In the last decade femoroacetabular impingement (FAI), defined as a conflict between anterior femoral head-neck junction and anterior acetabular rim, has been proposed as the beginning of early osteoarthritis of the hip and popularised with more than 200 papers published in peer-review journals. This syndrome leads lesions in the labrum and adjacent acetabular cartilage, which could result in degenerative joint disease. The treatment – femoroacetabular osteochondroplasty (FAO) – of this pathomorphology and its resulting chondrolabral injuries can be basically classified in three different methods: 1) save dislocation with full exposure of the hip; 2) hip arthroscopy; and 3) arthroscopically assisted anterior mini-open technique. The anterior mini-open approach is an intermuscular and internervous procedure. It is safe and reliable, and allows the preservation of tissues in order to minimise insult and provide the fastest post-operative management – similar to purely arthroscopic treatment.

In addition, the anterior mini-open approach can be used in greater or lesser extension in order to treat different pathologies of the hip. The first documented publication and technical description of this approach can be attributed to Carl Huerter.

**Features of mini-open anterior approach for FAI**

The mini-open anterior approach takes the advantage of the natural interval between sartorius and tensor fascia lata muscles, and has several features of paramount importance:

1. When compared with pure hip arthroscopy for FAI, the mini-open approach avoids excessive traction in the treatment of lesions of the internal compartment. An incision of only 5 mm to 6 mm is required to introduce a 4-mm diameter 70° arthroscope, minimising the risks of potential neural damage and scuffing of the femoral cartilage.

2. There is no concomitant need to perform either hip dislocation or trochanteric osteotomy. Moreover, the hip can be dislocated by detaching with reference sutures the upper insertion of tensor fascia lata before a ‘T-shaped’ capsulotomy. This technical detail is useful in other procedures as hip replacement or even in hip revision surgery.

3. The fate of the ‘big expandible external portal’. During the procedure there is a permanent double view directly from the external compartment of the hip with and/or without arthroscopic view, to the internal compartment. In the latter, a more expanded view of the internal compartment can be obtained from the external compartment. A permanent control and view of the femoroacetabular clearance can be obtained at any time throughout the procedure.

4. With proper instrumentation (retroverted blunt Hohmann retractors attached to a external frame), different femoral rotations and extended posterosuperior capsulotomy, the direct complete exposure of head–neck junction and acetabular rim can be obtained. We established an order from posterosuperior to anteroinferior to optimise this procedure, termed the ‘hip spaces rule’. 5. High accuracy in femoroacetabular reshaping in all planes according to former ‘hip spaces rule’ and radiological pre-operative planning. Planning is implemented intra-operatively with the images taken by fluoroscope in anteroposterior and axial projections. This accuracy therefore allows the procedure to be used to treat the conditions arising from FAI, where other authors may use more invasive procedures; conditions including coxa profunda, antero-latero-posterior femoral abutments, big labral cysts invading eminentia ileopectinea, the sequelae of slipped capital femoral epiphysis (SCFE), acetabular stress fractures, acetabular and femoral subchondral cysts curretage and autologous filling up, and whole labrum allogenic transplantations.

6. There is no real need to permanent image intensifier shots to control the femoral head-neck junction osteoplasty. At the beginning of the learning curve radiological checking is necessary. With increased experience, a check of the final reshaping may be necessary only. When compared with arthroscopic osteoplasty, limited use of image intensifier maybe needed.

7. This approach can constitute a part of other associated techniques as periacetabular osteotomy for the treatment of combined dysplastic and FAI.

8. Head–neck junction osteoplasty and eventual acetabular microfractures according to the Steadman technique can be safely done with the addition of autologous activated fibrine sealer. Viable chondral acetabular flaps (Beck III to Beck IV) can be safely reattached as subchondral bone is prepared with microfractures.

9. The post-operative management and rehabilitation programme implemented after pure arthroscopy can also be used.

With full understanding of the ‘hip spaces rule’ for the mini-open technique, and evolved technical improvements over the past nine years, we consider this procedure to be a very strong tool to deal with complex presentations of FAI, such as mixed cases with pronounced anterolateral femoral abutments, coxa retroversa minor, coxa profunda, some SCFE sequelae or even in complex arthroscopic procedures. In simpler indications, we use a purely arthroscopic femoroacetabular.

There is no fixed consensus concerning suitability in such a kind of deformities like coxa profunda. The surgeon’s experience and skills will be a determining factor. In cases of...
combined FAI with high riding greater trochanter, major SCFE sequelae are likely to be more properly addressed by dislocation of the hip, as with any intracapsular femoral osteotomies.

Surgical technique (Figs 1 and 2)\textsuperscript{14,16,17}

1. Positioning and approach. The patient is placed in a supine position in an extension table. No traction has to be applied during the approach. The incision begins 1 cm below and 1 cm lateral to the anterosuperior iliac spine. It runs 4 to 8 cm distally towards the peroneal head. This incision allows us to prevent further lesion of the posterior branch of lateral femorocutaneous nerve. Both fascias (cruralis and that of the muscle tensor fascia lata (TFL)) are then opened approximately 1 cm posterior to first fibres of TFL and the fat interval between the sartorius and TFL muscles is detected. This manoeuvre protects posterior branches of the lateral femorocutaneous nerve. Detachment of the reflected portion of rectus femoris muscle is performed. A curved blunt Hohmann retractor is introduced over the upper part of the capsule and a straight Hohmann retractor is placed between the iliofemoral muscle and capsule at least at 30° flexion of the hip to avoid the damage of femoral nerve. Capsulotomy is performed from distal to cranial through the interval between iliofemoral ligaments. During capsulotomy special care has to be taken to identify the labrum by pulling up when dissection reaches the acetabulum. A ‘T-shape’ capsulotomy is completed, following acetabular rim orientation. At this time, reference sutures are placed in both sides of the capsule and two blunt curved Hohmann retractors are located intrarticular around the femoral neck.

2. Inspection. The impingement manoeuvre should be clearly tested. Extension is applied for hip distraction. At this point less extension is required when compared with pure arthroscopy. Once the joint is distracted about 10 mm the use of an additional light source attached to Hohmann retractor or the 70° arthroscope by itself is recommended. Acetabular chondral and labral lesions can be inspected in the six zones defined by Ilizaliturri et al.\textsuperscript{21} On the femoral side, lesions can be directly identified as the cartilage shows inflammatory and prearthritic changes.

3. Acetabular osteoplasty and labral repair. Chondrolabral delamination is repaired through detachment of the labrum and acetabular rim trimming with 5 mm diamond burrs. In extensive ulcerations, microfractures are performed according to Steadman’s technique. The labrum is reattached with 3.1 mm resorbable transosseous anchors, when acetabular rim trimming is finished. Once acetabular osteoplasty is performed, extension is released. We do recommend not staying longer than one hour with applied extension to prevent potential neural lesions.

4. Femoral osteoplasty. Fluoroscope is used to identify intra-operative landmarks according to the pre-operative planning. In cam type, the bone bump is excised with ultra-sharp curved osteotomes and round burrs manipulated counter-clockwise to avoid excessive bone penetration. We start the bump resection at the posterosuperior head–neck junction with hyperextension-adduction-internal rotation and followed by flexion-abduction and external rotation to reach the posteroinferior head-neck junction and acetabular rim (‘hip spaces rule’) (Fig. 2). Pulse-lavage is used during all procedure to avoid heterotopic ossification. Final fluoroscope view is recommended after bone resection is completed. Finally, we should test the femoroacetabular clearance and range of movement, especially in flexion and internal rotation.

5. Closure. A drain can be applied optionally (for the last five years we have instead used a local catheter for local anaesthesia injection every 8 hours) and soft-tissue planes are reinserted in full extension of the hip to avoid capsular retraction. Special care must be taken to avoid injury to the branches of the lateral femoral cutaneous nerve during superficial closure.
6. Post-operative care. Indomethacin protocol is used to prevent heterotopic ossification. Gastroprotective drugs, low-molecular-weight heparin are also administrated according to our hip surgery protocol. Local catheter is removed one or two days after surgery depending on hospital discharge.

Results (Fig. 3)

Since 2005 different authors have reported results with this technique in retrospective studies. Of these studies, only one has level III of evidence. Global success rate ranges from 71% to 92%, with all different pre-operative degenerative stages (from Tönns 0 to Tönns 2) taken into account.

In the level-III study, a clear statistically significant difference was found between the clinico-functional results between Tönns 0 and Tönns 1 patients and Tönns 2 patients. These results have been stated in the midterm. The majority of authors describe mini-open approach with the use of adjunctive arthroscopy and an anterior Huerter approach or some modification there, through the internervous interval between the sartorius, rectus femoris and iliopsoas (femoral nerve) and the gluteus minimus/medius and tensor fascia lata (superior gluteal nerve). Intermittent hip distraction without frank dislocation or trochanteric osteotomy of the operative hip was performed. Incision length varied from 2 cm to 12 cm.

The rate of conversion to total hip replacement in the midterm ranges between 0% to 11%, and is more likely in cases of advanced and more extreme pre-operative changes. In a meta-analysis by Matsuda et al. from a global number of 176 hips there was one fracture of the femoral neck and two cases of deep infection; incidences similar to those after purely arthroscopic treatment of FAI. No cases of osteonecrosis have been reported. One stress femoral neck fracture was identified and treated without surgery. The most frequent complication arising from the mini-open procedure is related to temporary problems with posterior branches of the lateral femoral cutaneous nerve, with incidences ranging from 0% to 17.1%. With improved experience and skills it has been reduced in our experience to 5.5%.

Recently we have extended our comparative study (Evidence Level G.III) to a cohort of 296 patients operated between 2003 and 2008 (mean follow-up 5.2 years (2 to 8)). The Merle D’Aubigné score, the Western Ontario and McMaster Universities (WOMAC) osteoarthritis index and the University of California, Los Angeles (UCLA) activity level was assessed pre-operatively and at the latest follow-up. A Kaplan–Meier survivorship curve was established considering as an endpoint either loss to follow-up or conversion to total hip replacement. The chi-squared and Wilcoxon tests have been used for comparisons between groups according to pre-operative Tönns radiological stage.

This analysis provided a mean improvement in the Merle D’Aubigné score (15.7 pre-operatively to 17.4 at final follow-up), WOMAC (from 59.7 to 93.3) and UCLA activity level (from 7.3 to 8.7), which were all statistically significant changes (p < 0.001). Survivorship at eight years for all patients was 88.8%; it was 98.8% for Tönns 0 patients, 92.8% for Tönns 1 patients and 62.3% in Tönns 2 patients (p < 0.001; Fig. 4).

Discussion and conclusions

Although arthroscopic treatment of FAI is gaining acceptance worldwide, unsuccessful clinical results have been reported, especially regarding early stages in the learning curve. The most common problems involve incomplete resection and reshaping of bony deformities. In a cadaveric study comparing arthroscopic versus open femoral osteoplasty, Mardones et al. showed a tendency towards under-correction in the former technique. Moreover they could observe a certain tendency to under-correction at the most distal and posterior head-neck junction with arthroscopic osteoplasty. The lack of global external view results sometimes difficult, so that continuous pre-operative images – especially fluoroscopic axial projections – become mandatory.
In addition, Matsuda et al., in a meta-analysis comparing arthroscopy with dislocation and arthroscopic assisted mini-open technique, found that arthroscopically assisted mini-open approach is a good method to be introduced in the field of hip arthroscopy, avoiding the extensive learning curve with its price of unsuccessful results.

With regard to clinical and functional results, there is no consensus about which technique provides better results compared to the other. Dislocation adds the risk of problems related to trochanteric osteotomy including nonunions or even early secondary operation for removal of painful fixation screws causing trochanter pain, whereas the mini-open procedure has the risk of excessive compression of the posterior branch of the femoral cutaneous nerve. The rate diminished from 17.1% in the first reported cases to 5.5% by performing a double fascial pocket with fascia cruralis and fascia of the tensor fascia lata. Fascial incision should run 1 cm to 2 cm more lateral to classical Huerter approach. This pocket, retracted medially, contains these branches of the lateral femoral cutaneous nerve.

Several studies have demonstrated that patients with symptomatic FAI presenting in early changes of hip osteoarthritis (Tönnis 0 or Tönnis 1) may benefit from surgical treatment through a mini-incision approach, allowing patients to obtain a significant clinical and functional improvement.

The mini-open technique has been performed even in elite sportmen involved in high level competitions and provides a middle ground between formal surgical dislocation and arthroscopy.

In our experience save dislocation continues to have specific indications, such as in cases where complete access of the acetabular rim pathology has to be treated like marked coxa profunda – protrusio with addition of whole labrum transplantation, posterior femoro-acetabular impingement and severe cam impingement secondary to slipped capital femoral epiphysis.

In conclusion, we believe that the mini-open anterior approach is a reliable and reproduceable technique, presenting a direct view of the femoral and acetabular side of the structural deformities present in FAI. The clinical and functional results will depend directly on early diagnosis. From our experience, it should be recommended to this population to undergo to surgical procedure as soon as their clinical symptoms onset.

We agree with other authors that mild and regular cases of FAI cases done arthroscopically by mini-open is a safe procedure. Also, the access and visualisation available will lead to a better understanding of the underlying pathomorphologies and associated lesions, which may in turn inform and improve the learning curve associated with the arthroscopic management of FAI. In any case, as previously mentioned, according to our experience there are several presentations of FAI where other authors advocate for save dislocation, which can be solved through this surgical technique with increased skills. This would provide an immediate and intensive rehabilitation and post-operative management, completely parangonable to arthroscopy.

Moreover we are convinced and suggest, as we do in our institution, and recommended in meta-analysis, that hip arthroscopists should complete their technical skills in the treatment of FAI with this additional procedure.

**References**


