it's fixation in bone tissue. One way is to fix the implant by bone cement, where bone cement is creating junction between bone tissue and implant. Mechanical behaviour of this junction has a significant influence for reliability of hip joint because one of the main reasons of implant failure is release the implant from bone tissue. We investigated basic mechanical properties of bone cement for two reasons: 1) for comparative analysis of different types and different measuring conditions of bone cement, 2) to determining input values for material model for computer modelling (FEM analysis) of hip joint.

In this paper our work was aimed to testing equality of mean values of Young's modulus (flexural strength) for each variant of specimens (**table 1).** Moisture means that specimens were wetted in solution physiological before measurement. Specimens were measured under room temperature (22°C) and under higher temperature (37°C). Preparation of cement was proceed by manual mixing of components in open cup and vacuum mixing of components by special tool supplied by manufacturer. Specimens were done by filling cement into the special form with dimensions 3x4x45 mm. Loading specimens were proceeding on four-point (or three-point) bending tool which shows **figure 2**. The output of our measurement was dependence on loading force to deflection [1] (**figure 4**).

From statistical outcome (**figure 3**) of measured Young's modulus data (at the level of significance 0.05) we can describe the most important conclusion that cement type, way of preparing, temperature and moisture: 1) has significant influence to Young's modulus in variants SMART MM and PALA MM, SMART MMV and SMART MMVM, SMART MMVT and SMART MMT, SMART MM and SMART MMVT, SMART MMV and SMART MMVT; 2) has no significant influence in variants SMART MMV and SMART MM. Way of preparing has no significant influence to flexural strenght in variants SMART MM and SMART MMV (**figure 1**).

Table 1: Variants of specimens of bone cement

Type of specimens	Manual mixing (MM)	Manual mixing in vacuum (MMV)	Manual mixing in vacuum, moisture (MMVM)	Manual mixing in vacuum, temperature 37°C (MMVT)	Manual mixing, temperature 37°C (MMT)
SMARTSET HV (SMART)	12 specimens	20 specimens	7 specimens	12 specimens	14 specimens
PALACOS R (PALA)	12 specimens	x	x	x	x

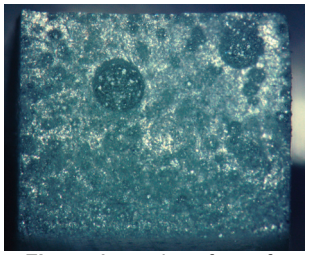

Figure 1: crack surface of specimen

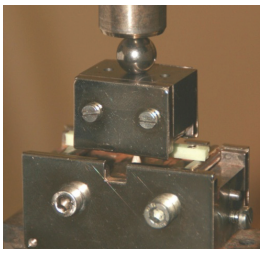

Figure 2: four-point load of specimen

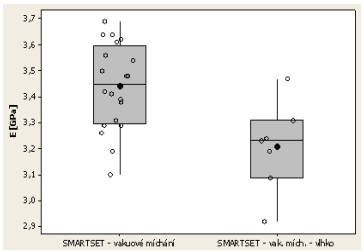

Figure 3: box-plot of realized measurement

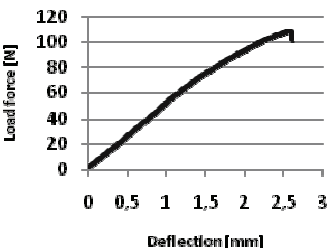

Figure 4: dependence on loading force to deflection

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