A radiographic cam deformity is gradually and exclusively acquired during skeletal maturation: a prospective study with a minimum of 2 years follow-up.

Poster No.: C-1252
Congress: ECR 2014
Type: Scientific Exhibit
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Keywords: Musculoskeletal bone, Anatomy, Pediatric, Plain radiographic studies, Screening, Outcomes analysis, Developmental disease
DOI: 10.1594/ecr2014/C-1252

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Aims and objectives

A cam deformity is an extra bone formation at the anterolateral head-neck junction.\(^1\) It is a major risk factor for hip osteoarthritis\(^2,3\) and its formation is thought to be influenced by high impact sporting activities during growth.\(^4,5\) The aims of this study are:

To prospectively study whether a cam deformity can evolve over time in adolescents and whether or not its formation only occurs during skeletal maturation.

To study whether clinical or radiographic features can predict the formation of a cam deformity.

Methods and materials

Preprofessional soccer players (n=63) who participated both at baseline (mean age 14.4 range 12-19 years) and follow-up (mean follow-up time 2.4±0.06 years) were included. At both time points, standardised anteroposterior and frog-leg lateral radiographs were obtained. The alpha angle was measured and the anterosuperior head-neck junction was classified as 1.normal 2.flattened or 3.having a prominence.

The alpha angle is measured by first fitting a circle to the femoral head. A line is then drawn through the center of the neck and the center of the head, and a second line is drawn from the center of the head to the point where the head neck junction first departs from the circle. The angle between these two lines is the alpha angle. We defined the presence of a cam deformity using a recently validated alpha angle threshold of >60° and the presence of a pathological cam deformity using an alpha angle >78°.\(^6\)

All radiographs were also scored semi-quantitatively by an experienced orthopaedic surgeon and musculoskeletal radiologist based on consensus, using a three-point scoring system. The anterior head-neck junction was classified as 1. normal: slight symmetric concavities of the anterior head-neck junction with respect to the posterior head-neck junction. 2. flattening of the head-neck junction: moderate decrease in the anterior head-neck offset with respect to the posterior head-neck junction. 3. presence of a prominence: a convexity in the anterior head-neck junction, as opposed to a concavity.

Radiographic and clinical parameters that might be predictive for, or are associated with a cam deformity were measured at baseline and included the anterosuperior growth plate extension as described by Siebenrock et al.\(^7\), the neck shaft angle (NSA) as measured on the AP radiographs, and the amount of internal hip rotation. The passive amount of
internal hip rotation was measured by a goniometer in supine position. To determine whether those parameters can predict the formation of a cam deformity, we studied all hips without a cam deformity at baseline, and compared the parameters between hips that had developed a cam deformity with those that had not at follow-up.

Differences in prevalence numbers and differences in alpha angle between baseline and follow-up were tested using Generalized Estimating Equations (GEE). The prevalence at both time points is presented for the entire group, by age categories (12-13 years, 14-15 years, and >16 years at baseline), and by growth plate status (open versus closed) at baseline. The association of the amount of growth plate extension, NSA, and internal rotation with the presence of a cam deformity were tested using GEE, all adjusted for age. Finally, in hips without a cam deformity at baseline (either hips with an alpha angle <60° or hips visually scored as ‘normal’), it was tested using GEE whether above mentioned measures could predict the formation of a cam deformity at follow-up.

**Results**

Overall, there was a significant increase in the prevalence of a cam deformity during follow-up, which was shown by an increase in alpha angle (mean 59.4° to 61.3°, p=0.018) and prevalence of a prominence (7.1% to 22.2%, p=0.001), see figure 1.

New cam deformities exclusively developed in hips with an open growth plate at baseline. After closure of the proximal femoral growth plate, there was no increase in prevalence or increase in severity of a cam deformity.

The anterosuperior head-neck junction gradually changed from being concave at the age of 12 years, to a flattening around the age of 14 years (figure 2), and finally to a convexity around the age of 16 years (figure 3). Of the soccer players aged 12 or 13 at baseline, 84.1% had a normal appearance of the head-neck junction, which decreased significantly to only 43.2% at follow-up (p<0.001). These soccer players predominantly acquired a flattened head-neck junction (p=0.002, figure 3). Among players aged >14 years at baseline, many hips with a flattened head-neck junction evolved towards a prominence, though the difference in prevalence per group was not statistically significant (p=0.15 for players aged 14-15 years and p=0.07 for players >16 years). Of the hips with an open growth plate at baseline, the prevalence of normal hips decreased significantly (p=0.001) and the prevalence of a prominence increased significantly (p=0.002). No difference in the prevalence of the visual scores between baseline and follow-up were found for hips with a closed growth plate at baseline (figure 4).

The amount of growth plate extension was significantly associated with the alpha angle and visual scores (p=0.001). A small neck shaft angle and limited internal rotation were associated with cam deformities (alpha angle >60°) and could also predict the formation of cam deformities (alpha angle >60°) significantly at follow-up.
Fig. 1: Figure 1. Prevalence of cam deformity per hip at baseline and follow-up based on the visual scores and the alpha angle. Prevalence of cam deformity at baseline and follow-up are presented for all hips (left column), by age categories (middle columns), and by growth plate status at baseline (right columns). The number of hips in each category is indicated on top of each column. B=baseline, FU=follow-up, GP=growth plate, y=years, AA=alpha angle * indicates a significant difference (p<0.05) between baseline and follow-up.
Fig. 2: Figure 2. Development from normal to flattening. Typical examples of hips with a normal, concave head-neck junction at baseline (left, arrows) that developed a flattened head-neck junction during follow-up (right, arrow heads). This was typically seen in soccer players aged 12-13 years at baseline. The corresponding AP view is shown in the upper left corner of each frog-leg lateral radiograph.
**Fig. 3**: Figure 3. Development from flattening to a prominence. Typical examples of hips with a flattened head-neck junction at baseline (left, arrows) that evolved into a prominence during follow-up (right, arrow heads). This was typically seen in soccer players aged 14-16 years at baseline. The corresponding AP view is shown in the upper left corner of each frog-leg lateral radiograph.
Fig. 4: Figure 4. Morphology of hips with a closed growth plate at baseline did not change. The morphology of hips with a closed growth plate at baseline (left) did not change during follow-up (right). Hips with a normal head-neck junction (top), flattening (middle), or prominence (bottom) appeared equal. The corresponding AP view is shown in the upper left corner of each frog-leg lateral radiograph.
Conclusion

The formation of a cam deformity is probably a result of frequent high impact sports activities that biomechanically triggers extra bone formation at the anterolateral head-neck junction. A cam deformity develops gradually in adolescents and only during skeletal growth, when the skeleton is highly responsive to mechanical loading. The formation or further development stops after closure of the growth plate. A better understanding of the timeframe in which a cam deformity develops may lead to development of preventive measures, which might have a potential impact on the prevalence of OA.

Personal information

References


