Hip Joint-Preserving Surgery for the Mature Hip: The Children's Hospital Experience

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Most osteoarthritis of the hip is associated with chronic abnormal hip mechanics,[1] related to potentially treatable anatomic abnormalities.[2] The rationale of mechanically-based measures to prevent or treat osteoarthrosis assumes the following: (a) the correctable mechanical abnormality is a major etiologic factor in osteoarthrosis; (b) relief of the mechanical abnormality can prevent or improve osteoarthrosis; and (c) joint-preserving measures in the individual patient are preferable to joint replacement.

Our evolving experience[3] and that of other centers with similar interests suggests that the success of such mechanically-based joint-preserving measures depends largely on two important factors: (a) the degree to which the joint-preserving treatment normalizes the mechanical environment of the hip and (b) the amount of irreversible articular damage that is present at the inception of the joint-preserving treatment.

For many years, classical realignment osteotomy of the dysplastic acetabulum has been well accepted as being effective in improving on the natural history of congruous acetabular dysplasia. Realignment osteotomies with the proximal femur similarly have an accepted place in treating the symptomatic patient with a severe healed slipped capital femoral epiphysis.[4]

Until recently, the predominant picture of abnormal hip mechanics was a largely static one, derived from Pauwels and others. In 1991, the Berne group first described the **acetabular rim syndrome** as a clinical presentation of dysplasia of the hip.[5] This led to a more generalized recognition of pathologic loading of the acetabular rim as an early major factor in hip arthrosis of various types. Follow-up has revealed that the rim loading by the femoral head in acetabular dysplasia involves **instability**, a major pathomechanical agent. Conversely, an equally important pathomechanical factor, **impingement**,[6] leads to a very different but equally malignant type of rim loading in Perthes disease, slipped epiphysis, and a number of other previously less well-recognized anatomic variants that include femoral retroversion, coxa vara, reduced femoral head-neck offset, coxa profunda, and protrusio.

As the pathomechanics of the hip have become better understood, new diagnostic and therapeutic methods have yielded very satisfying early results in both understanding and treating many symptomatic hips that only a few years ago were relegated unhappily to the idiopathic osteoarthritis category, often left to deteriorate on their own, to await the inevitable hip replacement when symptoms became intolerable.

The discussion of joint-preserving treatment around the hip may be subdivided into two broad categories: (a) dysplasia and (b) hip impingement syndromes.

HIP DYSPLASIA

In various parts of the world, 40 to 90% of osteoarthrosis is secondary to dysplasia.[7] In North America it is clearly the commonest single cause of OA. Since John Hall brought Salter's technique of innominate osteotomy from Toronto to Children's Hospital in 1971, we have had a major interest in acetabular redirectional osteotomy to treat incongruous dysplasia. Though innominate osteotomy gave excellent results in children, limited corrections in adolescents led to adoption of Wagner's technique, spherical (Dial) osteotomy in 1980. The Children's Hospital spherical osteotomy experience was generally satisfying,[8] but the Smith-Petersen approach required major abductor dissection, which led to prolonged limping in many patients. In 1991, the Bernese documentation of the frequency of labral tears associated with acetabular dysplasia prompted us to adopt the Bernese periacetabular osteotomy[9,10] as a procedure that allowed intraarticular work without compromising the blood supply to the femoral head or the acetabular fragment. The procedure also potentially allowed major multidirectional acetabular reorientation without abductor dissection.

By 1992, we had developed a modified surgical approach for PAO, the direct anterior approach, which further reduced the abductor morbidity formerly associated with acetabular redirectional procedures.[11]

Evolution of Diagnostic Methods in Hip Dysplasia

The clinical analysis of the mature dysplastic hip begins with the history, which seeks mechanical symptoms from abductor fatigue or anterior labral pathology. The physical exam includes the anterior impingement test and the apprehension test. The gold standard of imaging analysis in hip dysplasia remains the plain radiograph. Important radiographic views include the following: a standing AP film of both hips centered on the femoral

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heads, the faux profil of LeQuesne and DeSeze[12], and the von Rosen view, which is a flexion-abduction-internal rotation view done to confirm that there is adequate congruence in a view that simulates how the relationship of the femoral head and acetabulum will be after realigning osteotomy.

In our unit, preoperative assessment includes a CT scan of both hips with 4 mm cuts from the anterior inferior spine to the lesser trochanter, supplemented by a cut through the femoral condyles, which is important to sort out versional issues.

Delayed gadolinium-enhanced MRI of cartilage (the so-called dGEMRIC technique[13]) allows non-invasive pre-op assessment not only of labrum and rim, but also the biochemical status of the articular cartilage itself. A dGEMRIC index can be computed and reflects arthrosis-related loss of glycosaminoglycan from the articular cartilage. This index correlates much better with arthrosis-related pain than does cartilage space narrowing or bony change. dGEMRIC is being used prospectively to evaluate objectively the effect of our osteotomies.

Periacetabular Osteotomy Technique

Our current technique routinely employs the limited direct anterior approach, with an anterior Salter-type bikini incision between 10 and 15 cm long. The abductor origin is not disturbed, and the osteotomy cuts are done largely within the pelvis, with image intensifier control where direct vision is not possible. Anterior arthrotomy routinely is done to evaluate the rim and labrum, since the proportion of unstable labral tears is considerable, and greater with each passing decade.[14] Unstable labral tears are debrided. The realignment of the dysplastic acetabulum aims to establish a balance between instability and impingement. Specifically, the rim loading from instability used to be eliminated without incurring anterior or anterolateral impingement in activities of daily living. The optimal positioning of the osteotomized acetabulum remains the most difficult part of the procedure.

Stable fixation easily is achieved with multiple long cortical screws from the iliac crest into the acetabular fragment.

Early active postoperative function is routine; partial weight-bearing gait with crutches is begun on the third postoperative day or earlier. Partial weight-bearing is continued until bony healing is adequate, which is often by 8 to 10 weeks post-op.

Results of Acetabular Redirection

Since 1981, our experience numbers more than 600 acetabular redirection osteotomies, with the periacetabular technique employed exclusively over the last 12 years. All patients had a closed triradiate cartilage at the time of surgery. Patient age at surgery has ranged from nine to fifty years. Ninety per cent of patients have been female.

All hips were symptomatic pre-operatively. The great majority of operated hips remain asymptomatic or greatly improved post-op, the exception being those few with progressive arthrosis who required total hip replacement. Less than twenty hips have required subsequent total hip replacement. Each of these patients had at least grade 2 arthrosis prior to surgery

The complication rate has been low, with rate of infection 0.5% (all resolved with intravenous antibiotics and debridement). Neurapraxia of the peroneal branch of the sciatic nerve has occurred in less than 1%, and symptomatic ischial nonunion requiring plating occurred in 0.3%.

HIP IMPINGEMENT

Impingement is a major cause of osteoarthrosis.[6] In certain circumstances, the impingement is graphically obvious on imaging studies as static incongruity between articular surfaces. Recently, though, a more insidious and probably more prevalent form of impingement has been recognized. The second type of impingement is a dynamic phenomenon which occurs when hip range of motion required for activities of daily living is more than the arc of smooth articular hip motion which is present. Ganz *et al*. have written extensively on so-called "femoro-acetabular impingement", and have subdivided it into two main categories: (a) cam impingement which is caused by squeezing or jamming of an abnormally shaped femoral head and head-neck junction into the acetabulum during motion; (15) and (b) pincer impingement, which occurs when there is direct linear contact between the femoral head-neck junction and a limited portion of the acetabular rim.

Cam Impingement

Cam impingement is present in a number of well-recognized developmental abnormalities, including severe slipped capital femoral epiphysis and in many cases of Perthes disease. Less well-recognized is the cam impingement that can occur in coxa vara of various etiologies and the reduced femoral head-neck offset anatomic pattern.[15,16]

The clinical presentation of femoroacetabular impingement usually involves gradual onset groin pain in certain positions, particularly flexion and/or internal rotation. On physical examination, there usually is a preponderance of external over internal rotation, as well as a limitation of flexion. An impingement sign usually is present anteriorly, as abnormal contact occurs between the proximal end of the femur and the acetabular rim. Depending on the particular character of the impingement, a posterior impingement sign may be present as well.

Imaging analysis to detect potential causes of femoroacetabular impingement includes an antegrading pelvis film on which signs of abnormal femoroacetabular angulation and version should be sought. A true lateral radiograph of the upper femur taken in 15° of internal rotation will often reveal a lack of anterior head-neck offset that may be the commonest cause of cam-type impingement. Radial sequence MRI may also be helpful in complex cases.[17] We have found CT scan useful to characterize both acetabular and femoral version more directly.

The surgical treatment for impinging hips involves elimination of abnormal contact between the articular surfaces and the acetabular rim. The etiology of femoroacetabular impingement is often mixed, involving combinations of contributing deformity at both the femoral and acetabular levels. If there is a preponderance of deformity on one level, that level alone may approached surgically. If the deformity seems equally present in both the pelvic and femoral sides, both sides may need to be addressed.

Major confusion exists regarding the role of the labrum and of labral tears in the genesis of the clinical syndrome of femoroacetabular impingement. While the impinged labrum may tear, resecting a torn labrum in the presence of persisting femoroacetabular impingement will neither eliminate the symptoms nor halt the progression to osteoarthrosis. It is therefore reasonable to treat a labral tear as an isolated problem only when the labral tear occurs as a result of violent twisting trauma in the absence of underlying anatomic deformity. The labral tear which occurs either because of the shear forces in acetabular dysplasia or the jamming from cam or pincer impingement must be seen as a secondary lesion, with the underlying anatomic causes requiring the major therapeutic attention.

Our treatment of femoroacetabular impingement has consisted of a variety of procedures. These include "simple" redirectional intertrochanteric osteotomy in cases of idiopathic coxa vara, coxa retroverta, and slipped epiphysis. We also have satisfying early and middle-term experience with the Bernese technique of surgical hip dislocation via a transtrochanteric approach.[18] The surgical dislocation approach allows not only dynamic assessment of hip pathomechanics, but also allows the surgeon to deal directly with both intraarticular and periarticular lesions.[18,19]

Our present experience with surgical hip dislocation totals 78 cases, 25 of which have treated cam impingement from reduced offset, 19 have treated slipped epiphysis deformity and 15 from post-Perthes deformities, with a variety of other etiologies also treated. Using the surgical dislocation approach, six hips have undergone a Dunn-type osteotomy to eliminate the deformity of severe slipped capital femoral epiphysis. The results have generally been very satisfactory, though the variety of diagnoses and associated procedures makes detailed analysis difficult at this point. There have been three cases of segmental osteonecrosis, each of which occurred in association with the correction of severe slipped capital femoral epiphysis deformity. The planned use of a laser Doppler probe[20] to dynamically evaluate the femoral head blood supply during the course of the procedure is planned to minimize the risk of osteonecrosis in future slipped epiphysis cases.

HIP ARTHROSCOPY

Hip arthroscopy has assumed a prominent role in the treatment of mechanical disorders of the hip.[21-23] The minimally-invasive nature of hip arthroscopy is a major advantage in dealing with certain isolated lesions such as post-traumatic labral tears and loose bodies. Arthroscopy classically is done with the hip in traction, and no sense of dynamic hip abnormalities is directly gained, which is a relative disadvantage in diagnosing impingement lesions. Chondral flap and labral tears are dealt with in a straightforward manner, the resection of bony prominences in the femoral head-neck region is problematic due to the technical and visualization issues. Arthroscopy has been most useful in dealing with recurrent labral tears after acetabular dysplasia has been corrected by periacetabular osteotomy.

Our present experience with hip arthroscopy totals 136 cases, of which 25 were successfully performed in patients with recurrent labral symptoms after acetabular dysplasia has been corrected by periacetabular osteotomy .The vast majority of hip arthroscopy patients has indeed needed no further surgery and has been greatly improved by their procedure. A total of 6 patients had bilateral hip arthroscopy and another 13 patients required repeat hip arthroscopy to address recurrent labral tears. Complications have been negligible.

SUMMARY

It is beyond the scope of this brief review to deal in depth with any particular aspect of our multifaceted approach to hip joint preservation. Our efforts include the pursuit of a more complete understanding of the factors leading to osteoarthrosis of the hip. We seek to diagnose abnormal hip mechanics as early as possible, to correct the abnormal mechanics as completely as possible, with as little morbidity as possible.[24] Timely and accurate diagnosis remains the key factor in optimizing our results.

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