Assessment of arthroscopic management of femoroacetabular impingement. A prospective multicenter study

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Summary
Introduction: Surgical treatment of femoroacetabular impingement can be performed under arthroscopic control, to limit associated morbidity. Encouraged by recent good reports, arthroscopy is replacing alternative techniques for this indication.
Hypothesis: Arthroscopy enables femoroacetabular impingement to be corrected with a low rate of associated morbidity.
Aim of study: To assess the indications for and quality of the technique and its impact on preliminary results and complications. To investigate preoperative prognostic factors.
Patient and methods: One hundred and eleven hips in 110 patients (78 male, 32 female; mean age, 31 years) were operated on under arthroscopic control for femoroacetabular impingement, by six senior surgeons. Sixty-five patients showed no radiographic sign of osteoarthritis, and 36 showed grade-1 early osteoarthritis on the Tönnis scale.
Femoroacetabular impingement (FAI) has recently come to occupy an important place among mechanical hip disorders leading to osteoarthritis in young subjects [1—5]. The analysis of the pathology has laid the basis for modern surgical management, founded on correction of the underlying bony dysmorphia and treatment of the resulting joint lesions. The reference technique involves wide exposure by surgical dislocation [6,7]. This facilitates the performance and control of osteoplasty, but at the cost of invasiveness. Other approaches were therefore developed, such as a minimally invasive anterior approach with or without an arthroscopic approach [8—11]. Treatment completely under arthroscopic control was also developed in parallel and was quickly and widely adopted. The technique is attractive, being intrinsically minimally invasive. It is, however, technically demanding, and not without risk of complications. The charge book requires a result equivalent to that of open surgery.

The present prospective study sought to assess how far we were able to respect these conditions. We examined our preliminary functional results to determine whether the procedure (1) was effective in terms of impingement symptomatology while (2) remaining relatively innocuous. We also investigated (3) the impact of preoperative radiologic assessment on the type of bone resection chosen, and (4) whether individual or technical factors affected results.

Patients and methods

Patients

Patients undergoing arthroscopic management of FAI were prospectively included over a 1-year period from March 2008 to March 2009. Patients were consecutively operated on by six senior surgeons (NB, TB, JEG, FL, OM and AN) in five centers. The groups were homogeneous, limiting any center effect. Surgery was indicated for disabling symptomatology of more than 6 months' duration. Included patients presented with clinical and radiological signs of impingement [1] and limited osteoarthritis on radiography (< grade 2 on the Tönnis scale [12]). The mean interval between symptom onset and surgery was 2.5 years (range, 6 months to 10 years). Impingement secondary to dysmorphic sequelae of treated childhood pathology, trauma or surgical correction of dysplasia were excluded.

In all, 110 patients (111 hips) were included. Two-thirds of the patients were male (78 men, 32 women), and 57% of cases involved the right hip. Mean age was 31 years (range, 16—49 years). There was no loss to follow-up.

Surgical technique

Different installations and surgical sequences were employed. Dorsal decubitus on traction table with perineal support was chosen by five surgeons, and lateral decubitus on traction table with gluteal support by one [13]. Surgical chronology in the central and peripheral compartments varied according to the operator. Five of the six surgeons began with the peripheral compartment, without traction. Limited capsulectomy under visual intra-articular control was performed to facilitate exposure and bone resection, and could, if required, be completed by complementary capsulotomy, reducing traction force and enabling safer access to the central compartment. The sixth surgeon preferred primary central compartment access under traction.

Osteoplasty used a round or cylindrical motorized burr of 4 to 5.5 mm diameter.

Femoroplasty was systematically performed in case of impingement preoperatively classified as cam-type or mixed [1,14], and was performed in association with acetabuloplasty in five cases of pincer-type impingement reclassified as mixed following peroperative discovery of femoral asphericity. Femoroplasty quality was judged visually by a dynamic test in flexion and internal rotation to check for any residual impingement.

Acetabuloplasty was performed in case of crossover sign associated with > 25° anterior and/or lateral center-edge angles. It was systematic in case of pincer-type impinge-
Arthroscopic management of femoroacetabular impingement

Figure 1  A: acetabular rim trimmed to 2–3 mm depth anteriorly up to the edge of the stable cartilage. B: edge of the stable cartilage (cylindrical 4 mm-diameter burr, view of central compartment). C: fluoroscopic control of geographic situation of acetabuloplasty. The palpation hook serves as height reference. D: same hip under arthroscopic view (labrum non-conserved in osteoplasty region).

ment but was not performed in eight cases classified as mixed; this was a surgical response to an aspect of limited cartilage lesion and/or low anterior and lateral coverage angles. Acetabuloplasty depth was guided by the extent of the cartilage lesions, with the requirement to conserve coverage angles equal to or greater than 25°: 1 mm of bone resection was considered to correspond to roughly 1° of correction. In principle, bone resection did not exceed the border between healthy and damaged cartilage (Fig. 1 A, B). Osteoplasty could be under fluoroscopic control (Fig. 1 C, D). Central compartment joint-surface cartilage lesion depth was assessed on Outerbridge’s classification [15], and the clock-face location and extent were noted and assessed. The labrum was described in terms of size, aspect and lesion type. Lesion topography and area were also noted. Cartilage lesion area and depth was always variable. Delamination was the most frequent lesion type. The labrum was judged to be intact in eight cases, and damaged in the other 103. It was sutured in 14 cases of labral base deep tear with conserved labral body. The lesion was completed by arthroscopy knife, then sutures were passed around or through the labral body by forceps or Reverdin suture needle. Reattachment used bioresorbable anchors impacted in the bony edge of the acetabulum following acetabuloplasty or simple rasping. In 89 cases, debridement or partial resection was performed on a complex lesion considered to be unrepairable or by the surgeon’s choice. Debridement of unstable cartilage or labral lesions used a motorized shaver sometimes also using radiofrequency electrodes. In 41 cases, areas of bare subchondral bone (Outerbridge grade 4) remained after debridement or acetabuloplasty: their area was measured, and microfracture was performed.

Assessment

All patients underwent pre- and postoperative clinical assessment. Preoperative and end-of-FU functional assessment was on the Western Ontario and McMaster Universities

Figure 2  A: modified Dunn’s lateral axial view (hip in 60de flexion, foot in neutral rotation): clear asphericity of femoral head (α angle > 50°). B: correction following femoroplasty. C: corresponding arthroscopic view.
Osteoarthritis Index (WOMAC) index [16], expressed as a score out of 100. At end of follow-up, patients were asked if they were disappointed, moderately satisfied, satisfied or very satisfied with the result of their operation.

Preoperative and end-of-FU standard radiologic assessment comprised: AP pelvic, false profile and lateral or axial views showing the anterior side of the neck. Depending on the author, this was a cross-table lateral view, or a Ducroquet or modified Dunn lateral view (Fig. 2). All patients underwent complementary preoperative imaging (arthroscan, MRI or arthro-MRI). Femoral head sphericity was assessed by the $\alpha$ angle [17] measured on a lateral or axial view [18], with $\alpha < 50^\circ$ considered normal. Where X-ray views were uninformative, complementary measurements were made on the cross-sectional images, quality permitting.

Acetabular retroversion, indicated by crossover sign, was explored for on centered AP pelvic view [19]. The symphysis-coccyx distance was respected (1 to 2 cm) to avoid functional retroversion due to anterior pelvic tilt [1,20]. Osteoarthritis was assessed from the AP pelvic and false profile views [21], and graded according to the Tönnis classification [12]. So as better to differentiate grades 1 and 2, we completed the original items with a quantification of joint-space narrowing and presence/absence of anterosuperior femoral head off-centering on AP pelvic or false profile view (Table 1): if, on AP pelvic or comparative false profile view, narrowing of whatever extent was less than half the joint-space thickness, it was classified as grade 1 and, if it was more than half the joint-line thickness and/or in case of femoral head migration into the cartilage defect area, it was classified as grade 2 (Figs. 3A–B). Dysplasia characteristics were measured on the same incidences; dysplasia was considered borderline in case of center-edge angle between 20° and 25° [22].

On radiologic analysis, 41 hips (37%) were classified, on the basis of isolated femoral asphericity, as having cam-type impingement. Thirteen (12%) were classified, on the basis of acetabular retroversion, protrusion or coxa profunda, as pincer-type. Fifty-seven (51%) showed associated femoral and acetabular abnormality, and were classified as mixed. Seventy-five (68%) showed no osteoarthritis on X-ray (Tönnis grade 0) and 36 (32%) showed signs of early osteoarthritis (grade 1). Nine (8%) had borderline acetabular dysplasia angles, but center-edge angle was never less than 20°.

Given the variety of lateral and axial incidences used and their non-reproductibility, pre- and postoperative alpha angles could not be satisfactorily compared in only 41 cases.

### Statistical analysis

Quantitative data are reported as mean, standard deviation and range.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Characteristics according to Tönnis [12]</th>
<th>Additional characteristics in the present series</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No signs of osteoarthritis</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Slight narrowing of joint space, slight lipping at joint margin, slight sclerosis of femoral head or acetabulum</td>
<td>Narrowing of less than half the depth of the joint-space, without femoral head off-centering</td>
</tr>
<tr>
<td>2</td>
<td>Small cysts in, increased narrowing of joint space, moderate loss of sphericity of femoral head</td>
<td>Narrowing equal to or greater than half the depth of the joint-space, and/or femoral head off-centered</td>
</tr>
<tr>
<td>3</td>
<td>Large cysts, severe narrowing or obliteration of joint space, severe deformity of femoral head, avascular necrosis</td>
<td></td>
</tr>
</tbody>
</table>
The Student T test for matched series was used to compare pre- and postoperative scores. For group comparison, non-parametric Wilcoxon and Mann-Whitney tests were preferred, as the WOMAC score distribution was non-normal and certain groups counted no more than 30 subjects. A 5% first-order risk threshold was set to determine the significance of comparisons. All analyses used SPSS 13.0 software under Windows®.

Results

In all but one operation, central and peripheral compartment access enabled surgery to be performed as intended.

At a mean 10 months’ FU (range, 6–18 mo), mean WOMAC score had increased from 60.3 ± 14.8 (32–96) to 83 ± 16.4 points (37–100); i.e., a mean gain of 22.7 points (p < 0.001). Eighty-five patients (77%) were satisfied or very satisfied with their result; 25 (27%) were moderately satisfied and 12% disappointed. The satisfaction index correlated strongly with functional score (p < 0.001).

Five patients (4%) underwent revision for hip replacement (three for resurfacing with twin cups, and two for total hip replacement) at a mean 1 year (11–15 mo) after arthroscopy; they had shown preoperative signs of osteoarthritis (grade 1), not relieved by surgery.

At end of radiologic follow-up, there were no cases of worsening of osteoarthritis, including in the five reoperated patients. Mean α angle (n = 41) decreased from 64.6° ± 12° (55°–90°) preoperatively to 50.6° ± 6.3° (40°–75°) after femoroplasty (p < 0.001). Thirteen patients showed under-correction (34%), but without significantly poorer functional results.

Complications were observed in seven cases (6%). Three patients developed ectopic ossification: two Brooker grade 2 and one grade 3 [21]. The grade 3 case concerned a preoperatively osteoarthritic hip revised by total hip replacement. One grade 2 hip showed flexion limited to 100° ± 6.3° (40°–75°) after femoroplasty (p < 0.001). Thirteen patients showed under-correction (34%), but without significantly poorer functional results.

The present study involves a certain number of limitations:

• interpretation of the findings is subject to the shortness of follow-up: functional results generally stabilize at 6 to 12 months [9, 29, 31], so that success or failure cannot be definitively judged before 1 year’s follow-up;
• the multioperator design of the study entailed differences in technical sequence and methods of peroperative assessment of impingement resolution;
• radiologic assessment of the bone surgery performed was comparative only in a limited number of cases.

Discussion

The short-term efficacy of surgical treatment of FAI symptomatology is now well established, whatever the surgical technique and type of functional assessment employed [7–11, 13, 24–35].

The present functional results match those of the literature, being good or very good in almost 80% of cases. Most patients who did not show improvement had diffuse cartilage lesions associated with early osteoarthritis. In the other patients, free of osteoarthritis on X-ray, independently of cartilage status, bone abnormalities may have been insufficiently or inappropriately corrected, despite peroperative observation. Surgery should address the causes and consequences of impingement if it is to achieve an optimal result [36–38]. Osteoplasty planning, performance and assessment are thus a major operational issue.

Preoperative classification in terms of cam, pincer and mixed impingement is not always straightforward when based on standard X-ray alone [39, 40]. In the present series, this sometimes led to discrepancies between types as diagnosed radiologically and the osteoplasty actually performed.

To optimize the assessment of femoral head sphericity, it can be helpful for the lateral or axial view to be completed by radial cross-sectional imaging [41] or 3D reconstruction [42]. On the acetabular side, while the crossover sign indicates retroversion, this does not systematically mean excessive coverage, as seen in the possible association with dysplasia [43–45]. While the dysplasia parameters and angular values are well defined, the same is not yet true for the characteristics and limits of excess coverage [46, 47]. In the present study, retroversion had to be associated with anterior and/or lateral coverage angles greater than 25° for excessive coverage to be diagnosed and acetabuloplasty indicated.

Not only the dysmophia but also the quality of the osteoplasty may sometimes be difficult to assess, incurring a risk of inappropriate correction [48, 49]. Peroperative
Table 2  Impact of preoperative osteoarthritis (n, % incidence) on functional result (mean postop. score ± SD [gain in points, p value]) and satisfaction index (% incidence).

<table>
<thead>
<tr>
<th>Osteoarthritis</th>
<th>Number of hips (%)</th>
<th>WOMAC</th>
<th>Satisfied or very satisfied (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
<td>75 (68)</td>
<td>87.5±13 (26, p&lt;0.001)</td>
<td>81</td>
</tr>
<tr>
<td>Grade 1</td>
<td>36 (32)</td>
<td>73.7±19 (18, p&lt;0.001)</td>
<td>61</td>
</tr>
</tbody>
</table>

WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

Dynamic testing is not always informative, and fluoroscopy may then be very helpful in controlling bone resection [50–52]. Finally, mapping of labrum and cartilage lesions found during surgery may in some cases confirm diagnosis and further guide the choice and extent of osteoplasty to be performed [14,31].

The presence of established osteoarthritis emerged as an important negative prognostic factor for functional result. Only 60% of patients with early osteoarthritis (grade 1) showed improvement, and the five patients undergoing prosthetic revision were in this category. Whatever the technique employed, a 0 to 30% rate of revision with total hip replacement is reported following conservative surgery for FAI [9,13,24,26–33]. In studies using the Tönnis classification (Table 3), revision was mainly in case of osteoarthritis (grade ≥ 1). Revision was performed early, but incidence is still to be interpreted bearing in mind the very short follow-up reported in certain studies. It is noteworthy that the proportions of osteoarthritis grades differ greatly between series (Table 3). This probably corresponds more to variations in the interpretation of the Tönnis classification than to any center-dependent variation in epidemiological distribution. To facilitate the use of this classification, we introduced a quantification of joint-space narrowing.

Table 3  Frequency and characteristics of revision by total hip replacement or resurfacing (n and %) according to osteoarthritis grade in studies using the Tönnis classification [12].

<table>
<thead>
<tr>
<th>Authors, Technique used</th>
<th>Number of hips</th>
<th>Mean FU (range) (years)</th>
<th>Incidence and osteoarthritis grade</th>
<th>Arthroplasty (%)</th>
<th>Preop osteoarthritis in implanted hips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaulé et al. [26], SD</td>
<td>37</td>
<td>3.1 (2.1–5)</td>
<td>≤ G1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Beck et al. [24], SD</td>
<td>19</td>
<td>4.7 (4–5.2)</td>
<td>G0: 36% G1: 52%, G2: 10%</td>
<td>5 (26)</td>
<td>2 G1, 2G2 and 1 labral ossification</td>
</tr>
<tr>
<td>Gédouin et al. [13], A</td>
<td>38</td>
<td>1.3 (0.5–3)</td>
<td>G0: 79% G1: 21%</td>
<td>3 (8)</td>
<td>3 G1</td>
</tr>
<tr>
<td>Horisberger et al. [32], A</td>
<td>105</td>
<td>2.3 (1.3–4.1)</td>
<td>G0: 1% G1: 72%, G2: 27%</td>
<td>9 (8)</td>
<td>4 G1 and 5 G2</td>
</tr>
<tr>
<td>Larson and Giveans [29], A</td>
<td>100</td>
<td>0.82 (0.25–3)</td>
<td>G0: 71% G1: 17%, G2: 12%</td>
<td>3 (3)</td>
<td>2 G1 and 1 G2</td>
</tr>
<tr>
<td>Laude et al. [9], MO</td>
<td>100</td>
<td>4.8 (2.2–8.7)</td>
<td>G0: 70% G1: 30%, G2: 3%</td>
<td>11 (11)</td>
<td>NS</td>
</tr>
<tr>
<td>Peters et al. [33], SD</td>
<td>96</td>
<td>2.2 (1.5–8)</td>
<td>G0: 30% G1: 46%, G2: 24%</td>
<td>6 (6)</td>
<td>3 G1 and 3 G2</td>
</tr>
<tr>
<td>Sadri [27] SD vs A</td>
<td>31 (SD)</td>
<td>2 (2)</td>
<td>G: 100%</td>
<td>1 (3)</td>
<td>1 G0</td>
</tr>
<tr>
<td>Present series, A</td>
<td>111</td>
<td>0.83 (0.5–1.5)</td>
<td>G0: 68% G: 32%</td>
<td>5 (4.5)</td>
<td>5 G1</td>
</tr>
</tbody>
</table>

SD: Surgical dislocation; A: Arthroscopy; MO: Mini-open; NS: not supplied.
and off-centering of the femoral head to help differentiate between grades 1 and 2 (Table 1). From our own experience, and following the Bern team [42], we do not consider that conservative surgery provides lasting relief in FAI with associated osteoarthritis of more than grade 1 severity.

The impact of labral repair on functional results and its role in the prevention of osteoarthritis remain debated. Espinosa et al. [7] and Phillippon et al. [30] reported better results in case of labral repair than of simple debridement. Such were not the findings of Laude et al. [9], who found no significant difference between the two treatments. Biomechanically, it seems logical to conserve the labrum, but its preventive role with respect to osteoarthritis is based mainly on theoretical and experimental considerations [53,54]. Unlike in the case of meniscectomy, data are lacking regarding effect of partial labrum resection on the subsequent development of osteoarthritis. Only 14 patients in the present series underwent labral suture—not sufficient for any conclusion to be drawn, even though the mean functional and satisfaction scores in this group were high. Reattachment is a relatively complex technique, requiring a learning curve, and this may affect suture quality, impacting recovery of the labrum’s biomechanical role. Moreover, the additional operative time required entails an increased risk of traction-related complications. These difficulties and uncertainties led some of the surgeons in the present study to prefer debridement or partial resection instead of labrum repair. Others performed repair in case of labrum base deep tear, or following acetabuloplasty when the labrum body was conserved.

Arthroscopic treatment of FAI is technically demanding. It entails the complications risk inherent to any arthroscopy of the hip, but also risks specific to the treatment of FAI [50,55—58]. Complications may be related to the bone resection performed. This is the case for heterotopic ossification, the incidence of which varies between series (Table 4). It may be induced by defective bone debris evacuation, but is not specific to arthroscopy [9,26,27]. There is also a risk of increasing the rate of neurological complications inherent to traction. Acetabuloplasty, especially when associated to labral reinsertion, involves longer traction time than simple debridement. The rate of neuapraxia reported in recent series has been generally low (Table 4). Pudendal nerve damage may, however, be underestimated in the absence of focused interview [59,60]. In order to better prevent neurologic and perineal complications, therefore, traction time and intensity should be limited. By beginning surgery with the peripheral compartment, the hip relaxed, total traction time is shortened and traction intensity reduced thanks to prior capsulotomy. This attitude, reported by certain European teams, with technical variations [13,32,34,61,62], was adopted by five surgeons in the present study. This sequence had the advantage of limiting the risk of iatrogenic cartilage and labral lesion, central compartment access being under visual control. The risk of perineal complications induced by compression can also be reduced by the use of adapted perineal supports (wide, soft) or alternative systems [13,27].

| Table 4 | Comparison of complications (n (% incidence)) in series of arthroscopic treatment of femoroacetabular impingement. |
|-----------------|---------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Authors (date)  | Number of hips | Total complications (%) | Heterotopic ossification (%) | Neurologic complications | Perineal skin complications (%) |
| Byrd and Jones [29] | 207 | 3 (1.4) | 1 (0.5%) | 0 | 2 (1%) | 1 lateral femoral cutaneous, 1 pudendal |
| Gédouin et al. [34] | 38 | 0 | 0 | 0 | 0 | 0 |
| Horisberger et al. [30] | 105 | 12 (11) | 0 | 0 | 9 (8%) | 1 lateral femoral cutaneous and pudendal |
| Ilizaliturri et al. [26] | 19 | 0 | 7 (37) | 0 | 1 (1%) | 1 lateral femoral cutaneous |
| Larson and Giveans [27] | 100 | 7 (7) | 0 | 0 | 9 (9%) | 1 lateral femoral cutaneous |
| Phillippon et al. [28] | 122 | 0 | 0 | 0 | 0 | 0 |
| Sadri [25] | 32 | 1 (3) | 0 | 0 | 0 | 1 (0.9%) |
| Sampson [23] | 120 | 1 (0.8) | 0 | 0 | 1 (0.9%) | 1 (0.9%) |
| Present series | 110 | 7 (6) | 3 (2%) | 1 | 2 (1.8%) (1 femoral, 1 pudendal) |

a Not considered as complications: revision for osseous under-correction or implant; benign hematoma.
b Following crossover to open surgery.
Conclusion

Arthroscopy seems to be a reliable means of providing relief to patients suffering from FAI. Simple precautions and technical optimization should be effective in reducing the risk of complications. Preoperative analysis of impingement type and bone surgery planning still lack reproducibility: further studies will be needed to improve this aspect of the technique. Cartilage status is a major prognostic factor, and we would not recommend arthroscopy in case of evolved osteoarthritis. In early arthritis, results are moderately good, and it may be considered on a case-by-case basis, taking patient age into account. Follow-up was short in the present series; despite the multioperator design, however, the results agreed with the present data in the literature. Only prospective follow-up will help determine the impact of this technique on the natural history of FAI over the medium to long term.

Conflict of interest statement

None.

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