



Treatment of femoroacetabular impingement by arthroscopy versus anterior mini-open approach: Case-control study of a continuous series of 91 cases at a mean 4.6 years' follow-up

Pierre Martinot, Teddy Trouilleux, Julien Dartus, Sophie Putman, Julien Girard,
Henri Migaud

► To cite this version:

Pierre Martinot, Teddy Trouilleux, Julien Dartus, Sophie Putman, Julien Girard, et al.. Treatment of femoroacetabular impingement by arthroscopy versus anterior mini-open approach: Case-control study of a continuous series of 91 cases at a mean 4.6 years' follow-up. *Orthopaedics & Traumatology: Surgery & Research*, 2020, 106, pp.1575 - 1580. <10.1016/j.otsr.2020.07.006>. <hal-03492669>

HAL Id: hal-03492669

<https://hal.science/hal-03492669v1>

Submitted on 15 Dec 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY-NC 4.0 - Attribution - Non-commercial use - International License

Treatment of femoroacetabular impingement by arthroscopy versus anterior mini-open approach: Case-control study of a continuous series of 91 cases at a mean 4.6 years' follow-up.

Pierre **Martinot**^{a, b, *}, Teddy **Trouillez**^{a, b}, Julien **Dartus**^{a, b}, Sophie **Putman**^{a, b},
Julien **Girard**^{a, b}, Henri **Migaud**^{a, b}

a Université de Lille, Hauts de France, F-59000 Lille, France

b Service d'Orthopédie, Hôpital Salengro, Place de Verdun, CHU Lille, F-59000 Lille, France

* Corresponding author: Pierre Martinot,

Service d'Orthopédie, Hôpital Salengro, Place de Verdun, CHU Lille, F-59000 Lille, France

E-mail: pierre.martinot@hotmail.fr

Tel.: +33 (0)6 62 42 76 92

Fax: +33 (0)3 20 44 66 07

Abstract

Introduction

Femoroacetabular impingement is a frequent cause of hip pain, and can be managed by conservative surgery. Many studies assessed postoperative course, but none compared operative techniques within a given population. We therefore conducted a retrospective case-control study comparing the minimally invasive anterior Hueter approach versus arthroscopy, assessing difference in 1) functional gain and 2) complications and 3) analyzing the impact of labral or cartilage lesions on functional scores.

Hypothesis

Clinical results do not differ between the mini-open and arthroscopic approach.

Material and method

Between 2007 and 2018, 91 hips in 84 patients were treated for femoroacetabular impingement: 69/91 (75.8%) cam effect, 6/91 pincer effect (6.6%) and 16/91 mixed (17.6%). Fifty-five were treated by arthroscopy and 36 by the Hueter mini-open approach. There were 20 female and 71 male hips. Mean age at surgery was 32 years (range, 17-55 years). Potential predictive factors comprised Nötzli alpha angle, labral/cartilage lesion and type of surgery.

Results

Mean follow-up was 4.6 years (range, 1-16 years), with no loss to follow-up. The arthroscopy and Hueter groups showed no differences in functional improvement on Oxford-12 score (gain, -6.7 ± 5.9 versus -6.2 ± 8.1 ($p=0.73$), Postel Merle d'Aubigné (PMA) score (gain, 1.3 ± 1 versus 1.1 ± 0.9 ; $p=0.41$), operative time (75 versus 67 min; $p=0.16$), or alpha angle correction (-10.9 ± 12.9 versus -9.8 ± 7.1 ; $p=0.22$). Complications did not differ: 1/55 severe complications after arthroscopy (1 definitive femoral nerve palsy) versus 4/36 non-severe complications after Hueter (3 cases of dysesthesia in the lateral cutaneous nerve of the thigh, 1 rectus femoris enthesopathy) ($p=0.15$). Labral lesions (37/91) did not affect clinical outcome: gain, 1.2 ± 1 versus 1.3 ± 0.9 on PMA ($p=0.514$) and -7.3 ± 6 versus -6 ± 7.3 on Oxford-12 ($p=0.366$). Cartilage lesions (27/91) were associated with poorer outcome on PMA (gain, 1 ± 1.1 versus 1.3 ± 0.9 ; $p=0.002$) but not on Oxford-12 (gain, -6.1 ± 7.3 versus -6.7 ± 6.6 ; $p=0.288$).

Conclusion

Impingement correction by the minimally invasive anterior Hueter approach gave clinical results comparable to those of hip arthroscopy in terms of Oxford and PMA scores, alpha angle correction, operative time and complications rate. Cartilage lesions were associated with poorer clinical results.

Level of evidence: III; retrospective case-control study

Key-words: femoroacetabular impingement syndrome, mini-open Hueter approach, anterior approach, hip

arthroscopy, cam impingement, pincer impingement.

1. Introduction

Femoroacetabular impingement is a frequent cause of hip pain in young subjects [1]. Without treatment, it can lead to labral and cartilage lesions, resulting in osteoarthritis [2]. An international consensus statement addressed this pathology [3]. Conservative surgery is recommended, and is presently on the rise [4].

Several surgical approaches are discussed: surgical dislocation, minimally invasive anterior Hueter approach, anterolateral approach and arthroscopy [5-6]. Many patients are now treated by hip arthroscopy, reputed to be less invasive and hastening recovery [7]; however, it involves a learning curve, especially for conservative labrum procedures. The mini-open Hueter approach is classical and simple, providing rapid exposure [5].

Many studies assessed postoperative course, but none compared techniques between Hueter and arthroscopy. We therefore conducted a single-center retrospective case-control study comparing femoroacetabular treated by the Hueter approach versus arthroscopy, assessing difference in 1) functional gain and 2) complications and 3) analyzing the impact of labral or cartilage lesions on functional scores. The study hypothesis was that clinical results do not differ between the mini-open Hueter approach and arthroscopy.

2. Material and method

2.1 Patients

All patients operated on for femoroacetabular impingement between 2007 and 2018 with a minimum 1 year's follow-up were included. Impingement was defined on an association of clinical criteria (hip pain, snapping/catching/locking, pain on flexion, adduction and internal rotation (FADIR), positive impingement test, restricted internal rotation) and radiographic criteria (reduced anterior offset, pistol grip sign (pistol grip shaped head deformity), cam effect, acetabular retroversion, Nötzli alpha angle > 50°).

Labral and cartilage lesions were detected on systematic preoperative CT-arthrography. Patients with Tönnis grade > 2 radiographic osteoarthritis [8], epiphysiolysis [9], osteochondritis sequelae or history of infection or femoral neck fracture were excluded.

One hundred and seven hips in 100 patients were treated for femoroacetabular impingement between 2007 and 2018. Sixteen, in 16 patients, were excluded: 5 for history of slipped capital femoral epiphysis, 3 for neck fracture, 5 for Tönnis grade 3 radiographic osteoarthritis, and 3 for osteochondritis (Figure 1). Fifty-five hips in 50 patients underwent hip arthroscopy, and 36 in 34 patients the Hueter mini-open approach. The study thus concerned 91 hips at a mean 4.6 years' follow-up (range, 1-6 years). Median inclusion in arthroscopy was 2017. There were 41 left and 50 right hips; 20 female (22%) and 71 male hips (78%), for an M:F sex ratio of 3.5. Mean age at surgery was 32 ± 8.3 years (range, 17-55 years), mean weight 77.1 ± 12.1 kg (55-109 kg), mean height 1.80 ± 0.1 m (1.4-2) and body-mass index (BMI) 24.7 ± 2.9 (19.8-37.3).

Mean preoperative Postel Merle d'Aubigné (PMA) score [10] was 16.3 ± 0.9 (range, 13-18) and Oxford-12 score [11] 24 ± 7.7 (14-45) (Table 1). Mean preoperative ranges of motion were: flexion $110 \pm 10.9^\circ$ (80-140°), extension $10.5 \pm 9.4^\circ$ (0-40°), abduction $34.9 \pm 7.8^\circ$ (10-60°), adduction $27.6 \pm 7.6^\circ$ (10-40°), external rotation $32.7 \pm 9.4^\circ$ (-5 to 60°), and internal rotation $22 \pm 11.5^\circ$ (0-60°).

There were 69/91 cam effect (75.8%), 6/91 pincer (6.6%) and 16/91 (17.6%) mixed impingements. Cam effects concerned males in 74.7% of cases (53/71). Nötzli alpha angle was 50-55° in 18 hips (18/91 = 20%), >55° in 69 (69/91=76%), and ≤50° in 4 pincer-effect impingements; angles 50-55° concerned 8 mixed and 1 pincer impingement. Patients practiced sport in 97.6% of cases (82/84). Cam effects were more frequent in the arthroscopy group (50/55 versus 19/36) and mixed impingement in the Hueter group (13/36 versus 3/55) ($p < 0.01$).

Systematic preoperative CT arthrography detected labral lesions in 40.7% of cases (37/91): 28/55 (50.9%) in the arthroscopy group and 9/36 (25%) in the Hueter group ($p = 0.014$). Radiography found incipient osteoarthritis in 27% of hips (27/91): Tönnis 1 in 11 and Tönnis 2 in 6 in the arthroscopy group, and Tönnis 1 in 6 and Tönnis 2 in 4 in the Hueter group ($p = 1$) (Table1).

2.2 Methods

Two kinds of surgery were performed, according to the surgeon's preferences and experience, under the supervision of a senior surgeon. 1) Arthroscopy under general anesthesia used classical anterior and anterolateral portals plus extra portals for any associated procedure. Peripheral capsulotomy was followed by a central compartment procedure depending on the case (labral lesion, cartilage surgery) according to the preoperative CT-arthrography scan. 2) The mini-open Hueter approach used a <6 cm incision, without surgical dislocation under general anesthesia, with the same procedures and capsule suture; traction was applied in difficult cases. Both types of surgery involved regularizing the impingement by anterior femoroplasty or acetabuloplasty according to preoperative findings. Resection was controlled by dynamic tests or fluoroscopy in case of doubt. Operative time (incision to closure) was recorded for each operation.

2.3 Assessment

There was no loss to follow-up. All patients were assessed clinically by an observer not involved in the surgery. Minimum follow-up was 1 year. Potential factors for surgical outcome comprised gender, weight, height, body-mass index (BMI), operated side, age at surgery, pre- and post-operative sport, type of impingement (cam, pincer, mixed), preoperative and last follow-up PMA score [10], preoperative and last follow-up Oxford-12 score (12-60 points) [11], preoperative and last follow-up ranges of motion on goniometry, Nötzli alpha angle [12], labral and/or cartilage lesion on CT-arthrography, type of procedure, associated procedures, complications and operative time. Conversion to arthroplasty was recorded during follow-up.

2.4 Statistics

Quantitative variables were reported as mean and standard deviation or median and interquartile range after checking normal distribution graphically and on Shapiro-Wilk test. Qualitative variables were reported as number and percentage; in case of sufficient sample ($n \geq 5$), intergroup comparison used chi-square test, or else Fisher exact test. In case of sufficient sample, quantitative variables were compared on Student test, or on non-parametric Wilcoxon test in case of non-normal distribution. Pre- to post-operative differences according to group were assessed on linear models with and without adjustment on initial value. The significance threshold was set at $p=0.05$. Analyses used SAS software, version 9.4 (SAS Institute, Cary, NC, USA).

3. Results

Mean follow-up PMA score was 17.5 ± 1 (range, 14-18) and Oxford score 17.6 ± 8.5 (12-45). Mean clinical ranges of motion were: flexion, $113^\circ \pm 10$ (90-140°), extension $10^\circ \pm 10$ (0-40°), abduction $35^\circ \pm 9$ (0-60°), adduction $27^\circ \pm 8$ (10-40°), external rotation $35^\circ \pm 7$ (10-50°), and internal rotation $25^\circ \pm 10$ (0-60°).

Associated procedures varied, with 13 labral sutures (10 arthroscopic, 3 Hueter), 26 partial labral resections (21 arthroscopic, 5 Hueter) and 3 microfractures (2 arthroscopic, 1 Hueter), with significantly more associated procedures in the arthroscopy group ($p=0.007$) (Table 2).

There was no significant intergroup difference in improvement in Oxford score (-6.2 ± 8.1 with arthroscopy and -6.7 ± 5.9 with Hueter; $p = 0.73$) or PMA score ($+1.1 \pm 0.9$ with arthroscopy and 1.3 ± 0.9 with Hueter; $p = 0.41$) (Table 3).

There was no significant intergroup difference in improvement in ranges of motion (notably for internal rotation: $p = 0.69$), except in external rotation with greater gain with arthroscopy ($p = 0.042$); however, this gain, although statistically significant, was only of 3.3° and not clinically important (Table 3). Alpha angle correction did not significantly differ between groups ($-10.9^\circ \pm 12.9$ with arthroscopy and $-9.8^\circ \pm 7.1$ with Hueter; $p = 0.22$) (Table 3). In both groups, correction was satisfactory, with postoperative values of 49.5° (range, 48-52°) with arthroscopy and 48° (41-52°) with Hueter.

Sixty-two patients (73.9%: 62/84) returned to sport at their previous level, with no significant intergroup difference: Hueter, 64.7% (22/34), and arthroscopy 80% (40/50) ($p=0.15$).

Labral lesions (37/91) had no significant impact on clinical results, with improvement of 1.2 ± 1 versus 1.3 ± 0.9 points in PMA score ($p=0.4112$) and -7.3 ± 7.1 versus -6.0 ± 7.3 points in Oxford score ($p=0.369$) (Table 4).

The 27 patients with cartilage lesions on CT-arthrography showed significantly less improvement in PMA score (gain, 1.0 ± 1.1 versus 1.3 ± 0.9 points; $p = 0.0207$). The difference in Oxford score was non-significant (-6.1 ± 7.3 versus -6.7 ± 6.6 ; $p = 0.288$) (Table 5).

There was a significant difference in clinical results between patients with Tönnis grade 0 and Tönnis

grade 1 or 2, with respective gains of 1.35 ± 0.87 versus 0.96 ± 1.1 ($p = 0.012$) in PMA score, but no significant difference in Oxford score (-6.62 ± 6.54 versus -6.19 ± 7.47 ; $p = 0.28$) (Table 6).

Five patients experienced complications, in 5 hips (5/91: 5.49%). One was severe, with definitive femoral nerve deficit (arthroscopy group) with neurapraxia on electromyography, while the others (all Hueter group) were not: 1 lateral femoral cutaneous nerve sensory deficit, 2 lateral femoral cutaneous nerve territory dysesthesias, and 1 anterior rectus femoris enthesopathy. The severe complication was due to intraoperative problems leading to prolonged traction and surgery time (120 min). There was no significant intergroup difference in number of complications ($p=0.15$).

Six patients (6/91: 6.6%) underwent subsequent arthroplasty, with no significant difference between groups ($p=0.21$). Four were from the arthroscopy group (4/55: 7.3%), with 2 total hip arthroplasty (THA) at 2 years and 2 hip resurfacings; 2 (2/36: 5.5%) were from the Hueter group, with one THA at 2 years and one at 4 years.

4. Discussion

To our knowledge, arthroscopy and the mini-open Hueter approach have not previously been compared in a given population for the treatment of femoroacetabular impingement. No significant differences emerged in clinical PMA and Oxford scores or ranges of motion, and the two techniques thus seemed comparable. Account was taken of a potential bias in preoperative clinical scores (poorer baseline mean Oxford-12 score in the Hueter group: Table 1) by analyzing improvement per group at follow-up. Analysis of the literature confirmed the study hypothesis that minimally invasive open surgery is non-inferior to arthroscopy [4], but also confirmed that results are good with both the Hueter [13-15] and the arthroscopic approach [16-18]. Neither technique seemed unsuited to the treatment of femoroacetabular impingement [19]. According to some authors, the two may in fact be combined [20]. On the other hand, arthroscopy involves a longer learning curve, whence some poorer results for less experienced surgeons [21].

Complications rates did not significantly differ according to technique, although there were more injuries to the lateral cutaneous nerve of the thigh on the Hueter approach. Rates for this complication range from 5.5% to 20%, but appear linked to the choice of approach [22,23]. In the literature, hip arthroscopy is associated with few complications, with rates of 1.4-5% [24,25], mainly implicating prolonged traction by less experienced surgeons (which probably also accounted for the case of femoral nerve deficit in the present arthroscopy group, with neuropraxia on electromyography). Reported rates of revision after primary hip arthroscopy reflect the difficulty of the technique, which mainly consists in the difficulty of assessing resection compared to open surgery [26-30].

Patients with cartilage lesions showed relatively greater improvement in PMA but not Oxford score. Preoperative CT-arthrography cartilage assessment found no significant difference according to surgery group. A trend emerged for Tönnis lesion grade, such that grade-2 patients had sub-significantly poorer

PMA and Oxford scores. Other authors likewise highlighted a negative impact of grade ≥ 2 cartilage lesions, bearing out the present trend [2,31,32]. The small numbers of patients in the two Tönnis 2 groups may account for the failure to disclose a significant difference. MRI can be used to assess cartilage [33], but our use of CT-arthrography is one of the strong points of the present study, providing a primordial predictive factor for medium to long-term progression [34].

According to some authors, surgical dislocation provides good results in femoroacetabular impingement [35,36]; in our experience, however, the mini-open Hueter approach gives sufficient visibility for correction and complementary procedures in case of labral or cartilage lesions. Dislocation provides access to the neck and acetabulum, facilitating treatment of impingement, but seems to give poorer results on some quality of life indices [37]. In the present study as in the literature, analysis of alpha angle correction ($<50^\circ$) [38,39] showed that both techniques provide sufficient access. Although primary success rates are high, failure rates for both techniques are non-negligible; cartilage status, possible labral lesion and any under-correction need screening, and revision surgery should not be abstained from when indicated [40]. In our opinion, although some authors reported good results with arthroscopy [41], open surgery should be used for recurrence of impingement, especially in case of prior failure of arthroscopy. The present rate of conversion to arthroplasty was comparable to those in certain registries: respectively, 6.6% and 5.9%. This would seem to support our choice of technique (according to osteoarthritis stage, labral lesions, etc.) [42].

The present study had several limitations. Sample size was small, hindering interpretation; no significant differences emerged on clinical criteria, possibly due to lack of power. Secondly, surgery was performed by different operators, which may have induced variable results but enhanced external validity. Thirdly, the Oxford-12 and PMA scores used for clinical assessment are not specific to femoroacetabular pathology. However, the retrospective design would have led to excessive missing data using more specific scores, and using Oxford-12 as a Patient Reported Outcome Measure (PROM) enhanced internal validity, being assessed by the actual patient both preoperatively and at follow-up. Fourthly, the treatment of labral pathology may have affected results: the literature [43-45] testifies to better clinical results after suture rather than resection, whereas resection predominated in the present series (26 resections for 13 sutures), and suture was more frequent in the arthroscopy group, although this seemed to make no significant difference. Although central compartment status was not systematically documented, no impact of labral lesions on functional results was seen, relativizing any bias. And lastly, the two groups were not comparable on all parameters and notably not on type of impingement, internal rotation and Oxford score. We tried to take this into account by analyzing the preoperative to follow-up differential so as to assess the actual effect of the procedure, and these differences were weighted on statistical analysis.

5. Conclusion

The mini-open Hueter approach gave clinical results (PMA and Oxford-12 scores) comparable to those of arthroscopy in correcting femoroacetabular impingement. Likewise, gain in motion, and in internal rotation

in particular, did not significantly differ between the two techniques. The complications rate was low (5.7%), and comparable between techniques. Clinical results were poorer in case of cartilage lesions. The mini-open Hueter approach thus seems to be a suitable solution for femoroacetabular impingement for surgeons lacking experience in hip arthroscopy.

Disclosure of interests: None of the authors have conflicts of interest to disclose in relation to the present article. Elsewhere, Henri Migaud is Editor in Chief of Orthopaedics & Traumatology: Surgery & Research and an education and research consultant with Corin, Zimmer-Biomet, MSD and SERF; Julien Girard is an education and research consultant with Corin, Microport and Smith & Nephew. Sophie Putman is an education and research consultant with Corin.

Funding: None

Author contributions: P. Martinot: data acquisition, analysis and interpretation; article writing. T. Trouilleux: data acquisition, analysis and interpretation; article writing. J. Dartus: critical revision for intellectual content. S. Putman: critical revision for intellectual content, approval of final version. J. Girard: surgery, critical revision for intellectual content, approval of final version. H. Migaud: surgery, critical revision for intellectual content, approval of final version.

References

- [1] Accadbled F, Pailhé R, Launay F, Nectoux E, Bonin N, Gicquel P; SOFCOT. "Femoroacetabular impingement". Legg-Calve-Perthes disease: from childhood to adulthood. *Orthop Traumatol Surg Res* 2014;100:647-9.
- [2] Wagner S, Hofstetter W, Chiquet M, Mainil-Varlet P, Stauffer E, Ganz R, Siebenrock KA. Early osteoarthritic changes of human femoral head cartilage subsequent to femoro-acetabular impingement. *Osteoarthritis Cartilage* 2003;11:508-18.
- [3] Griffin DR, Dickenson EJ, O'Donnell J, Agricola R, Awan T, et al. The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): an international consensus statement. *Br J Sports Med* 2016;50:1169-76.
- [4] Minkara AA, Westermann RW, Rosneck J, Lynch TS. Review and Meta-analysis of Outcomes After Hip Arthroscopy in Femoroacetabular Impingement. *Am J Sports Med* 2019;47:488-500.
- [5] Harris JD, McCormick FM, Abrams GD, Gupta AK, Ellis TJ, et al. Complications and reoperations during and after hip arthroscopy: A systematic review of 92 studies and more than 6,000 patients. *Arthroscopy* 2013;29:589-95.
- [6] Chiron P, Espié A, Reina N, Cavaignac E, Molinier F, Laffosse JM. Surgery for femoroacetabular impingement using a minimally invasive anterolateral approach: analysis of 118 cases at 2.2-year follow-up. *Orthop Traumatol Surg Res* 2012;98:30-8.
- [7] Frank RM, Ulwani G, Clapp I, Chala J, Nho SJ. High rate of return to cycling after hip arthroscopy for femoroacetabular Impingement Syndrome. *Sport Health* 2018;10:259-265.
- [8] Tönnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. *J Bone Joint Surg Am* 1999;81:1747–1770.
- [9] Murgier J, Espie A, Bayle-Iniguez X, Cavaignac E, Chiron P. Frequency of radiographic signs of slipped capital femoral epiphysiolysis sequelae in hip arthroplasty candidates for coxarthrosis. *Orthop Traumatol Surg Res*. 2013;99(7):791-797.
- [10] Merle D'Aubigné R. Numerical classification of the function of the hip. 1970. *Rev Chir Orthop* 1990;76:371-4
- [11] Delaunay C, Epinette JA, Dawson J, Murray D, Jolles BM. Cross-cultural adaptations of the Oxford-12 HIP score to the French speaking population. *Orthop Traumatol Surg Res* 2009;95:89-99.
- [12] Nötzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. *J Bone Joint Surg Br* 2002;84:556-60.

- [13] Bellotti V, Cardenas C, Astarita E, Moya E, De Meo F, Ezechieli M, Ribas M. Mini-open approach for femoroacetabular impingement: 10 years experience and evolved indications. *Hip Int* 2016;26 Suppl 1:38-42.
- [14] Parvizi J, Huang R, Diaz-Ledezma C, Og B. Mini-open femoroacetabular osteoplasty: How do these patients do? *J Arthroplasty* 2012;27:122-5.
- [15] Ribas M, Ledesma R, Cardenas C, Marin-Peña O, Toro J, Caceres E. Clinical results after anterior mini-open approach for femoroacetabular impingement in early degenerative stage. *Hip Int* 2010;20:S36-S42.
- [16] Byrd JW, Jones KS. Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. *Clin Orthop Relat Res* 2009;467:739-46.
- [17] Matsuda DK, Carlisle JC, Arthurs SC, Wierks CH, Philippon MJ. Comparative systematic review of the open dislocation, mini-open, and arthroscopic surgeries for femoroacetabular impingement. *Arthroscopy* 2011;27:252-69.
- [18] Sonnenfeld JJ, Trofa DP, Mehta MP, Steini G, Lynch TS. Hip Arthroscopy for Femoroacetabular Impingement. *JBJS Essent Surg Tech* 2018;8:e23.
- [19] Horisberger M, Brunner A, Herzog RF. Arthroscopic treatment of femoroacetabular impingement of the hip: A new technique to access the joint. *Clin Orthop Relat Res* 2010;468:182–190.
- [20] Laude F, Soriali E, Nogier A. Femoroacetabular impingement treatment using arthroscopy and anterior approach. *Clin Orthop Relat Res* 2009;467:747-52.
- [21] Ilizaliturri VM Jr. Complications of arthroscopic femoroacetabular impingement treatment: A review. *Clin Orthop Relat Res* 2009;467:760–768.
- [22] Cohen SB, Huang R, Ciccotti MG, Dodson CC, Parvizi J. Treatment of femoroacetabular impingement in athletes using a mini-direct anterior approach. *Am J Sports Med* 2012;40:1620-7.
- [23] Wilson AS, Cui Q. Current concepts in management of femoroacetabular impingement. *World J Orthop* 2012;18;3:204-11.
- [24] Clarke MT, Villar RN. Hip arthroscopy: complications in 1054 cases. *Clin Orthop Relat Res*. 2003;406:84–88.
- [25] Sampson TG. Complications of hip arthroscopy. *Clin Sports Med* 2001;20:831-5.
- [26] Philippon MJ, Schenker ML, Briggs KK, Kuppersmith DA, Maxwell RB, Stubbs AJ. Revision hip arthroscopy. *Am J Sports Med* 2007;35:1918-21.
- [27] Clohisy JC, McClure JT. Treatment of anterior femoroacetabular impingement with combined hip

arthroscopy and limited anterior decompression. *Iowa Orthop J* 2005;25:164–171.

[28] Barton C, Banga K, Beaulé PE. Anterior Hueter approach in the treatment of femoro–acetabular impingement: Rationale and technique. *Orthop Clin North Am* 2009;40:389-95.

[29] Kuhns BD, Frank RM, Pulido L. Open and Arthroscopic Surgical Treatment of Femoroacetabular Impingement. *Front Surg* 2015;2:63.

[30] Tissot C, Merlini L, Mercier M, Bonin N. Reasons for and functional results of repeated hip arthroscopy: A continuous prospective study of 17 revisions out of 295 primary hip arthroscopies at mean 28months' follow-up. *Orthop Traumatol Surg Res* 2017;103:645-649.

[31] Kirschbaum SM, Sitterlee F, Perka C, Müller M. Mini-open approach shows good results in treatment of femoroacetabular impingement. *Z Orthop Unfall* 2017;155:209-219.

[32] Papalia R, Del Buono A, Franceschi F, Marinozzi A, Maffulli N, Denaro V. Femoroacetabular impingement syndrome management: arthroscopy or open surgery? *Int Orthop* 2012;36:903-914.

[33] Morgan P, Spiridonov S, Goebel R, Nissi M, Frei R, Ellermann J. MR Imaging with T2*- mapping for improved acetabular cartilage assessment in FAI-a case report with arthroscopic correlation. *Orthop Traumatol Surg Res* 2014;100:971-3.

[34] Gicquel T, Gédouin JE, Krantz N, May O, Gicquel P, Bonin N; SoFCOT. Function and osteoarthritis progression after arthroscopic treatment of femoro-acetabular impingement: a prospective study after a mean follow-up of 4.6 (4.2-5.5) years. *Orthop Traumatol Surg Res* 2014;100:651-6.

[35] Beaulé PE, Duff MJ, Zaragoza E. Quality of life following femoral head-neck osteochondroplasty for femoroacetabular impingement. *J Bone Joint Surg Am* 2007;89:773–779.

[36] Beck M, Leunig M, Parvizi J, Boutier V, Wyss D, Ganz R. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. *Clin Orthop Relat Res* 2004;418:67-73.

[37] Nwachukwu BU, Rebolledo BJ, McCormick F, Rosas S, Harris JD, Kelly BT. Arthroscopic versus open treatment of femoroacetabular impingement: A Systematic Review of Medium-to Long-Term Outcomes. *Am J Sports Med* 2016;44:1062-8.

[38] Nötzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. *J Bone Joint Surg Br* 2002;84:556–560.

[39] Johnston TL, Schenker ML, Briggs KK, Philippon MJ. Relationship between offset angle alpha and hip chondral injury in femoroacetabular impingement. *Arthroscopy*. 2008;24:669–675.

[40] May O, Matar WY, Beaulé PE. Treatment of failed arthroscopic acetabular labral debridement by femoral chondro-osteoplasty: a case series of five patients. *J Bone Joint Surg Br* 2007;89:595- 8.

[41] Shapira J, Kyin C, Go C, Rosinsky PJ, Maldonado DR, Lall AC, Domb BG. Indications and Outcomes of Secondary Hip Procedures After Failed Hip Arthroscopy. A Systematic Review. *Arthroscopy* 2020 ;36 :In press. doi: 10.1016/j.arthro.2020.02.028.

[42] Kester BS, Capogna B, Mahure SA, Ryan MK, Mollon B, Youm T. Independent risk factors for revision surgery or conversion to total hip arthroplasty after hip arthroscopy: A review of a large statewide database from 2011 to 2012. *Arthroscopy* 2018;34:464-470.

[43] Skendzel JG, Philippon MJ. Management of labral tears of the hip in young patients. *Orthop Clin North Am* 2013;44:477-87.

[44] Philippon MJ, Schroder e Souza BG, Briggs KK. Labrum: resection, repair and reconstruction sports medicine and arthroscopy review. *Sports Med Arthrosc Rev* 2010;18:76-82.

[45] Wolff AB, Grossman J. Management of the Acetabular Labrum. *Clin Sports Med* 2016;35:345-360.

Figure legend

Figure 1: Study flowchart

Table 1: Preoperative data.

Preoperative parameters	Arthroscopy group N=55	Mini-open Hueter group N=36	p value
Gender, n (%)			0.32
Female	14 (27.9)	6 (22.2)	
Male	41 (72.1)	30 (77.8)	
Side, n (%)			0.74
Left	24 (44.2)	17 (44.4)	
Right	31 (55.8)	19 (55.6)	
Sport, n/N (%)			0.15
Yes	50/50 (100.0)	32/34 (94.1)	
No	0 (0.0)	2 (5.6)	
Type of impingement, n (%)			<0.001
Cam	50 (90.9)	19 (52.8)	
Pincer	2 (3.6)	4 (11.1)	
Mixed	3 (5.5)	13 (36.1)	
Age, mean±SD	32.3 ± 8.5	31.4 ± 7.9	0.61
BMI, mean±SD	24.7 ± 3.2	24.6 ± 2.9	0.92
PMA score, Median (Q1;Q3) [10]	17 (16 ; 17)	16 (16 ; 17)	0.57
Oxford-12 score [11], Median (Q1;Q3) [9]	19 (17 ; 26)	24 (21.5 ; 30)	0.036

BMI: body-mass index; PMA: Postel Merle d'Aubigné [10]; SD: standard deviation; significant p values in **bold**.

Preoperative parameters	Arthroscopy group N=55	Mini-open Hueter group N=36	p value
Range of motion, Median (Q1;Q3)			
Flexion, °	110 (110 ; 120)	110 (100 ; 120)	0.18
Extension, °	10 (0 ; 10)	10 (8 ; 15)	0.021
Abduction, °	40 (30 ; 40)	38 (30 ; 40)	0.59
Adduction, °	30 (20 ; 30)	25 (20 ; 30)	0.096
External rotation, °	30 (30 ; 40)	35 (30 ; 40)	0.13
Internal rotation, °	20 (15 ; 30)	20 (10 ; 30)	0.20
Alpha angle, °, mean±SD [12]	61.5 ± 11.4	58.5 ± 6.3	0.12
Labral lesion on CT-arthrography, n (%)	28 (50.9)	9 (25)	0.014
Cartilage lesion on CT-arthrography, n (%)	17 (27.9)	10 (25.9)	0.75
Tönnis radiographic osteoarthritis grade [8], n (%)			1.00
Tönnis 0	39 (70.9%)	26 (72%)	
Tönnis 1	10 (18.2%)	6 (17%)	
Tönnis 2	6 (10.9%)	4 (11%)	

significant p values in **bold**.

Table 2: Operative and follow-up data.

Postoperative parameters	Arthroscopy group N=55	Mini-open Hueter group N=36	p value
Return to sport, n/N (%)	40/50 (80)	22/34 (64.7)	0.15
Procedures, n (%)			0.007
Labral suture	10 (18.2)	3 (8.3)	
Labral resection	21 (38.2)	5 (13.9)	
Microfractures	2 (3.6)	1 (2.8)	
Arthrolysis	0 (0.0)	1 (2.8)	
PMA score, median(Q1;Q3) [10]	18 (18 ; 18)	18 (17 ; 18)	0.11
Oxford-12 score, median (Q1;Q3) [11]	13 (12 ; 16)	14.5 (13 ; 26.0)	0.011
Ranges of motion, median (Q1;Q3)			
Flexion, °	110 (110 ; 120)	110 (110 ; 120)	0.72
Extension, °	10 (0 ; 10)	10 (5 ; 15)	0.12
Abduction, °	40 (30 ; 40)	40 (30 ; 40)	0.76
Adduction, °	30 (20 ; 30)	30 (20 ; 30)	0.54
External rotation, °	40 (30 ; 40)	30 (30 ; 40)	0.15
Internal rotation, °	30 (20 ; 30)	20 (20 ; 30)	0.22
Alpha angle, °	49.5 (48 ; 52)	48 (41 ; 52)	0.13
Complications, n (%)	1 (1.8)	4(11.1)	0.15
Surgery time, mean±SD	74.7 ± 30.8	67.4 ± 19.1	0.16
Subsequent arthroplasty, n (%)	2 (3.6)	4 (11.1)	0.21

PMA: Postel Merle d'Aubigné score [10]; SD: standard deviation; significant p values in **bold**.

Table 3: Gain in function and motion according to group

Improvement	Arthroscopy group (n = 55)	Mini-open Hueter group (n = 36)	p value non-adjusted on T0	p value adjusted on T0
PMA [10]	1.3 ± 1	1.1 ± 0.9	0.41	0.32
Oxford-12 [11]	-6.7 ± 5.9	-6.2 ± 8.1	0.71	0.39
Motion				
Flexion (°)	0.2 ± 4.5	3.3 ± 13.1	0.10	0.41
Extension (°)	-0.6 ± 4.5	-1.7 ± 9.9	0.50	0.99
Abduction (°)	-0.2 ± 2.1	0 ± 6.8	0.85	0.79
Adduction (°)	1.0 ± 3.7	2.5 ± 4.9	0.092	0.17
External rotation (°)	3.3 ± 6.5	0 ± 5.5	0.042	0.043
Internal rotation (°)	2.9 ± 7.6	3.6 ± 9.1	0.69	0.67
Alpha angle [12] (°)	-10.9 ± 12.9	-9.8 ± 7.1	0.69	0.22

PMA: Postel Merle d'Aubigné score [10]; significant p values in **bold**.

Data reported as mean ± standard deviation.

Table 4: Impact of labral lesion on functional improvement

Improvement	No labral lesion N=54	Labral lesion N=37	p value adjusted on preoperative value
PMA score [10]	1.3 ± 0.9	1.2 ± 1.0	0.41
Oxford-12 score [11]	-6 ± 7.3	-7.3 ± 6	0.37

PMA: Postel Merle d'Aubigné [10]

Data reported as mean ± standard deviation

Table 5: Impact of CT-arthrography cartilage lesion on functional improvement

Improvement	No cartilage lesion N=64	Cartilage lesion N=27	p value adjusted on preoperative value	Interaction with type of surgery
PMA score [10] overall	1.3 ± 0.9	1 ± 1.1	0.021	0.16
Mini-open Hueter group	1.23 ± 0.76	0.90 ± 1.10		
Arthroscopy group	1.42 ± 0.95	1.06 ± 1.14		
Oxford-12 score [11] overall	-6.7 ± 6.6	-6.1 ± 7.3	0.29	0.76
Mini-open Hueter group	-5.58 ± 8.36	-7.70 ± 7.39		
Arthroscopy group	-7.39 ± 5.02	-5.18 ± 7.37		

PMA: Postel Merle d'Aubigné [10]; significant p values in **bold**.

Data reported as mean ± standard deviation

Table 6: Impact of radiographic osteoarthritis grade on functional improvement (Tönnis 0 versus Tönnis 1 and 2)

Improvement	Tönnis 0 N=65	Tönnis 1+2 N=26	p value adjusted on preoperative value
PMA score [10]	1.35 ± 0.87	0.96 ± 1.11	0.012
Oxford-12 score [11]	-6.62 ± 6.54	-6.19 ± 7.47	0.28

PMA: Postel Merle d'Aubigné [10]

Data reported as mean ± standard deviation; significant p values in **bold**.

Figure 1:

