Role of patient activity level in the degenerative process associated with cam femoral acetabular impingement.

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BACKGROUND & PURPOSE

Purpose
Assess the role of patients' activity level on subchondral BMD in cam deformity and normal subjects

Hypothesis
A higher activity level leads to higher subchondral BMD in patients with femoroacetabular cam impingement

Femoroacetabular impingement (FAI) is associated with degeneration of the hip and proposed as the mechanism for early osteoarthritis. While the pathogenesis of osteoarthritis is multifactorial, joint injuries and excessive loading are known to accelerate degeneration. As the mechanical demand exceeds the tolerance of the cam-deformity hip joint, damage like labral degeneration, cartilage delamination and finally osteoarthritis will occur.
A large portion of the adult population with FAI remains asymptomatic. However, up to 80% of symptomatic cam deformity patients have bilateral involvement, with only one third having bilateral symptoms. Therefore, the differentiation of causation versus association of FAI and hip osteoarthritis remains ill defined.

The development from cam deformity to cartilage damage to involvement of the subchondral bone is an interesting study focus. Based on femoral and acetabular bone mineral density (BMD) imaging it is known that the presence of the cam deformity predisposes to arthritic changes, even in asymptomatic individuals (Speirs et al. 2013). Higher BMD is likely to result in increased subchondral stiffness, which may increase joint contact stresses and lead to accelerated degeneration. This seems to be due to mechanical overloading of the hip joint, leading to stiffening of the subchondral bone plate. Deformity morphology, tissue properties, joint motion and loading are involved in the contact mechanics of the femoral deformity and acetabular rim. The patient's activity may be a determining factor in this progression of the early degenerative changes.

METHODS

Twenty three symptomatic cam-type FAI subjects (Surgical) were recruited and age-matched to asymptomatic volunteers from the general population. Depending on their alpha angle (Table 1), these asymptomatic subjects were categorized as Bump (n=26) or Control (n=18). The activity level of each subject was recorded using the University of California Los Angeles (UCLA) activity score. Alpha angle and BMD were measured by QCT.

All subjects underwent bilateral CT scans from the iliac crest to the lesser trochanter, as well as the knees, and included a calibration phantom in the field of view (Model 3, Mindways Software, Austin, TX, USA). The QCT imaging technique for the measurement of alpha angle (3:00 and 1:30 locations, Fig 1A) and subchondral BMD of acetabulum and femur have been described earlier (Speirs et al. 2013). For Surgical subjects, QCT was performed prior to surgery. CT scans were segmented to define regions of interest (Fig 1A). The acetabulum was divided into wedge-shaped sections around the circumference and into two levels based on the depth from the acetabular rim (Fig 1B). The femoral head-neck junction region was divided into sections around the circumference with a depth of 5 mm from the bone surface (Fig 1C). Only regions in the impingement region were considered, i.e. the antero-superior quadrant of acetabulum and femur (Fig 1B and 1C). From the CT intensity measurement, with the use of the calibration phantom, a volume-average BMD was calculated for each section of interest.

Statistical Analysis
One-way ANCOVA (with L5 BMD as correction factor) was used for analysis between groups. The correlation between activity level, femoral and acetabular BMD was examined using Pearson correlation. All statistical analyses were performed using SPSS (Version 23.0, SPSS Inc. Chicago, IL).

TABLE 1 Patient demographics

	N	Alpha angle (1:30)	Age (years)	BMI (kg/m^2)	Male % (n)	UCLA activity
Control	18	49.6˚ (4.2˚)	33.2 (6.7)	26.2 (3.0)	89% (16)	8.8 (1.9)
Bump	26	65.2˚ (8.8˚)	31.3 (6.3)	25.3 (2.9)	85% (22)	8.9 (1.6)
Surgical	23	64.6˚ (7.1˚)	37.6 (8.5)	27.5 (5.5)	87% (20)	7.1 (2.6)

FIGURE 1

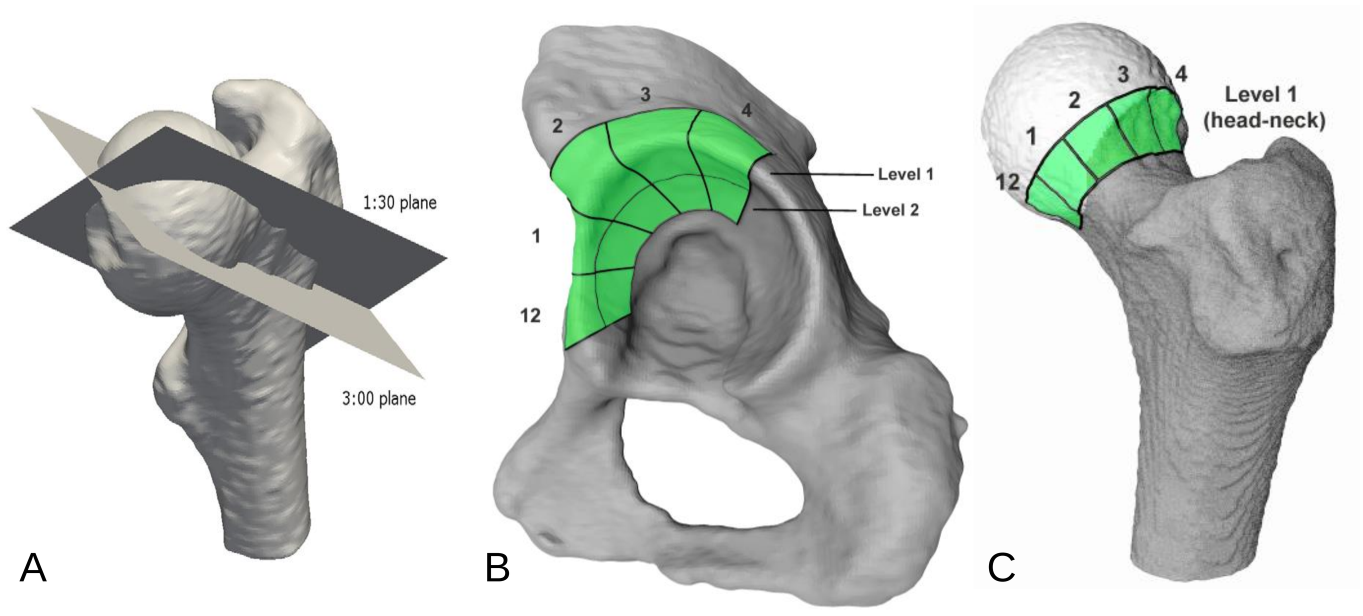


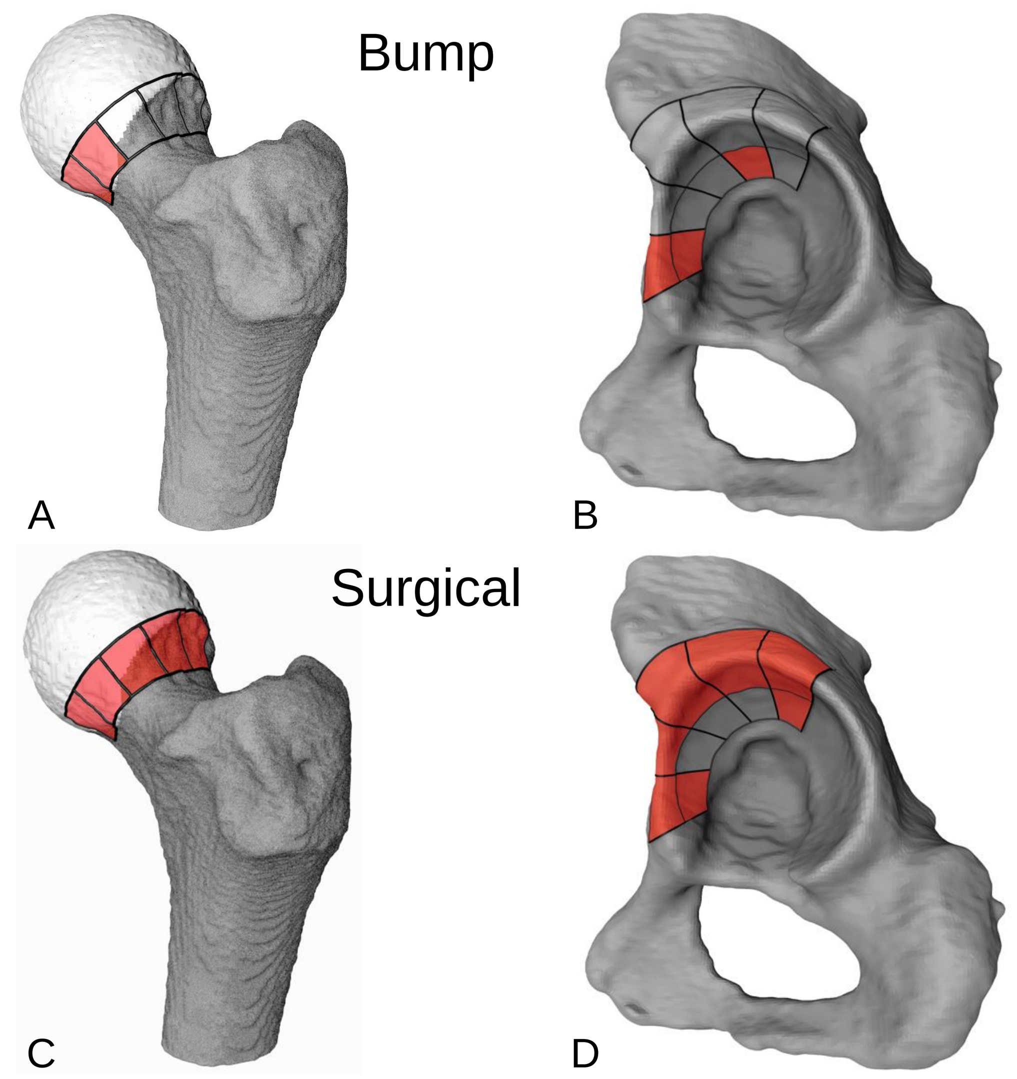
TABLE 2 Pearson's correlation BMD *versus* UCLA

UCLA	Femur level 1 (head-neck) 12	1	2	3	4
Control	-	-	-	-	-
Bump	0.506 *.006*	0.457 *.012*	-	-	-
Surgical	0.492 *.009*	0.616 *.001*	0.588 *.002*	0.423 *.022*	0.419 *.023*

UCLA	Acetabulum level 1 (rim) 12	1	2	3	4	Acetabulum level 2 (middle) 12	1	2	3	4
Control	-	-	-	-	-	-	-	-	-	-
Bump	0.398 *.027*	-	-	-	-	0.417 *.021*	-	-	0.353 *.045*	-
Surgical	0.517 *.006*	0.491 *.009*	0.522 *.005*	0.669 *<.001*	0.550 *.003*	0.403 *.028*	-	-	-	0.371 *.041*

In the table p-value is presented in grey below the correlation coefficient R

FIGURE 2 Pearson's correlation BMD *versus* UCLA



RESULTS

Patient demographics are shown in Table 1. Gender and BMI are comparable between the three groups. The Surgical group was significantly older than the Bump group (37.6 vs 31.3, p=0.009). In the Bump and Surgical group the femoral and acetabular BMD was 15 to 30% higher compared to Control subjects.

The activity level based on UCLA score did not differ between Control versus Bump subjects. The UCLA scores of the Surgical subjects however, were significantly lower compared to the Control (7.13 vs 8.68, p=0.046) and Bump subjects (7.13 vs 8.96, p=0.012).

Correlations between UCLA and BMD are represented in Table 2 and Fig 2 and 3. The Control group showed no significant correlations between BMD and UCLA. In the Bump group there was a significant positive correlation between UCLA activity level and the femoral subchondral BMD located at the cam deformity (R=0.457-0.506, Fig 2A). This correlation was found in sections 1 and 12 (Fig 1C). On the acetabular side, significant correlations were also found at Section 12 on both rim and middle level and Section 3 at the middle level (Fig 2A).

For the Surgical subjects, a significant correlation between UCLA activity score and subchondral femoral BMD was found (R=0.423-616, Figure 2B) for all femoral bump sections. The acetabular side also showed a significant positive correlation (R=0.432-0.669, Fig 2B) with UCLA activity score in the Surgical subjects. This correlation was found in all 'impingement' region sections of rim level (Fig 1 and 2B). At the middle level (level 2) the only correlations of BMD with activity level were found at Section 12 and 4.

CONCLUSION

Activity level serves as a predictor for increased subchondral BMD at the impingement location of cam deformity patients.

Patients with a symptomatic cam deformity have the most extensive representation of activity correlated stiffening of the subchondral bone. Asymptomatic cam deformity subjects show a less extensively located correlation, while control subjects (without a cam deformity) do not show any correlation between activity level and BMD of the anterosuperior femur and acetabulum.

DISCUSSION

This knowledge contributes to the unraveling of predictive factors that influence FAI joint damage. The next challenge will be to determine the right moment and the right intervention in order to prevent rather than palliate cam-induced degeneration.

The Surgical group, consisted of subjects with FAI-induced mechanical joint overload damage to cartilage or labrum, show a significant correlation between activity level and increased BMD at the acetabular rim femoral impingement region. This supports the hypothesis of edge loading with cam deformity which results in osteoarthritis.

A clearly different and more limited correlation pattern between activity and BMD has been shown for the Bump subject, which was almost only confined to Section 12 of the femoral and both acetabular levels. This group of individuals is highly active, show only local 'overloading' of their impingement region and remains asymptomatic. Sooner or later, however, they will turn into being symptomatic. Would an intervention in this group, like activity level adaptation or surgical cam resection, reverse, stop or slow down their development into a degenerative hip joint?

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