THE HUMAN HIP JOINT: DENSITY DISTRIBUTION AS A MIRROR OF THE LONG TERM LOAD INTAKE

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Introduction

As connective part of the trunk and the lower extremities, our hip joint has to deal with forces that exceed the body weight by multiple times in everyday life. To gain inside of the magnitude of forces acting onto the acetabulum (AC) and the caput femoris (CF), direct-piezo-electric pressure measurements and pressure-sensitive film measurements were used showing the momentary stress distribution [Adams, 1985; Afoke, 1987]. We are aiming to describe a method to visualize the long term load intake of a joint using conventional CT-data as it is accessible for every clinical patient. Since the subchondral bone plate (SBP) of a joint is known to adapt to its mechanical needs and serves with its mechanical strength as a mirror of long term load intake, we analysed the mechanical strength and visualized the density distribution to investigate if density data acquired from conventional CT-scans can give information about the strength of the SBP.

Methods

25 acetabula and capita femoris were collected from human cadavers (12 male, 13 female, average age: 81 years). On each, measurements were performed at 35-40 standardized points. To visualize the density distribution patterns, the CT-data of the samples were evaluated with the method of CT-osteoabsorptiometry (CT-OAM) [Mueller-Gerbl, 1989] (Fig. 1a, 2a-c).

To determine the mechanical strength, an indentation test machine (Synergie 100, MTS Systems, 2 kN loadcell) was used. The penetration forces of the SBP were recorded and visualised (Fig. 1b, 2d-f). Linear regression was used to evaluate statistical correlations.

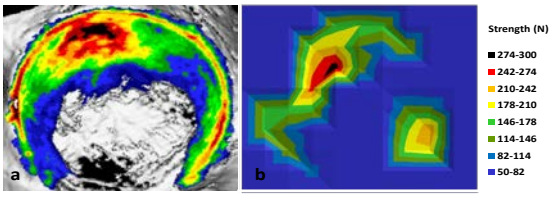

Figure 1: a) density distribution of AC-9
b) strength distribution of AC-9.

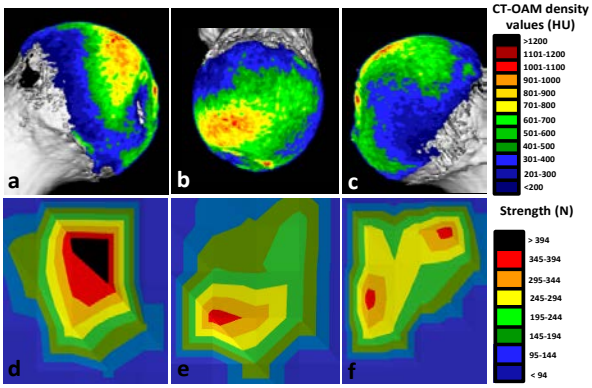

Figure 2: a-c) density distribution CF-8
d-f) strength distribution of CF-8.

Results

The distribution showed inhomogeneous but regular and reproducible patterns of density and strength throughout the joint surface. Differences in level of mineralization could be seen in-between the samples. Maxima were found to be monocentric anterosuperior and near the rim of the AC and in the superior area of the CF. A linear correlation between density and mechanical strength (r^2 = 0.77 – 0.97; p < 0.01) was found in every sample.

Discussion

A direct relationship between the SBPs density and its mechanical strength could be demonstrated. Since the SBP adapts to its mechanical needs, areas of high load transmission increase in strength by osteoblastic calcium deposition. This increase in calcium is presented in the density. Knowing that the long term load intake of the SBP mirrors in the adapted strength, the density distribution charts generated by CT-OAM are able to give conclusive information about the long term load distribution within a joint using conventional CT-data.

References

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