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Evaluation and Treatment of Borderline Acetabular Dysplasia

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Introduction

Acetabular dysplasia is a well-recognized cause of hip pain and dysfunction, with an associated risk of developing osteoarthritis (OA).[1-4] In this condition, insufficient coverage of the femoral head by the acetabulum leads to anterolateral migration of the femoral head within the acetabulum, leading to shear-type loading of the anterolateral acetabular cartilage and subsequent accelerated joint degeneration.[5]

The lateral center-edge angle (LCEA), first described by Wiberg in 1939, is the most commonly cited radiographic measure of acetabular coverage.[6] According to Wiberg's original description, hips with LCEA below 20° were considered pathologic and hips with LCEA more than 25° were normal. Hips with LCEA between 20° and 25° were considered uncertain. This uncertainty has created confusion in the literature concerning the spectrum of acetabular dysplasia severity, and nonspecific terms such as mild dysplasia[7-12] and borderline dysplasia[13-22] have been interchangeably used to describe these hips. The majority of currently available literature on these hips comes from hip arthroscopy studies, and the definitions of "mild" and "borderline" coverage have varied from as low as 16° to as high as 28°. In line with the confusion in classification of these hips, the best method to surgically address "mild" or "borderline" dysplastic hips, either via acetabular reorientation or arthroscopic soft tissue repair, is a topic of significant debate among hip preservation surgeons.

How Do We Treat Borderline Dysplasia?

Periacetabular Osteotomy

The periacetabular osteotomy (PAO), first described by Ganz, is the standard treatment of symptomatic acetabular dysplasia as it permits acetabular reorientation to optimize acetabular coverage while maintaining posterior column integrity.[23] The basic design for the PAO procedure, as developed by Ganz and Mast in the 1980s, is still followed today, with osteotomies of the anterior ischium; superior pubic ramus; anterior to posterior supra-acetabular ilium; and posterior column. With time, modifications to the approach have been implemented to reduce the degree of surgical dissection and expedite recovery.[24,25] Below is a brief description of the PAO surgical technique.

Patient Setup

The patient is positioned in the supine position on a radiolucent Jackson-type table. Anesthesia is typically accomplished through a combination of general anesthesia with a lumbar plexus block to permit early postoperative mobilization. Neuromuscular blockade is avoided to allow intraoperative monitoring of motor nerve function, as the femoral, obturator, and sciatic nerves lie in close proximity to the osteotomy cuts. To help minimize blood loss, transexamic acid is routinely dosed intravenously at the start of surgery, and a cell-saver system is commonly used to provide an autologous transfusion at the end of the case. Fluoroscopy is used throughout the PAO to obtain AP pelvis and false profile images, and the C-arm should be positioned opposite of the operative hip and oriented perpendicular to the patient and bed.

Surgical Approach and Osteotomies (Figure 1A)

The limited direct anterior approach is routinely employed through a bikini-line incision, followed by a wafer-type osteotomy of the anterior superior iliac spine (ASIS) to medialize the oblique abdominal and sartorius muscle bellies and sparing the abductor muscles. This enables subperiosteal exposure of the anterior ilium, iliopectineal line, posterior column, quadrilateral surface, and the superior ramus to and beyond the iliopectineal eminence. The rectus tendon origin routinely is preserved unless an extensive arthrotomy is required, in which case the rectus tendon origin can be divided to provide more capsular exposure.[25]

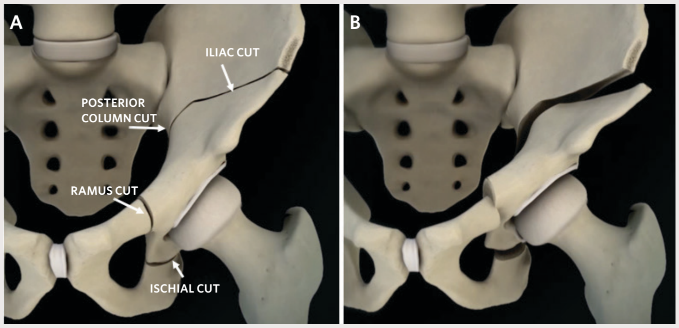

Figure 1. Schematic of the periacetabular osteotomies **(A)** and reduction maneuver **(B)** to improve anterolateral coverage of the femoral head.

The partial ischial osteotomy is approached through the iliopectineal bursa, located between the medial capsule and the psoas tendon. This interval is accessed by elevation of the iliocapsularis off of the hip capsule from lateral to medial, eventually encountering the psoas sheath at the medial edge of the capsule. This interval is opened and developed until the infracotyloid groove of the ischium can be palpated with a long scissors. This interval is further developed with blunt elevators (lane bone levers) to permit safe passage of the Ganz angled chisel onto the anterior ischium. The chisel must not be placed distal to this position as it would risk damage to the obturator externus muscle and medial femoral circumflex vessels. The ischial osteotomy is performed under fluoroscopic guidance, with the chisel tip starting just distal to the inferior lip of the acetabulum and aiming cephalad in the direction of the ischial spine, leaving a 1 cm bone bridge below the acetabulum. Both medial and lateral cortices of the anterior ischium must be divided as the chisel advances from anterior to posterior. The leg is placed into extension and external rotation while the lateral osteotomy pass is made to relax the sciatic nerve, which lies in close proximity to the lateral ischium. Fluoroscopic imaging is useful both in initial placement of the chisel (AP and false profile projections) and in confirming that the osteotomy progresses satisfactorily (false profile). The depth of the cut on false profile imaging should be just posterior to a line tangential to the posterior aspect of the acetabulum on false profile images.

The superior pubic ramus osteotomy is performed next. Hip flexion and adduction relax the iliopsoas musculature and allow dissection onto the superior ramus medial to the pubic eminence. Retractors are placed anteriorly and posteriorly around the ramus, into the obturator foramen and within a periosteal sleeve, to protect the obturator neurovascular bundle. The osteotomy is completed just medial to the iliopectineal eminence with either an osteotome, oscillating saw, or Gigli saw. Positioning of this osteotomy just medial to the pubic eminence allows a broader surface for contact after fragment reorientation, and it keeps the osteotomy lateral to the path of the psoas tendon, decreasing postoperative tendonitis. Confirmation of completeness of the osteotomy is mandatory, since this osteotomy must be free to allow acetabular reorientation.

The supra-acetabular iliac osteotomy is performed next. Prior to creating this osteotomy, its trajectory must be planned. The posterior endpoint of the iliac osteotomy will also mark the start of the posterior column osteotomy, connecting the iliac and ischial cuts. This posterior point must be identified and marked to ensure a safe trajectory for the posterior column osteotomy. This point is located approximately 1 cm medial to the pelvic brim and should provide a linear trajectory along the posterior column between iliac and ischial osteotomies on false profile imaging. Once the posterior endpoint is marked, a lateral subgluteal window is made parallel to this mark at the anterior ilium, typically at a level at or just distal to the ASIS osteotomy. A small lateral retractor (baby Hohmann) is inserted through this window to protect the abductors, while a reverse Hohmann retractor is placed on the quadrilateral plate to expose the inner table of the iliac wing. An oscillating saw is used to osteotomize the ileum. This osteotomy should traverse the ilium from the distal aspect of the ASIS osteotomy to a point 1 cm shy of the iliopectineal line. This osteotomy should be nearly perfectly vertical in orientation and will appear to parallel an imaginary floor when viewed on false profile imaging.

The posterior column osteotomy is made entirely from within the pelvis under fluoroscopic guidance. It begins at the posterior end of the iliac osteotomy and is directed toward the ischial osteotomy, bisecting the posterior column as it passes over the iliopectineal line midway between the posterior acetabulum and the greater sciatic notch. Straight osteotomes are used to create the medial pass to the level of the isthmus, after which a curved osteotome can be inserted to angle the trajectory anteriorly to connect with the previously made anterior ischial osteotomy. The corner of the iliac and posterior column osteotomies is then completed with an angled AO chisel, and a bone spreader is then placed in the anterior iliac osteotomy and placed on tension to help mobilize the acetabular fragment. At this point, the acetabular fragment often breaks free. If not, the angled Ganz chisel is used to osteotomize the remaining lateral posterior column down to the ischial cut. The sciatic nerve is in close proximity to the distal, lateral aspect of this osteotomy, so the leg is again placed in extension and external rotation for this cut.

Acetabular Correction (Figure 1B, see Page 2)

Prior to acetabular reorientation, the freedom of movement of the osteotomized acetabular fragment must be confirmed. The acetabular reorientation typically involves improving lateral coverage, anterior coverage, and posterior coverage, in varying proportions, and depends on preoperative examination and imaging. Placement of a Schanz screw just distal to the iliac osteotomy is routinely used to grip the acetabular fragment to control reorientation. Supplemental use of a Weber bone clamp adjacent to the ramus osteotomy also is helpful during reorientation. After the desired reorientation is achieved, provisional fixation is obtained with multiple smooth Kirschner wires drilled through the iliac crest and into the acetabular fragment.

Correction is scrutinized with AP and false profile views. Care is taken to reproduce an accurate AP pelvis view for correction evaluation. General guidelines for an optimal correction on the AP pelvis image include a horizontal sourcil; no lateral translation of the hip center; no crossover sign; well-balanced anterior and posterior walls; and concentric reduction of the femoral head under the weight-bearing zone of the acetabulum. On the false profile view, anterior coverage is assessed, as well as potential impingement, which can be visualized dynamically with fluoroscopic images in flexion and internal rotation. If a satisfactory correction is achieved and confirmed on radiographic and impingement testing, definitive fixation can be performed. Routine adequate fixation can be achieved by replacing the provisional fixation wires with multiple screws (3.5 mm or 4.5 mm) through the iliac crest and into the acetabular fragment. After fragment fixation, soft tissue closure must be secure, since early postoperative function is desirable. Careful attention to the soft tissues during exposure facilitates healing of not only soft tissues but of the underlying bone.

Postoperative Care

Patients are mobilized to a bedside chair on the morning following surgery, and gait training with a foot-flat partial weight-bearing pattern begins later that afternoon. By postoperative day two, the lumber plexus catheter is discontinued and physical therapy continues. Aspirin (81 mg daily) and naproxen (500 mg BID) are used for the first month to prevent DVT and heterotopic ossification, respectively. Discharge from the hospital usually occurs on the second or third postoperative day. Resumption of full weight-bearing follows recovery of necessary muscle function and evidence of adequate radiographic osteotomy healing, typically around eight weeks postoperatively.

Routine radiographs are taken at monthly intervals until complete osteotomy healing. Full activity, including sport, is resumed according to individualized progress, though a six-month recovery is common before full return of maximum achievable function has taken place.[26,27] Patients are followed annually with clinical examinations and radiographs, or more frequently if required.

PAO has been well documented to provide long-term improvements in function and minimize the risk of arthritis progression in patients with acetabular dysplasia.[28,29] Two studies to date have focused specifically on outcomes of PAO in patients with LCEA between 18 to 25°, with improved patient-reported outcomes and minimal complications at one year and two years postoperatively.[30,31] In a multicenter cohort, patients with “mild” dysplasia (LCEA > 15°) did well following PAO, but their improvements were not as significant as patients with more severe preoperative dysplasia.[32]

Arthroscopic Management of Borderline Dysplasia

Several studies have noted arthroscopic techniques to address the soft tissue pathology of borderline acetabular dysplasia.[1,7,9,14,18,21,22,33,34] Our arthroscopic approach to borderline dysplasia is briefly described below.

Patient Setup

Hip arthroscopy is performed in the supine position on a traction table with a well-padded perineal post. A preoperative fascia iliaca single-shot block is commonly used. General anesthesia is used with muscle relaxation to permit a gentler hip subluxation for arthroscopic access.

Arthroscopic Technique

The operative leg is placed into a position of abduction (20°), flexion (20°), and internal rotation as the limb is placed into traction to relax tension on the iliofemoral ligament. Once traction is applied, the leg is moved into a position of slight adduction and neutral extension, allowing the femoral head to subluxate from the acetabulum. Access to the hip joint is made via fluoroscopic guidance for the anterolateral portal, and a mid-anterior portal is made under direct visualization.

An interportal capsulotomy is created to allow central compartment access, but an effort is made to avoid T-capsulotomy extension in those patients with acetabular under-coverage. After capsulotomy, a thorough diagnostic evaluation of the hip is performed, evaluating the hip capsule, acetabular labrum, cartilage of the acetabulum and femoral head, and the ligamentum teres. The arthroscope is kept in the anterolateral portal, and the mid-anterior portal is used for instrumentation. The capsulolabral interval is developed to facilitate capsular plication at the end of surgery. Intra-articular repairs are made based upon this diagnostic evaluation. The acetabular labrum is repaired using all-suture anchors (Q-FIX, Smith & Nephew) in a labral-base stitch pattern after gentle decortication of the acetabular rim, with care taken to avoid any meaningful bony resection.[35] The chondrolabral junction is preserved in all cases if possible. In cases of cartilage injury to the acetabulum or femoral head, a gently chondroplasty is performed for partial thickness defects to stabilize loose tissues, and a microfracture is considered in cases involving full thickness defects.

After central compartment work is completed, traction is released and the femoral head is visualized as it is reduced within the acetabulum; its concentric reduction is confirmed on fluoroscopic imaging. The peripheral compartment work is then performed, specifically addressing any cam-type femoral offset deformities found on preoperative imaging. We start our cam resections with the arthroscope in the mid-anterior portal and the arthroscopic burr in the anterolateral portal, and the most lateral aspect of the cam is addressed first. We then proceed from lateral to medial, ensuring our decompression decorticates all sclerotic bone and traverses distally down the femoral neck to avoid distal impingement.[36] As we move more anteromedial with our decompression, the portals are switched, bringing the arthroscope through the anterolateral portal and using the mid-anterior portal for our burr. Thorough imaging of the hip is performed after cam decompression to ensure adequate deformity correction.

After completion of peripheral compartment work, a capsular closure is performed. The hip is placed into a position of abduction (20°) and flexion (20°) to again relax the anterior capsular structures. The arthroscope is kept in the anterolateral portal, and a suture passing device (SlingShot, Stryker) is used in the mid-anterior portal. The capsule is repaired in a medial to lateral direction. A series of #2 nonabsorbable sutures are passed through the proximal and distal capsular leaflets in a simple-suture pattern, with an effort to place the distal capsular stitches in a medialized position to allow plication after tensioning. All sutures are placed prior to tying to maintain visualization for suture passing. The sutures are then tied under arthroscopic visualization from medial to lateral, completing the capsular plication.

Postoperative Care

Patients are placed into a hinged brace in the operating room to help limit extension and external rotation. Patients are discharged on the date of surgery and maintain foot-flat touchdown weight-bearing restrictions for the first two weeks, at which time patients gradually are allowed to bear weight as tolerated. Extension and external rotation motions are limited for six weeks postoperatively, after which motion is unrestricted. Return-to-play considerations are made on an individualized basis, but a six-month recovery typically is expected in these patients.

Literature regarding outcomes following hip arthroscopy for borderline acetabular dysplasia have mixed results. Several studies have shown good functional results of hip arthroscopy for the treatment of intra-articular pathology in patients with borderline dysplasia at short-term follow-up,[14,18,21,22,33] while other studies noted inferior results of arthroscopy in patients with dysplasia.[9,21,34] A systematic review of hip arthroscopy in dysplastic patients noted a 14.1 percent revision rate and 9.5 percent rate of progression to total hip arthroplasty at an average of 29 months following hip arthroscopy.[37]

Why Are We Failing?

The results of surgical outcomes for borderline dysplasia are variable at best. The unpredictability of results, especially with hip arthroscopy, may be attributable to a highly variable degree of bony morphology in patients with LCEA 18 to 25° when considering all relevant anatomic features. The LCEA is a reliable measure of lateral acetabular coverage, but this does not qualify as a surrogate for the global morphology of the hip. All of these features should be evaluated and considered during the diagnostic evaluation of the symptomatic hip with borderline dysplasia, and better understanding of the global morphology of the hip may improve our surgical decision-making.

Radiographic Evaluation of Borderline Dysplasia

Thorough imaging of the painful nonarthritic hip is essential to develop appropriate treatment plans for these patients. Radiographs serve as the first-line imaging modality in these patients and must be thoroughly scrutinized. Clohisy et al. have provided a comprehensive review of hip radiography techniques to provide practical details on the acquisition and interpretation of hip radiographs.[38] Our standard radiographic sequence includes an AP pelvis (with attention to proper positioning and alignment), 45° Dunn-lateral, and false profile views. With this group of radiographs, it is possible to thoroughly evaluate much of the proximal femoral and acetabular morphology. In the following sections, we will discuss the relevant radiographic parameters to evaluate in patients with nonarthritic hip pain, especially those with borderline acetabular coverage. (Figure 2)

LCEA

The LCEA is a radiographic assessment of lateral acetabular coverage in the frontal plane using an AP pelvis radiograph. Multiple methods of performing the measurement have been described. First described by Wiberg et al., the measurement is formed by a vertical line (or parallel to long axis of the body) starting from the center of the femoral head with a line

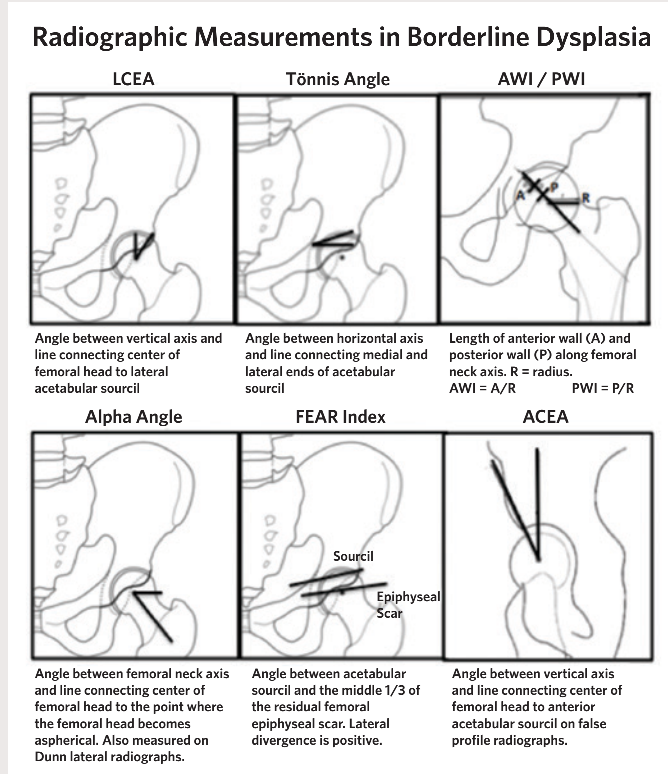

Figure 2. Radiographic measurements of the proximal femur and acetabulum relevant to the evaluation of borderline or mild acetabular dysplasia.

to the most lateral point of the acetabular roof.[6] He declared an LCEA value of greater than 25° (mature hips) to be considered "normal," while values less than 20° were considered pathologic. More recently, the LCEA measurement has moved from the lateral-most point of the acetabular roof to the lateral-most point of the acetabular sourcil, as this has been identified on CT-based studies to more accurately represent the weight-bearing region of the acetabulum.[39,40] The magnitude of the LCEA has been linked to the progression of OA irrespective of symptoms during early adulthood,[41] and one study noted a 13 percent increased likelihood of developing OA for each 1° loss of lateral coverage below 28°.[42]

Tönnis Angle

The Tönnis angle, or the "acetabular roof angle of Tönnis" attempts to quantify the inclination of the acetabular sourcil, or the weight-bearing dome of the acetabulum.[43] The measurement is performed using an AP pelvis radiograph and is formed between a horizontal line and a tangential line extending from the medial edge to the lateral edge of the sourcil. Values greater than 13° are considered abnormal.

The medial edge of the sourcil can be difficult to distinguish in some patients, specifically those with dysplasia where medial-unloading can blur the sourcil's appearance. The modified Tönnis angle was described as an alternative method in cases where the medial edge was unclear; using this approach, the medial sourcil is identified as the intersection of the acetabulum with a horizontal line tangential to the vertex of the femoral head.[44] The Tönnis angle and modified Tönnis angles have been observed to have a high degree of correlation in cases without joint space narrowing and subluxation of the hip.

AWI/PWI

The anterior wall index (AWI) and posterior wall index (PWI) attempt to characterize acetabular pathomorphology by quantifying the anterior and posterior acetabular coverage.[45] The measurement is performed using an AP pelvis radiograph. To calculate wall indices, a best-fitting circle is created around the femoral head and its radius is noted. Next, a line is then drawn down the center of the femoral neck, passing through the center of the femoral head, to its articular margin. The length of this line occupied by both the anterior wall (A) and posterior wall (P), are recorded. The AWI and PWI are calculated by dividing the measurement of the anterior wall coverage (A) or posterior wall coverage (P) by the radius of the femoral head circle. The average AWI for a normal hip was 0.41, and values below 0.3 are concerning for under-coverage. The average PWI for a normal hip was 0.91, with values below 0.8 concerning for under-coverage.

ACEA

The anterior/ventral center edge angle (ACEA) utilizes the false-profile radiograph to evaluate the anterior acetabular coverage of the femoral head. The angle is measured by a vertical line through the center of the femoral head and a second line through the center of the hip towards the most anterior aspect of the acetabular dome.[46] Values less than 20° are considered abnormal.[47]

Alpha Angle

A common measurement used to assess for cam deformity is the alpha angle.[48] The alpha angle attempts to quantify the point at which the femoral head loses its sphericity. It can be measured on any radiographic projection, and each projection highlights the contour of different aspects of the femoral head/neck junction. The AP pelvis (12:00), Dunn lateral (1:00), and false profile (2:00) views provide a thorough evaluation of femoral head sphericity across the anterosuperior head. The alpha angle is calculated by first drawing a best-fitting circle around the femoral head. Beginning at the center of the femoral head, two lines are drawn: one is drawn through the center of the femoral neck, and a second is drawn to the point at which the femoral head loses its sphericity. The angle created by these two lines is the alpha angle. The thresholds for diagnosing cam deformity have been debated; with values ranging from 50° to 83° indicating moderate to severe cam.[49]

FEAR Index

The Femoral-Epiphyseal Acetabular Roof (FEAR) index was developed to assess for joint reactive forces in borderline dysplastic hips.[50] Using standard AP pelvic radiographs, the central one-third portion of the physeal scar of the femoral head is identified and a line is created to denote its trajectory. A second line created to denote the acetabular sourcil in a manner similar to the Tönnis index. The FEAR index is measured by the angle between these two lines and can be either positive (angle facing laterally with apex medially) or negative (angle facing medially with apex laterally). The initial investigation of this measurement reported that painful hips with mild lateral under-coverage and FEAR indices greater than 5° (opening laterally) are likely indicative of underlying joint instability.

Imaging Clusters

To evaluate the global morphology of symptomatic “mild” or “borderline” dysplastic hips (LCEA 18 to 25°), we recently reviewed the aforementioned radiographic parameters of patients undergoing hip preservation surgery at a tertiary referral center.[51] Ninety-nine patients underwent either hip arthroscopy or PAO over a five-year period, and their preoperative imaging was reviewed for LCEA, Tönnis Angle, AWI/PWI, ACEA, alpha angle (AP and Dunn views), and FEAR index.

A cluster analysis was performed in an attempt to identify morphologic patterns within these patients. Male and female patients were separated for the cluster analysis as significant gender-based differences were noted with several radiographic parameters. Our cluster analysis results are presented in Figure 3. Male patients showed three morphologic clusters: global impingement (high alpha angle on AP/Dunn and low PWI), focal impingement (high alpha angle on Dunn and low PWI), and isolated lateral acetabular insufficiency (low LCEA). Female patients also had three morphologic clusters: impingement (high alpha angle on AP/Dunn), anterolateral acetabular deficiency (low LCEA, low AWI, low ACEA, high FEAR), and isolated lateral acetabular insufficiency (low LCEA).

The cluster analysis confirmed that significant morphological differences exist in the cohort of patients with LCEA 18 to 25° and these findings helped to make some sense of disparate results reported in the current literature. Three patient clusters, two in males (global impingement and focal impingement) and one in females (impingement) had morphological features consistent with femoroacetabular impingement. The arthroscopic results specific to these clusters were reported on by Nawabi et al., who described the outcomes of hip arthroscopy for cam resection and capsulolabral repair in patients with LCEA 18 to 25°.[22] They noted results comparable to those found in patients with normal acetabular coverage undergoing arthroscopic cam resection.

Male Borderline Clusters				Female Borderline Clusters		
Global Impingement	Focal Impingement	Lateral Deficiency	Cluster	Impingement	Anterolateral Deficiency	Lateral Deficiency
35%	40%	25%	Incidence	16%	58%	26%
Cam morphology on AP and Dunn	Cam morphology on Dunn	Normal proximal femur	Femoral Morphology	Cam morphology on AP and Dunn	Normal proximal femur	Normal proximal femur
Superior acetabular retroversion and low LCEA	Superior acetabular retroversion and low LCEA	Isolated low ICEA	Acetabular Morphology	Isolated low ICEA	Combed lower lateral (LCEA) and anterior (AWI, ACEA) coverage	Isolated low ICEA
+	+		Impingement Morphology	+		
			Dysplasia Morphology		+	
		+	Undetermined			+

Figure 3. Morphologic cluster results for male and female patients with LCEA 18 to 25° and the postulated pathoanatomic categorization (impingement, dysplasia, undetermined) of these clusters.

The anterolateral acetabular deficiency cluster in females showed numerous features of acetabular dysplasia. From the arthroscopy literature, a recent study noted that inadequate anterior acetabular coverage was predictive of poor outcomes following hip arthroscopy.[52] From the PAO literature, McClincy et al. noted that the majority of PAO patients had numerous radiographic features of dysplasia aside from LCEA measurement, and that anterior coverage was the most commonly deficient region.[30] Outcomes of PAO in patients with LCEA 18 to 25° have been favorable in two short-term studies, but neither focused specifically on patients with combined anterior and lateral under-coverage.[30,31]

Case Presentation

An 18-year-old female presented for evaluation with an 18-month history of left hip pain. She described her pain as being localized both to the anterior groin with a “popping” sensation during certain movements, and to the lateral hip with an achy fatigue-type pain that worsened with prolonged upright activities. She noted increasing difficulties with recreational running. Physical therapy provided minimal symptom relief.

On examination, she was found to have excellent range-of-motion, with 100° of hip flexion and 25° of internal rotation in flexion. She was irritable with FADIR, FABER, and anterior apprehension testing. She had a positive Stinchfield test (resisted straight leg raise) and tenderness over her psoas and greater trochanter.

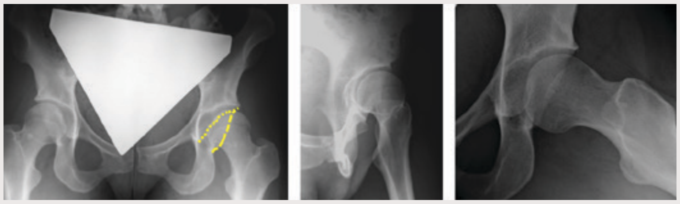

Figure 4. Preoperative AP Pelvis, Dunn lateral, and False Profile radiographs. On the AP Pelvis, the anterior wall is denoted by the dotted line and the posterior wall is denoted by the dashed line.

Her radiographic examinations are shown in Figure 4. They indicate mild lateral under-coverage (LCEA 20°) and significantly diminished anterior coverage (AWI 0.1, ACEA 10) with no evidence of pathologic femoral asphericity. A diagnostic ultrasound-guided injection into her hip joint was performed, which provided significant transient relief.

She underwent a PAO and had an uneventful recovery. She was allowed to progress her weight-bearing at eight weeks and achieved radiographic union at three months. She returned to running at 4.5 months and was back to her standard mileage at six months. At her one year follow-up appointment, she reported no symptoms or limitations referable to her hip. (Figure 5)

Borderline Dysplasia — Beyond Radiographs

Obtaining information regarding anterior and posterior acetabular coverage, proximal femoral morphology, and rotational alignment of the femur and acetabulum is crucial in decision-making before potential surgical intervention in borderline hips. Cross-sectional and three-dimensional (3D) imaging via CT is a useful adjunct in the assessment and management of osseous morphology in borderline hips.

CT imaging is increasingly performed in the preoperative setting to characterize bony anatomy. Recent advancements have allowed for high-quality CT imaging with much lower radiation exposure than previous testing.[53]

Nepple et al. described a method of utilizing CT for determining variability in 3D acetabular deficiency and morphology.[54] Also, by including cuts of the distal femur, CT enables precise calculation of both acetabular and femoral version, both of which have shown predictive power in determining the stability of the hip.[55-57] Above all, through image reconstruction, CT provides a three-dimensional view of the hip to help us contextualize radiographic measurements into a cohesive understanding of hip morphology.

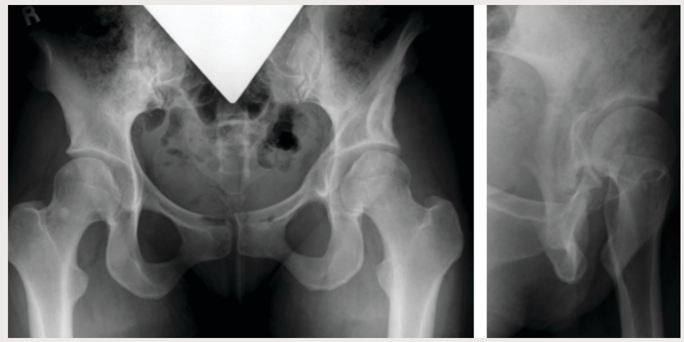

Figure 5. One-year postoperative AP Pelvis and False Profile radiographs following periacetabular osteotomy.

Conclusions

The management of borderline dysplasia is an active controversy in the field of hip preservation. Much of the literature up to this point has isolated the definition of borderline dysplasia to the LCEA measurement. As awareness of the variable deformities present in acetabular dysplasia increases, isolated reliance on measurement of lateral femoral head coverage to define severity of under-coverage will continue to mislabel patients. Future studies should strive to more thoroughly define the characteristics of mild acetabular under-coverage. This will enable meaningful comparative effectiveness studies between hip arthroscopy and periacetabular osteotomy in the treatment of acetabular dysplasia in these patients. These studies can strive to help identify the patient subgroups to treat with either a hip arthroscopy or periacetabular osteotomy.

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