Gluteus minimus-induced femoral head deformation in dysplasia of the hip

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ABSTRACT – Lateral notching of the femoral head is considered pathognomonic for spastic subluxation of the hip. Less frequently, flattening is seen with extrusion of the femoral head in nonspastic hip dysplasia. The aim of this study was to throw light on its underlying pathomechanism. On the radiographs of 297 hips with developmental dysplasia, lateral flattening of the femoral head was seen in 18 hips (6%), but notching was present in only 1. Of 7 dysplasias due to cerebral palsy, 6 showed lateral notching. The gluteus minimus was felt to be responsible for the lateral femoral head changes as the muscle counteracts lateral migration of the femoral head. Intraoperative dissection of 3 hips supported this view. 1 hip with developmental dysplasia and lateral notching was subjected to a periacetabular osteotomy. At surgery, the tendon of the gluteus minimus was found to fit tightly into the notch. Of 2 hips with spastic dysplasia, 1 presented with and the other without lateral notching. In the hip with lateral notching, the gluteus minimus had a normal appearance and it lay in the defect of the femoral head. In the hip without notching, the gluteus minimus was atrophied with signs of fatty degeneration. We therefore believe that lateral notching is a sign of hypertonicity of the gluteus minimus muscle.

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Progressive subluxation of the femoral head is a common problem in cerebral palsy. Lateral notching of the femur has been observed in some patients (Samilson et al. 1972, Hoffer 1986, Cooperman et al. 1987) and is thought to be pathognomonic for spastic subluxation of the hip (Renshaw et al. 1995). Chronic pressure from structures like the ligamentum teres, the joint capsule, the reflected portion of the rectus tendon and the abductor musculature in general has been hypothesized as the cause (Samilson et al. 1972, Baxter and D'Astous 1986, Root et al. 1986, Cooperman et al. 1987, Renshaw et al. 1995, Root et al. 1995, Brunner 1997, Lundy et al. 1998). However, none of these explanations as to the underlying pathomechanism is entirely satisfactory.

On the basis of previous anatomic studies of the gluteus minimus muscle (Beck et al. 2000), we analyzed radiographs of dysplastic hips and examined during surgery the topographic relation of this muscle to the femoral head with notching.

Patients and methods

We analyzed the radiographs of 304 hips which were subjected to a Bernese periacetabular osteotomy (Ganz et al. 1988) and/or an intertrochanteric femoral osteotomy for the presence of superolateral notching or flattening of the femoral head. Notching was defined as a concave interruption in the lateral contour of the femoral head. Flattening was defined as a flat area on the lateral contour of the femoral head. Patients with Perthes' disease, avascular necrosis of the femoral head and previous operations of the hip were not included. On the basis of patients' charts and operative reports, all hips were classified as either developmental or neurogenic dysplasia.

In 3 hips of 3 patients, the capsule, labrum and the muscles around the hip joint were carefully identified during surgery and their position was related to changes in the femoral head. 2 patients had cerebral palsy. 1 had bilateral notching of the femoral head on plain radiographs and 1 with uni-

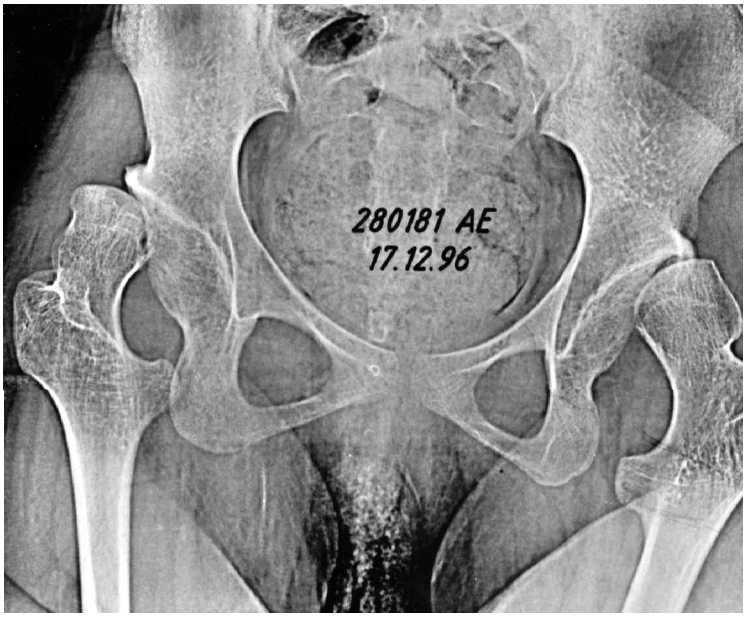


Figure 1. Preoperative radiograph of case 1. Spastic dislocation of both hips with deep notching on the lateral aspect of the right femoral head, and less severe femoral head deformation on the left side.

lateral disease had no notching. The third patient without neurological impairment had acetabular dysplasia and superolateral notching.

Results

7 hips in 6 patients (1 bilateral) had neurogenic dysplasia with subluxation. 297 hips had developmental dysplasia: 239 of these showed little, if any, lateral migration of the femoral head, 51 hips were subluxed, defined as a break in Shenton's line, and 7 had a high subluxation.

6 of the 7 hips with neurogenic dysplasia had superolateral notching of the femoral head (Figure 1), while 1 had no lateral femoral head changes. Flattening of the femoral head was present in 19 (6%) developmentally dysplastic hips: 3 of the 7 hips with a high subluxation, 13 of the 51 subluxed hips, and 3 of the 239 undisplaced hips. Only 1 patient, with developmental dysplasia and a subluxed hip, had superolateral notching .

We determined the topography of the gluteus minimus muscle relative to the joint during surgery in 3 hips.

Case 1. A 16-year-old girl with spastic cerebral palsy presented with severe subluxation of both hips and progressive pain on the right side. Bilateral superolateral notching of the femoral head was present (Figure 1). We made an intertrochanteric varus osteotomy of the right hip together with a periacetabular osteotomy to restabilize the femoral head in the socket. After the greater trochanter was osteotomized and mobilized anteriorly and superiorly, we visualized the inferior portion of the gluteus minimus adjacent to the tendon of the piriformis. While the gluteus medius muscle had an atrophic appearance, with scattered fatty replacements, the gluteus minimus seemed normal. Dissection via the gap between the gluteus minimus and piriformis muscle increased the superior and anterior mobilization of the gluteus minimus, leaving its tendinous insertion in the trochanteric fragment intact. We could then inspect the posterosuperior, superior and anterosuperior joint capsule. Palpation of the lateral capsule gave the impression of a flattened femoral head. Retraction of the gluteus minimus showed that the muscle belly and, more anteriorly, its tendon were located in this area of the capsule. The reflected head of the rectus femoris muscle originated from the roof of the acetabulum and merged directly with the head anterior to the joint. It was not responsible for the deformation of the femoral head.

After a Z-shaped capsulotomy, with preservation of the retinacular blood vessels to the head (Gautier et al. 2000), the large triangular notching of the lateral contour of the femoral head became visible (Figure 2). Release of the gluteus minimus muscle clearly showed how it fell back into the notching. Internal rotation of the femur tightened the muscle in the notching. The inferior portion of the muscle with its fibers in posteroanterior direction was especially involved and internal rotation in full extension of the femur created the highest pressure of the muscle against the femoral head.

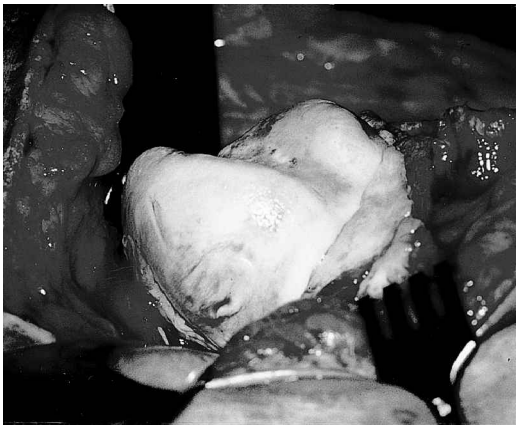
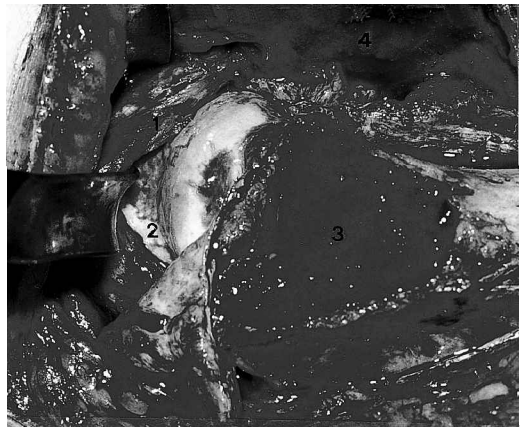
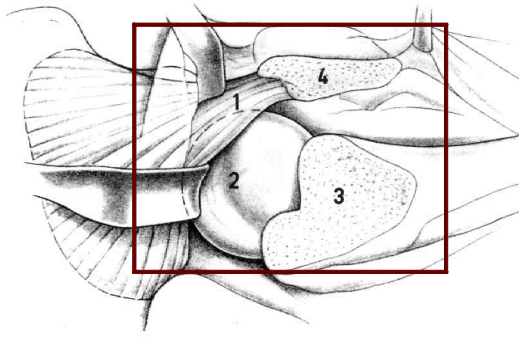


Figure 2. Intraoperative view of the anteriorly dislocated right femoral head, showing the notching of the lateral contour of the femoral head.



The femoral head relocated in the acetabulum.



The gluteus minimus is retracted superiorly, allowing visualization of the notching of the femoral head. (1) Gluteus minimus. (2) Notching of the femoral head. (3) Osteotomy of the greater trochanter. (4) Mobilized trochanter fragment with gluteus minimus, medius and vastus lateralis attached to it.

The tension was markedly reduced by abduction of the leg which also reduced the femoral head into the acetabular socket.

Case 2. A 30-year-old woman with neurogenic dysplasia and severe spasticity had painful progressive high subluxation of the left hip with osteoarthrosis. Radiographs showed no lateral femoral head deformations. An osteotomy of the greater trochanter was done and the trochanter mobilized anteriorly, leaving the gluteus medius and vastus lateralis muscle attached to it. The space between the piriformis and the gluteus minimus muscles was identified and widened, making the joint capsule accessible. The gluteus medius was atrophied, but otherwise looked normal. The gluteus minimus was flabby and had fatty deposits between the muscle fibers. Motion of the hip did not increase pressure of the gluteus minimus against the capsule. We made a Z-shaped capsulotomy with preservation of the retinacular blood vessels and dislocated the femoral head anteriorly. As expected, the labrum was avulsed, with adjacent severe degenerative changes in the acetabular and femoral head cartilage. Therefore, a total hip prosthesis was implanted.

Case 3. A 26-year-old man, with developmental dysplasia and subluxation of the left hip, underwent a periacetabular osteotomy. Radiographs showed superolateral notching of the femoral head. The exposure was extended to the gluteus minimus muscle, which we carefully dissected from the superolateral capsule. The reflected portion of the rectus femoris muscle origin could be seen cranial to the capsule, covering the extruding femoral head anteriorly. The pressure from the gluteus minimus tendon onto the femoral head was present in flexion and internal rotation, and was even more pronounced in extension and internal rotation. Capsulotomy confirmed that the gluteus minimus fitted tightly into the lateral femoral head defect.

Discussion

Lateral notching of the femoral head is a common phenomenon in spastic hips. Rarely, it can also be observed in developmental dysplasia of the hip with extrusion of the femoral head. This morphological change in the femoral head has been attrib-

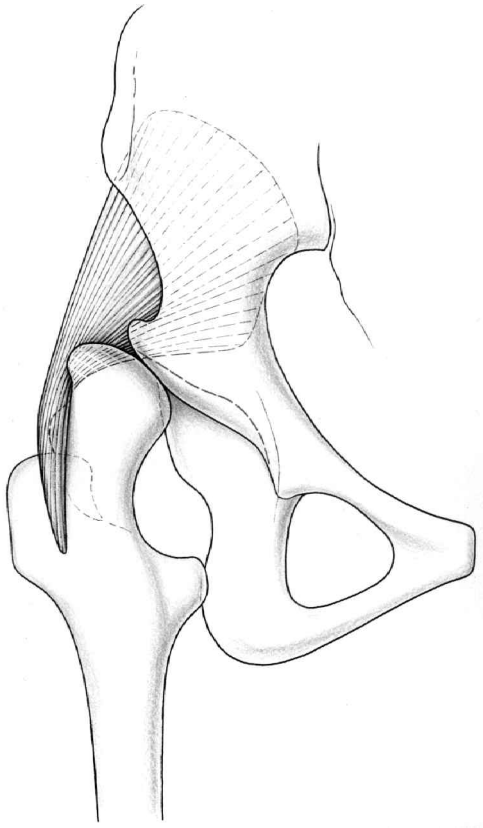


Figure 3. Schematic illustration of the gluteus minimus muscle. The inferior portion of the muscle passes laterally to the femoral head and lies within the notching of the femoral head.

uted to various structures, such as a taut ligamentum teres or a taut superior joint capsule (Samilson et al. 1972). A hypertrophied and taut ligamentum teres was also felt to be responsible for medial notching (Baxter and D'Astous 1986). Root et al. (1986, 1995) described a triangular appearance of the femoral head with superolateral flattening and medial notching, but did not attempt to explain its etiology. Superior or lateral flattening has been said to result from spastic tone, which forces the head against an unyielding structure, such as the ligamentum teres, capsule or hip abductors (Cooperman et al. 1987). Renshaw et al. (1995) believed that the uncovered capital femoral epiphysis is subjected to strong deforming pressures by the overlying hip joint capsule and spastic abductor muscles resisting proximal migration of the femoral head. Others believe that the lateral notching is due to the pressure of the overlying reflected head of the rectus femoris (Brunner 1997). Lundy et al. (1998) analyzed 12 proximal femora, which had been resected for painful subluxation. All had a deep sagittal impression defect on the superolateral portion of the femoral head. This impression was thought to be caused by the superior acetabular labrum.

However, in subluxed hips, the superolateral part of the femoral head does not meet the acetabular rim. A lesion caused by the rim would be on the superomedial or superior portion of the femoral head. Samilson et al. (1972) also found that the posterolateral head notching was not due to the pressure of the acetabular rim.

Our findings indicate that this lateral notching is caused by the muscle and tendon of the gluteus minimus, as it hinders the femoral head from migrating out of the acetabulum. The constant pressure of the muscle creates, with time, a deep groove in the femoral head. In the normal hip, mainly the inferior part of the muscle passes lateral to the femoral head. The tendon first attaches to the anterolateral hip joint capsule before it continues to its insertion on the ridge on the anterior aspect of the greater trochanter (Beck et al. 2000). Depending on the position of the femoral head, the notching is superolateral, lateral or posterolateral. In coxa valga, the course of the gluteus minimus relative to the femoral head migrates cranially. In subluxation or dislocation, it migrates inferiorly and an increasing part of the gluteus minimus muscle and tendon may lie laterally to the femoral head (Figure 3). We conclude that the gluteus minimus causes the lateral notching of the femoral head in cerebral palsy, and that notching is a sign of spastic involvement of the gluteus minimus.

Flattening and notching may also be seen in developmental dysplasia in the presence of an extruding femoral head, or a hypertrophied and/or hyperactive gluteus minimus muscle. This hinders further migration of the femoral head. We found lateral flattening of the head in 6% of the developmental dysplastic hips. Its presence had a positive correlation with the degree of lateral migration of the femoral head, as almost half of the high subluxed hips had flattening but only 1% when the femoral head was more stable in the socket. It is important to note that the incidence of lateral flattening may actually be even higher than that

which we found, as the femoral head changes can be seen only on radiographs where the x-ray beam is parallel to the flattening. Rotation of the femur may have hidden some of the deformations.

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