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*ORIGINAL STUDY*

# Hip deformity in symptomatic adult Perthes' disease

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**Only a limited number of patients that suffered from Legg-Calvé-Perthes' disease (LCPD) develop pain in early adulthood. Classical hinged abduction is well known and is thought to be responsible for secondary lateral insufficiency of the acetabulum, which may become painful. Another possible explanation, which was put forward more recently, is anterior femoroacetabular impingement. We collected information about the exact morphology of the proximal femur and the acetabulum of 15 hips in 15 young adults (mean age : 25.3 years) who had hip surgery consequent to childhood Perthes' disease in our hospital between 1974 and 2001. In addition to the well known lateral bulging of the femoral head, averaging 112% of the functional radius, we found an even larger anterior bulging, averaging 115% of the functional radius. The mean torsion of the femoral head was –3.6 degrees, which in fact corresponds to a retrotorsion. Retroversion of the acetabulum was found in at least 5 of the 15 hips in which the version could be adequately assessed (33%). Since any of the above deformities favours anterior femoroacetabular impingement and thus hinged flexion, this could well be a contributor to the development of the classic sequelae of LCPD and to the later development of osteoarthritis.**

**Keywords** : hip ; Legg-Calvé-Perthes' disease ; femoroacetabular impingement ; retrotorsion ; retroversion.

## INTRODUCTION

Although Legg-Calvé-Perthes' Disease (LCPD) is generally a self-limiting disease in childhood, a large part of the affected children develop a painful hip and osteoarthritis in adulthood after a pain-free period. Its incidence is reported to be between 9.5% and 50% (*5, 8, 19, 24, 26, 33, 40, 43*).

The aetiology of the secondary degenerative changes is still not well understood, but it has been shown that the long term prognosis (*5, 8, 19, 33*) depends on the severity of the residual deformities of the hip joint and especially its congruence (*22*). Residual deformities are reported to be determined by several factors : the size of the epiphysis involved in the necrosis (*4, 5, 33, 41, 42*), the age at onset (*3, 4, 24, 30, 41-43*), sex (*4, 43*), persistent lateral deficiency (*5*), premature arrest of the physis leading to leg length discrepancy (*5, 42*) and the adequacy of treatment (*41*).

The classic flat varus hip with a high riding trochanter is well known, but deformities tend to vary. Since the initial necrosis involves especially

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the lateral and anterior part of the femoral head, there is a tendency for the femoral head to flatten and to start bulging in these areas. The resulting hinged abduction is believed to be a contributor to pain and to the development of osteoarthritis due to impingement of this bulge on the lateral rim of the acetabulum (*2, 6, 13, 14, 28, 42*).

Snow *et al* (*39*) described the existence of anterior femoroacetabular impingement after Perthes' disease as a cause for pain in young adults in 1993. Looking into this phenomenon, and considering that the necrotic area is located in the anterior part of the femoral head, we hypothesised that the known lateral bulging of the femoral head could well go together with a bulging deformation on the anterior side of the femoral head, and that this could be responsible for the anterior femoroacetabular impingement and thus hinged flexion.

We therefore looked at the morphology of the hip of all young adult patients who were surgically treated in our institution following LCPD in childhood.

Table I. — Data of the patients

| No | Sex | Age at surgery (years) | Side | Surgery | Stulberg |
|---|---|---|---|---|---|
| 1 | M | 22 | R | McM | III |
| 2 | M | 24 | L | McM | IV |
| 3 | M | 25 | L | Valg | IV |
| 4 | M | 24 | L | Valg | IV |
| 5 | M | 35 | R | Valg | IV |
| 6 | M | 28 | R | Valg | II |
| 7 | M | 31 | L | Valg | II |
| 8 | M | 27 | L | Valg | IV |
| 9 | M | 21 | L | Valg | IV |
| 10 | M | 23 | R | Valg | III |
| 11 | M | 26 | R | Valg | II |
| 12 | M | 18 | R | Valg | II |
| 13 | M | 24 | L | Cheil | II |
| 14 | F | 22 | L | Cheil | III |
| 15 | M | 30 | L | Cheil | III |
| | Δ | 25.3 | | | |

McM : MacMurray osteotomy, Valg : valgus intertrochanteric osteotomy, Cheil : surgical dislocation of the hip and cheilectomy , Δ = average.

## MATERIALS AND METHODS

### Patients

All patients that had surgical treatment for sequelae of LCPD in the last 27 years in our institution without obvious radiological arthritis were included in this study. There had to be a pain-free interval between the time the LCPD had healed in childhood and symptoms started. Of all patients, preoperative anteroposterior and a type of lateral radiograph had to be available as measurements should be done on these radiographs.

Twenty-seven patients with 28 hips were identified, among which the radiographs of 20 patients with 21 hips were available for evaluation .On six radiographs there was obvious arthritis (all elderly patients), so 15 hips remained. Ten patients had LCPD on the left hip, of which one was a female, nine on the right hip and one bilateral. Five hips were classified as Stulberg II, four as Stulberg III and six as Stulberg IV (*18, 40*). The average age at surgery was 25.3 years (range : 18 to 35). In 12 patients an intertrochanteric osteotomy was performed (*29*), three patients had a surgical resection of the femoral head-neck junction (cheilectomy) (*9, 27*) (table I).

### **Measurements** (fig 1)

All measurements were done on the preoperative radiographs only.

The functional centre of the femoral head was defined by Cho *et al* (7) as the point around which most of the femoral head rotates. In an ideal situation, the femoral head is round and therefore the anatomical centre coincides with the functional centre. However, a deformed head not only turns, but also hinges and slides within the acetabulum, causing the functional centre to change position and to depend on the position of the hip. We therefore used the functional centre of the head (FCH) in neutral position as the anatomical centre. This was done using the Mose template, which was also used to determine an optimal sphere, an ideal circle around the FCH within the femoral head under the weight bearing surface of the acetabulum and the 0° line parallel to the neck axis.

Using the FCH and the optimal sphere the following measurements were performed on AP and lateral radiographs :

| | |
|---|---|
| $r$ | The radius of the optimal sphere |
| $r_{(0\text{-}360)}$ | The distance between the FCH and the joint surface and the distance between the FCH and the acetabulum, every 10 degrees up to the head-neck junction (*7, 20*). This was necessary to determine the maximum radius in the lateral and medial direction on the AP radiograph and for the anterior and posterior radius on the lateral radiograph |
| $d$ | The maximum diameter of the head (*35*) |
| $s$ | The minimum radius to the surface of the femoral head (*35*) |
| $r_{offset}$ | The maximal anterior radius perpendicular to the axis of the neck (*10*) |
| $r_{neck}$ | The minimal anterior radius of the neck perpendicular to the axis of the neck (*10*) |
| $d_{contra}$ | The diameter of the contralateral hip |
| $r_{ant}$ | The maximal radius from the Functional Centre of the Head (FCH) to the anterior surface of the femoral head, determined via the $r_{(0\text{-}360)}$. (see above) |
| $r_{post}$ | The maximal radius from the FCH to the posterior surface of the femoral head |
| $r_{lat}$ | The maximal radius from the FCH to the lateral surface of the femoral head |
| $r_{med}$ | The maximal radius from the FCH to the medial surface of the femoral head |
| ABA | The Anterior Bulging Angle. The angle between the neck axis and the radius at the anterior side that is 2 mm longer than $r$. (*25*) |
| PBA | The Posterior Bulging Angle. The angle between the neck axis and the radius at the posterior side that is 2 mm longer than $r$. |
| LBA | The Lateral Bulging Angle. The angle between the neck axis and the radius at the lateral side that is 2 mm longer than $r$. |
| MBA | The Medial Bulging Angle. The angle between the neck axis and the radius at the medial side that is 2 mm longer than $r$. |
| $\alpha$ S | The Angle of Sharp (*40*) |
| $h$ | The trochanteric height, i.e. the height between the tip of the greater trochanter and a line through the FCH and the centre of the opposite femoral head (fig 1) (*40*) |
| $\alpha$ | The maximal width of the femoral head parallel to the inter-teardrop line in the AP radiograph (fig 1) (*40*) |
| $\beta$ | The maximal distance between the medial surface of the femoral head and the lateral acetabular rim parallel to the inter teardrop line (fig 1) (*40*) |
| $\infty$ | Crossover sign, indicating a retroversion of the acetabulum (see text and also fig 3) (32) |

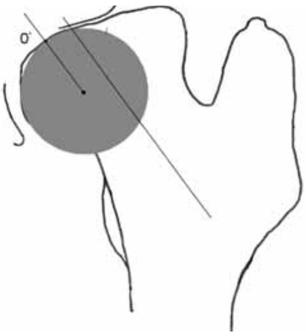
(*all results of the measured distances were given in mm and the results of the angles in degrees*).

*Derived Calculations* :

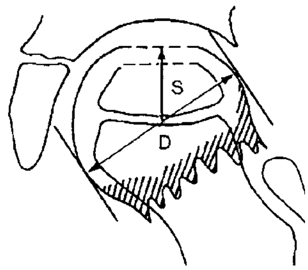
Using the above measurements the following variables were calculated :

| | |
|---|---|
| AOS | Anterior Offset. The space between the femoral head and the neck. Normal values : 11.6 mm ± 0.7 mm (*10*) : $r_{offset} - r_{neck}$ |
| AOSR | Anterior Offset Ratio. The diameter of the femoral head was used to ratio the offset (*10*) Our hips were deformed so we used the diameter of the contralateral head $AOS / d_{contra}$ |
| ABQ | Anterior Bulging Quotient. The degree of anterior bulging. $r_{ant} / r$ |
| PBQ | Posterior Bulging Quotient. The degree of posterior bulging. $r_{post} / r$ |
| MBQ | Medial Bulging Quotient. The degree of medial bulging. $r_{med} / r$ |
| LBQ | Lateral Bulging Quotient. The degree of lateral bulging. $r_{lat} / r$ |
| ShX | Caput (Shigeno) Index. The degree of sphericity. Normal values are 75% or higher (*36*) $d / s / 2$ |
| OX | Ovoid index. Indicates the plane where the femoral head is the broadest $r_{lat} + r_{med} / r_{ant} + r_{post}$ |
| AC | Acetabular coverage (*16, 40*). $\beta / \alpha \times 100\%$ |
| rR | The revised retrotorsion. The retrotorsion can be assessed by measuring the distance between the neck axis and the centre of the head. In our study this was defined as the distance between the neck axis and the middle of line D. $\frac{1}{2}d - r_{offset}$ |

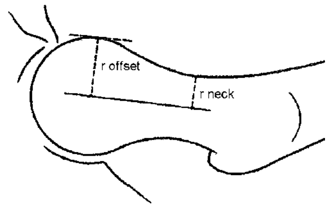
(*all results of the calculated distances were given in mm and the results of the angles in degrees*).



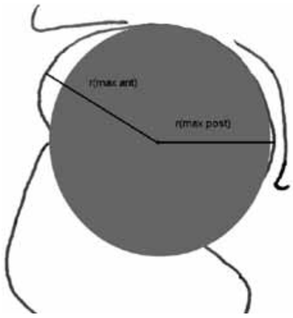

The optimal sphere. the ideal circle within the femoral head at the weight-baring surface of the acetabulum and the 0° line parallel to the neck axis.



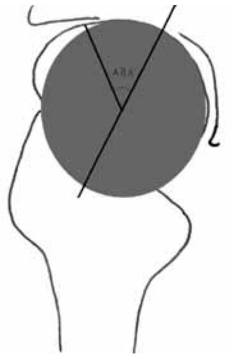

d : The maximum diameter of the head and s : The minimum radius from the middle of D to the surface of the femoral head.



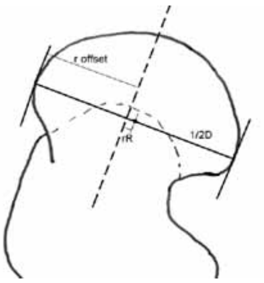

$\mathbf{r}_{offset}$ : the maximal radius perpendicular to the neck axis between the anterior surface of the femoral head and the neck axis and $r_{(neck)}$ : the minimal radius perpendicular to the neck axis between the anterior surface of the neck and the neck axis.



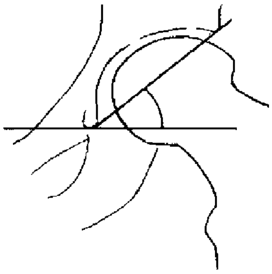

$r_{ant}$ and $r_{post}$ :maximum radius in the anterior and posterior direction. See also figure 2.



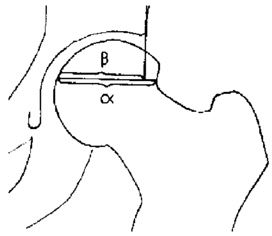

ABA. the anterior bulge angle.



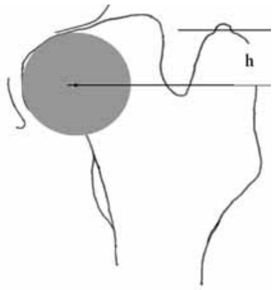

rR : Revised retrotorsion.



αS : The Angle of Sharp.




α : The maximal width of the femoral head parallel to the inter-teardrop line and β : The maximal distance between the medial surface of the femoral head and the lateral acetabular.




h : The trochanteric height, the height between the tip of the greater trochanter and a line through the FCH and the centre of the opposite femoral head.

| | | |
|---|---|---|
| **a** | **b** | **c** |
| **d** | **e** | **f** |
| **g** | **h** | **i** |

***Fig. 1.*** — Some measured parameters

Table IIa. — Results of the Anterior-Posterior measurements (+ = positive, - = negative, 0 = not assessable)

| No | r (mm) | d (mm) | s (mm) | $d_{contra}$ (mm) | $r_{med}$ (mm) | $r_{lat}$ (mm) | MBA (°) | LBA (°) | αS (°) | h (mm) | α (mm) | Δ (mm) | ∞ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | affected | unaffected |
| 1 | 35 | 64 | 26 | 56 | 40 | 36 | 6 | | 42 | 2.5 | 70 | 57 | 0 | + |
| 2 | 35 | 65 | 38 | 54 | 37 | 40 | 24 | 68 | 36 | 4.5 | 57 | 42 | + | + |
| 3 | 40 | 76 | 22 | 56 | 43 | 49 | 5 | 50 | 56 | 4 | 72 | 42 | 0 | - |
| 4 | 33 | 76 | 20 | 28 | 33 | 53 | | 33 | 44 | 3.5 | 67 | 38 | + | + |
| 5 | 49 | 77 | 27 | 64 | 50 | 49 | | | 41 | 4 | 81 | 46 | - | - |
| 6 | 40 | 74 | 25 | 60 | 40 | 41 | | | 60 | 5 | 60 | 44 | 0 | - |
| 7 | 29 | 63 | 27 | 61 | 31 | 31 | | | 38 | 4.5 | 50 | 46 | 0 | - |
| 8 | 29 | 65 | 16 | 60 | 31 | 41 | 40 | 42 | 58 | 4 | 50 | 31 | + | - |
| 9 | 44 | 71 | 22 | | 48 | 45 | 1 | | 55 | 5 | 65 | 42 | - | - |
| 10 | 29 | 70 | 27 | | 36 | 34 | 12 | 80 | 50 | 5 | 74 | 36 | - | - |
| 11 | 33 | 68 | 27 | 56 | 35 | 35 | | | 44 | 5 | 74 | 46 | + | + |
| 12 | 38 | 73 | 29 | | 40 | 40 | | | 40 | 4 | 74 | 46 | + | + |
| 13 | 30 | 56 | 27 | 52 | 31 | 30 | | | 45 | 4 | 55 | 44 | - | - |
| 14 | 29 | 59 | 20 | 48 | 35 | 29 | 5 | | 42 | 4 | 57 | 46 | - | - |
| 15 | 31 | 66 | 27 | 54 | 36 | 31 | 5 | | 45 | 4.5 | 60 | 44 | - | - |
| Δ | 36.3 | 71.9 | 26.3 | 56.4 | 39.0 | 41.3 | 12 | 55 | 46.2 | 3.9 | 68.6 | 44.9 | | |

Table IIb. — Results of the lateral measurements

| No | R (mm) | d (mm) | s (mm) | $r_{offset}$ (mm) | $r_{neck}$ (mm) | $r_{ant}$ (mm) | $r_{pos}$ (mm) | ABA (°) | PBA (°) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | 61 | 29 | 28 | 19 | 32 | 32 | | |
| 2 | 29 | 63 | 26 | 32 | 17 | 30 | 40 | | 28 |
| 3 | 48 | 99 | 35 | 32 | 22 | 48 | 49 | | |
| 4 | 28 | 70 | 27 | 33 | 15 | 37 | 34 | 30 | 75 |
| 5 | 33 | 80 | 33 | 35 | 18 | 44 | 36 | 86 | 62 |
| 6 | 40 | 82 | 34 | 31 | 12 | 43 | 41 | 70 | |
| 7 | 29 | 62 | 25 | 25 | 16 | 32 | 31 | 75 | |
| 8 | 30 | 62 | 25 | 34 | 14 | 33 | 30 | 55 | |
| 9 | 38 | 77 | 28 | 34 | 17 | 41 | 39 | 30 | |
| 10 | 35 | 72 | 30 | 33 | 16 | 37 | 36 | | |
| 11 | 30 | 66 | 30 | 28 | 16 | 34 | 33 | 64 | 102 |
| 12 | 33 | 68 | 32 | 34 | 17 | 36 | 33 | 2 | |
| 13 | 21 | 60 | 20 | 30 | 14 | 38 | 21 | 55 | |
| 14 | 27 | 58 | 26 | 27 | 11 | 29 | 29 | | |
| 15 | 33 | 68 | 32 | 30 | 14 | 34 | 34 | | |
| Δ | 32.2 | 69.8 | 28.8 | 31.1 | 15.8 | 36.5 | 34.5 | 52 | 67 |

## RESULTS

In tables IIa, IIb and III all the different measurements and calculations are summarised per hip. The results in each subgroup are also shown. The averages are shown under the columns. In figures 1 and 2 some measurements mentioned in the last paragraph are visualised for better understanding.

The average radius (r) was 36.3 mm in the AP direction and 32.2 mm in the lateral direction, the maximum diameter (d) was 71.9 mm and 69.8 mm respectively. The minimum radius (s) was 26.3 mm

Table III. — Results of the derived calculations

| No | AOS (mm) | AOSR | MBQ | ABQ | LBQ | PBQ | ShX ap | ShX lat | OvoidX | Acetabular coverage | rR (°) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9 | 0.16 | 114% | 107% | 103% | 107% | 0.81 | 0.95 | 1.05 | 81% | 2.5 |
| 2 | 15 | 0.18 | 106% | 103% | 114% | 138% | 1.17 | 0.83 | 1.03 | 74% | -0.5 |
| 3 | 10 | 0.18 | 108% | 100% | 123% | 102% | 0.58 | 0.70 | 0.77 | 58% | 18 |
| 4 | 18 | 0.64 | 100% | 132% | 161% | 121% | 0.52 | 0.77 | 1.09 | 57% | 7 |
| 5 | 17 | 0.27 | 102% | 133% | 100% | 109% | 0.70 | 0.83 | 0.96 | 57% | 5 |
| 6 | 19 | 0.32 | 100% | 108% | 103% | 103% | 0.68 | 0.83 | 0.9 | 73% | 10 |
| 7 | 9 | 0.15 | 107% | 110% | 107% | 107% | 0.86 | 0.80 | 1.02 | 92% | 6 |
| 8 | 20 | 0.33 | 107% | 110% | 141% | 100% | 0.49 | 0.81 | 1.05 | 62% | -3 |
| 9 | 17 | | 109% | 108% | 102% | 103% | 0.61 | 0.73 | 0.92 | 65% | -4.5 |
| 10 | 17 | | 124% | 106% | 117% | 103% | 0.77 | 0.83 | 0.97 | 49% | 3 |
| 11 | 12 | 0.21 | 106% | 113% | 106% | 110% | 0.79 | 0.91 | 1.03 | 62% | 5 |
| 12 | 17 | | 105% | 109% | 105% | 100% | 0.79 | 0.94 | 1.07 | 62% | 0 |
| 13 | 16 | 0.31 | 103% | 181% | 100% | 100% | 0.96 | 0.67 | 0.93 | 80% | 0 |
| 14 | 16 | 0.33 | 127% | 107% | 100% | 107% | 0.68 | 0.9 | 1.02 | 80% | 2 |
| 15 | 16 | 0.30 | 116% | 103% | 100% | 103% | 0.81 | 0.94 | 0.97 | 73% | 4 |
| Δ | 15.2 | 0.28 | 109% | 115% | 112% | 108% | 0.75 | 0.83 | 0.99 | 68% | 3.6 |

in the AP view and 28.8 mm in the lateral. The maximum diameter of the contralateral hip ($d_{contra}$) was 56.4 mm. The average Ovoid index was 0.99 with 12 hips being broader in the sagittal plane and 8 being broader in the coronal plane. In only one hip did the diameter on the AP view equal the diameter in lateral view. This showed that the heads were generally flat heads with a large diameter especially in the AP view. The $r_{(0\text{-}360)}$ is set out in fig 2 : The circle represents the optimal sphere, the bold line represents the mean shape of the femoral head in relation to the optimal sphere. From these figures the maximum radius in the anterior, posterior, medial and lateral direction were determined.

The average maximum radius perpendicular to the neck ($r_{offset}$) was 31.1 mm with a average radius of the neck ($r_{neck}$) of 15.8 mm. So there was generally enough offset, with an calculated offset (AOS) of 31.1-15.9= 15.2 mm (normal value : 11 to 17) with an offset ratio (AOSR) of 0.28.

As explained before, the maximum radius in the four wind directions were determined with use of the $r_{(0\text{-}360)}$ : The maximum anterior radius from the functional centre of the head ($r_{ant}$) was 36.5 mm, the maximum posterior radius was 34.5 mm, giving a larger part of the head being anterior than posterior in the lateral radiograph. The maximum lateral radius from the functional centre of the head was 41.3 mm, the maximum medial radius was 39.0 mm, giving a slightly larger part of the head being lateral than medial on the AP radiograph.

Nine hips had an Anterior Bulging Angle (ABA) with an average of 52°. Four hips had a Posterior Bulging Angle (PBA) with an average of 67°. Five hips had a Lateral Bulging Angle (LBA) with an average of 55°. Eight hips had a Medial Bulging Angle (MBA) with an average of 12°. Bulging in relation to the optimal sphere of the head was 115% in the anterior direction (ABQ), 108% in the posterior direction (PBQ), 109% in the medial direction (MBQ) and 112% in the lateral direction (LBQ). This means that the most bulging and thus flattening of the femoral head appeared anteriorly and laterally and even more anteriorly.

The average Sharp-angle ($\alpha S$) was 46.2°. The average acetabular coverage was 68%. The average trochanteric height (h) was 3.9 mm (range : 2.5 to 5). The average maximal width of the femoral head parallel to the inter-teardrop line ($\alpha$) was 68.6 mm. The average maximal distance between the medial surface of the femoral head and the lateral acetabular rim ($\beta$) was 44.9 mm. The average Shigeno index (ShX) was 0.75 on the AP view and 0.83 on the lateral view.

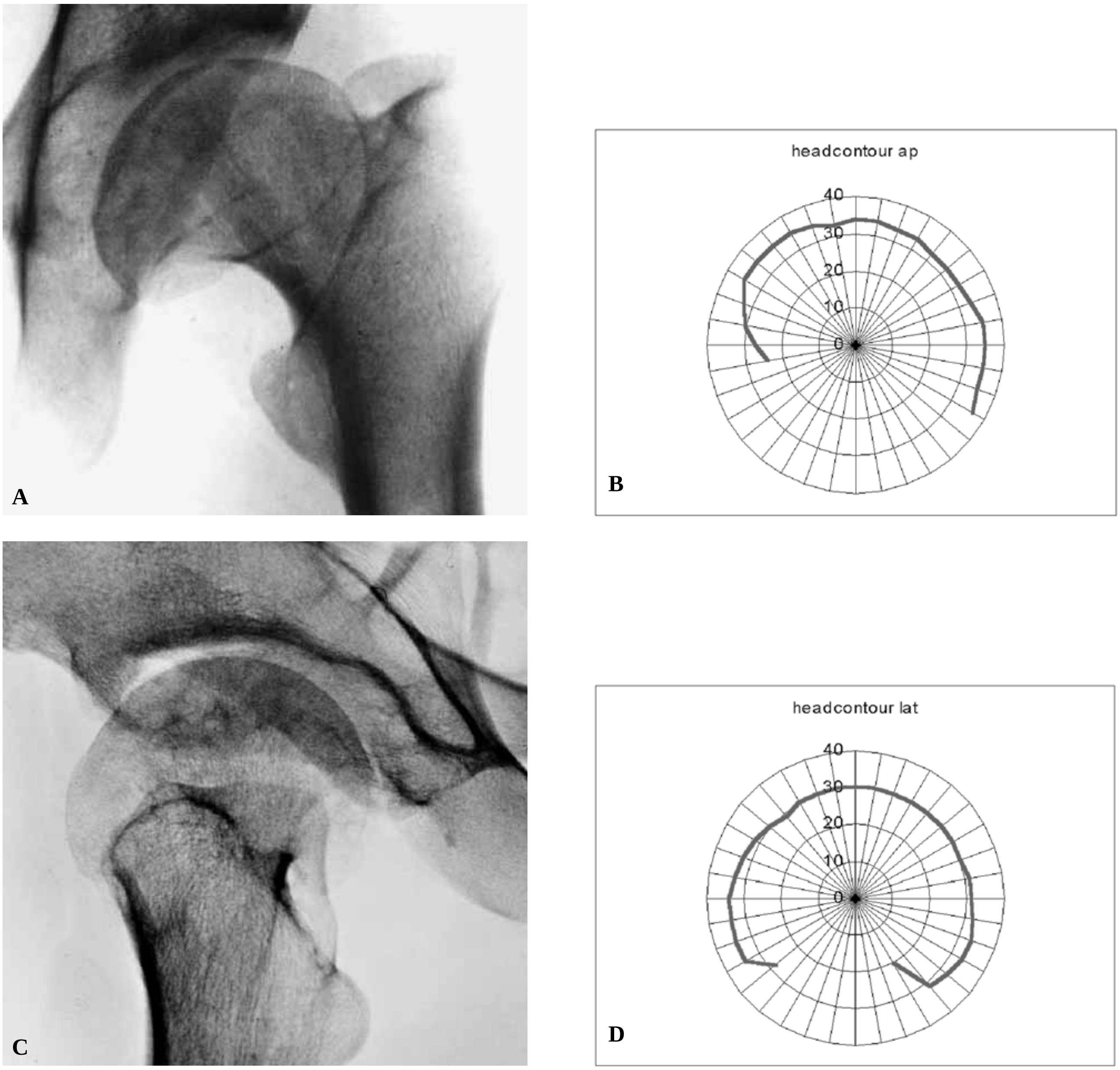



*Fig. 2.* — A : AP radiograph of the right hip of patient 11. B : $r_{(0\text{-}360)}$ : The head contour in the AP view measured every 10° interval. 0° line and thus axis of the neck is projected at 12 o'clock. C : lateral radiograph of the hip. D : $r_{(0\text{-}360)}$ : head contour in the lateral view. From these views the maximum radii of the head in the anterior, posterior, lateral and medial direction were determined.

In 5 affected hips there was a definite retroversion (∞) on the AP radiographs (33%). In 4 further hips this could not be properly defined (see discussion). There was an anteversion in the other hips. In 5 hips on the contralateral side there was also a definite retroversion on the AP radiographs. In all these hips the other side was also retroverted or could not be properly defined.

The average revised retrotorsion (rR) was 3.6 mm with 2 hips having no torsion at all and 3 hips having an antetorsion.

## DISCUSSION

A limited number of patients who suffered from Legg-Calvé-Perthes' disease (LCPD) in childhood develop pain in early adulthood, a high percentage will ultimately develop osteoarthritis. The main prognostic factor seems to be the congruency of the joint. Hinged abduction is a well known feature in post-LCPD patients and is presumed to be a major contributor to the development of osteoarthritis (*2, 6, 13, 14, 28, 31*).

Snow *et al* (*37*) reported anterior femoroacetabular impingement as the cause of pain on flexion and internal rotation of the femoral head in four post-LCPD patients presenting after a pain-free interval. They were able to visualise the impingement and a correlating acetabular defect on the anterior acetabular rim. Since then much more knowledge about impingement has become available and the symptoms of restricted flexion, limited or absent internal rotation in flexion, and with variable groin pain are now well known (*26*). Also, magnetic resonance imaging studies have revealed the acetabular labral disease and adjacent cartilage damage to be associated with impingement (*9, 18, 27, 32*).

Few studies on the morphology of the femur and acetabulum causing this entity have been published (*32*). Several authors have developed radiographic classifications and measurements for hips of children suffering from LCPD (*7, 11, 15, 16, 25, 26, 34, 35*). However, not much was known about the morphology of the deformed head in adults who previously suffered from LCPD. Moreover, only few methods were available for evaluating the morphology in deformed hips. In addition most previous radiological studies focussed on children and on the AP view only. Looking for applicable methods for measuring the deformed hips we found that hardly any was available. Reference points used in children were difficult to extrapolate to adult hips, since often the epiphyses were used as reference point (*1, 16*). In other methods the anatomical centre of the head was used as reference point (*7, 25*), but in the sometimes severely deformed and multiple operated hips in our study this again proved difficult. All methods frequently used for radiological evaluation of post Perthes' hips (Stulberg *et al* (*40*), Herring *et al* (*15*), Fredensborg (*11*), Mose (*25*) and Heyman (*16*)) use AP radiographs only. They can not reveal deformities in the sagittal plane and were therefore not of practical use to us. Furthermore, most classifications give a qualitative assessment and not a quantitative. Therefore, we were forced to use some new methods.

Shigeno and Evans (*35*) reported a new arthrographic index to determine the loss of sphericity of the femoral head during the active stage of LCPD. This index was derived from the caput index introduced by Jonsater (*21*). Although originally for children, this quantitative method was deemed appropriate for our purpose and was used in our hips. Also, this index could be used in two directions. From this index several new indices and quotients were derived, which enabled us to show the existing anterior bulging.

Again, Shigeno and Evans (*36*) also concluded that the deformation of the cartilaginous femoral head was significantly greater in the AP radiograph than in the lateral radiograph during the fragmentation phase. The average arthrographic index in our study was smaller in the AP direction than in the lateral direction. However, Cho *et al* (*7*) stated that in children the femoral head was deformed on the sagittal as well as, or even more than on the coronal view. Bulging was not until now included in these measurements. We can now confirm identical findings in adult patients after LCPD.

The anterior bulging alone can explain the existence of anterior acetabular impingement. The bulge impinges on the anterior and anterolateral part of the rim of the acetabulum in flexion and especially flexion-internal rotation, causing hinging. Although not all of our patients may have had the same deformation, as this may be different from patient to patient, the anterior bulge was obvious in all of them.

Anterior impingement may also be caused by retroversion of the acetabulum (*12, 32*) or retrotorsion of the femoral head (*9*). On the radiograph of an acetabulum with "normal" version, the anterior wall shadow meets the posterior wall shadow at the superolateral aspect of the acetabulum, and they do not overlap as the lines are followed inferiorly. In an acetabulum with retroversion, the two shadows

***Fig. 3.*** — Typical radiograph of one of the hips with a clear retroversion of the acetabulum ; note the "crossover sign". In a normal acetabulum, the outline of the anterior wall runs medially from the outline of the posterior wall. In a retroverted acetabulum these two lines will cross and meet at the lateral edge, hence cross-over sign.

cross over the femoral head, making a figure of 8 pattern or cross over sign (fig 3) (*32*). We found a retroversion of the acetabulum in 5 out of these 15 hips, corresponding to 33%. There were 4 more where retroversion was likely, but the pelvic tilt of these radiographs was such that the version could not be properly analysed (*38*). The rate of retroversion in the normal population is 5% (*12*). Even in patients with acetabular dysplasia the rate is reported as 16% (*23, 37*). Moreover, if a retroversion was found the unaffected hip was also found to have this morphology, which seems to be an interesting phenomenon. In addition we found a slight average retrotorsion of the head that may have contributed to the impingement.

As this was a retrospective study, no MRI, CT scan or arthrogram data were available. However, the correlation between conventional radiography, arthrography and MRI was investigated previously and no evidence of a major difference was found between the form of the cartilage on the femoral head and the underlying bone in children suffering from LCPD (*17*).

Recent insights in the exact development of femoroacetabular impingement has shown that its damaging effect is caused not only through a hinging, but also through a much more complicated gliding effect of the femoral head in the acetabulum, damaging the hip not only through abutment of the femoral neck on the acetabular rim (*20*). Since anterior bulging, retrotorsion of the femoral head or retroversion of the acetabulum alone can lead to anterior femoroacetabular impingement, this whole pattern of deformities could well have been a major contributor to the symptoms of our patients. Furthermore, considering that flexion is a much more executed movement in normal daily activity than abduction, anterior femoroacetabular impingement and thus hinged flexion, could well be the major contributor to the typical groin pain in our patients and, in fact, be responsible for the development of osteoarthritis in later life.

In patients that suffered from LCPD during childhood it is obligatory to look for signs of femoroacetabular impingement. This diagnostic workup should thus also include proper cross-table lateral radiographs of the joint (*10, 11*) and possibly CT scan and/or (arthro-)MRI. It could well be that by early treatment of the impingement the high rate of secondary osteoarthritis in later life could be reduced.

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