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Portal enlargement in hip arthroscopy preserving the iliofemoral ligament: a novel access technique protecting soft tissue restraints

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ABSTRACT

Capsulotomy in different modalities has been used to provide adequate exposure to access both the central and peripheral compartment in hip arthroscopy. Even though the hip joint has inherent bony stability, soft tissue restraints may be important in patients with ligaments hyperlaxity or in some cases with diminished bony stability. Biomechanical studies and clinical outcomes have shown the relevant role of the capsule in hip stability, mainly the role of the iliofemoral ligament. Although is not very common, iatrogenic post-arthroscopy subluxation and dislocation have been reported and many surgeons are concerned about the role aggressive capsulotomy or capsulectomy in this situation, thus capsule repair has become very popular. We present a novel technique to access the hip without cutting the iliofemoral ligament. With this technique we can obtain adequate arthroscopic access to the hip joint in order to treat adequately the central compartment pathologies reducing the risk of iatrogenic post-operative hip instability.

INTRODUCTION

The osseous anatomy of the hip provides inherent stability to the joint [1]. Despite this, there is a growing body of evidence that suggests that soft tissue constraints surrounding the hip are important for stability and function [2, 3]. These soft tissue constraints may become more important in the setting of underlying soft tissue laxity due to repetitive microtrauma, in patients with collagen disorders such as Ehlers—Danlos syndrome [4], or in patients with bony instability such as acetabular dysplasia [5, 6] (including borderline acetabular dysplasia). Abnormalities in the osseous and soft tissue anatomy can lead to pain and disability. Surgeons should also be familiar how the osseous and soft tissue constraints of the hip contribute to native hip biomechanics so that restoration or preservation of normal anatomy and optimal function can be targeted whenever possible.

Femoroacetabular impingement (FAI) has become the most common indication for hip arthroscopy [7]. Adequate arthroscopic access and visualization are vital to be through and precise treatment of FAI. Inadequate correction of bony deformity is considered to be the most common cause of failure of arthroscopic treatment [8]. Capsular management is a fundamental aspect of arthroscopic exposure [9–11]. This ranges from simple portal enlargements to different types of capsulotomies or capsular resection. Post-operative soft tissues stability and kinematics of the hip joint may be affected by how the capsule is managed initially and repaired after the procedure [12]. With better awareness of the importance of the hip capsule, more emphasis has been placed on preserving or repairing the hip capsule in those patients that may be prone to instability (i.e. ligamentous laxity).

The objective of this study is to present a novel technique of capsular management designed to provide adequate exposure in hip arthroscopy while preserving the iliofemoral ligament; by performing portal enlargement cuts and elevation of the capsule from its anterior superior insertion and no repair of the capsular cuts after completion of the surgical procedure. Early results are presented.

MATERIALS AND METHODS

This study included arthroscopic hip surgeries performed by the senior author (V.M.I.) from January 2013 to December 2017, where a capsulotomy technique that preserves the iliofemoral ligament was performed. Exclusion criteria were revision arthroscopy, synovial disease, cases where an extensive capsulotomy was performed as part of the access and/or treatment procedure. Patients with Tönnis grade 2 or above were not included in the study.

Investigational review board approval was obtained before initiation of this study.

Indications for surgery

Clinically, all patients had signs and symptoms of FAI for greater than 3 months and failed with non-operative treatment. Signs and symptoms of FAI included groin pain, pain surrounding the hip, and positive labrum impingement tests. Non-operative treatment included a minimum of 6–8 weeks of physical therapy.

Capsule anatomy

The capsule is composed of internal fibers directed circumferentially and define the circular zona orbicularis, which forms a collar around the femoral neck. The external ligaments are directed longitudinally. Anteriorly is the iliofemoral ligament ('Y' of Bigelow), which is stiffer and more resilient to force compared with the ischiofemoral ligament and pubofemoral ligament.

Technique

We designed a portal enlargement technique and capsular elevation with the objective of preserving as much as possible the integrity of the iliofemoral ligament while providing adequate exposure and access to the acetabular rim, the labrum and the femoral neck–head junction. The senior author technique of accessing the central compartment using cannulated instruments, fluoroscopy guidance and traction was used.

Based on the footprint of the insertion of the hip ligaments on the acetabulum and their trajectory around the hip capsule [13] the portals are established like follows.

Using fluoroscopic guidance, with the hip in traction, the anterolateral portal (ALP) (entry site at the superior anterior corner of the greater trochanter) is established with a spinal needle, directed to the central compartment of the hip (separation of the acetabular rim and femoral head of at least 10 mm at the image intensifier is needed). The capsule was distended with air once the needle was in an intraarticular position, this increases the separation between the head and the acetabulum. The needle must remain close to the proximal femoral head to prevent labral penetration, landing on top of the femoral head with the blunt side of the bevel to prevent damage to the femoral head cartilage. With the portal established cannulated instruments are used and a 4 mm 70° scope is introduced at the ALP. The first examination of the hip joint is carried out at this point without fluid. The anterior hip triangle is identified arthroscopically, and a needle is positioned at the site of direct anterior portal (DAP) and observed entering the joint at the center of the anterior hip triangle. A working portal is established next at the DAP using cannulated instruments and a slotted cannula. With a slotted cannula in position the fluid pump is started (40–60 mmHg) and a radiofrequency monopolar hook is used to enlarge the portal 5 mm medially and slightly laterally without connecting the entry site of the anterolateral and DAPs. This cut will be located between the inferior aspect of the iliofemoral ligament and the superior aspect of the pubofemoral ligament. The arthroscope is repositioned at the DAP and the ALP used as a working portal. The entry site of the ALP is identified arthroscopically and enlarged with a monopolar hook probe directed posteriorly about 2 or 3 cm. This capsular cut is between the superior margin of the iliofemoral ligament and the superior margin of the ischiofemoral ligament (Fig. 1). At this point the portals are considered established and we usually do our arthroscopic exam of the central compartment. With the DAP remaining the viewing portal, a view of the lateral perilabral sulcus is obtained, the ALP is used as the working portal and the synovial tissue is removed from the lateral perilabral sulcus using a shaver and a radiofrequency ablation device until the insertion of the hip capsule is observed lateral to the acetabular rim (note that the insertion of the labrum is not separated at any time). A unipolar hook probe is used to elevate de capsule 1–1.5 cm proximal to its insertion, during this process traction is released to increase the space at the perilabral sulcus (Fig. 2). The acetabular rim may be assessed at this point with a 4 mm 30° arthroscope using an over the top view; if present a pincer deformity can be managed at this point using a spherical burr. If suture anchor fixation of the labrum is needed traction is re-established and suture anchors are placed using a standard technique (Figs 3 and 4). After work is completed at the lateral acetabular rim the viewing and working portals are exchanged positioning the 30° arthroscope at the ALP. The anterior perilabral sulcus is accessed and the synovial tissue removed with a shaver and radiofrequency ablation probe until the capsular insertion is clearly visible.

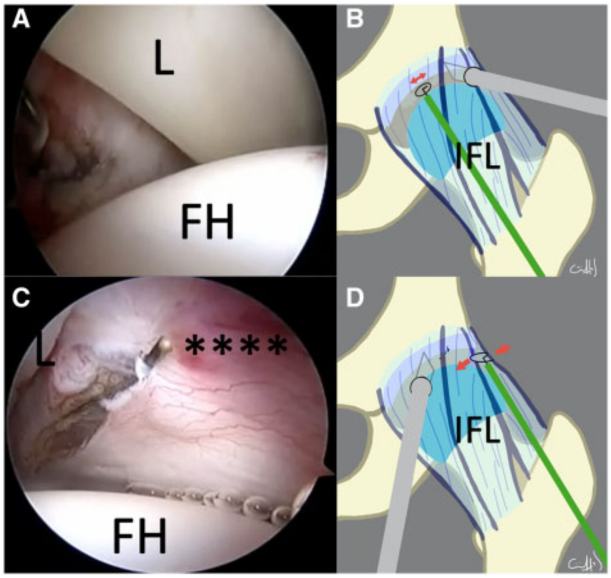

Fig. 1. (**A**) Arthroscopic photograph (left hip) that demonstrates a small capsular enlargement of the entry point of the direct anterior portal (DAP) on the anterior hip capsule between the labrum (L) and the femoral head (FH); note the hip is with traction. (**B**) Schematic representation of a left hip that demonstrates the arthroscope in position at the anterolateral portal (ALP) as the capsular enlargement of the entry point of the DAP is being performed with a radiofrequency hook. The iliofemoral ligament (IFL) is preserved between the portals. (**C**) Arthroscopic photograph (left hip) that demonstrates a linear cut of the lateral hip capsule directed posteriorly from the entry point of the ALP as viewed from the DAP (the tip of the radiofrequency hook is observed at the anterior margin of the capsular cut). The capsule is preserved intact between the portals (****) Note that the hip is in traction. A small portion of the labrum (L) is observed at the top left and the FH is at the bottom of the photograph. (**D**) Schematic representation in a left hip. The arthroscope has been shifted to the DAP and a radiofrequency hook is used to enlarge the entry point of the ALP. This cut is mainly directed posteriorly and the portals are not connected. The hip is with traction.

A monopolar radiofrequency hook probe is used to elevate the capsular insertion proximally 1–1.5 cm, during this process traction is also released to increase the space at the anterior perilabral sulcus (Fig. 5).

As before, the acetabular rim may be assessed and treated at this point.

A clinical photograph obtained during total hip replacement that shows the anterior hip capsule and the iliofemoral ligament is used to demonstrate the site and direction of the resulting capsular cuts end the iliofemoral ligament in between them (Fig. 6).

If anterior suture anchor fixation is needed, traction is re-established and a percutaneous mid anterior portal is established. Anchors are delivered from the mid anterior portal and suture management is performed form the previously established DAP. Stability of the labrum is reassessed and traction is released to assess the labral seal around the femoral head and to provide access to the hip periphery (Fig. 7). The capsular cuts are at this point used as windows to access the femoral head neck junction, bringing the hip joint through range of motion facilitates exposure of cam type deformities to the field of view, the viewing and working portals are exchanged to obtain a complete examination of the femoral head–neck junction and impingement is observed under direct arthroscopic vision (Fig. 8). Fluoroscopy is also used to help navigate the pincer and cam decompression throughout the process (Fig. 9).

This controlled and reproducible sequence of capsulotomy without connecting the DAP with the ALP expose and address all pathology of the central and peripheral compartment while preserving the anatomy and integrity of the ligaments. We typically use a standard ALP and modified anterior portal to safely access the central compartment in traction. The capsule is cut with a radiofrequency hook parallel to the labrum, without connecting the anterior and ALPs, cutting away from the site of the iliofemoral ligament. The capsule was then elevated 1.5–2 cm from the iliac bone proximal to the labral insertion.

Clinical outcomes

The patient-reported outcomes (PRO) used were the Inverted Polarity Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (0–96 points). Pain was assessed with the use of a visual analog scale (VAS) in which 0 was no pain and 10 was the worst pain. PROs and VAS scores were obtained pre-operatively and post-operatively at 6, 12 and 24 months. Any complications, revision surgical procedures and conversions to total hip arthroplasty were noted.

Measurements

The lateral center-edge angle (LCEA) was measured pre and post-operative in all the patients that had mixed or pincer type FAI, the alpha angle was also measured pre and postoperative in all patients that had mixed and cam type FAI. The LCEA was also measured pre and post-operative in the two cases with sub-spine impingement (there were no cam deformities in these two cases) (Fig. 10).

Statistical analysis

The series were divided into three groups based on the diagnosis (Mixed type FAI, Pincer type FAI and Cam type

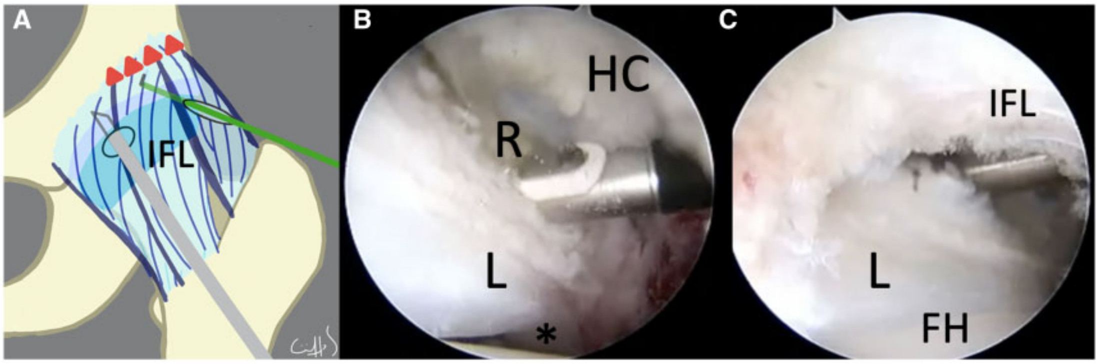

Fig. 2. (**A**) Schematic representation of a left hip. The hip is without traction. The arthroscope is in position at the DAP. A radiofrequency hook is used to elevate de lateral hip capsule from its insertion proximal to the acetabular rim (red arrows). Note that both portals have been enlarged and the iliofemoral ligament (IFL) is preserved between the portals. (**B**) Arthroscopic photograph (left hip). Traction is being released (*). A radiofrequency probe is used to ablate tissue from the acetabular rim (R) proximal to the labrum (L). The lateral hip capsule (HC) is at the top of the photograph. (**C**) Arthroscopic photograph (left hip) The femoral head (FH) and the labrum (L) are at the bottom of the photograph, the hip is without traction. The intact iliofemoral ligament (IFL) is at the top. A radiofrequency probed is observed behind the iliofemoral ligament (IFL) as the lateral hip capsule is elevated from its insertion above the acetabular rim.

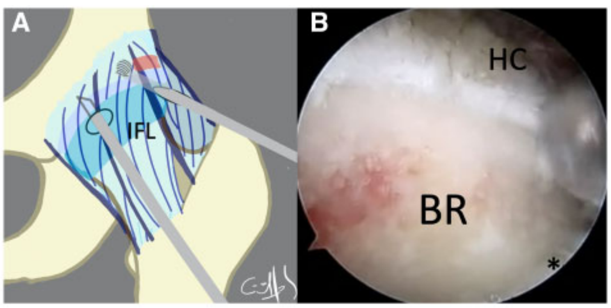

Fig. 3. (**A**) Schematic representation of remodeling of the lateral aspect of a pincer deformity. The arthroscope is at the DAP. An arthroscopic burr is at the ALP and is used to resect a pincer deformity. Note the hip is without traction to release tension on the hip capsule, the working space was created by elevating the hip capsule from its insertion (Fig. 2). The iliofemoral (IFL) ligament is intact between the portals. (**B**) Arthroscopic photograph (left hip). The burred surface of the rim (BR) from the resection of the pincer deformity is at the center of the photograph. The hip capsule (HC) is observed lateral to the Burred rim. The insertion of the lateral labrum (*) is at the bottom right.

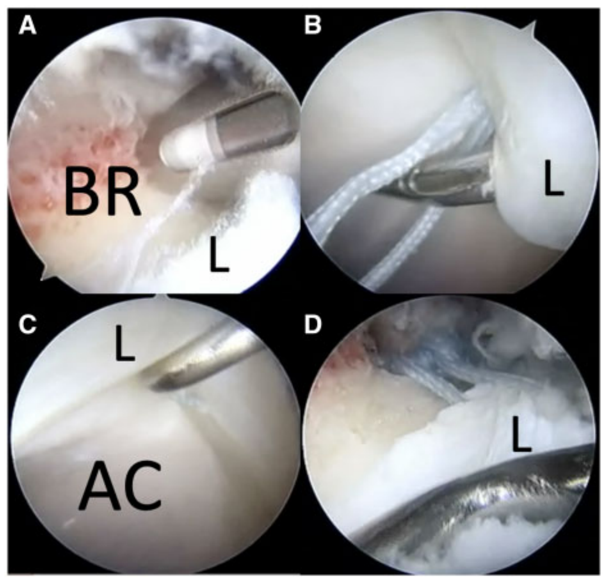

Fig. 4. Arthroscopic sequence demonstrating anchor placement and labral reinforcement (left hip). (**A**) A suture anchor is introduced at the burred surface of the acetabular rim (BR), the labrum (L) is at the bottom. (**B**) A suture has been passed into the joint entering from the insertion of the labrum (L). A suture retriever is shown as it is penetrating the mid aspect of the labrum (L) to retrieve the suture from inside the joint (double pass technique for a mid-substance labral repair). (**C**) The lateral acetabulum (AC) and the lateral labrum (L) are observed from the articular side as a probe is used to demonstrate labral stability. A suture can be observed in position to the right of the probe. (**D**) Capsular side view that demonstrates the knot on the acetabular rim and the suture through the labrum (L) a probe is in use to assess stability of the labrum.

FAI). The two patients with sub-spine impingement were analyzed independently.

The clinical outcomes data (WOMAC and VAS) and the angle measurements were analyzed using a Kolmogorov–Smirnov test which resulted in abnormal distribution of data and a Wilcoxon test was selected to compare the medians for the pre-operative scores and the follow-up scores (6, 12 and 24 months) for all the groups. A P values of <0.05 was considered significant when comparing groups.

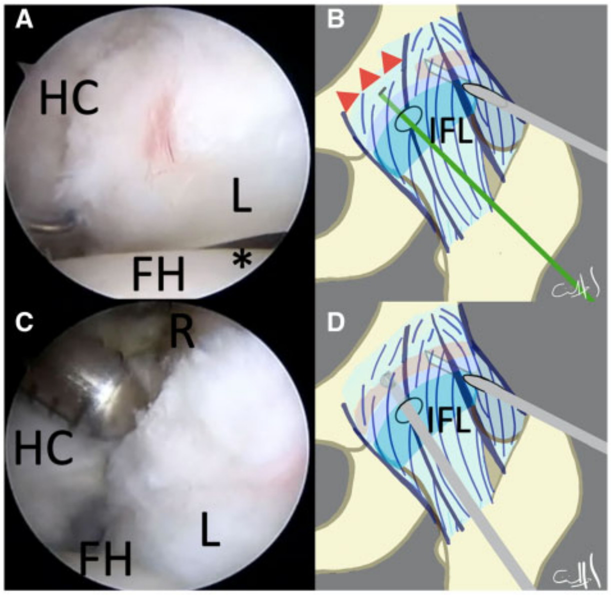

Fig. 5. (**A**) Arthroscopic photograph (left hip). The arthroscope is viewing from the ALP, the labrum (L) and femoral head (FH) are at the bottom as traction is released (*). The anterior hip capsule (HC) is at the top of the photograph. (**B**) Schematic representation of a left hip. The arthroscope is in position at the ALP and a radiofrequency hook probe at the DAP and is used to elevate the anterior hip capsule from its insertion proximal to the anterior rim. The iliofemoral ligament (ILF) is intact between the portals. (**C**) Arthroscopic photograph (left hip). The anterior labrum (L) and the anterior femoral head (FH) are at the bottom of the image. Note the hip is without traction. The anterior acetabular rim (R) is observed proximal to the labrum (L). The anterior hip capsule (HC) is to the right. A shaver is used to remove synovial tissue from the rim (the capsule was previously elevated using the radiofrequency hook). (**D**) Schematic representation of the left hip. The arthroscope is in position at the ALP. The hip is without traction. An arthroscopic burr is in position at the DAP and is used to resect the anterior pincer deformity.

The SPSS V 22.0 was used for data analysis.

RESULTS

We identified 61 hip arthroscopies on patients that met the inclusion and exclusion criteria during the study period. We had 42 female patients (average age of 33.4 years) and 19 male patients (average age of 23.6 years). Of these, 49 (96.7%) had FAI and 2 were diagnosed with sub-spine impingement.

Thirty-four patients in the series had Mixed type FAI (55.7%), 17 (27.8%) Pincer type FAI and 8 (13.11%) Cam type FAI and 2 patients with sub-spine impingement (the patients with sub-spine impingement also had pre-operatively an LCEA >40).

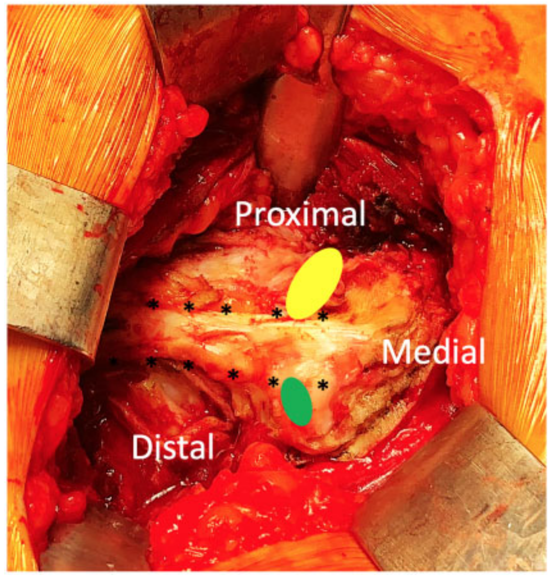

Fig. 6. Clinical photograph of the iliofemoral ligament (outlined by *) during total hip replacement. The yellow oval corresponds to the site of the capsular cut at the lateral hip capsule, the green oval corresponds to the medial capsular cut. By not joining the capsular cuts the majority of the iliofemoral ligament remains intact between the cuts.

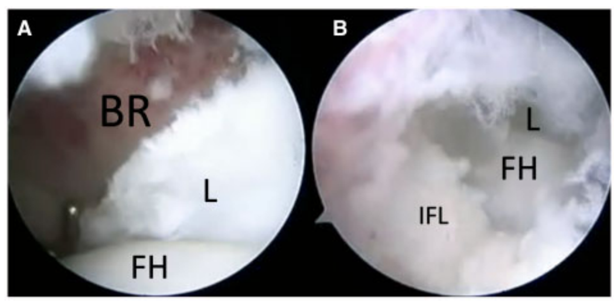

Fig. 7. Arthroscopic photographs (left hip). (**A**) The labral seal around the femoral head (FH) is assessed, the labrum (L) is adequately 'sealing' the femoral head (FH) inside the acetabulum, the burred rim (BR) is proximal to the labrum (L). (**B**) An 'outside view' from the anterolateral postal demonstrates the integrity of the iliofemoral ligament (IFL). The femoral head (FH) and the labrum (L) can be observed through the extended cut of the ALP at the hip capsule.

Pre-operatively the median LCEA Mixed type FAI was 49° (range 46–52), post-operatively was 30° (range 28–35). A statistical significant difference was found when comparing the median pre-operative and post-operative LCEA for the Mixed type FAI group ($P < 0.001$).

The LCEA pre-operative Pincer type FAI was 50° (range 48–54.7), post-operatively was 30° (range 28.5–31.7). A statistical significant difference was found when

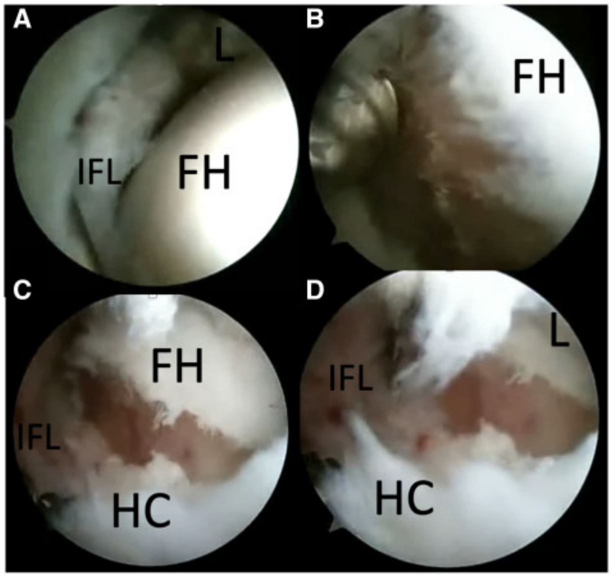

Fig. 8. Arthroscopic photographs (left hip). (**A**) The femoral head (FH) is at the center observed through the 'window' lateral to the iliofemoral ligament. The labrum (L) is at the top of the photograph and the iliofemoral ligament (IFL) to the left. (**B**) The femoral head (FH) is observed to the right as a burr is used to remodel the cam deformity (at the femoral head-neck junction). (**C**, **D**) After cam decompression dynamic examination is performed to observe the femoral head (FH) entering the acetabulum. Th iliofemoral ligament is to the left of both photographs and the hip capsule at the bottom. In (D) the labrum is at the top right corner.

comparing the median pre-operative and post-operative LCEA for the Pincer type FAI group ($P < 0.001$).

The labrum was preserved in every case without disrupting the chondral labral interface throughout the case [14]. Suture Anchor reinforcement of the labrum insertion was performed in every case, 1 anchor was used in 36 patients, 2 anchors were used in 23 patients and 3 anchors were used in only 2 cases.

The alpha angle preop Mixed type FAI was 56° (range 52–62), post-operatively was 46° (range 40–48). A statistical significant difference was found when comparing the median pre-operative and post-operative alpha angle for the Mixed type FAI group ($P < 0.001$).

The alpha angle preop Cam type FAI was 60° (range 58–62), post-operatively was 44° (range 42.5–49.5). A statistical significant difference was found when comparing the median pre-operative and post-operative alpha angle for the Cam type FAI group ($P = 0–007$).

The LCEA preop sub-spine type was 45° (range 42–45), post-operatively was 26.5° (range 26–26.5).

PROs score and VAS were obtained pre-operatively and at 6, 12 and 24 months post-operatively (no patients were lost to the last follow-up evaluation).

The pre-operative median WOMAC score for the Mixed type FAI group was of 38 points (range 30–42), at 6 months postop was of 73 points (range 61.2–81.5), at 12 months was of 83 points (range 77–84.7) and at 24 months was of 84 points (range 82–86). When the medians were compared in the Mixed type FAI groups there was a statistical significant difference between the pre-operative and 6, 12 and 24 months postop ($P < 0.001$).

For Pincer type FAI, median pre-operative WOMAC score was of 37.5 points (range 32.2–41), at 6 months was of 71.5 points (range 62.5–79.7), at 12 months was of 81 points (range 77.5–83.5) and at 24 months was of 88 points (85–89). When the medians were compared for the Pincer type FAI group statistical significant difference was found between the pre-operative scores and the 6, 12 and 24 month scores ($P < 0.001$).

For Cam type FAI the median pre-operative WOMAC score was of 40 points (range 32.5–47), at 6 months postop was of 80 points (range 74–82), at 12 months was of 84 points (range 81–87) and at 24 months was of 88 points (range 87–89.7). When the medians were compared for the Cam type FAI group statistical significant difference was found between the pre-operative and 6 months scores ($P < 0.001$), between pre-operative and 12 months scores ($P = 0.008$) and the pre-operative and 24 months scores ($P = 0.012$).

For the two patients with sub-spine impingement the pre-operative WOMAC scores were of 36 and 39 points, respectively, at 6 months postop were 74 and 78, at 12 months were 82 and 83 and at 24 months 88 points for both.

The pre-operative median VAS score for Mixed type FAI was 7 points (range 7–8), at 6 months was 3 points (range 2–3), at 12 months was 1 point (range 1–2) and at 24 months was 1 point (range 1–2). The median pre-operative median VAS score for Pincer type FAI was 7 points (range 7–8), at 6 months postop was 3 points (range 2–4), at 12 months was 2 points (range 1–2) and at 24 months was 2 points (range 1–2). The pre-operative median VAS score for Cam type FAI was 8 points (range 7–8), at 6 months postop was 2 points (range 2–5), at 12 months was 2 points (range 1–2.5) and at 24 months was 2 points (range 1–2).

The pre-operative VAS score for sub-spine impingement was of 7 points for both patients, at 6 months postop was 3 and 4 points, respectively, at 12 months was 2 and 3 points, respectively, and at 24 months was of 1 point for both.

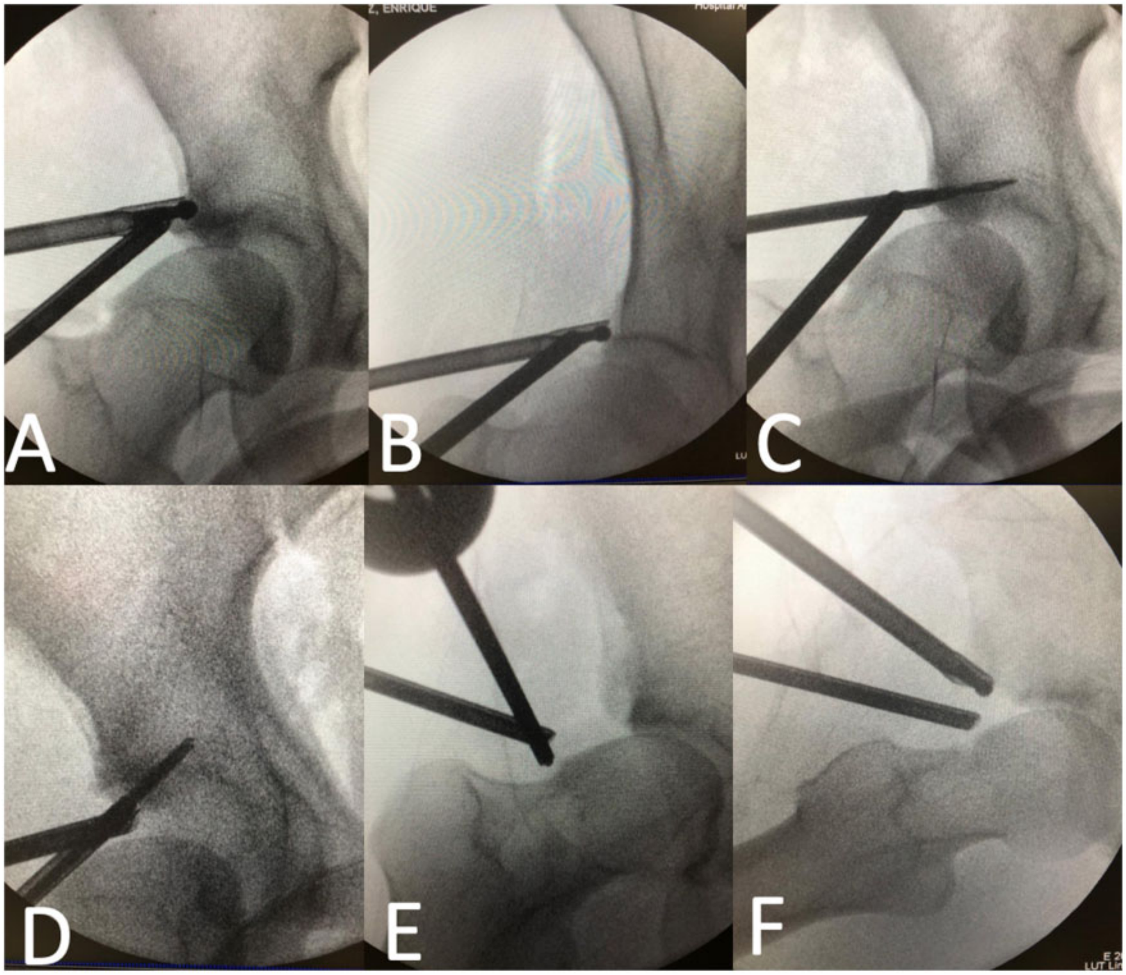

Fig. 9. Fluoroscopy sequence of a pincer and a cam deformity arthroscopic decompression in a right hip. (**A**) The arthroscope is at the bottom as a burr is observed on top of a pincer deformity at the lateral rim. Note that the hip is without traction. (**B**) This figure demonstrates the burr in position after resection of the lateral aspect of the pincer deformity. (**C**) A drill is in position at the lateral rim for anchor placement. (**D**) A drill is in position at the anterior rim for anchor placement. (**E**) Decompression of the cam deformity. (**F**) Photograph of the end result, the proximal femur is in lateral view.

None of the patients in the series presented complications related to the surgical procedures or required further intervention.

DISCUSSION

Biomechanical studies have shown that the capsule plays an important role in hip joint stability. Instability or dislocation is a complication that can be present after capsulotomy during hip arthroscopy, and routine capsular closure or plication in non-arthritic patients may result in superior outcomes compared with unrepaired capsulotomy, even more in those patients that the capsulotomy was not completed. Domb *et al.* [15] found that patients who underwent capsular repair had favorable results with comparable safety and efficacy to those without capsular closure. Biomechanical studies have been paramount in the evolution of hip-preservation surgery and, for years, have provided valuable information about capsular anatomy and function [12]. Many studies showed that surgical treatment of the capsule is a non-eligible component of restoring proper hip function and motion [16, 17]. Furthermore, cases of dislocation or subluxation after hip arthroscopy raise concerns about post-operative or even iatrogenic instability, particularly with the increasing prevalence of arthroscopic procedures [18].

Published studies have presented on biomechanics and post-operative instability have accumulated, arthroscopic capsular repair has increased in prevalence and trended toward becoming a routine procedure [2, 19]. In a survey of 27 high-volume hip arthroscopy surgeons performed by

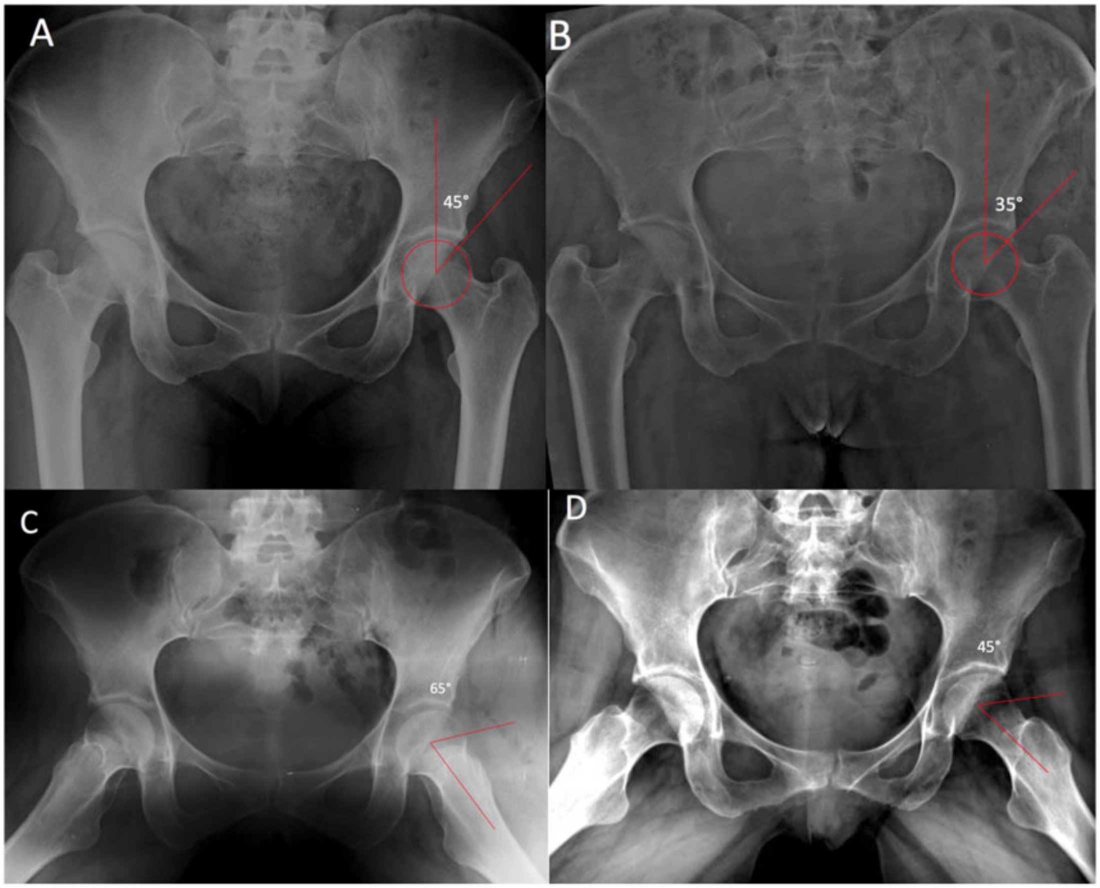

Fig. 10. Pre-operative and post-operative radiographs of a mixed FAI case (left hip). (**A**) Pre-operative AP pelvis with lateral-center edge angle measurement of 45°. (**B**) Post-operative AP pelvis with lateral center edge angle measurement of 35°. (**C**) Pre-operative frog-leg lateral with an alpha angle measurement of 65°. (**D**) Post-operative frog-leg lateral with an alpha angle measurement of 45°.

Gupta *et al.* [20], all performed routine capsulotomy to gain access to the joint.

Capsular closure was performed by three surgeons (11%) in every case whereas three surgeons (11%) reported never closing the capsule. The decision-making process for capsular treatment varies among surgeons and depends mainly on the patient's individual characteristics. Most of the surgeons in the study by Gupta *et al.* (78%) based the decision to perform capsular closure on intraarticular pathology and underlying conditions, such as instability. Thus, a routine application of capsular repair techniques that individually integrates each patient's history, clinical presentation and intraoperative findings appears to be becoming the norm in hip arthroscopy.

In our study, we present an access technique that preserves the iliofemoral ligament and we report on the results of PROs and the change in radiographic measurements of impinging deformities.

Based on our findings we can demonstrate that by using this technique we can obtain adequate arthroscopic access to the hip joint in order to adequately perform the treatment of impinging deformities demonstrated by a significant improvement in PROs between the pre-operative and post-operative follow-up scores in Mixed, Pincer and Cam type FAI, respectively. The same is true for pain VAS, where patients also improved between their pre-operative and progressive follow-up status.

We were also able to obtain significant improvement in radiographic measurements of Mixed, Pincer and Cam type FAI.

Statistical analysis of the cases with sub-spine impingement was not performed because there were only two patients in the series but both patients presented improvement in the PROs, VAS and radiographic measurements between the pre-operative and follow-up evaluations.

In theory preserving the iliofemoral ligament will diminish the risk of soft tissue instability of the hip due to capsular resection. In this study, we were able to demonstrate with clinical outcomes and radiographic results that we could effectively manage FAI deformities using the described access technique.

CONCLUSION

In conclusion, with the increasing number of hip arthroscopies being performed around the world yearly, the number of complications related with the procedure, are increasing. Thus, the development of new surgical techniques that allow to preserve most of the soft tissues surrounding the hip is attractive. Our described technique preserves the iliofemoral ligament to prevent instability and/or dislocations. We demonstrated that good results based on clinical outcomes and radiographic measurements are achievable using this ligament spearing approach.

Study limitations

In this study, we present a surgical technique to treat FAI and impinging deformities without cutting the iliofemoral ligament. Even though we had good clinical results, no biomechanical analysis of the function of the preserved iliofemoral ligament was performed. Further studies are needed, including comparative studies that address interportal capsulotomy cutting through the iliofemoral ligament with and without repair and iliofemoral ligament preservation and look at post-operative instability.

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CONFLICT OF INTEREST STATEMENT

None declared.

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