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# COMPUTER SIMULATIONS OF OSTEOPOROTIC CHANGES IN HUMAN PELVIS JOINT REGION

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## ABSTRACT

The diseases of bone system are the men's frequent affections. One of them is the *osteoporosis*. This is the metabolic disease manifesting the progressive decrease of the osseous pulp and the change of bone structure coming to the large risk of fracture. A few years ago it was thinking that osteoporosis touches mainly older person, however suffers from it more and more young people (even about fortieth years old). At persons suffering from this disease more often occurred the fractures e.g. in reach of hip joint and spine. The therapy of osteoporosis usually is beginning when there is some fracture and consists in providing analgesic and stabilization of places of fractures. It would be better to prevent that disease because lack of movement is cause of weakness of bones. Knowledge of physical properties of bone tissue is helpful in diagnosing of the diseases of the bone system [4]. From mechanical point of view the fracture of bone occurs in two cases:

- the correct structure of bone but the loads are so big that cause the stresses larger than stress limit,
- the disorders of bone structure caused decrease of strength properties of bone when normal activity of organism can result stresses larger than stress limit.

In the paper the second case is analyzed (which take place in osteoporosis). Unfortunately, incipient phases of osteoporosis progresses without symptoms (first symptoms appear when the risk of fracture is large). The most common preventive examination is bone densitometry and computed tomography. In routine examinations customary tomography gives enough information and to enable to make a correct decision. However when data will be use to building a quantitative model of a bone tissue this method can be insufficient. Then it is necessary to perform Quantitative Computed Tomography.

To present the problem of the osteoporosis the strength analysis of the human hip joint is performed (health joint and the joint with osteoporotic changes). Numerical simulation gives important information about behaviour of object if conditions in numerical model are similar to analyzed structure (geometry, material properties and boundary conditions). Geometry of the model is made on the base of date from coordinate measuring machine and CT [3]. It is concentrated on the pelvic bone. It is important to delimitate of material properties which are changed during osteoporosis. During examinations the bone system as well as density phantom of density is X-rayed.

The phantom is composed of regions representing specimens of bone density. The X-ray photographs are analyzed by use specialist software (the dependence between quantity of the absorbed radiation and the radiological density is used). Obtained density is standardized in Hounsfield scale (HU). Then on base of HU density the density of bone tissue is delimitated. In the next step the delimitation of material properties of bone tissue is performed (especially elastic modulus) On the basis of an experimental research the dependences between bone density and material properties are developed [2].
The Computed Tomography is performed in cross-section for the different places so material properties are delimitated in the same places of bone (on the base of linear regression for measuring points the calibration curve is created, it enable to calculate the properties for every voxel in photographs) - the more exact data from CT - the better representation of bone structure. It is very important because bone tissue is non-homogenous, especially pelvic bone, with regard to complex geometry and functions in organism, is characterized by changeability of material properties [1].
Delimitated properties are used in the numerical model. Next the boundary conditions are assumed (symbolize action of muscles and joints with another elements of bone system). The model is restrained in three regions:

- in acetabulum in place of contact with femoral bone,
- in joint between pelvis and sacral bone,
- in pubic symphysis.

Strength calculations are performed using the MSC Patran/Nastran system. The structure is analyzed on the base of distributions of equivalent stresses, strains and displacements. Obtained results can be helpful to estimate the effort of pelvic and femoral bone and planning surgical interventions during treatment of injuries caused by osteoporosis.

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## REFERENCES

[1] M. Binkowski, A. Dyszkiewicz, Z.Wróbel, “The analysis of densitometry image of bone tissue based on computer simulation of X-ray radiation propagation through plate model”, Comput. Biol. Med., vol. 37, pp. 245-250, 2006.

[2] A. Dąbrowska-Tkaczyk, J. Domański, Z. Lindemann, M. Pawlikowski, K. Skalski, “Stress and strain distributions in the bones of hip joint assuming non-homogenous bone material properties”, Proc. of II Int. Conf. on Computational Bioengineering 2005, vol. 2, pp. 263-275.

[3] A. John, “Identification and analysis of geometrical and mechanical parameters of human pelvic bone”, Scientific papers of SUT, No 1651, Gliwice, 2004 (in Polish).

[4] A. John, P. Wysota, “Elastoplastic analysis of the plate stabilizer and femur bone”, in "17 International Conference on Computer Method in Mechanics", Łódź-Spała, pp. 187-188, 2007.