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Structural Evaluation of Human Cartilage after Femoral Neck Fracture with Differential Scanning Calorimeter

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Abstract

As osteoporosis and hip fracture incidence are increasing with consequent high morbidity and mortality rates worldwide associated health care costs are on a continuous rise. Greater economic efficiency, sustainability and better patient care are key issues. As a choice of primary therapy arthroplasty is becoming more and more relevant. In conjunction to this phenomenon the amount of biological waste materials increases and the issues of possible utilization have to be addressed.

Keywords: Hip fracture; Scanning calorimetry; Arthroplasty; Cryopreservation

Short Communication

Consequences of hip fractures are quite adverse and severe resulting in high morbidity and mortality worldwide. Fragility fractures account for more disability-adjusted life years (DALY) than most common cancers in Europe [1]. Most Europeans have a high hip fracture risk which is related to the phenomenon called the "Graying of Europe" not to mention life style factors that accompany urbanization. These are the main causes of the increasing trends of osteoporosis and other age-related co-morbidities that increase the risk of falls. Among the many risk factors for osteoporosis and in particular hip fracture we would like to emphasize the ones that seem to have relevance in this geographical area. These include calcium-vitamin D homeostasis, physical activity, the obesity epidemic and socioeconomic prosperity. In conjunction with bone health as highlighted by Sebestyen et al. [2] seasonality also influences patient outcome in the age group of 60 and above. Complication rates were Significantly higher in winter months than in other seasons suggesting that this is related to vitamin D deficiency.

In the quest to eliminate displacement and possible avascular necrosis of the femoral head operative treatment is preferred in the clinical management of femoral neck fractures. Timing of surgical intervention strongly influences surgical outcomes. Providing definitive care within the first 12 hours after injury significantly reduces mortality and the effects of co morbidities [3]. Relapsed time from injury also affects the preservation of structural organization of the hyaline cartilage. Hemi prosthesis placement for femoral neck fractures is quite common after which the biological waste materials (extracted femoral head and parts of the neck) can still be utilized. One option in the case of cartilage is osteochondral allograft transplantation. Possible allografts are prepared, collected, tested and preserved according to well-defined protocols. Cryopreservation at 80 °C and length of storage time both impact the integrity and the biomechanical characteristics of collagen structure [4].

Various methods are used for the prediction of primary complications such as nonunion and avascular necrosis. The most important feature of avascular necrosis of the femoral head is hyaline cartilage damage. In the complex biochemical network of metabolic homeostasis activity shifts towards catabolic processes as cartilage degenerates. As previous studies demonstrated Differential Scanning Calorimetry (DSC) is a useful and well-applicable method for demonstration of thermal consequences of local and global conformational changes and for the quantitative detection of degenerative processes [5,6]. As

Naumov et al. [7] pointed out DSC is non-invasive, specific and adequate method for the follow-up of pathological structural differences of human cartilage. After DSC analysis not only the shapes of DSC scans were different but the DSC curves of degenerated cartilage samples had a wide endothermic transition. As a sign of extensive damage two distinctive thermal domains formed on the DSC curves of severe avascular necrosis cases (6 months after the fracture) which most probably indicate the protein denaturation and calcium deposit formation. From the perspective of derived calorimetric enthalpy values significant linear correlation with elapsed time from injury to surgery was also attained. This positive association demonstrates how structural changes of the cartilage due to hypoxic degeneration correlated with elapsed time from injury.

Based on our previous results DSC proved to be a reliable method for qualitative evaluation of human cartilage samples following longer preservation time. Our observations on thermal parameters of denaturation demonstrated an increasing thermal stability until the third week of preservation (higher T_m and calorimetric enthalpy values). Cartilage structure started to show signs of decay at week 6 indicated by a significant decline in Tm. Overall when it comes to optimal reutilization of biological waste materials of arthroplasty the use of harvested cartilage for surgical surface repair after 6 or more weeks of storage time should be reconsidered prior to application [8]. At the same time focus should be placed on the practical and effective use of bone which seems to be left unaffected by longer preservation times.

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