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Operative Techniques in

Sports Medicine

Hip Morphology and Its Relationship to Pathology: Dyplasia to Impingement

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Developmental dysplasia of the hip (DDH) and femoroacetabular impingement are conditions that occur in adolescents and young adults that cause hip pain. The morphology of both conditions will be discussed as they relate to pathology. Radiographs taken in both conditions many times are read as "normal." On careful analysis, these conditions can be easily seen on radiographs. Reinhold Ganz with the Bern Hip Group and Jeff Mast have developed outstanding open techniques to correct both with a periacetabular osteotomy to correct DDH and a safe surgical dislocation of the hip to alleviate femoroacetabular impingement. Although not correcting the structural defects in DDH, arthroscopy may be helpful in alleviating pain. An arthroscopic equivalent to the open surgical dislocation of the hip will be presented. The early results are favorable.

KEYWORDS developmental dysplasia of the hip, femoroacetabular impingement, hip arthroscopy, resection osteoplasty, femoral head-neck reshaping, surgical dislocation of the hip

Hip pain in younger individuals has been associated with abnormal morphology of the hip joint itself. Developmental dysplasia of the hip is a cause of instability, whereas femoroacetabular impingement slightly captures the joint and may reduce motion because of pain typically in flexion and internal rotation. Both conditions lead to early degenerative changes and arthritis of the hip.[1,2] In developmental dysplasia, there is a shallow socket associated with femoral neck anteverion. This has been studied extensively and surgical remedies have been well described.[3-6] In recent times, there has been more attention paid to the acetabular morphology and its association with dysplasia and femoroacetabular impingement syndrome.[7]

Development Dysplasia

In developmental dysplasia of the hip (DDH), the deficient bony coverage by the acetabulum over the femoral head leads to increased forces that are concentrated anteriorly and superiorly. Typically, in dysplasia, there is an enlarged acetabular labrum to substitute for the bony rim. It resists subluxing forces; however, eventually, the structural resistance fails with a labral tear or separation from the acetabular rim. As a result, the femoral head will sublux anterior and superiorly. Occasionally, a bony fragment may avulse with the labrum. This also may be associated with a paralabral cyst or ganglion and the labrum may contain myxoid degeneration.[2,8,9]

Recognizing dysplasia of the hip is most often quite obvious. When looking at an anterior to posterior radiograph, a steeply sloped acetabulum is deficient in the coverage of the femoral head. There are several methods to measure hip dysplasia.[7]

Radiograph Analysis

The lateral center edge angle,[7] (CE angle of Wiberg) is measured on an anteroposterior view from the center of the femoral head vertically and an angle measured from the lateral rim. An angle less than 20° is consistent with dysplasia. Greater than 25° is considered normal with an angle between 20° and 25° as borderline. The anterior center edge angle[7] is measured on a false profile view. Lequesne and de Sèze concluded that less than 20° was consistent with dysplasia. The femoral head extrusion index[7] is the percentage of the femoral head outside of the acetabular roof. Greater than 25% was consistent with hip dysplasia.

The acetabular index of the weight-bearing surface[7] (acetabular index) is the angle formed by the acetabular roof

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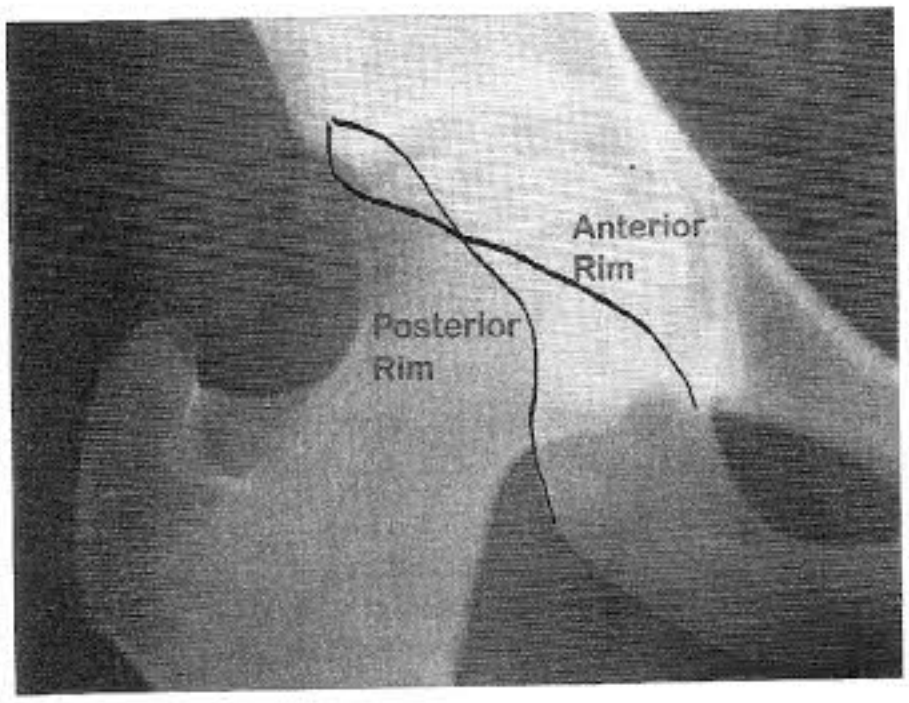


Figure 1 Right hip: this is an example of the figure 8 created when tracing the rims of a retroverted acetabulum creating a crossover sign[7].

"eyebrow or sorcil." Normal values are from 4° to 10°. Greater than 10° is consistent with acetabular dysplasia. Congruence[7] between the femoral head in the acetabulum is also measured. The acetabular and femoral head the subchondral bone should be concentric in normal hips. If they are not concentric, the incongruence is consistent with dysplasia.

Acetabular version[7] can also be measured on plane roentgenograms. This is done on an anteroposterior radiograph in which the coccyx must be centered over the pubic symphysis and should be not separated more than 2 cm. Deviations from this will not control inclination in the sagittal plane. Lines are then traced from the anterolateral edge of the acetabulum along the anterior and poster projections of the rim. If the posterior line is traced more laterally than the anterior wall, the acetabulum is anteverted.

If the anterior wall is traced more laterally than the posterior wall, the acetabulum is retroverted. A figure-of-8 sign appears when the anterior wall crosses the poster wall on a tracing (Fig. 1). This is consistent with an excess anterior bony rim, which may cause impingement on the femoral head neck junction, causing relative retroversion. If the shadows traced are equal, the acetabular is believed to be in neutral version.

Periacetabular Osteotomy

There are many different ways to treat hip dysplasia using both femoral and acetabular osteotomies. Ganz and coworkers[9] pioneered a periacetabular osteotomy for adolescents and young adults with dysplastic hips and associated pain.[10] Most had a gradual onset of hip pain without radiographic evidence of arthritis. They all had radiographic evidence of dysplasia. They concluded the advantages over previous techniques were that it was done through a single incision and a large multidirectional correction could be accomplished. Additionally, the blood supply to the acetabulum was preserved; the poster column of the hemipelvis was left intact, thus allowing early weight bearing, and the need for minimal fixation and the true pelvis was unaltered, allowing for normal childbearing in women who had the operation.

Siebenbroch et al[30,31] reported on their first 75 patients showing overall (72%) good to excellent results. They showed that 87% of the hips continued to function well at 10 years, and the joint space was preserved in 82%. They found those who had labral lesions had a significantly worse outcome.

At the annual Bern hip symposium, Mammoth Lakes, 2003, it was reported that some individuals postoperatively developed groin pain. When investigated, they found that there were some with overcorrection of the acetabulum causing relative overcoverage or retroversion of the acetabulum. It was from those patients, they concluded, that the pain was coming from femoroacetabular impingement. They noticed the same type of hip pain in patients without dysplasia. Investigations into those patients led to the discovery of femoroacetabular impingement syndrome as we know today. They treated it with a surgical hip dislocation and resection osteoplasty at the femoral head neck junction and the acetabular rim.

The treatment of hip dysplasia by arthroscopic means cannot correct the bony architecture of the hip. However, in individuals with hip pain associated with hip dysplasia, palliation may be accomplished. Few articles have addressed this.

Arthroscopic Treatment of DDH

Byrd and Jones[13] looked at 48 patients with either hip dysplasia or borderline hip dysplasia from a population of 186 cases done consecutively. They measured dysplasia with the CE angle of Wiberg. They defined dysplasia as a CE angle of less than 20°. Borderlines were measured as those between 20° and 25°. Their average follow-up was 27 months with a range of 12 to 60 months. The age range was 14 to 64 years old. The arthroscopic procedures performed were directed by the pathology as follows: label excision (32), chondroplasty (25), debridement of the ligamentum teres (13), microfracture (8), removal of loose bodies (8), debridement of the pulvanar (3), diagnostic arthroscopy (2), and thermal capsulorrhaphy (1).[13]

They used a modified Harris hip score in which range of motion was not a factor. They showed significant improvement with an average score preoperatively of 57 and a postoperative score of 83. They concluded that there is no statistical difference between the dysplastic group and the general arthroscopic population.

We had studied a group of 28 patients treated arthroscopically for labral tears followed between 3 and 96 months.[14] The exact etiology of those tears was not studied. We found the presence of arthritis on plane roentgenograms correlated with poor results (21% good to excellent.) In the absence of arthritis on plane roetenogramns, we found 71% had good excellent results. At arthroscopy, if there were no chondromalacia of the femoral head, the results were 92% good to excellent. Likewise, if there was no acetabular chondromala-

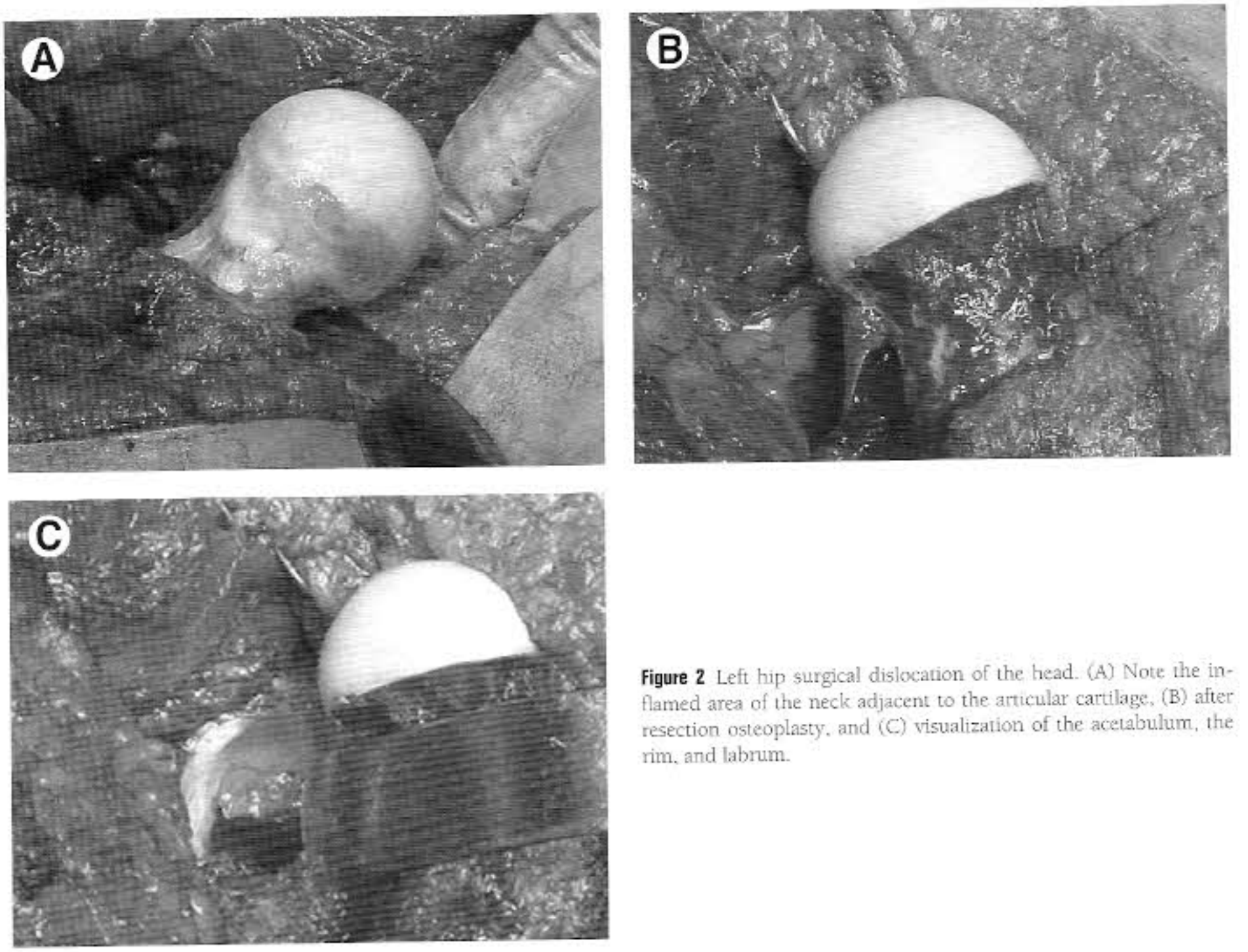


Figure 2 Left hip surgical dislocation of the head. (A) Note the inflamed area of the neck adjacent to the articular cartilage, (B) after resection osteoplasty, and (C) visualization of the acetabulum, the rim, and labrum.

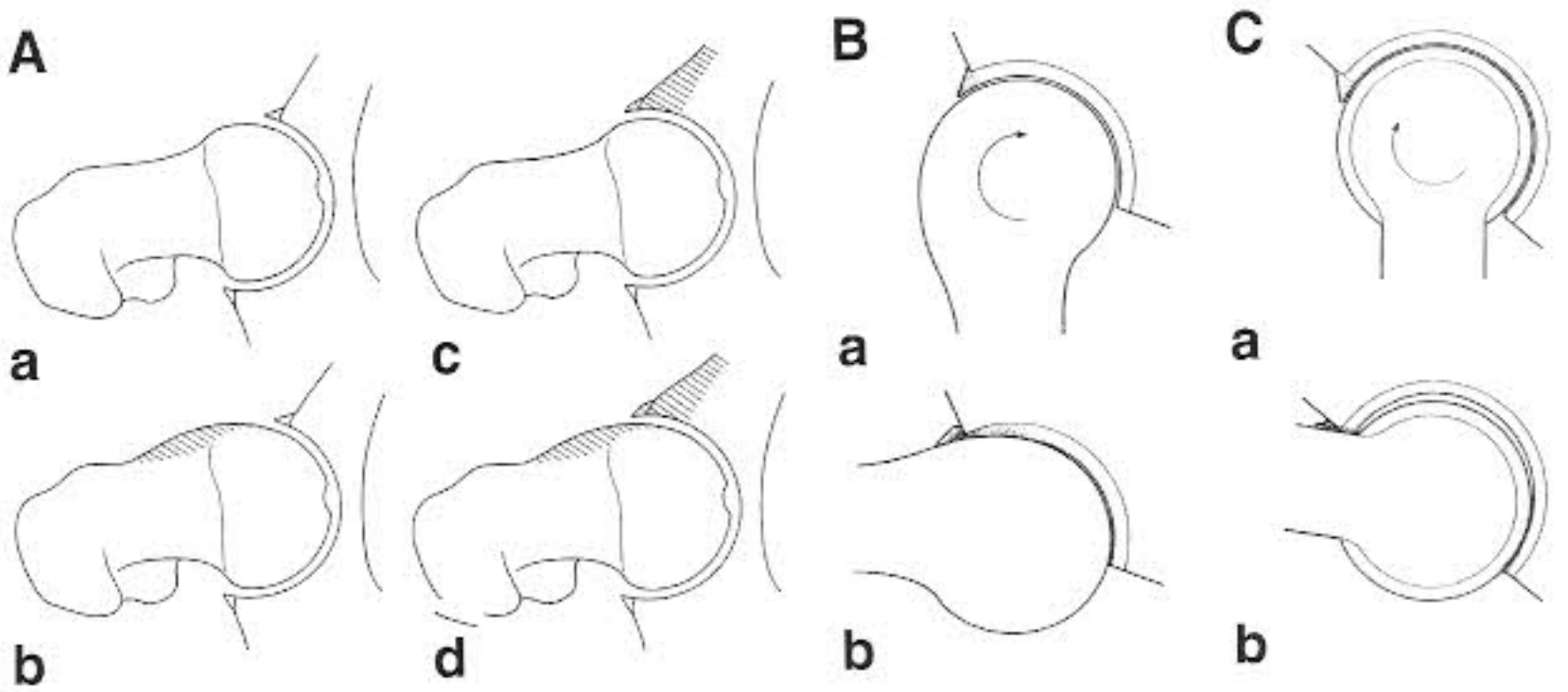


Figure 3 (A) Femoroacetabular impingement factors are reduced joint space clearance and repetitive abutment against the labrum and the articular cartilage of the acetabulum. (a) Normal hip, (b) bony excrescence causes reduced head neck offset, (c) acetabular over coverage of the femoral head, and (d) combined acetabular over coverage and reduced had head neck.[18] (B) Cam impingement. (a) In extension, the spherical portion of the femoral head does not abut the rim of the acetabulum. (b) In flexion, the acetabular articular cartilage is compressed by the aspherical portion of the femoral neck and the labrum is abutted.[15] (C) Pincer impingement. (a) Normal extension and (b) in flexion crushes a small band of the acetabular cartilage and the labrum. As the head is levered out of the acetabulum, a posterior contra-coup lesion occurs.[15] (Reprinted with permission from Beck et al[15] and Lavigne et al.[18])

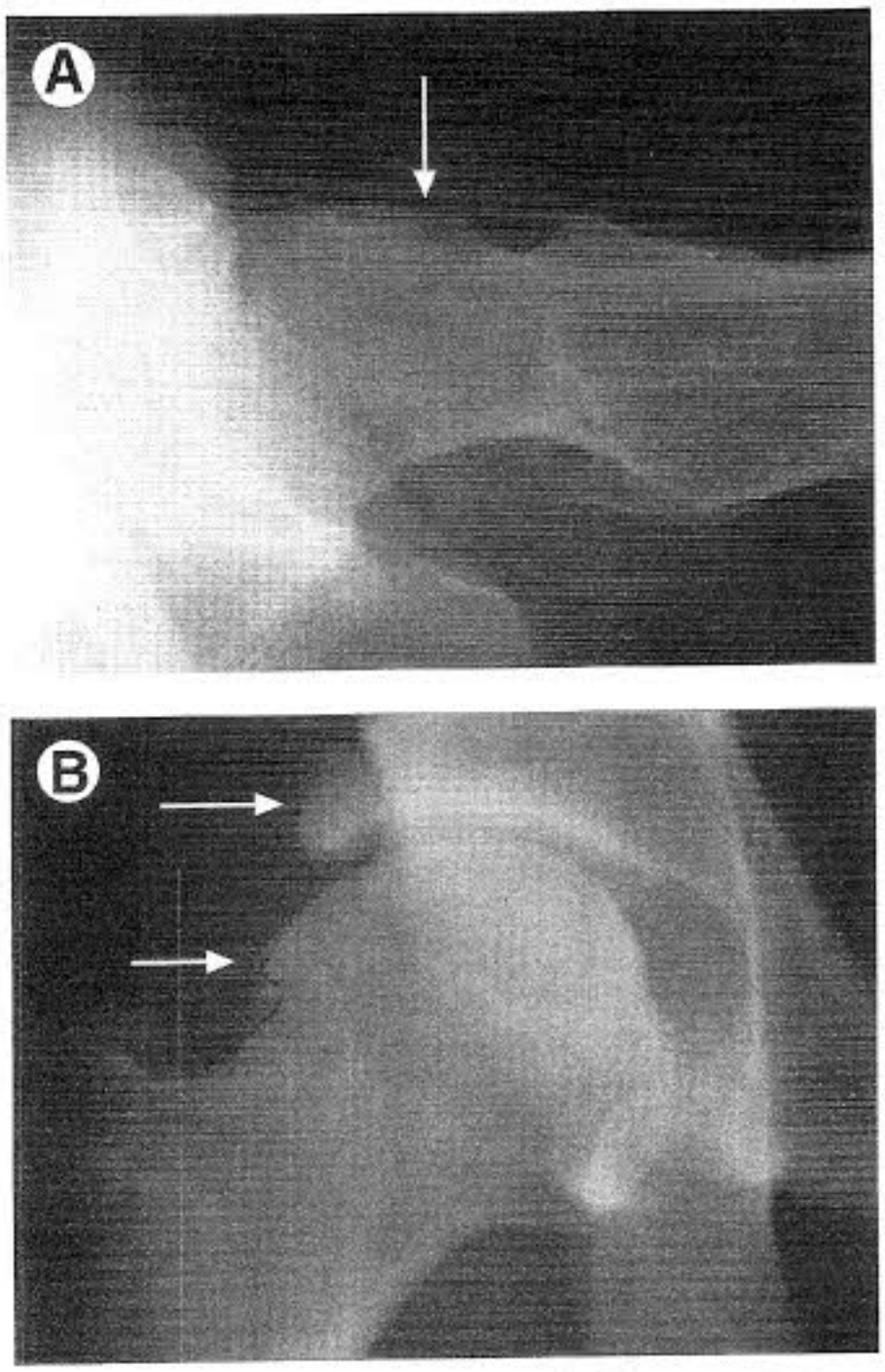


Figure 4 a Left hip radiograph in young girl with cam type impingement. Out of round bump on the head overloads the acetabular cartilage as it is rotated into the joint (arrow). (B) Right hip radiograph in a young man with pincer type impingement. Shortened head neck offset abuts the rim of the acetabulum (lower arrow), eventually causing ossification of the labrum which then looks similar to a shear type fracture (upper arrow).

cia, we found 82% had good excellent results. A number of those patients had DDH. In retrospect, most of those patients suffered from either hip dysplasia or unrecognized femoroacetabular impingement as the etiology to their labral tears.

Femoroacetabular Impingement

Femoroacetabular impingement was relatively unknown by US orthopedic surgeons until the last 3 to 4 years. The Bern Hip Group headed by Reinhold Ganz had studied this entity extensively and recently published on its etiology and treatment using a surgical dislocation of the hip.[1,15-23] (Fig. 2). They found it to be present in adolescents and young adults and postulated that it is a precursor to early osteoarthritis. It is described as a mechanical conflict between the femoral head neck junction and the acetabular opening and rim. As the out of round femoral head is stuffed into the acetabulum, mechanical forces may abrade the articular cartilage near the rim. As the cartilage breaks down, the labrum may separate and tear away from the rim (Fig. 3A).

In total hip replacement, we have known for many years that poor head neck offset of the femoral component with small head sizes may cause impingement of the polyethylene cup. Abnormal denting of the polyethylene would then lead to early failure, third body wear, and failure of the entire implant.[24-27]

Similarly, the natural hip depends on appropriate head neck offset to provide good joint clearance. With a reduced neck offset or sphericity of the femoral head, early contact or incongruence with increased loading of the acetabular rim will reduce joint clearance and cause femoroacetabular impingement.

Types of Femoroacetabular Impingement

Two distinct types of femoroacetabular impingement were observed during surgical dislocation of the hip.[15] Cam type occurs from an out of round femoral head in which there is a bony bump in the area of the anterolateral head neck junction. The increase in radius of the femoral head causes a mismatch between the femoral head and the acetabulum. As the head is forced into the acetabulum, especially in flexion and rotation inward, the compressive and sheer force overloads the articular cartilage of the acetabulum. As a result, chondral changes occur at the anterior and anterosuperior cartilaginous labral junction of the acetabulum. The articular cartilage avulses from the labral rim causing a cleft type defect seen on magnetic resonance imaging. Along with the labral tear, a subchondral bone avulsion may occur that may be seen at the anterior superior edge on a plain radiograph (Fig. 3B).

Pincer-type femoroacetabular impingement occurs with direct contact on the acetabular rim by the head neck junction. It usually occurs from over coverage by the acetabulum, such as seen in Coxa profunda or acetabular retroversion. The recurrent abutment against the labrum causes labral degeneration or ossification. The ossification gives an appearance of a deepened acetabulum. Continued abutment against the ossified labrum levers the head out of the socket, causing

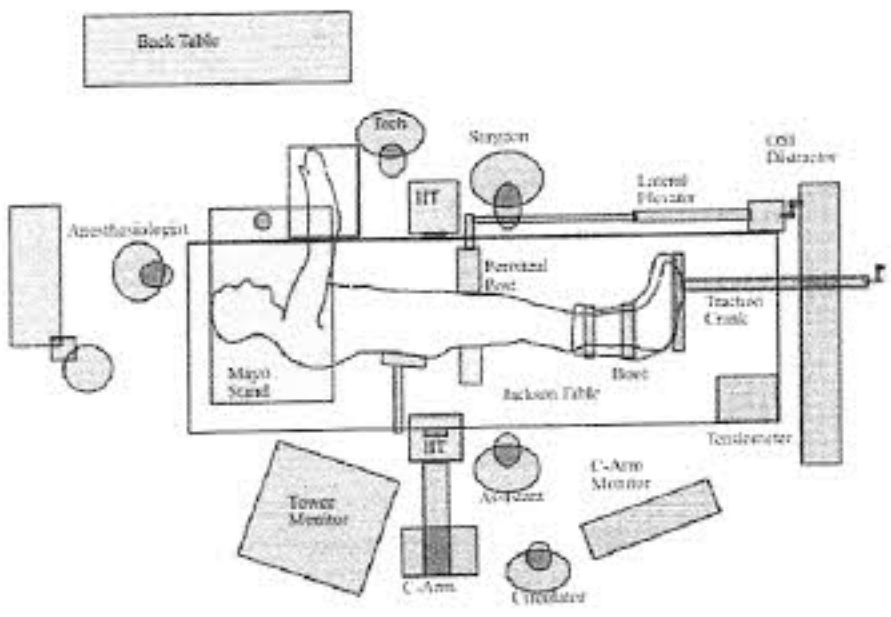


Figure 5 Room setup. Note the surgeon stands anterior to the patient and the c-arms brought under the patient.

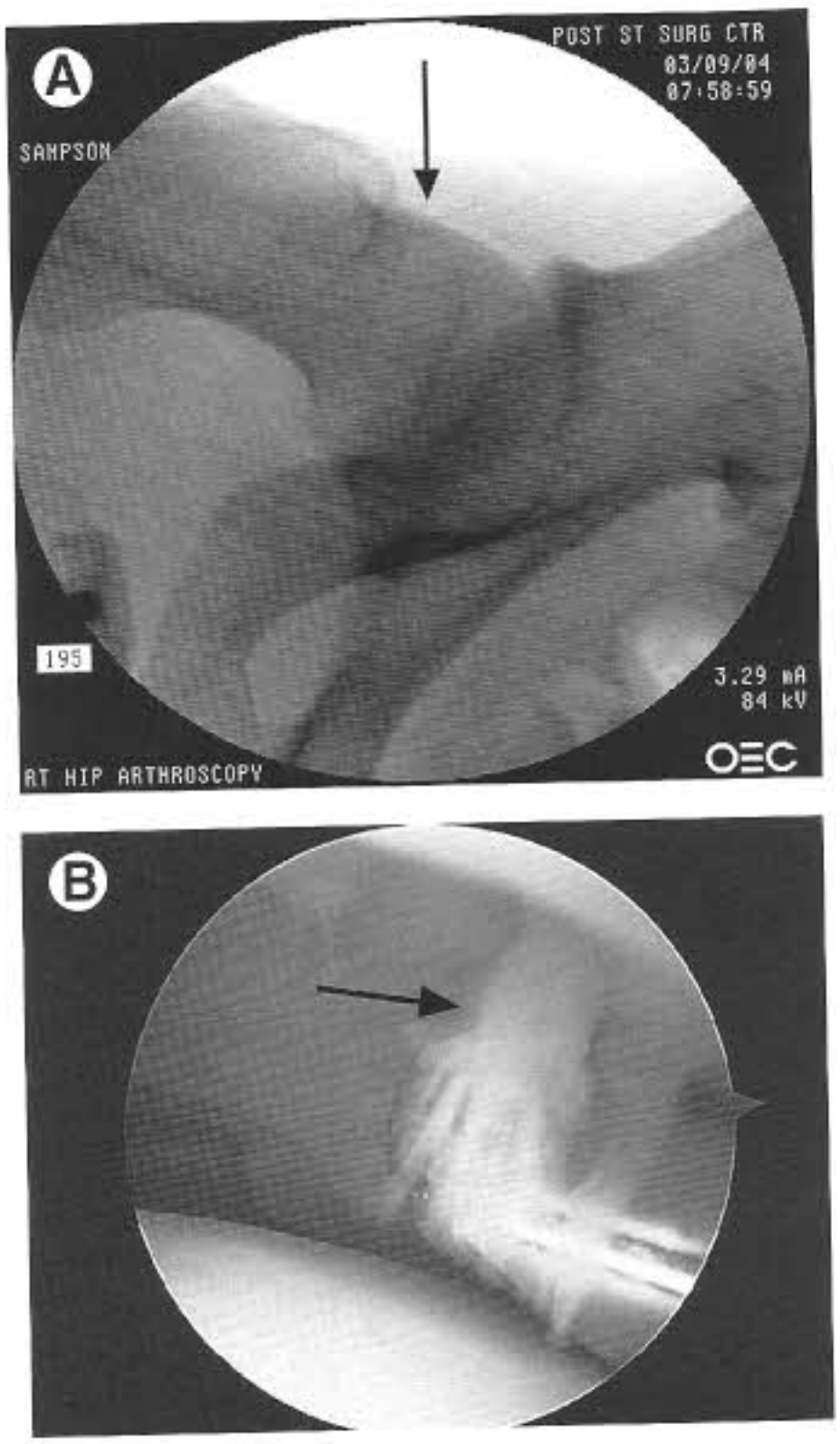


Figure 6 A young professional bull rider with right-sided cam impingement. (A) Lateral fluoroscopic view shows the prominence at the head/neck junction at the physeal line (arrow). (B) Arthroscopic view from the anterolateral portal shows a combined element of articular and labral fibrillation (arrow) being debrided from the posterolateral portal.

a chondral lesion in the posterior inferior aspect and the development spur in this region (Fig. 3C). Lavigne and coworkers[18] believed that the pincer-type chondral lesions were limited to small rim area and more benign than the cam type. They found that the pincer type was seen more in middle-aged women participating in athletic activities requiring a great deal of motion compared with the cam type seen in young athletic men (Fig. 4A and B).

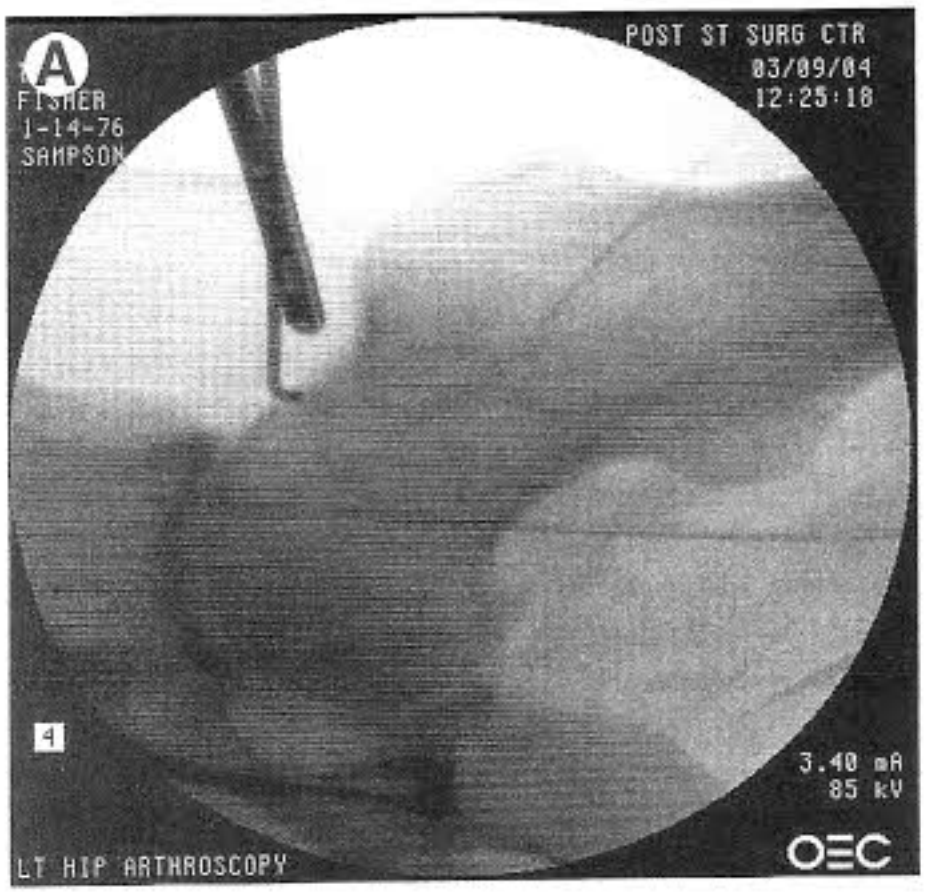
Surgical Dislocation for Femoroacetabular Impingement

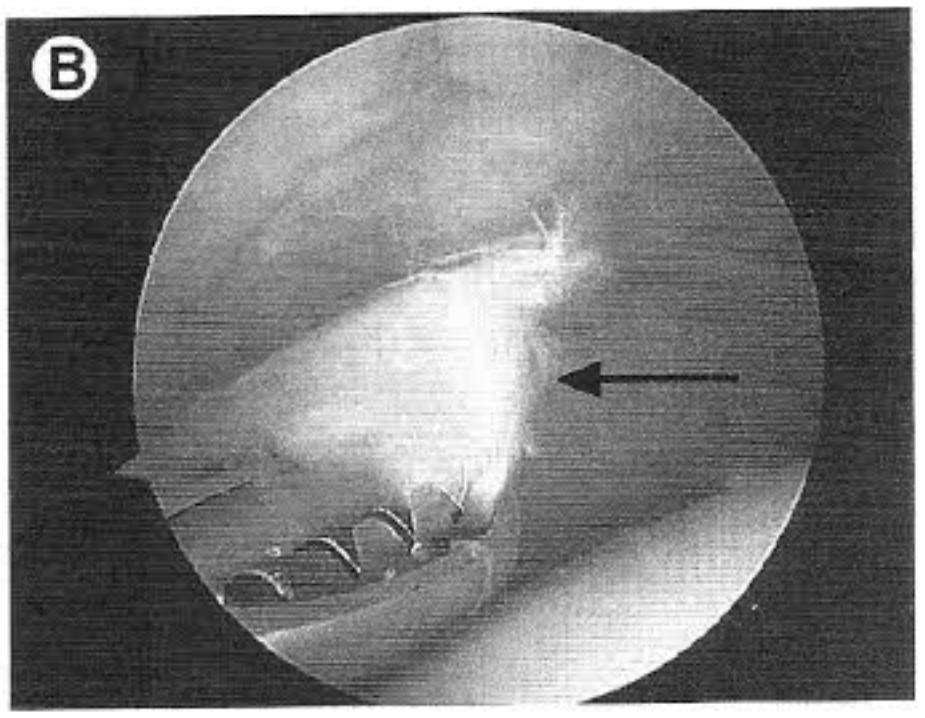
The Bern Hip Group developed a joint preserving surgical approach to remove the offending bone by reshaping the femoral head neck junction or the acetabular ran. To do this safely, they studied the blood supply to the femoral head and found if they preserved the lateral to the epiphyseal branch of the medial femoral circumflex artery, other capsular arteries can be killed without causing avascular necrosis.[28] The procedure is done with the patient in the lateral decubitus position through a lateral approach to the hip. A trochanteric osteotomy (trochanteric flap) and an anterior dislocation of the hip allows for a 360° view of the head and neck and a good view into the acetabulum. Labral tears may be treated with partial resection or repair, and acetabular rim osteophytes are removed. The head neck may be reshaped and contoured using osteotomes. Postoperatively, patients are kept on 2 crutches, nonweight bearing until the trochanteric osteotomy has healed.

The goal was to eliminate pain and the pathologic cause of early degenerative joint disease. They studied 19 patients with a mean age of 36 years old (21-52 follow-up for an average of 4.7 years [4-5.2 years]). They found good results in 14 of 19 and no osteonecrosis. They concluded that the surgical dislocation with correction of femoroacetabular impingement yielded good results in patients with early degenerative changes not exceeding grade 1. It was not beneficial to those with advanced degenerative changes or extensive articular cartilage damage.[13]

Reinhold Ganz was of the opinion that the arthroscope may be used for debridement or for labral tears; however, access to the underlying causes of hip impingement was technically challenging if not impossible.[18] It was for that reason, as well as our experience at accessing difficult areas of the hip to remove osteophytes and treat labral tears, that we were challenged to create an arthroscopic equivalent to the surgical hip dislocation procedure. It was evident that most of the resection osteoplasty of the femoral head neck junction was done midlaterally to anteriorly and medially (T.G. Sampson and J.M. Glick, personal observation/communication, 2003). It was also evident that an experienced surgeon resected the appropriate amount of bone on the first try (T.G. Sampson and J. Mast, personal observation/communication, 2003). It was rare to remove more bone after checking head neck clearance by flexing the hip during the procedure. From that, it was believed that a 360° view of the femoral head neck junction was not entirely necessary. Most of the boney excrescence in femoroacetabular impingement is anterior extending lateral. Likewise, most of the acetabular lesions and the exostoses occurred anterior. In addition, most of the labral lesions associated with impingement and the chondral defects of the acetabulum occurred anteriorly with a few extending posteriorly.

Initially, the procedure was tried using 3 standard portals with the hip in traction and the capsule left intact. We noticed that the majority of the procedure could be done without any traction if the hip was placed in some flexion to open up the capsule for better viewing. Because of some difficulties with exposure, we settled on an anterior capsulectomy for the best exposure.





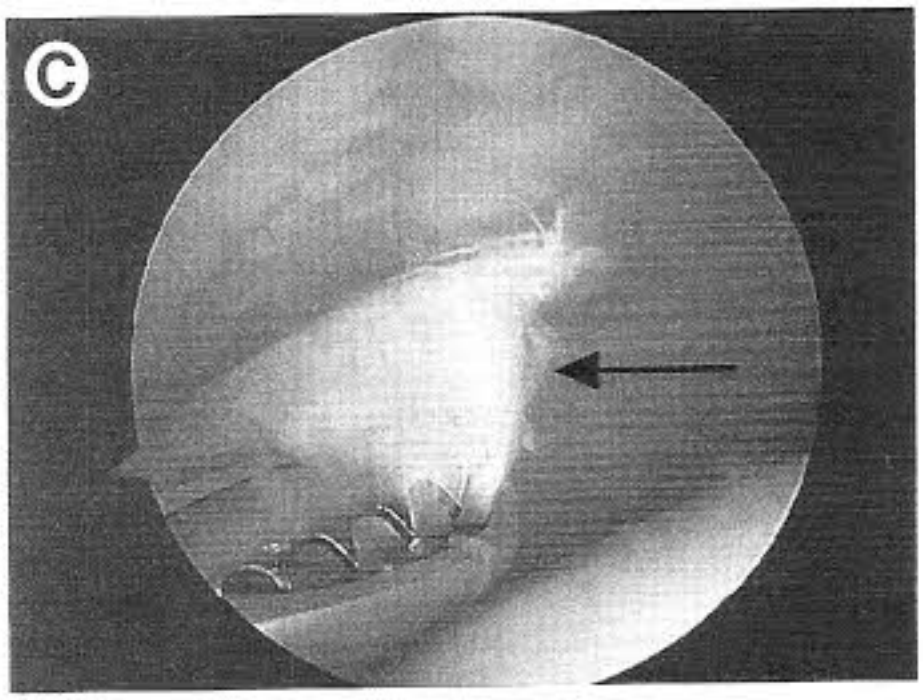


Figure 7 A young professional bronco rider with left-sided cam impingement. (A) Lateral fluoroscopic view shows the probe and scope positioned for the capsulectomy with the hip is in maximal external rotation. (B) An acetabular cartilage delamination (arrow) defect viewed through the anterolateral portal being debrided through the anterior portal with a shaver. (C) Note the fibrillated cartilage adjacent to healing cartilage (arrow).

Technique of Arthroscopic Treatment of the Femoroacetabular Impingement

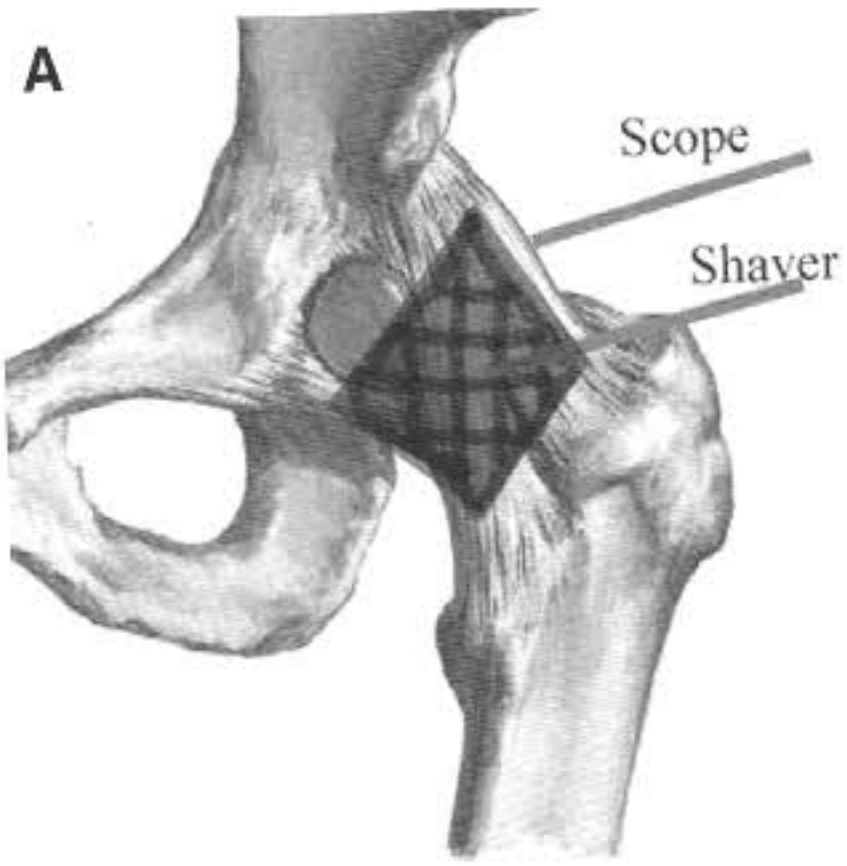
The patient is placed in a lateral decubitus position and set up identical to the "lateral approach."[29-32] This may be done in the supine position as well. A standard distractor is used, and the peroneal post should be at least 9 cm in diameter. The peroneal post is placed eccentrically toward the operated hip to reduce the chance of a pudental nerve palsy.[33] The c-arm fluoroscope is brought in under the table, providing a good anterior to posterior your view (Fig. 5). After the leg is set up in the traction device, the hip is fluoroscoped looking for the maximal offset of the femoral head neck junction or lateral bony excrescence. Typically, this is best seen with the hip and maximal external rotation, which rotates the anterior aspect of the femoral head into the field.

Three standard portals will be used: the posterolateral, anterolateral, and anterior portals. With adequate distraction, the hip joint is decompressed with a large spinal needle, allowing room air to break the suction seal. Using a cannulated system, the arthroscope is first introduced in the posterolateral portal with a 30° arthroscope. The anterolateral portal is then created, and the hip is first viewed under air followed by viewing under fluid.

The hip joint is swept with the arthroscope in the usual way. Typical findings in patients with femoroacetabular impingement show fraying or tearing of the labrum anteriorly and laterally. There may be articular cartilage damage from grade 1 to 4 and occasionally extending from midlateral to posterior.

Labral lesions are debrided with a shaver or a radiothermal device, and the articular cartilage is debrided or smoothed (Fig. 6A and B). Occasionally, delamination defects are encountered and must be debrided back to stable cartilage (Fig. 7A-C). The use of microfracture or picks has been done to stimulate cartilage production.

The traction is let down completely, although the hip is kept in extension with typical traction time from 12 to 30 minutes. The scope is then placed in the anterolateral portal



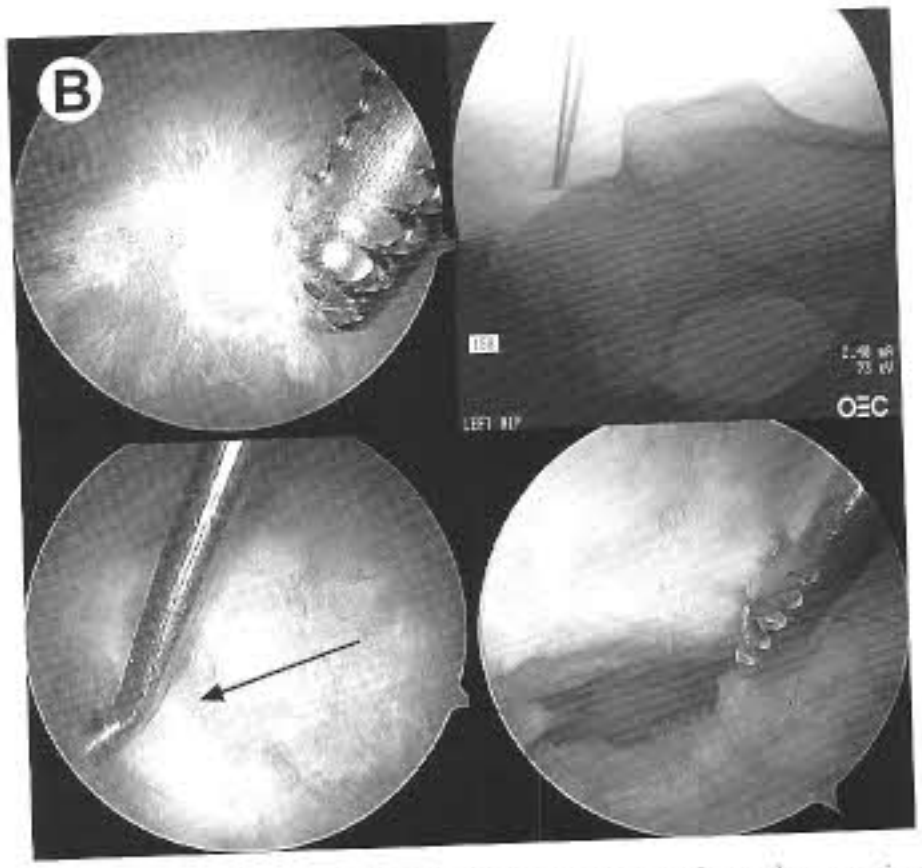


Figure 8 Capsulectomy. (A) Exposure is obtained from the anterior medial to the anterior lateral femoral neck. (B) Upper left shows the shaver outside the left hip capsule with the scope in the anterior portal and the shaver in the anterolateral portal. The upper right is a fluoroscopic view of the shaver and the hip is in maximal external rotation. The bottom left shows a probe at the cleft between normal head cartilage and the hyperemic boney bump (arrow). The bottom right is a view into the medial peripheral space.

on the capsule, checked for position with the C-arm, and with the trochar the muscle is separated from the capsule. The anterior portal is then created.[32] All surgery is done outside the joint while viewing the capsule. The potential space between the muscle and capsule is developed by bringing the shaver to the tip of the arthroscope and under direct vision; the sweeping motion will separate them.

An anterior capsulectomy is then done with a series of instruments, including a cutting radiothermal device, Beaver blade, and the motorized shaver. During this process, the foot is maintained in maximal extra rotation to position important retinacular vessels posterior and away from the capsulectomy (Fig. 8).

Exposure of the entire bony bump or osteophyte is accomplished. Often, a cleft or demarcation at the osseous cartilaginous junction to the femoral head neck junction and the base of the neck is seen. The capsule may be retracted with a probe to view the external portion of the labrum.

The resection osteoplasty is done with a 4.0 unhooded round burr. The area of resection is first outlined and then contoured between the outlines. The scope and burr are moved between portals to get a 3-dimensional view. Throughout the procedure, several radiographs are taken using the fluoroscope to ensure that adequate contouring is done and enough bone is resected (Figs. 9 and 10). Finally, the leg is detached from the traction device and put through a range of motion with direct viewing from the arthroscope to document clearance at the head/neck junction and the acetabular rim.

If there is an acetabular rim osteophyte, this may be resected in the same fashion behind the intact labrum. Occasionally, the labrum must be excised. To date, we have not detached the labrum to remove a rim osteophyte and then done a labral repair.

Postoperatively, the patients are placed on 2 crutches for protected weight-bearing and prevention of falls. They are

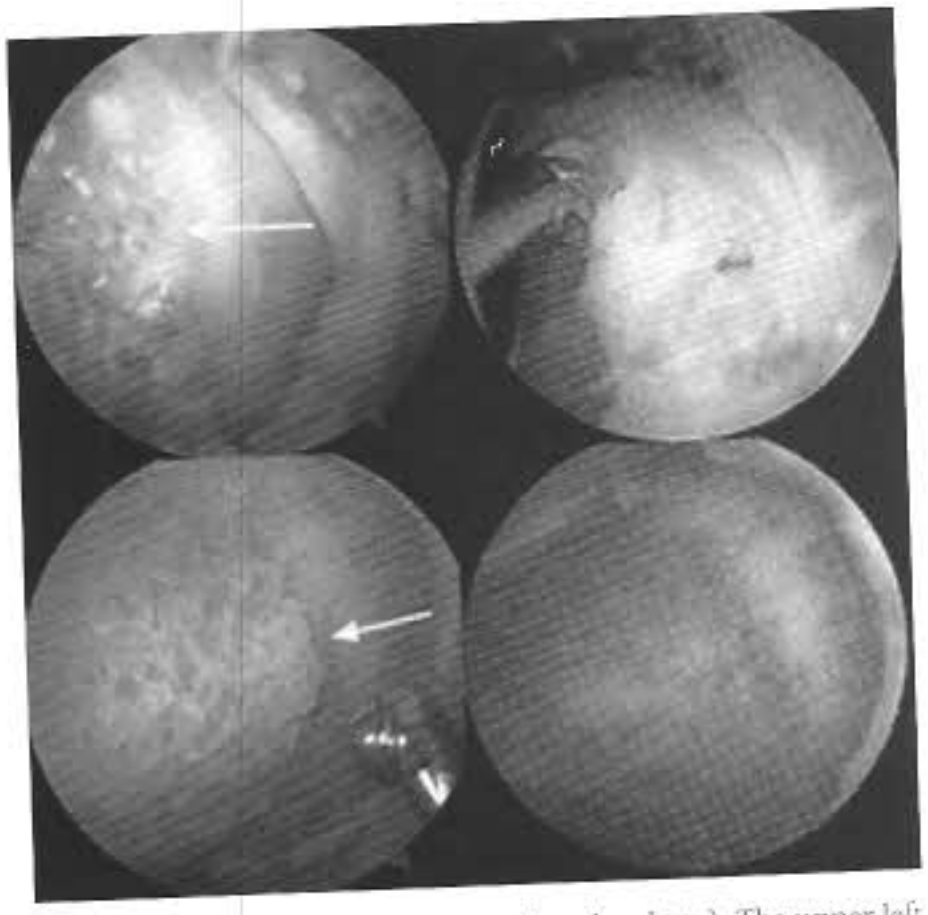


Figure 9 Resection osteoplasty (osteochondroplasty). The upper left shows the bump is well exposed viewing from the anterolateral portal of this right hip. Note the inflamed bony excrescence adjacent to the normal articular cartilage (arrow). The upper right shows the 4-mm unhooded burr is used to resected and reshape the head neck junction coming in from the anterior portal. The bottom left shows the progress of resection (arrow) and the bottom right shows the completed partial ostectomy. The exposure is similar to the open procedure.

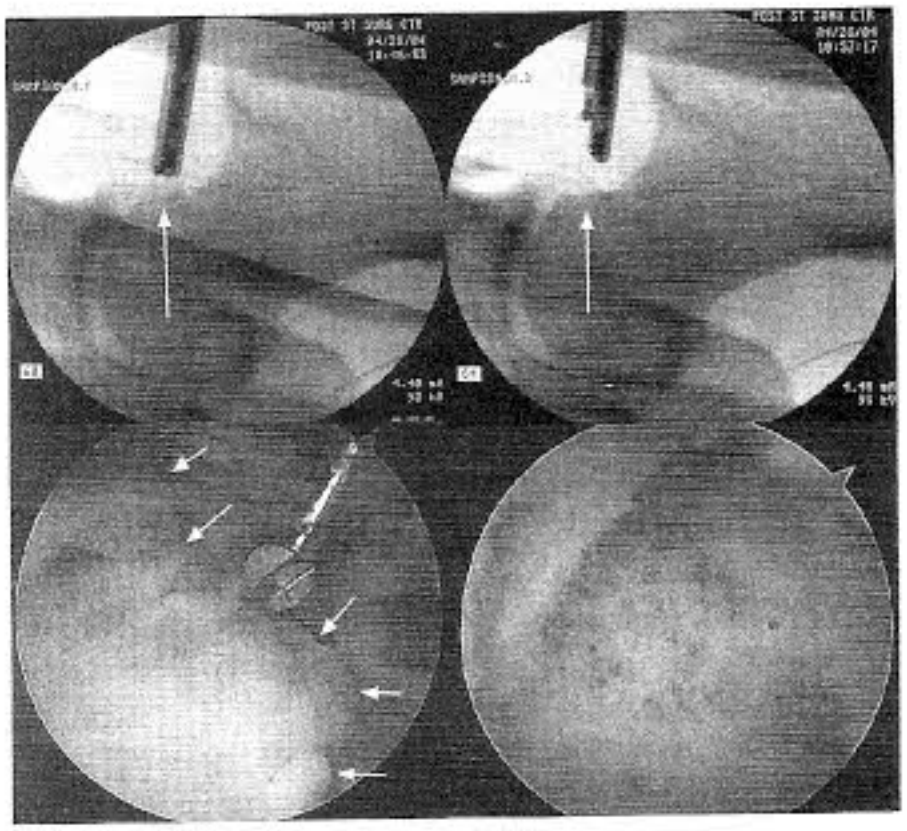


Figure 10 A left hip in a young man with cam impingement showing the upper fluoroscopic views and bottom arthroscopic views from the anterior portal. The left are preresection of the head/neck bump and right are postresection (arrows).

allowed to shower the next day and come off crutches when they feel they can. There instructed to not engage in any sporting activities or excessive activities 1 month. They may begin range of motion exercises such as the use of the stationary bicycle or swimming. At 1 month, the activity level is increased and physical therapy is used if their range of motion is poor. By 3 months, all restrictions are removed.

Results

Since November 2002, 90 patients had undergone arthroscopic treatment for femoroacetabular impingement. Our preliminary experience has been that nearly all patients had elimination of their impingement sign (pain on internal rotation and flexion of the hip) and were quite happy with their results. One patient suffered a pathologic fracture, which was nondisplaced and required closed pinning. There are no other complications. The early results seem similar to those reported in the open dislocation procedure and patients were off their crutches within 2 to 4 weeks.

Conclusion

Abnormal hip morphology causes pathologic conditions in the joint. Both developmental dysplasia and femoroacetabular impingement are precursors to early arthritis. These conditions can be treated both open an arthroscopically. A periacetabular osteotomy is needed to correct the anatomy in developmental dysplasia; however, arthroscopic debridement may relieve the symptoms caused by associated pathology.

Reinhold Ganz and his Bern Hip Group and Jeff Mast have made significant contributions to our understanding of femoroacetabular impingement. Their results have been favorable and have shown that it may prevent the progression of arthritis. An arthroscopic equivalent to the open surgical dislocation has been presented. Our experience has been that this can be done safely and effectively with favorable early results.

Acknowledgments

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