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THE ACETABULAR MINERALISATION PATTERNS REFLECT THE BIOMECHANICAL SITUATION IN NORMAL AND DYSPLASTIC HIP JOINTS

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Introduction:
By means of CT osteoabsorptiometry (CT OAM, 1989, 1998) the distribution of mineralization within joint surface can be displayed in-vivo giving information on the actual individual loading history of a joint. In order to see if these density patterns reflect the theoretically derived stress distribution within a joint surface we investigated normal hip joints and patients with hip dysplasia before and after a triple osteotomy had been performed.

Methods:
Production of CT datasets (section thickness 1 and 2 mm) of 15 healthy hip joints (aged 18-88 years, 10 male, 5 female) and 16 patients aged 19-47, 4 male, 11 female) with hip dysplasia. For all CT investigations a reference phantom was used comprising of two stable plastics, a water-equivalent standard and a bone-equivalent standard containing 200 mg hydroxyapatite/ml (Kalender et al., 1987).
Three-dimensional reconstruction of the density distribut ion patterns using a maximum intensity projection. In these images the number of pixels of all Hounsfield values (HU) were collected. By calibration with the reference phantom the calcium content in mg/ml for each pixel was calculated. The following integration gave the calcium content of the entire joint surface. For expressing values independent of the size of the joint surface, the amount of each HU value was expressed as a percentage of the entire surface and integrated again. This allows direct comparisons between individuals. For the quantitative evaluation of the location of the maxima, the center of gravity of the zones of highest density was determined in terms of coordinates. Finally the data were evaluated statistically.

Results:
In the healthy hip joints a main maximum was found in the anterior-superior section of the acetabular roof clearly separated from the limbus, and 2 smaller maxima in the anterior and posterior horn. In the patients the overall mineralisation was decreased, the size of the main maximum was smaller and denser and a displacement of the maximum towards the limbus could be observed. In patients with a milder form of dysplasia the displacement took place towards anterior-superior, patients with a severe dysplasia exhibited a considerable displacement towards the edge either in a posterior or anterior direction. 1 year after a performed triple osteotomy the size of the maxima had increased, whereas the mineralisation showed a decrease pointing to an improvement of the biomechanical situation.

Discussion:
These results show that the density pattern of acetabular joint surface reflects in individual mechanical situation of each hip joint, which corresponds well with theoretical models (Dalstra et al., 1995, Schüller et al., 1993). Surprisingly, the dysplasia in severe cases could lead to a displacement of the zones of highest density and therefore of highest stress either posteriorly or anteriorly, which leads to the question, whether different surgical procedures are required to improve the outcome of an operation. The mineralisation in the subchondral bone plate turns out to be a sensitive parameter of changing mechanical situations in a joint leading to the conclusion that CT-OAM – which is applicable in the living – supplements morphological judgement and offers a further and very useful tool for assessing new procedures in joint surgery.

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