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Contemporary Concepts in the Young Adult Hip Patient: Periacetabular Osteotomy for Hip Dysplasia

Benjamin R. Coobs, MD [a], Ao Xiong, MD [b], John C. Clohisy, MD [a]

[a] Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, Missouri
[b] Orthopedic Department, Peking University Shenzhen Hospital, Shenzhen, Guangdong, China

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ABSTRACT

The Bernese periacetabular osteotomy, as originally described by Dr. Reinhold Ganz, is an effective treatment for symptomatic acetabular dysplasia in the pre-arthritic young adult hip. This technique has experienced several recent modifications in an attempt to optimize the clinical outcomes of these patients. We will review the clinical presentation of acetabular dysplasia, indications for surgery, contemporary refinements in technique and clinical results following periacetabular osteotomy. In well-selected patients, this reconstructive osteotomy should be considered safe and effective in alleviating pain and improving hip function.

Developmental dysplasia of the hip (DDH) is a common condition that is associated with pain, functional limitations and secondary osteoarthritis [1,2]. Acetabular deformity results in structural instability, increased joint reactive forces and mechanical overloading of the acetabular rim that, when left untreated, can lead to progressive hip degeneration [3]. DDH represents a significant world-wide disease burden and is thought to be the etiology of 25–43% of end-stage osteoarthritis of the hip [1,4–6]. Symptomatic acetabular dysplasia commonly presents in the skeletally mature, young, active patient in the pre-arthritic phases of the disease process [2].

Recent treatment of acetabular dysplasia has focused around reconstructive acetabular osteotomies to correct the hip joint pathomechanics with a goal of decreasing pain, improving function and delaying the development of secondary osteoarthritis [7–10]. Periacetabular osteotomy (PAO), as originally described by Ganz et al, has become popularized as an effective treatment for symptomatic dysplasia with specific technical advantages over previous surgical treatment methods [11]. However, these techniques continue to be improved to optimize the outcomes of patients with symptomatic acetabular dysplasia. This article will review the clinical presentation of DDH in the skeletally mature patient, indications and contraindications for periacetabular osteotomy, contemporary refinements in PAO surgical technique and the clinical results of corrective periacetabular osteotomy.

Clinical Presentation

Classic acetabular dysplasia represents a diverse clinical spectrum of disease ranging in presentation from hip dislocations in the infant to activity related hip pain in the skeletally mature young adult. Only recently has the clinical presentation of symptomatic acetabular dysplasia in skeletally mature patients been fully characterized [2]. The presenting symptoms in these patients can be variable and radiographic analysis challenging, especially in individuals with mild acetabular deformity. Nunley et al recently described the clinical presentation and minimum two-year outcomes following PAO in 57 consecutive skeletally mature patients with a total of 65 symptomatic hips [2]. A majority of those patients were female (72%) and presented with an insidious onset of activity related hip pain (88%) localizing to the groin (72%) and/or the lateral aspect of the hip (66%). Most of those patients had moderate-to-severe pain (77%) on a daily basis and were physiologically young and otherwise healthy. Physical exam findings included a limp (48%), positive Trendelenburg sign (38%) and a positive impingement test (97%). Unfortunately, a delayed diagnosis was also common with an average of 61.5 months between onset of symptoms and a formal diagnosis of DDH.

Accurate radiographic analysis of young adult patients with acetabular dysplasia is a critical component of the clinical evaluation [12]. The two most important radiographic views for analyzing acetabular morphology are the standard anteroposterior (AP) pelvic and false-profile views. The specific techniques for obtaining these radiographic views

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Reprint requests: John C. Clohisy, MD, Washington University Orthopedics, Campus Box 8233, One Barnes-Jewish Hospital Plaza, IOH Suite 5505, St. Louis, MO 63110.

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have been previously published [12]. From the AP pelvis image the lateral center edge angle (LCEA) [13] and acetabular index (AI) [14,15] angle can be measured. The false-profile view allows examination of anterior coverage by measuring the anterior center edge angle (ACEA) [16]. Radiographic parameters that raise concern of symptomatic acetabular dysplasia include LCEA < 20°, AI > 10° and ACEA < 18°. Radiographic analysis for any evidence of femoral head subluxation and detailed interpretation of femoral anatomy should also be performed as part of the routine evaluation of these patients. Clinical soft tissue laxity, increased proximal femoral valgus deformity or excessive antetorsion may decrease the threshold to proceed with PAO in a patient with symptomatic acetabular dysplasia.

Indications/Contraindications for PAO

Reorientation periacetabular osteotomy is indicated in active patients with preserved articular cartilage and symptomatic acetabular dysplasia following closure of the physis [11,17]. Patients being considered for PAO should be physiologically young and relatively healthy. In general, patients younger than 40 years of age are viewed as good candidates for surgery. Adequate pre-operative hip range of motion is important (>95° flexion, > 30° abduction) as PAO may reduce native hip motion. Additionally, patients must be considered to have a viable joint with regard to the health of the articular cartilage. Other indications for PAO include severe acetabular dysplasia [7], acetabular retroversion [18] or secondary dysplasia resulting from other primary hip disorders [19].

Radiographic parameters which may indicate PAO in symptomatic acetabular dysplasia include a LCEA < 20°, AI > 10° and ACEA < 18°. Pre-operative images should be closely scrutinized to ensure adequate hip joint congruency and absence of significant secondary osteoarthritis (Tönnis grade 0 or 1). Nevertheless, the radiographic features of the hip must be interpreted in the context of the history, examination and other disease characteristics. Magnetic resonance arthrography of the hip can be obtained to evaluate for chondrolabral damage, which will help guide treatment decision-making. Significant cartilage damage on MRA may be a contraindication for PAO. However, evidence of a labral tear may lead to consideration of labral repair through either concomitant hip arthroscopy or an open arthrotomy at the time of PAO. Additional pre-operative imaging in patients with severe deformities can include computed tomography with 3D reconstructions, which can provide valuable information for pre-operative planning. Evidence of significant hip joint laxity, femoral neck valgus or increased femoral antetorsion will decrease the surgical threshold to perform PAO in borderline dysplastic cases. Furthermore, with a rigorous pre-operative evaluation, the possible need for additional procedures to address secondary impingement or severe proximal femoral deformities [20] can be determined.

Patients with advanced osteoarthritis (Tönnis grade ≥ 2), physiologically older age, or low pre-operative functional scores experience less favorable results and, in general, are poor candidates for PAO [10]. Reduced hip joint range of motion (<90°) and obesity (BMI > 30 kg/m^2) are relative contraindications for PAO. Recently, obesity has been demonstrated to be a significant risk factor for the development of major complications (defined as grade III to V complications according to the modified Dindo-Clavien classification system) [21] with 22.3% of obese patients (BMI ≥ 30 kg/m^2) compared to 3.1% of non-obese patients (BMI < 30 kg/m^2) sustaining major complications following PAO [22].

Contemporary Refinments to PAO Surgical Technique

Traditional advantages of the Bernese periacetabular osteotomy over previous osteotomy techniques as originally described by Ganz continue to be realized (Table 1) [11]. The Bernese periacetabular osteotomy is performed in the supine position on a radiolucent table through a modification of the Smith–Peterson approach [23]. The four orthogonal periacetabular cuts are technically reproducible and allow for substantial multidirectional correction of the mobilized acetabulum. Preservation of the posterior column results in excellent pelvic and acetabular fragment stability following correction and screw fixation. This promotes early mobilization and reliable healing. Preservation of the acetabular fragment blood supply also promotes healing and the freedom to perform hip joint arthrotomy without concern for further compromise to the vascularity of the fragment.

Table 1
Comparison of the Traditional Advantages and Contemporary Refinements of the PAO for Hip Dysplasia.

Bernese Periacetabular Osteotomy	
Traditional Advantages	Contemporary Refinements
Four orthogonal cuts	Reduced surgical morbidity
• Reproducible • Multidirectional correction	• Limited osteotomy exposure • Muscle sparing approaches
Preservation of fragment vascularity	Acetabular reduction assessment
• Reliable healing	• Intraoperative fluoroscopy
Preservation of posterior column	Treatment of additional pathology
• Excellent fragment stability • Early mobilization	• Concomitant hip arthroscopy • Labral repair/osteochondroplasty • Femoral deformity correction

Contemporary refinements to the original surgical technique have focused mostly on limiting surgical morbidity, improving methods to assess acetabular fragment reduction and dysplasia correction, treating other hip deformities concomitantly, management of acetabular retroversion and decreasing the recovery period. An improved understanding of periacetabular vascularity encouraged placement of the supraacetabular osteotomy more cephalad protecting blood supply from the superior gluteal artery and maintaining adequate bone for screw purchase [24,25]. Muscle-sparing approaches including preservation of the abductor attachments [26] to the lateral iliac crest and maintenance of the rectus femorus attachment [27] have led to more rapid post-operative recovery, improved fragment vascularity and decreased rates of heterotopic ossification. To protect the abductors and sciatic nerve during osteotomy of the supraacetabular ilium, a subgluteal window is elevated off the lateral iliac crest to the greater sciatic notch. Preservation of the rectus femorus attachment is made possible through a dissection carried medial to the direct head of the rectus between the iliocapsularis and hip joint capsule for completion of the ischial osteotomy. If the patient requires an arthrotomy to address intraarticular pathology, this dissection precedes lateral to the insertion of the direct head of rectus. Occasionally, the reflected head of the rectus femorus needs to be divided to facilitate intraarticular access and is then later repaired.

Achieving accurate acetabular correction is critical to the proper execution of periacetabular osteotomy and has significant clinical implications for the success and durability of the procedure. Formal assessment of acetabular reduction has traditionally been accomplished through plain radiographs [12]. Intraoperative fluoroscopy is used by many surgeons to assess acetabular reduction as routine use of fluoroscopy is already commonly performed to monitor the osteotomy cuts and it is more convenient when compared to plain radiographs if multiple reduction maneuvers are required. Recently, the intraoperative fluoroscopic assessment of PAO reduction was shown to correlate strongly to the postoperative plain radiographs suggesting that the routine use of intraoperative fluoroscopy to assess acetabular fragment reduction is safe and effective [28].

Acetabular retroversion is a common variant from the classic form of DDH and is thought to be present in one out of six cases of acetabular dysplasia [29]. Additionally, retroversion of the acetabulum is observed