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TREATMENT OF FEMORO-ACETABULAR IMPINGEMENT: PRELIMINARY RESULTS OF LABRAL REFIXATION

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Background: Recent advances in the understanding of the anatomy and function of the acetabular labrum suggest that it is important for normal joint function. We found no available data regarding whether labral refixation after treatment of femoro-acetabular impingement affects the clinical and radiographic results.

Methods: We retrospectively reviewed the clinical and radiographic results of fifty-two patients (sixty hips) with femoro-acetabular impingement who underwent arthrotomy and surgical dislocation of the hip to allow trimming of the acetabular rim and femoral osteochondroplasty. In the first twenty-five hips, the torn labrum was resected (Group 1); in the next thirty-five hips, the intact portion of the labrum was reattached to the acetabular rim (Group 2). At one and two years postoperatively, the Merle d’Aubigné clinical score and the Tönnis arthrosis classification system were used to compare the two groups.

Results: At one year postoperatively, both groups showed a significant improvement in their clinical scores (mainly pain reduction) compared with their preoperative values (p = 0.0003 for Group 1 and p < 0.0001 for Group 2). At two years postoperatively, 28% of the hips in Group 1 (labral resection) had an excellent result, 48% had a good result, 20% had a moderate result, and 4% had a poor result. In contrast, in Group 2 (labral reattachment), 80% of the hips had an excellent result, 14% had a good result, and 6% had a moderate result. Comparison of the clinical scores between the two groups revealed significantly better outcomes for Group 2 at one year (p = 0.0001) and at two years (p = 0.01). Radiographic signs of osteoarthritis were significantly more prevalent in Group 1 than in Group 2 at one year (p = 0.0001) and at two years (p = 0.009).

Conclusions: Patients treated with labral refixation recovered earlier and had superior clinical and radiographic results when compared with patients who had undergone resection of a torn labrum. Although the results must be considered preliminary, we now recommend refixation of the intact portion of the labrum after trimming of the acetabular rim during surgical treatment of femoro-acetabular impingement.

Level of Evidence: Therapeutic Level III. See Instructions to Authors for a complete description of levels of evidence.
tant role in the recognition of femoro-acetabular impingement and the development of a new strategy for treating it. Surgical hip dislocation allows the circumferential inspection of the acetabular rim, including the labrum, acetabular cartilage, and femoral head-neck junction, and provides an opportunity to treat intracapsular pathology. Treatment is aimed at improving the range of motion by reducing acetabular overgrowth (with methods that include débridement of damaged articular cartilage) and restoring a normal femoral head-neck offset. Until June 2001, it was our practice to address acetabular overgrowth by resecting the torn labrum after trimming the acetabular rim. However, histologic investigations of the resected labra showed that the tip of the labrum remained intact in the majority of hips and that the interface between the border of the acetabular cartilage and the base of the labrum showed substantial degeneration. These histologic findings prompted us to modify the technique of trimming the acetabular rim by débriding only the degenerated portion of the labrum while preserving its intact peripheral portion. Since July 2001, we have reattached the intact tip of the labrum to the resected surface of the remaining osseous acetabular rim.

To our knowledge, there is no information on the clinical and radiographic effects of labral refixation in patients treated for femoro-acetabular impingement. We performed a retrospective study to compare the outcomes of treatment of femoro-acetabular impingement with and without preservation of the labrum.

**Materials and Methods**

Between June 1999 and July 2002, 141 consecutive patients (149 hips) underwent surgical dislocation of the hip to treat femoro-acetabular impingement. Criteria for inclusion in the present study were the availability of complete preoperative and postoperative clinical (Merle d'Aubigné) scores and radiographic documentation (anteroposterior pelvic and cross-table lateral hip radiographs). Forty-eight patients (forty-eight hips) were excluded from the study because of incomplete clinical or radiographic documentation. To obtain comparable study populations, we also excluded patients with open growth plates (four patients with four involved hips), an age of greater than forty years (twenty-nine patients with twenty-nine involved hips), previous hip surgery (seven patients with seven involved hips), and participation in professional athletic activity (one patient with one involved hip). Professional or semi-professional athletes were excluded because they depend on sponsors and are thus motivated by financial interests to report an excellent result. No patient was excluded because of a high-work-load occupation.

The resulting two groups consisted of twenty patients (twenty-five hips) who had undergone surgery between June
1999 and June 2001 (Group 1) and thirty-two patients (thirty-five hips) who had undergone surgery between July 2001 and July 2002 (Group 2). Of these fifty-two patients, thirty-three were men and nineteen were women. The average age was thirty years (range, twenty to forty years). All of the patients had a moderate or low-work-load occupation. All patients had not responded to conservative treatment of the femoro-acetabular impingement, which included activity modification, restriction of athletic pursuits, and avoidance of symptomatic motion for a minimum of six months. The indications for surgery were persistent pain, mechanical symptoms, and radiographically confirmed structural abnormalities of the hip. Each patient was treated with the surgical technique described by Ganz et al.\textsuperscript{6,10} and was retrospectively assigned to one of two groups on the basis of the treatment of the labrum. Group 1 comprised patients who had undergone labral resection and resection of the overgrown portion of the acetabular rim, and Group 2 comprised patients who had undergone refixation of the acetabular labrum after rim resection.

Clinical evaluations were performed preoperatively and at one and two years postoperatively, by examiners other than the operating surgeons, with use of the classification system of Merle d’Aubigné and Postel\textsuperscript{12,13} (see Appendix). This score assigns a minimum of 0 points and a maximum of 6 points for pain, range of motion, and walking ability. A higher score indicates less pain and better function. The severity of the osteoarthritis was classified on the basis of anteroposterior pelvic radiographs, with use of the method described by Tönnis et al.\textsuperscript{14,15} (see Appendix).

The study was approved by the institutional review board of our hospital.

\textbf{Clinical Symptoms of Femoro-Acetabular Impingement}

Femoro-acetabular impingement usually presents in active young adults, who experience a slow onset of groin pain because of repetitive impingement between the femoral head and neck and the acetabular rim\textsuperscript{1}. During the initial stages, pain is intermittent and may be exacerbated by high demands on the hip during activities such as sports. Often, the individual experiences pain after sitting for a prolonged period\textsuperscript{14,16}. Examination of the hip frequently reveals limitation of the
range of motion, particularly internal rotation and adduction with the hip flexed to 90°.

**Impingement Test**

The impingement test is performed with the patient supine. The hip is internally rotated and adducted as it is passively flexed to 90°. The combination of flexion and adduction leads to the approximation of the femoral neck and the acetabular rim. Additional forceful internal rotation induces shearing forces at the labrum, creating a sharp pain.

**Imaging Studies**

Standardized conventional anteroposterior pelvic radiographs were made with the patient supine, a tube-to-film distance of 120 cm, and the tube oriented perpendicular to the table. Both lower limbs were positioned in 15° of internal rotation to present the anteverted femoral neck in its maximum length. The central beam was directed to the midpoint between the superior border of the pubic symphysis and a horizontal line connecting both anterior superior iliac spines. Pelvic inclination was standardized to a distance of 3 to 4 cm between the sacrococcygeal junction and the superior border of the pubic symphysis. Neutral pelvic rotation was achieved when the tip of the coccyx was aligned with the middle of the pubic symphysis and the radiographic teardrops, the obturator foramina, and the iliac wings were symmetrical.

Commonly observed radiographic and morphological abnormalities in hips with femoro-acetabular impingement include an anterosuperior osseous prominence at the femoral head-neck junction (Fig. 1-A), coxa profunda, protrusio acetabuli, ossification of the acetabular rim (Fig. 1-B), or acetabular retroversion (Figs. 2-A and 2-B). Although conventional radiography remains indispensable for assessment of the hip, it may be insufficient to detect subtle femoral alterations leading to femoro-acetabular impingement. Therefore, all patients underwent preoperative magnetic resonance arthrography to define the type of femoro-acetabular impingement and to assess the extent of labral and cartilaginous damage. To better delineate alterations of intra-articular structures within the hip that were not readily detectable on conventional radiographs, we used small flexible surface coils to study the hip of interest, injected gadolinium intra-articularly, and performed radial imaging sequences perpendicular to the true plane of the acetabulum (Fig. 3). These modifications made it possible to achieve an undistorted image of each aspect of the acetabular rim.

Magnetic resonance arthrography demonstrates the following changes commonly found in patients with femoro-acetabular impingement. The axial thin-slice fast low-angle shot (FLASH) sequence identifies anteversion or retroversion of the acetabulum and the presence or absence of cysts in the acetabular rim. The axial T1-weighted sequence demonstrates the shape of the anterior aspect of the femoral head and neck, the presence or absence of impingement cysts, the thickness of the joint capsule, and the presence or absence of periarthritis lesions. The sagittal and coronal oblique proton-density-weighted sequences identify the condition of the acetabular and femoral cartilage with regard to focal abrasion or cartilage tears and the presence and shape of labral tears and alterations in the labral substance (e.g., mucoid metaplasia, osseous apposition to the rim, or intralabral cysts). The radial proton-density-weighted sequence shows the exact site and extent of labral tears and focal cartilage lesions (Fig. 3).

**Operative Technique**

The patient is placed in the lateral decubitus position, and a Kocher-Langenbeck or Gibson-type approach is combined with a trochanteric flip osteotomy performed according to the technique described by Ganz et al. After approaching the capsule in the interval between the piriformis and gluteus minimus muscles, the surgeon performs a z-shaped capsulotomy for the right hip or an inverse z-shaped capsulotomy for the left hip (Fig. 4). Surgical dislocation is performed anteri-
ory. The insertions of the external rotator muscles and the piriformis muscle are left intact. The vascular supply to the femoral head is protected as long as the obturator externus muscle-tendon unit remains intact. With dislocation, a full 360° view of the femoral head and the acetabulum is effected. The site of femoro-acetabular impingement is documented, and the femoral head-neck junction, labrum, and acetabular cartilage are evaluated for the presence of any lesions. Immediately after the surgery in each of the patients in our study, the operating surgeon drew a standardized map of the operative findings, detailing the location and extent of labral and cartilage lesions (see Appendix). The map was included as part of the medical record.

The surgical treatment for femoro-acetabular impingement secondary to a femoral abnormality involves removal of any nonspherical portions of the femoral head, as assessed by overlaying the femoral head with a transparent spherical template matching the head size and restoring the normal diameter of the neck (Fig. 5). The minimal amount of bone necessary is resected to restore femoral head sphericity. Treatment of femoro-acetabular impingement due to acetabular causes includes resection of the relative anterior overgrowth (Figs. 6-A and 6-B). The amount of rim resection is determined by the degree of overcoverage and the magnitude of the damage to the acetabular cartilage. The acetabular overcoverage is corrected to a residual lateral center-edge angle of ≥20° to 25°. When the excessive acetabular rim is resected, the damaged acetabular cartilage is included in the resection. When there is residual acetabular cartilage damage after the bone resection, cartilage débridement is combined with microfracture of the subchondral bone. Since all of our patients who underwent surgical hip dislocation had been seen to have damage of the acetabular rim on preoperative magnetic resonance arthrography, both rim resection (débridement of degenerated labrum and/or cartilage) and femoral osteochondroplasty (Fig. 7) were always performed. Assessment of intraoperative impingement is repeated after each resection step to avoid residual abutment of the femoral head-neck junction and to minimize the amount of resection.

The labrum is reattached with two to six bone anchors

![Fig. 4](image-url)

Line drawing depicting a z-shaped capsulotomy for the right hip. The longitudinal limb (A) of the capsulotomy is performed parallel to the axis of the femoral neck (the iliofemoral ligament) and then is continued in line with the anterior intertrochanteric crest (B). The distal transverse limb is then directed anteriorly and medially at the base of the femoral neck toward the calcar area. Note that the most inferior portion of the capsular incision is now directed more medial than was initially described by Ganz et al., to avoid bleeding from a capsular branch of the lateral femoral circumflex artery (C). A cuff of capsular tissue is left on the inferior aspect of the neck for later reattachment of the capsular flap (D). Finally, the proximal transverse limb is formed by incising the capsule posteriorly along the superior aspect of the acetabular rim until the piriformis tendon is reached, with care taken not to damage the underlying labrum (E).
Fig. 5

A transparent, spherical template is used to identify the nonspherical portion of the femoral head-neck junction. The femoral osteochondroplasty is performed at the location where the template is lifted off from the femoral head (arrow). Only the minimum amount of bone necessary is resected to protect the superolateral entrance of the nutritional blood vessels to the femoral head.

Fig. 6-A

Fig. 6-B

**Fig. 6-A** Line drawing showing detachment of the acetabular labrum to address acetabular overgrowth. The tip of the acetabular labrum is sharply transected from the degenerated labral base with use of a knife and is taken down like a bucket-handle tear of a meniscus. **Fig. 6-B** Line drawing showing trimming of the excessive acetabular anterior overgrowth in a hip with acetabular retroversion. This resulted in restoration of normal acetabular version.
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 (GII Titanium Anchor; DePuy Mitek, Norwood, Massachusetts) placed around the acetabular rim, approximately 1.0 to 1.5 cm apart, close to the subchondral plate (Figs. 8, 9-A, and 9-B). Then, the labrum is further repaired to the rim with nonabsorbable sutures (Ethibond 1-0; Ethicon, Johnson and Johnson, Somerville, New Jersey). The knots of the sutures are placed on the capsular side of the labrum-bone junction. The capsule must be closed without tension (to avoid compromising the blood supply to the femoral head) at the site of arthrotomy by the end of each procedure. The resection is considered adequate if impingement is absent during flexion, adduction, and internal rotation.

 Statistical Analysis
 The nonparametric Wilcoxon signed-rank test was used to evaluate the significance of changes in each measured variable from the preoperative to the postoperative state within each group, and the nonparametric Mann-Whitney U test was employed to measure the significance of differences in outcomes between the two groups. Correlations between progression of radiographic changes of the hip and the overall outcome within both groups were determined with use of the Spearman correlation matrix. A p value of <0.05 was considered to be significant.

 Results
 Preoperatively, there were no significant gender-ratio or age differences between the two groups. The two groups also had similar preoperative Merle d’Aubigné overall scores (p = 0.98) and pain scores (p = 0.7) as well as similar radiographic grades of osteoarthritis (p = 0.3). There were no significant differences between the groups regarding the extent or depth of the damage to the articular cartilage found intraoperatively (p = 0.07). In Group 1, the average sector of acetabular cartilage damage ranged from 11 o’clock to 3 o’clock and the average depth of the cartilage lesions was 12 mm (range, 5 to 15 mm). The average sector of the acetabular cartilage lesions in Group 2 also ranged from 11 to 3 o’clock and the depth of cartilage damage averaged 9 mm (range, 5 to 20 mm).

 Clinical Outcome
 In Group 1 (labral resection), the mean Merle d’Aubigné score improved from 12 points (range, 8 to 13 points) preoperatively to 14 points (range, 14 to 18 points) at one year (p = 0.0003) and 15 points (range, 10 to 18 points) at two years (p = 0.0009) (Table I). The mean pain score improved from 1.4 points (range, 0 to 2 points) preoperatively to 3.4 points (range, 0 to 6 points) at one year (p = 0.005) and 4.0 points (range, 0 to 6

 Fig. 7
 Line drawing of a resection osteochondroplasty performed to restore normal femoral head-neck offset and femoral head sphericity.
Fig. 8
Intraoperative photograph showing the technique of labral refixation. After trimming of the acetabular rim, the labrum is reattached with screw-anchors placed approximately 1.5 cm apart. Sutures are used to reattach the capsular side of the labrum (arrows) to the acetabular rim.

Fig. 9-A
Preoperative anteroposterior pelvic radiograph showing bilateral combined femoro-acetabular impingement secondary to nonspherical femoral heads and cephalad acetabular retroversion. Proximally, the anterior aspects of the acetabular rims (solid lines) project laterally to the posterior aspects of the rims (dotted lines), representing the pincer component. The osseous prominences on the femoral heads at the lateral head-neck junctions (arrows) reflect the cam component.
points) at two years (p < 0.0001). Although the majority of patients in Group 1 had a good or excellent clinical result at one year, some patients had a moderate or poor outcome. These patients had a high preoperative pain level (mean pain score, 1 point; range, 0 to 2 points). Group 1 had no significant gain in the range of motion at one or two years.

In Group 2 (labral refixation), the mean Merle d’Aubigné score increased from 12 points (range, 5 to 16 points) preoperatively to 17 points (range, 14 to 18 points) at one year (p < 0.0001) and remained at 17 points (range, 13 to 18 points) at two years (p < 0.0001) (Table I). The mean pain score was 1.5 points (range, 0 to 2 points) preoperatively, improved to 5.5 points (range, 1 to 6 points) at one year (p < 0.0001), and remained almost the same at 5.6 points (range, 4 to 6 points) at two years (p < 0.0001). There were no significant gains in any of the arcs of motion at one or two years (Table I).

Group 2 had significantly better clinical outcomes than Group 1 at one year (p = 0.0001) and at two years (p = 0.01). According to the system of Streック for grading the overall Merle d’Aubigné score, 28% (seven) of the twenty-five hips in Group 1 had an excellent result at two years, 48% (twelve) had a good result, 20% (five) had a moderate result, and 4% (one) had a poor result, whereas 80% of the thirty-five hips in Group 2 had an excellent result, 14% had a good result, and 6% had a moderate result at two years. There were no poor results at two years in Group 2. The increase in the overall Merle d’Aubigné score was 15% in Group 1 but twice that (30%) in Group 2 (p = 0.001). The average pain score was improved by 59% in Group 1 and by 73% in Group 2 (p = 0.0009). In both groups, there was a high correlation between pain and the overall clinical outcome (r = 0.85; p < 0.0001). There were no surgical complications in either group.

Radiographic Findings

Group 2 had significantly less radiographic evidence of progression of osteoarthritis at one year (p = 0.02) and two years (p = 0.009). In Group 1, the average Tönnis grade doubled from 0.6 preoperatively to 1.2 at one year (p = 0.002) and remained nearly the same (1.3) at two years (p = 0.01) (Table I). In Group 2, the Tönnis grade at one year was the same as the preoperative value (0.5) but the score progressed slightly to 0.8 at two years (p = 0.0027). No significant correlation was found between the Tönnis grade and the overall Merle d’Aubigné score (r = 0.3; p = 0.4) or between the Tönnis grade and the Merle d’Aubigné pain score (r = 0.3; p = 0.78). All patients were seen radiographically to have a normalized acetabular orientation and depth and a restored femoral head-neck offset at one and two years postoperatively.

Discussion

Labral tears have been described in association with hip dysplasia, with trauma, and, most recently, with femoroacetabular impingement. In dysplastic hips, labral tears result from high shear stresses caused by the anterolateral migration...
of the femoral head from the deficient acetabular coverage. Labral injuries can also occur as a result of acute hip trauma. More recently, the concept of femoro-acetabular impingement has been proposed as a potential cause of labral damage in the nondysplastic hip. With both cam-type and pincer-type femoro-acetabular impingement, motion-induced damage at the anterosuperior aspect of the acetabular rim is initiated at the junction between the labrum and the adjacent acetabular cartilage. Recently, Ito et al. reported that the tip of the labrum remains intact in most hips with femoro-acetabular impingement, even in the presence of osteoarthritis.

Anatomical studies performed by Seldes et al. showed the existence of small groups of blood vessels in the circumferential synovial layer surrounding the labrum at its site of attachment to the peripheral surface of the acetabular rim. Petersen et al. showed, with immunohistochemical analysis, that the vascularization of the labrum is predominantly provided by the capsule of the hip, which nourishes the peripheral third of the labrum; in contrast, the inner two-thirds of the labrum are almost avascular. Because of the almost avascular nature of the labral substance, we considered it important to provide a bleeding cancellous bone surface to obtain stable labral refixation. Labral refixation was performed with a technique similar to that used for reattaching the torn labrum in the shoulder with metal suture-anchors.

The acetabular labrum functions as a shock absorber and effects proper joint lubrication and pressure distribution. Biomechanical studies performed by Ferguson et al. revealed that hydrostatic fluid pressurization within the joint space is greater in the presence of an intact labrum, which may enhance joint lubrication. Hydrostatic pressurization was impaired in hips without an acetabular labrum. Absence of this fluid seal resulted in higher joint loads on force transmission and poorer joint lubrication. Thus, the labrum acts like a seal that prevents fluid loss from the joint and protects articular cartilage. In addition, Kim and Azuma investigated the innervations of the acetabular labrum that provide nociception and proprioception and concluded that the labrum functions as a “sensible shock absorber” of the hip. These biomechanical and physiologic functions of the labrum can be preserved to some extent if the labrum can be reattatched and heals.

In this study, patients treated with labral refixation recovered earlier and had superior clinical and radiographic results when compared with patients who had had resection of the torn labrum. Improvements in hip scores were mostly attributable to improvements in pain scores. The findings of our study are supported by the results reported by Ferguson et al. However, we must emphasize that our short-term results must be evaluated after a longer period of follow-up to better understand the ultimate effect of this new approach.

Weaknesses of this study include its retrospective nature and its lack of randomization. In addition, the Tönnis radiographic grading system and the Merle d’Aubigné clinical score lack sufficient sensitivity to assess subtle changes associated with early osteoarthritis secondary to femoro-acetabular impingement. Most patients with femoro-acetabular impingement experience intermittent pain, sometimes only during athletic activities, but have no substantial functional loss. As Groups 1 and 2 were sequential, not simultaneous, cohorts, some of the improvement in outcome in Group 2 could be attributed to improved surgical technique, which is inevitable with greater experience. However, because the groups were similar in terms of pathological findings, age, and sex, we believe that they were comparable.

Femoro-acetabular impingement may be an important factor in the pathogenesis of osteoarthritis of the hip, particularly in hips currently considered to have an “idiopathic” etiology. In light of reports of encouraging results after the treatment of femoro-acetabular impingement, these new data on the effect of labral refixation may be important as preservation of the intact portion of the labrum yielded better early results. On the basis of the results of this study, we consider refixation of an intact portion of the labrum to be superior to labral resection. Long-term follow-up will be necessary to assess whether use of this technique results in improved functional outcomes and a reduction in the prevalence of symptomatic osteoarthritis in affected patients.

Appendix

Tables showing the Merle d’Aubigné score and the Tönnis osteoarthritis classification score and a figure depicting an intraoperative map are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on “Supplementary Material”) and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM).

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