AOA Symposium. Hip Disease in the Young Adult: Current Concepts of Etiology and Surgical Treatment

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AOA Symposium

Hip Disease in the Young Adult: Current Concepts of Etiology and Surgical Treatment*

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The understanding, diagnosis, and treatment of arthritic hip disease in young patients are rapidly evolving. A variety of new and refined surgical techniques are now being utilized worldwide, and continued progress in this realm of orthopaedics is inevitable.

This report is based on a symposium presented at the Annual Meeting of the American Orthopaedic Association on June 13-16, 2007, in Asheville, North Carolina.

Nevertheless, there are major challenges to optimize the introduction and utilization of these procedures on a more widespread basis. In this American Orthopaedic Association (AOA) symposium, the attendees were asked whether "the overall quality of diagnostic evaluation and surgical treatment of prearthritic and early arthritic hip disease in the United States is optimal, acceptable or deficient"[1]. Fifty-seven percent of the respondents answered that diagnostic and surgical care is deficient, indicating a need for improved medical management of these patients.

Progress in this subspecialty area is dependent on the development of improved methods of patient evaluation and selection for surgery, effective dissemination of new knowledge, and the clinical investigation of refined and new surgical interventions. Young adult patients pose a unique challenge in that they present to the orthopaedic surgeon

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with hip symptoms that originate from a wide range of disease processes, and the patient age range spans from adolescence through middle age. Perhaps most notable is that these patients present to a variety of orthopaedic surgeons with different treatment perspectives. These include general orthopaedists as well as pediatric, sports medicine, adult reconstruction, and trauma subspecialists.

The purposes of this report are to describe the spectrum of hip disease encountered in young adult patients and to review the contemporary concepts of the etiology and surgical treatment of such disorders. Importantly, there is a relative lack of high-level clinical evidence for alternative hip procedures. The majority of reports regarding these interventions are Level IV, and many of the technical aspects of treatment continue to evolve without the support of strong clinical outcomes research. This fact underscores the need for surgeons to carefully consider the utilization of new procedures in these patients and to perform higher-level clinical studies to assess the true value of these interventions.

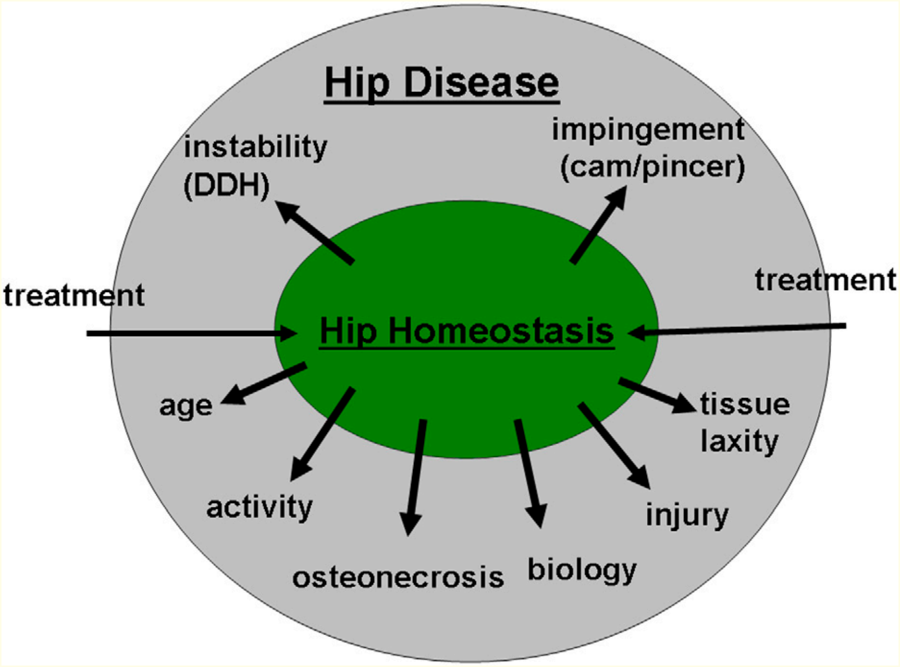

Fig. 1

A diagram depicting the most common etiologies of hip disease. It is important to note that many patients have a combination of factors that play a role in the pathophysiology of hip disease. DDH = developmental dysplasia of the hip. (Reproduced, with modification, from: Beaulé PE. Young adult with hip pain monograph. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2007. p 2. Reprinted with permission.)

I. Etiology of Hip Disease

Mechanical hip dysfunction is a major cause of early hip degeneration and osteoarthritis[2-8]. A variety of structural hip disorders have been proposed as etiologies of joint pathomechanics. These include developmental dysplasia of the hip, Perthes disease, slipped capital femoral epiphysis, and impingement disorders[3,4,9]. Mechanical disorders of the hip can be divided into two major categories: structural instability (dysplasia) and femoroacetabular impingement, or combinations of the two (Fig. 1). Osteoarthritis most commonly occurs secondary to repetitive and/or chronic shear stress at the acetabular rim[10,11]. Acetabular dysplasia and femoroacetabular impingement are the two most common causes of excessive shear stress and acetabular rim syndrome[10].

In developmental dysplasia of the hip, inadequate osseous coverage of the femoral head results in mechanical overload of the anterolateral acetabular rim and labrum. As a result, patients with developmental dysplasia of the hip commonly have the development of anterolateral labral tears, anterolateral acetabular chondromalacia, acetabular rim fractures, and synovial cysts. This acetabular rim overload syndrome progresses to arthrosis with time unless the hip joint pathomechanics are corrected[12].

Femoroacetabular impingement is characterized by decreased clearance and abnormal contact between the femoral head-neck junction and the acetabular rim[3,9] (Fig. 2). These disorders are due to proximal femoral and/or acetabular rim deformity and are now recognized as common causes of prearthritic hip pain and secondary osteoarthritis[3,9]. Abnormal femoroacetabular abutment, particularly in positions of hip flexion and internal rotation, predispose affected patients to labral tears, articular cartilage damage, and premature osteoarthritis. Impingement abnormalities can be divided into two major categories, namely, cam-type and pincer-type impingement disorders (Fig. 2)[9].

Cam femoroacetabular impingement results from deformities of the proximal part of the femur. Most commonly, the anterolateral head-neck junction has an insufficient head-to-neck offset, creating a relative prominence at the anterolateral head-neck junction. This results in repetitive trauma of the anterolateral head-neck junction with the anterosuperior acetabular rim and results in shear stresses at the chondrolabral junction that can eventually produce chondrolabral separation, labral detachment, and articular cartilage damage[13] (Figs. 3-A through 3-D).

Pincer impingement disease results from acetabular overcoverage of the femoral head, resulting in repetitive abutment of the femoral neck against the labrum and prominent acetabular rim. The acetabular labrum is com-

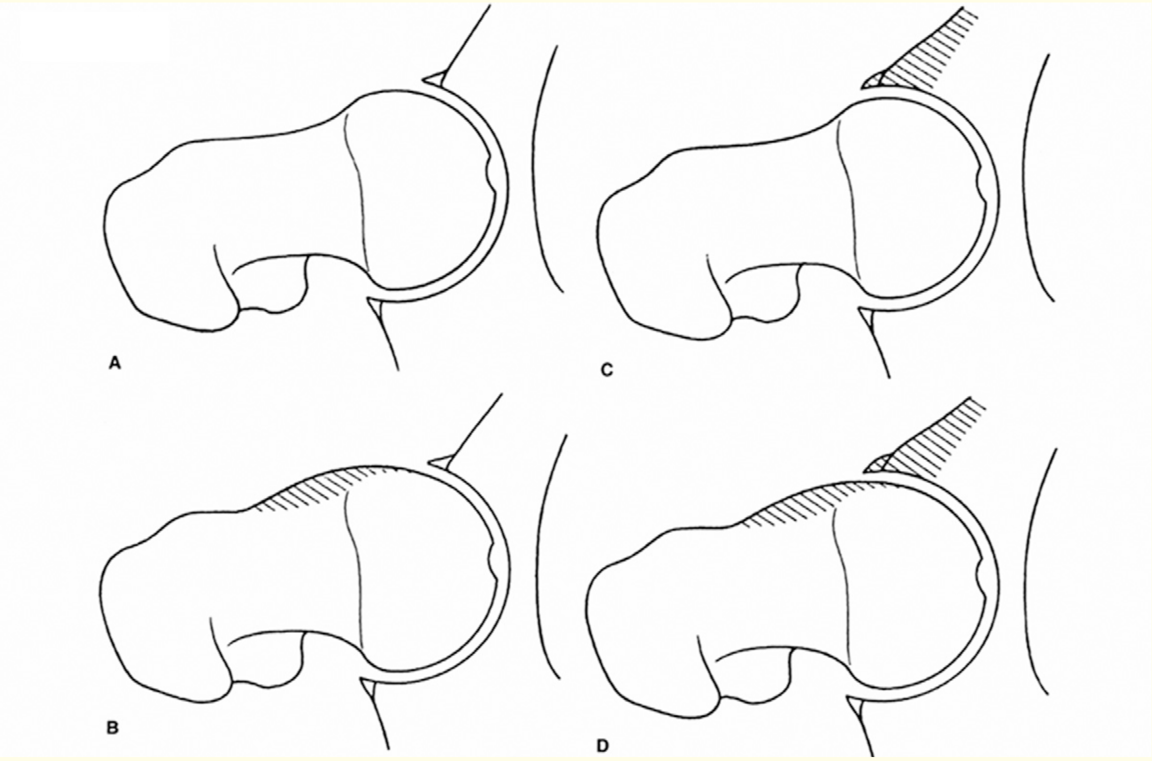

Fig. 2

Femoroacetabular disease patterns. The reduced clearance during joint motion leads to repetitive abutment between the proximal part of the femur and the anterior acetabular rim. *A:* The normal clearance of the hip. *B:* Reduced femoral head and neck offset (cam impingement). *C:* Excessive overcoverage of the femoral head by the acetabulum (pincer impingement). *D:* A combination of reduced head and neck offset and excessive anterior overcoverage (combined impingement). (Reproduced, with modification, from: Lavigne M, Parvizi J, Beck M, Siebenrock KA, Ganz R, Leunig M. Anterior femoroacetabular impingement. Part I. Techniques of joint preserving surgery. Clin Orthop Relat Res. 2004;418:61-6. Reprinted with permission.)

pressed between the neck and rim, causing both labral and articular cartilage damage. Retroversion of the acetabulum, coxa profunda, and protrusio[14,15] are the major pathomechanic etiologies of pincer impingement. These abnormalities can also be combined with cam femoral deformities, creating a combined impingement disorder[13].

In addition to structural disorders of the hip, osteonecrosis of the femoral head with the potential for collapse and joint deterioration is a common cause of hip dysfunction in young patients. Additional patient-specific factors can also contribute to early hip disease and subsequent degeneration (Fig. 1). These include sports activities, patient age, soft-tissue laxity, previous injury or trauma, and so-called biologic susceptibility[16] of the joint. All of these factors alone or in combination can contribute to the onset and progression of hip disease.

II. Clinical Evaluation

A detailed patient evaluation is focused on identifying the specific etiology of the patient's symptoms, carefully defining the structural anatomy of the hip joint, and assessing the extent of joint degeneration[2]. Patient-specific factors, such as age, activity level, comorbidities, and physical condition, are also important determinants in the final treatment plan.

Patient Interview

The medical history should include the age and overall health of the patient, a detailed description of the pain characteristics, the activity level, associated comorbidities, and any previous hip disease or related treatments. Care should be taken to carefully determine the specific pattern of symptoms. It should be clarified whether the symptoms are primarily associated with weight-bearing activities or hip flexion positions such as sitting. Hip pain exacerbated by sitting is commonly associated with femoroacetabular impingement. A history of true locking or catching can be indicative of an intra-articular mechanical problem such as an acetabular labral tear or chondral flap.

Physical Examination

On examination, the overall physical condition of the patient is observed. The sitting posture and gait pattern should be noted. Abductor strength, limb lengths, and neurovascular status are determined. An assessment of hip range

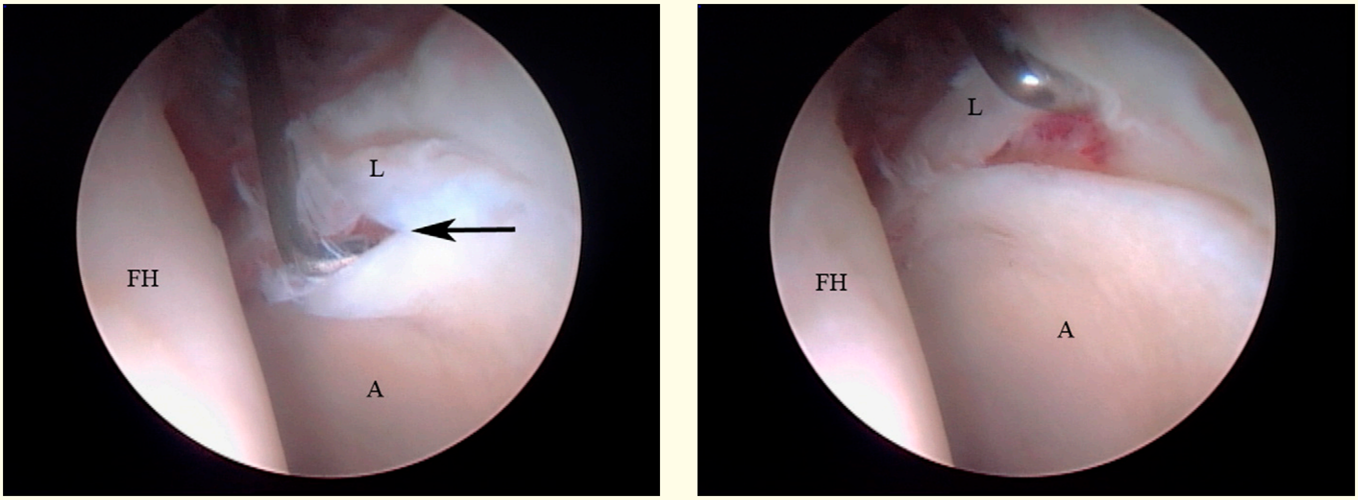

Fig. 3-A

Fig. 3-B

Figs. 3-A through 3-D A thirty-one-year-old woman with cam impingement that was managed arthroscopically. At arthroscopy, the anterolateral acetabular rim cartilage was delaminated (arrow) (Fig. 3-A), and the acetabular labrum was torn along the articular margin (Fig. 3-B). FH = femoral head, A = acetabulum, and L = labrum.

of motion is extremely important in delineating an accurate diagnosis and for selecting the most appropriate surgical intervention. Specifically, the range of hip flexion must be measured accurately. Internal rotation should be assessed at 90° of flexion as a screening maneuver for anterior femoroacetabular impingement. Patients with so-called classic developmental dysplasia of the hip tend to have good hip flexion and internal rotation in flexion. Patients with femoroacetabular impingement have restricted hip flexion and reduced internal rotation in flexion. An additional examination maneuver that is noteworthy is the anterior impingement test, which is performed by passively placing the hip in flexion, adduction, and internal rotation. A positive test reproduces the patient's groin pain. It is a sensitive screening test for patients with acetabular labral disease and impingement. It can also be utilized as a nonspecific screening tool for intra-articular disease and hip joint irritability. In the setting of an uncertain diagnosis, the physical examination can be expanded to include a fluoroscopically guided, diagnostic hip injection and an examination after the injection.

Imaging

The goals of imaging are to assess the structural anatomy of the hip, the congruency of the articulation, and the

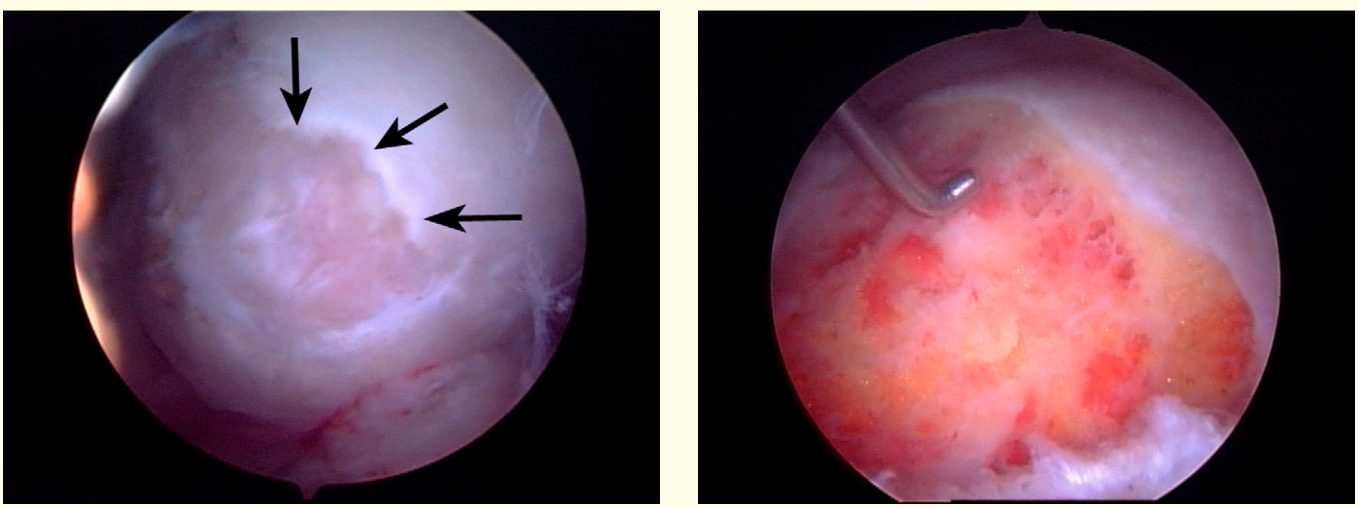

Fig. 3-C

Fig. 3-D

The impingement lesion of the femoral head-neck junction (arrows) can be noted (Fig. 3-C), and the prominence of the anterolateral head-neck junction was removed with an arthroscopic burr (Fig. 3-D) to relieve anterior femoroacetabular impingement.

integrity of the cartilage space. A supine or standing anteroposterior pelvic radiograph can provide the majority of information regarding structural anatomy. The anteroposterior pelvic radiograph depicts the acetabular coverage of the femoral head, head sphericity, acetabular inclination, horizontal position of the joint center, loss of joint space, and the version of the acetabulum. The degree of inclination (the Tönnis angle) of the sourcil (the weight-bearing dome of the acetabulum) is measured, with normal values being between 0° and 10° from the horizontal[17]. The lateral center-edge angle assesses lateral acetabular coverage of the femoral head, and normal values are between 25° and 35°[11,17]. Specific lateral radiographs can be considered to better define the osseous anatomy of the proximal part of the femur, the anterior and posterior joint spaces, and acetabular rims, not all of which may be well visualized with the anteroposterior pelvic radiograph. Lateral radiographs include the false-profile[18], true cross-table lateral, frog-leg lateral[19], or Dunn radiographs[20]. The false-profile radiograph demonstrates the anterior coverage of the femoral head, joint space integrity of the anterosuperior and posteroinferior aspects of the joint, and anterior acetabular rim osteophytosis (Fig. 4). The other lateral radiographs are most valuable for defining the structural anatomy of the anterolateral head-neck junction. Ideally, an initial radiographic screening by a general orthopaedist includes an anteroposterior pelvic radiograph and a lateral radiograph of choice. If additional evaluation and imaging is required, this may be best orchestrated by the treating surgeon.

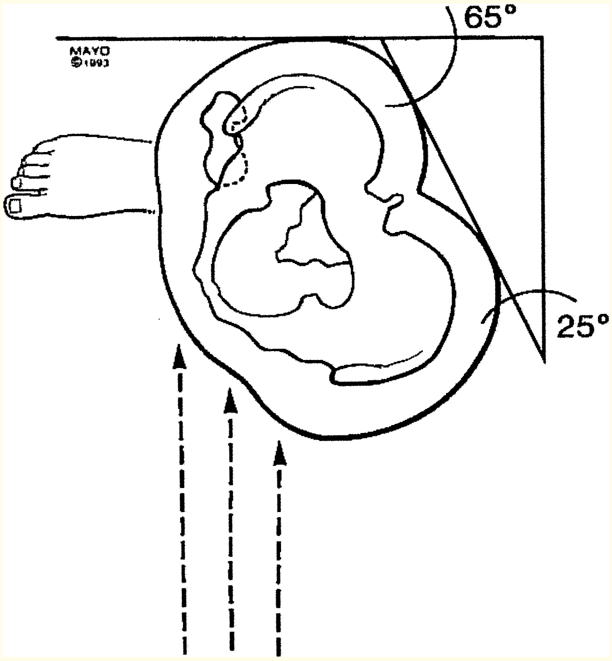

Fig. 4
Schematic drawing demonstrating the false-profile radiographic technique. The right hip is being imaged. (By permission of the Mayo Foundation.)

Magnetic resonance imaging, magnetic resonance arthrography, and computed tomography scanning are effective in excluding other sources of hip symptoms and in defining the detailed intra-articular and extra-articular abnormalities about the hip. A standard magnetic resonance imaging scan is most useful as a screening mechanism to diagnose osteonecrosis of the femoral head, stress fractures, neoplasm, and infection. Magnetic resonance arthrography with a small field of view centered on the hip has been popularized for more detailed evaluation of intra-articular structures. Para-axial magnetic resonance arthrography imaging has been endorsed as an optional imaging strategy for visualization of the anatomy of the femoral head-neck junction and evaluation of impingement abnormalities[21,22]. The dGEMRIC (delayed gadolinium-enhanced magnetic resonance imaging of cartilage) imaging technique holds promise in assessing the integrity of articular cartilage and quantitating early arthritic disease. This imaging modality assesses the glycosaminoglycan content of the articular cartilage and has been shown to be of prognostic value in predicting the response of dysplastic hips to joint-preserving osteotomies[23]. Computed tomography scanning has assumed a larger role for detailed evaluation of osseous hip anatomy[24], and it can be utilized to better characterize osseous impingement lesions, assess acetabular version, and delineate structural anatomy in severely deformed hips. Three-dimensional reconstructions are particularly informative in characterizing and localizing osseous impingement lesions and in planning the details of impingement lesion resection.

III. Open Treatment of Femoroacetabular Impingement

Surgical treatment for symptomatic femoroacetabular impingement (Table I) should primarily address relief of the mechanical impingement and consider treatment of any secondary intra-articular disease. The specific type of treatment depends on the pattern and extent of impingement disease. Less invasive surgical techniques are most commonly considered for focal cam impingement, while more invasive open procedures are most suitable to treat nonfocal or combined cam-pincer disease patterns. Open interventions include anteversion periacetabular osteotomy, surgical dislocation of the hip, and anterior arthrotomy tech-

TABLE I Common Findings in the Evaluation of Femoroacetabular Impingement

Patient history
Predominant anterior inguinal (groin) pain
Pain exacerbation with activity and hip flexion (sitting)
Mechanical symptoms
Physical examination
Limited passive hip flexion (≤105°)
Limited internal rotation at 90° of hip flexion (≤15°)
Positive anterior impingement test
Radiographic evaluation
Anteroposterior pelvic radiograph
Cam impingement: aspherical femoral head and insufficient head-neck offset
Pincer impingement: excessive head coverage (acetabular retroversion, protrusio, or profunda)
Lateral radiographs (cross-table, Dunn, or frog-leg lateral)
Aspherical femoral head and insufficient head-neck offset
Imaging
Magnetic resonance arthrography
Acetabular labral tears, acetabular rim chondromalacia, and insufficient head-neck offset
Computed tomography
Cam impingement: aspherical femoral head and insufficient head-neck offset
Pincer impingement: acetabular retroversion, overcoverage, and rim fractures

niques. Less invasive options include a limited anterior approach to the hip alone or in combination with hip arthroscopy. Isolated hip arthroscopy techniques to address intra-articular disease components and associated impingement lesions have also evolved.

Anteversion periacetabular osteotomy is an uncommonly performed procedure that is indicated in the setting of major acetabular retroversion and posterior wall insufficiency[15]. This technique can provide anteversion correction of the acetabulum and improved mechanics between the femoral head-neck junction and the acetabular rim. This procedure is indicated in a small subgroup of patients with pincer impingement.

A trochanteric slide osteotomy with surgical dislocation of the hip is the most well-documented surgical strategy for the treatment of impingement disease[25-29]. This surgical approach preserves the blood supply to the femoral head, yet it allows complete dislocation of the hip with circumferential exposure of the acetabulum and the femoral head-neck junction. Care is taken to preserve the deep branch of the medial femoral circumflex artery[28]. This procedure allows direct visualization and correction of impingement disease that can encompass osteochondroplasty of the femoral head-neck junction, osteochondroplasty of the acetabular rim, repair of the acetabular labrum, relative femoral neck lengthening, trochanteric advancement, and articular cartilage procedures of the femoral head and acetabulum.

Less invasive surgical procedures are now being developed and refined to address impingement disease. The goals of these procedures are to treat intra-articular disease precisely with arthroscopic techniques and to correct the cam and/or pincer structural abnormalities either arthroscopically or through direct visualization by less invasive open procedures. Access to the anterolateral femoral head-neck junction, acetabular labrum, and acetabular rim can be obtained through the Smith-Petersen interval or the Heuter anterior approach. The anterolateral head-neck junction is contoured to create a more normal head-neck offset. The acetabular labrum can be inspected and repaired, and acetabular rim trimming can be performed if needed. Hip arthroscopy can be used as an adjunct to the anterior approach to address acetabular labral tears, articular cartilage disease, and synovitis.

Hip arthroscopy techniques are now evolving to the point at which a variety of impingement disease patterns can be treated arthroscopically[30-33]. Nevertheless, extensive arthroscopic experience and understanding of hip pathomechanics are needed to apply these surgical techniques effectively. Disease components in the central compartment are treated, and then the peripheral compartment of the joint is visualized and femur-based cam impingement abnormalities are corrected (Figs. 3-A through 3-D). Additionally, techniques have been developed for acetabular labral takedown, repair, and trimming of the acetabular rim[32]. Presently, published clinical follow-up on arthroscopic impingement procedures is very limited, and there is a need for studies to define the efficacy of these procedures.

IV. Open Treatment of Developmental Dysplasia of the Hip

Hip-preserving acetabular reorientation osteotomies allow a major correction of dysplasia and great improvement in clinical function[28,34-42]. For example, the periacetabular and rotational acetabular osteotomy can provide major, multidimensional acetabular correction for the mechanically jeopardized dysplastic hip. Additionally, acetabular reorientation can be augmented by a variety of other surgical techniques to optimize the procedure[11,34,35,37,40]. Acetabular labral repair or partial resection, femoral head recontouring, femoral head-neck junction osteochondroplasty, relative femoral neck lengthening, trochanteric advancement, and proximal femoral osteotomy are now part of the surgeon's armamentarium and can be utilized to refine the hip reconstruction. With use of these surgical techniques and strategies, the symptomatic dysplastic hip can be preserved, and relief of pain and improved function is predictable[34,37,40,41,43,44]. Optimal candidates have no or minimal secondary osteoarthritis and a highly congruent hip joint while maintaining hip range of motion. Although there are several osteotomy techniques to reorient the acetabulum, including rotational acetabular osteotomies and triple innominate osteotomies, the Bernese periacetabular osteotomy[37] has been widely adopted. Surgical correction is directed at the restoration of joint stability while minimizing secondary impingement[11].

TABLE II Periacetabular Osteotomy Assessment*

1	Acetabular sourcil (weight-bearing surface) is repositioned in a more horizontal orientation with a superolateral inclination of 0° to 10°
2	Lateral femoral head coverage is improved with a goal of achieving 25° to 35°
3	The hip joint center is translated medially (if needed) to place the medial aspect of the femoral head to within 5 to 10 mm of the ilioischial line
4	Version is correct; look for undesirable retroversion as detected by crossover of the anterior and posterior rims
5	Anterior femoral head coverage is improved to 20° to 25° on the false-profile radiograph (and is not excessive)
6	The correction maintains or produces a congruent joint space, and subluxation is corrected
7	Adequate head-neck offset is present or has been restored with osteochondroplasty
8	Adequate internal fixation with acceptable screw position
9	Hip flexion of ≥90° and hip abduction of ≥30°

*These are optimal parameters, and the correction obtained will vary depending upon the severity and characteristics of the deformity.

Surgical Technique Concepts for Periacetabular Osteotomy

The periacetabular osteotomy is usually performed through a modified Smith-Petersen abductor-sparing approach[11,35,45]. The fundamental goal is correction of the acetabular insufficiency by repositioning the weight-bearing surface laterally and anteriorly to enhance femoral head coverage. The abnormal lateral position of the hip joint center can also be corrected by medial translation of the acetabulum[46]. In addressing dysplasia, the end goal is to achieve stability and medialization without retroverting the acetabulum and potentiating impingement. The standard reduction maneuver is a combination of internal rotation, forward tilt (extension), and medial translation. Intraoperatively, the surgical correction obtained must be carefully scrutinized with plain radiographs or fluoroscopy (Table II). Following acetabular redirection, there should be a minimum of 90° of flexion and 30° of abduction.

On completion of the periacetabular osteotomy, we routinely perform an anterior arthrotomy to assess both the labrum and the anterolateral head-neck offset. Degenerative labral tears, unstable flaps, or entire detachments may be débrided and/or repaired. Alternatively, if labral disease is suspected from the history, physical examination, and magnetic resonance arthrography, it may be advantageous to combine hip arthroscopy with the acetabular osteotomy. Commonly, there is insufficient anterolateral femoral head-neck offset[47], and an osteochondroplasty may be performed as an adjunct to acetabular reorientation. This minimizes secondary hip-joint impingement. If relative coxa valga precludes the restoration of satisfactory lateral coverage and residual instability remains, a proximal femoral varus osteotomy is performed. When a Perthes-like deformity (instability with impingement) is addressed, it is typically necessary to combine the periacetabular osteotomy with a valgus flexion-producing proximal femoral osteotomy and/or extensive recontouring of the head-neck junction and trochanteric advancement. This enhances the range of motion in abduction and flexion and prevents secondary femoroacetabular impingement[36].

The Bernese periacetabular osteotomy (and other acetabular reorientation techniques) predictably relieves pain and increases the function of the involved hip (Fig. 5). The reported outcomes of surgical treatment for symptomatic hip dysplasia have been very satisfactory as recently reported by Millis and Murphy[11], Matheney et al.[40], and Siebenrock et al.[41]. The utilization of this procedure is now expanding to encompass severely dysplastic hips, acetabular dysplasia with associated Perthes-like femoral deformities, and hips that have had a previous osteotomy[34,36,48].

V. Hip Arthroscopy

The number of hip arthroscopy procedures is increasing on an annual basis. With appropriate indications, sound patient selection criteria for surgery, and realistic patient expectations, hip arthroscopy can be a reliable intervention for the diagnosis and treatment of intra-articular and periarticular disease. Nevertheless, it is important to realize that the majority of clinical evidence is Level IV and Level V, with relatively short-term follow-up in most studies. Clearly, there is a major need for higher-level clinical evidence to determine the true efficacy of hip arthroscopy procedures.

Indications and Contraindications

The most common indications include acetabular labral disease, focal articular cartilage lesions, femoroacetabular impingement, loose bodies, and synovial disorders[49-53]. Absolute contraindica-

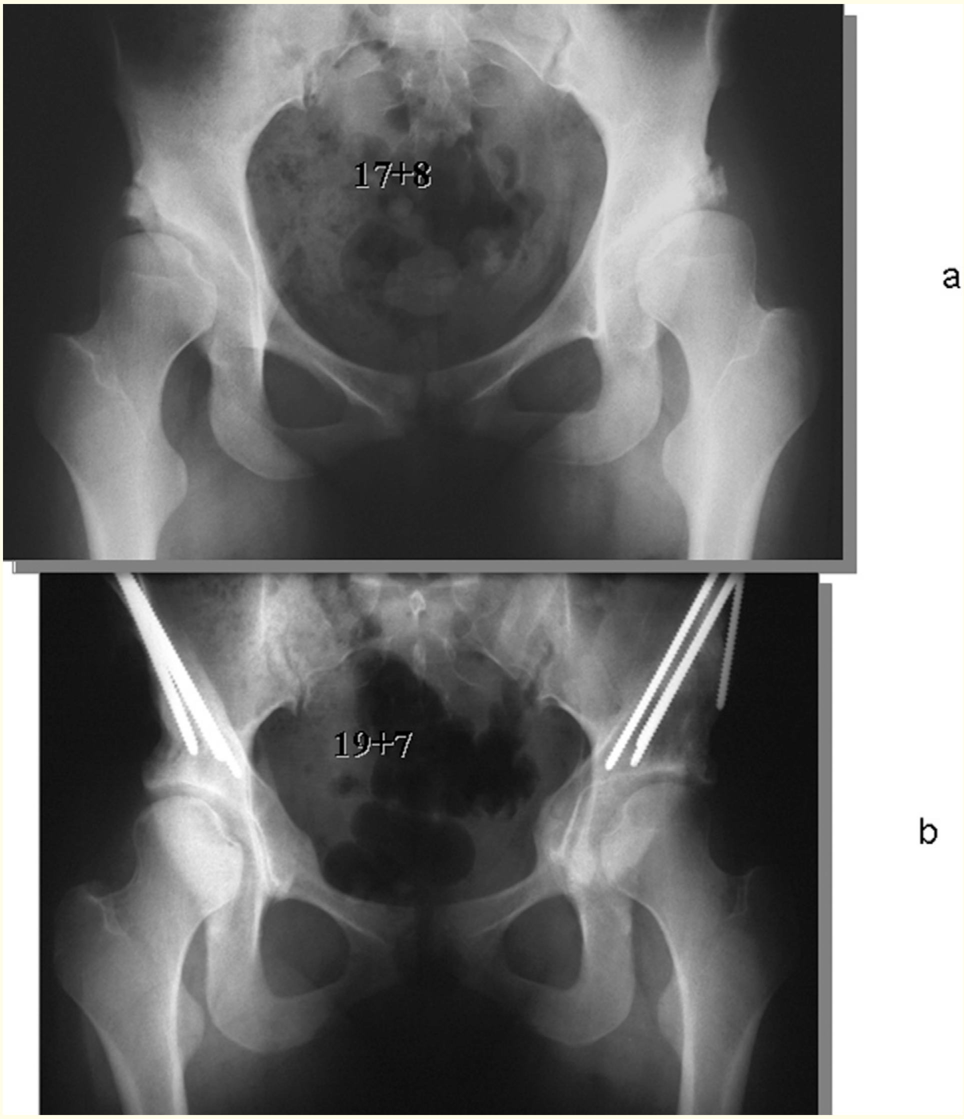

Fig. 5
Anteroposterior radiographs of a seventeen-year-old girl with symptomatic bilateral acetabular dysplasia and acetabular rim fractures (a). She was treated with staged periacetabular osteotomies and had an excellent clinical result with both hips (b).

tions to hip arthroscopy include any clinical situation that prevents safe distraction of the hip joint. Relative contraindications include altered anatomy precluding safe portal placement (previous surgery), open wounds, severe obesity, and infection (other than to wash out a hip that has an active joint infection). Additionally, arthroscopic treatment alone is rarely appropriate in the setting of major, uncorrected structural deformities and is unlikely to benefit patients with advanced osteoarthritis or osteonecrosis with femoral head collapse.

Nonstructural Intra-Articular Disorders

In its most basic form, hip arthroscopy serves as a diagnostic tool. Given that both magnetic resonance imaging and magnetic resonance arthrography have limited sensitivity for detecting certain intra-articular disorders[54], hip arthroscopy occasionally plays a diagnostic role in evaluating hip pain of unknown etiology. Nevertheless, in the large majority of patients, the diagnosis and underlying pathomechanics of the joint are elucidated prior to surgery. Current concepts suggest that labral tears in young to middle-aged patients are often the result of other intrinsic disorders, such as developmental dysplasia of the hip, femoroacetabular impingement, and hip instability[6,7,55]. Thus, an effort should be made to identify and correct the underlying etiology of the labral tear in addition to treating the tear itself.

Hip arthroscopy is increasingly used to treat acetabular labral tears and associated abnormalities, yet the diagnosis of these lesions and the selection of appropriate surgical candidates are still evolving. Studies have found the most common locations for labral disease are the anterior or anterior-superolateral regions[51,56-58]. Partial arthroscopic resection of symptomatic acetabular labral tears has a reported success rate of between 68% and 84%[50,51,55,59,60], with less predictable results in the setting of more extensive articular cartilage disease[51,61]. Arthroscopic acetabular labral repair is technically feasible, although the indications and clinical outcomes need to be defined. Interest in labral repair is increasing as there is clinical and basic-science evidence that supports the importance of the labrum for normal hip function by acting as a gasket, maintaining joint fluid pressure, and providing structural stability[27,62]. Short-term preliminary reports with this type of tear pattern have suggested that outcomes are equivalent to those of partial labrectomy[63,64].

Arthroscopic treatment for focal chondral damage has been reported, with mixed results[52,65]. As discussed previously, chondral damage is highly associated with labral tears, and the preoperative diagnosis of chondral damage remains a considerable challenge[54,66]. Although microfracture and abrasion chondroplasty of the hip are also possible, the indications and outcomes need to be defined[65]. Symptomatic soft-tissue instability of the hip is an uncommon entity that has recently been proposed as a cause of hip symptoms. The diagnosis is challenging, and there is an incomplete understanding of this diagnosis and the role of surgical treatment. It may present as chronic hip pain in athletes (including gymnasts and ballet dancers), after a traumatic episode, or more commonly in active individuals with underlying hyperlaxity states. These patients may respond to capsulolabral repair[67]. Recent reviews of the topic have suggested that arthroscopic examination is indicated when hip instability is suspected and the patient gets relief from an intra-articular anesthetic injection but fails to respond to six months of conservative treatment[68,69]. There is an obvious need to more clearly define the diagnosis, indications, and results of treating soft-tissue laxity about the hip, as current evidence for intervention is primarily Level V.

Arthroscopic treatment is possible for other uncommon conditions of the hip such as rupture of the ligamentum teres[70] and synovial disorders[53,71,72]. Arthroscopic management of adhesive capsulitis and of infection have also been reported[73-76].

Mild Structural Disorders

The optimal treatment strategies for intra-articular hip disease associated with mild structural abnormalities remains controversial. Specifically, the necessity for and degree of deformity correction need to be determined. Advances in hip arthroscopy have led to the development of specific techniques for the treatment of hip impingement disorders[30-33], yet further evaluation of the clinical results of these techniques is necessary to accurately establish the advantages and disadvantages of these procedures.

The role of hip arthroscopy in the dysplastic hip remains quite controversial, as an arthroscopic procedure cannot correct the underlying pathomechanics of the joint and may even accelerate the degenerative process[51]. Therefore, comprehensive correction of the underlying structural abnormality of the hip should be strongly considered. Nevertheless, arthroscopy has been used successfully in the treatment of some intra-articular disease patterns (labral tears, chondral flaps, and ligamentum teres tears) in patients with mild developmental dysplasia of the hip and mechanical symptoms[77]. Arthroscopy should be considered only for patients with mild dysplasia or as a relatively short-term solution for symptom relief in patients who are not appropriate candidates for an osteotomy. For example, débridement of an irreparable labral tear for temporary symptom relief may be appropriate in certain patients. In contrast, we would not recommend labral repair without concurrent structural deformity correction.

The role of hip arthroscopy in the treatment of femoral head osteonecrosis or established osteoarthritis is very limited. Uncommonly, it may offer the potential for relief of mechanical symptoms by débridement of chondral or labral flaps[61,78-80]. The results clearly deteriorate with increasing levels of chondral damage and joint involvement.

Surgical Technique—General Principles

Hip arthroscopy is performed with the patient in either the supine or lateral position, depending on surgeon preference[81,82]. The key requirement for both positions is adequate joint distraction (8 to 10 mm) to allow safe access to the central compartment (the area between the acetabulum and the femoral head). The peripheral compartment (the intracapsular space outside the acetabulum) can be accessed without traction. Almost all surgeons utilize the anterior and anterolateral portals, while some surgeons also advocate the routine use of a posterolateral portal. An anterior capsulotomy or partial capsular resection facilitates visualization in the peripheral compartment. If it is needed, an accessory anterolateral portal can be established approximately 4 to 5 cm distal to the anterolateral portal[83].

For the correction of a cam impingement deformity, the arthroscope is placed in the peripheral compartment and an arthroscopic burr is used to resect the prominent, nonspherical area on the anterolateral femoral head-neck junction. Care is taken to avoid damage to the blood supply to the femoral head by protecting the posterolateral retinacular vessels that originate from the medial circumflex femoral artery[84]. For correction of a pincer impingement deformity, the arthroscope is placed in the central compartment and the anterolateral and anterior portals are used to perform an acetabular "rim trimming." The damaged labrum in the area of excess acetabular rim can be detached while the joint is distracted. It is important to emphasize that the takedown of an intact chondrolabral junction is controversial and of uncertain benefit. After release of the damaged labrum, a burr is then used to resect the area of overhanging acetabulum. After resection, the labrum is repaired with suture anchor fixation or, alternatively, is resected. Recent evidence[27] has indicated that, with open treatment of impingement disease, labral repair is associated with improved clinical outcomes compared with a full-thickness resection.

VI. Treatment Options for End-Stage Hip Disease

Despite the innovation and positive clinical results with various surgical techniques for joint preservation, many young patients present for treatment with end-stage degeneration of the hip and are not candidates for joint-preserving surgery. In this clinical setting, joint replacement procedures are considered with the goals of relieving pain, maintaining activity levels, restoring hip function, and enhancing quality of life. The introduction of alternative prosthetic bearing surfaces and improved hip-resurfacing implants suggests that there is potential for improved function and survivorship of prosthetic hip reconstructions. The major challenges going forward are to identify the optimal prosthetic bearing surfaces, determine the clinical efficacy of contemporary hip replacement and hip resurfacing implants, and delineate the mid-term to long-term survivorship of these two procedures. In choosing between hip replacement and hip resurfacing, the surgeon should consider a variety of factors including patient age, sex, activity level, body-mass index, and comorbidities[85]. Proximal femoral bone quality and a history of surgery should also be assessed as these variables may impact the success of the surgical procedure.

Total Hip Replacement

The excellent clinical results of total hip replacement in all age groups are well known, and, with the use of improved wear-resistant bearing couples, these results will most likely continue to improve over time. Total hip replacement has several advantages. These include broader criteria for patient selection, less invasive surgical techniques, implant modularity, documented long-term efficacy, protection from proximal femoral fracture, and technical ease. Total hip replacement is appropriate in the vast majority of young patients, even in the setting of poor proximal femoral bone stock (cystic degeneration, osteonecrosis, and osteoporosis), femoral head-neck deformity, compromised acetabular bone stock, inflammatory arthritis, limb-length discrepancy, and obesity. Additionally, less invasive surgical techniques[86] and multimodality pain management protocols have quickened patient recovery and reduced perioperative pain associated with the procedure. The implant-related versatility of hip replacement is also advantageous with respect to bearing surface materials (ceramics, highly cross-linked polyethylene, and metals), femoral head-neck diameter sizes and lengths, and acetabular liner options (elevated lips, offset, and constrained). Implant fixation characteristics with contemporary devices are excellent and durable. With aging, the femoral neck and intertrochanteric region of the proximal part of the femur are "protected" from fracture by the femoral implant. Technically, primary total hip arthroplasty is a straightforward procedure performed with a variety of surgical approaches and techniques. Arguable disadvantages of total hip replacement relative to total hip resurfacing include dislocation (with standard femoral head sizes), compromise of proximal femoral bone stock with component insertion, the potential for excessive lengthening[87], proximal femoral stress-shielding over long periods of time[88], and perceived activity limitation. It should be noted that prosthesis survivorship as a means of measuring outcome has limitations in terms of assessing health-related quality of life[89], especially in active, high-demand patients. Consequently, integrating patient activity level in the assessment of total hip arthroplasty function provides relevant qualitative information that is not contained in current hip-scoring systems[90,91]. Using the University of California at Los Angeles (UCLA) activity score[92], one recent study compared the outcome of total hip replacement and hip resurfacing. That prospective randomized trial showed that patients with hip resurfacing had a higher mean activity score than their total hip counterparts at twelve months of follow-up. This potential disadvantage of total hip replacement must be confirmed with longer-term follow-up studies and must be interpreted in the context of a lower risk of revision surgery after total hip replacement[93-95]. Nevertheless, these data are consistent with the concept that patients with a high activity level may be the most appropriate candidates for a hip-resurfacing procedure. These data also underscore the need for improved, validated activity scores for high-demand patients. Such scores will facilitate surgical decision-making and will be the basis for comparison studies of total hip replacement and resurfacing.

Hip Resurfacing

Resurfacing arthroplasty of the hip has experienced a resurgence in popularity over the last decade[96]. With improvement in design technology and metallurgy, many of the problems that plagued early designs, such as massive bone loss with cemented acetabular components[97] and high polyethylene wear rates associated with larger femoral head sizes, have been overcome[98-101]. Current hip-resurfacing systems utilize a hybrid design, with a press-fit acetabular component and a cemented femoral component[96,102]. Early and mid-term results have been reported and are favorable compared with early designs of hip-resurfacing implants[103-106]. As in other alternative hip procedures, careful patient selection helps to minimize complications and the need for early reoperation[85]. Conversely, because of the improved survivorship of total hip replacement[107] and the excellent short-term performance of new bearing couples[108,109], one may rightly question the role of hip resurfacing in today's armamentarium of replacement procedures.

Several potential advantages are emphasized by the proponents of hip resurfacing. These include preservation of proximal femoral bone stock, more physiologic stress transfer in the proximal part of the femur[110], more normal hip kinematics[96], a low dislocation rate, and easy femoral revision procedures[111]. Perhaps the most emphasized potential benefit is the tolerance of high activity levels that may enhance quality of life or patient-perceived quality of life. Thus, there is a major need for investigation of activity levels and quality of life after hip resurfacing. An additional theme in hip-resurfacing reports is that careful patient selection is important to optimize clinical results and avoid complications. The surface arthroplasty risk index[85] (Table III) is useful in guiding the treatment decision-making process when contemplating hip resurfacing compared with total hip replacement[103].

The disadvantages of hip resurfacing include a larger surgical exposure and a technically more demanding procedure, limitations in the setting of compromised femoral bone quality, a lack of modularity, limitations with regard to lengthening the extremity, early femoral neck fracture, and metal ion-associated problems. Over long-term follow-up periods, the potential complications of recurrent femoroacetabular impingement and proximal femoral fracture also need to be investigated. In a practical sense, hip resurfacing has not been within the training curriculum of orthopaedic surgeons for the last two decades and a learning curve will likely occur as the procedure is utilized more commonly. For example, the failure mechanisms of femoral loosening[103,112-115] secondary to malalignment and femoral neck fractures are commonly related to surgical technique. The prevalence of femoral neck fracture has been reported to range from 0.8% to 1.45%[105,112], and these fractures tend to occur within the first six months after surgery, with osteonecrosis and femoral neck notching being implicated as potential causes[113,116,117]. On the other hand, the prevalence of failures secondary to femoral component loosening has been reported to range from 6% to 10%[103,114,115].

TABLE III Surface Arthroplasty Risk Index[92]

	Points
Femoral head cyst of >1 cm in size	2
Patient weight of <82 kg	2
Previous hip surgery	1
UCLA activity level of >6	1
Maximum score	6

An additional controversial aspect of hip resurfacing is the importance of metal ion release from the bearing surface. The major concern is for patients with compromised renal function since metal ions generated from a metal-on-metal bearing are excreted through the urine, and the lack of clearance of these ions may lead to excessive levels in the blood[118,119]. Currently, the only clear complication from exposure to metal ions is a hypersensitivity reaction, which occurs in approximately 0.3% of patients[120,121]. The clinical findings associated with this phenomenon are persistent pain and periprosthetic osteolysis with or without component loosening[120,121]. More importantly, a recent paper examining metal ions in umbilical cord blood showed that cobalt and chromium ions cross the placental barrier[122] and may be a source of concern for women of childbearing age who are contemplating a resurfacing procedure. Clearly, a major disadvantage of hip resurfacing remains the associated release of metal ions, which leaves the patient exposed to elevated ion levels for decades.

The key aspects to the surgical technique for hip resurfacing can be divided into three steps: the choice of the surgical approach, selection of implant size, and positioning of the implant[103,123]. In terms of surgical approach, the vascularity of the proximal aspect of the femur should be considered because the femoral component rests on the reamed femoral head. Disruption of the blood flow to the femoral head via the posterior approach could cause an osteonecrotic event that disrupts the bone-cement interface and leads to premature loosening or, in extreme cases, neck fracture[116]. Nevertheless, several centers have reported excellent short-term to medium-term results using the posterior approach. With respect to implant sizing, it is recommended that referencing should be off the femur in order to avoid neck notching. Once the femoral component size is selected, then one verifies that the matching acetabular component is appropriate for the patient's anatomy. If the anatomy necessitates an in-between size, it is better to go up one size with the acetabular implant than to notch the femoral neck when preparing it for a smaller femoral component. Finally, implant positioning in hip resurfacing is more demanding since the margin for acceptable implant positioning is narrower. On the acetabular side, it is critical to avoid excessively vertical placement because of the risk of runaway wear. One should aim for an abduction angle of 40° to 45°. Alternatively, an excessively horizontal position of the acetabular component can be a source of anterior femoroacetabular impingement and should also be avoided. On the femoral side, slight valgus orientation relative to the femoral neck is favorable to implant survivorship by minimizing tensile stresses on the femoral neck[124].

Metal-on-metal hip-resurfacing arthroplasty will continue to play a role in the treatment of end-stage hip arthritis in young patients. Currently, the ideal candidate is an active male patient who is less than sixty years of age with a diagnosis of osteoarthritis. Since we now have hip resurfacing implants with good-to-excellent clinical results at short-term to mid-term follow-up, it is imperative that future studies better define optimal patient selection criteria for surgery, investigate the true quality-of-life benefit, and determine longer-term complications and survivorship. Future clinical studies should focus on comparing the results of resurfacing procedures and total hip replacement in similar patient cohorts.

Hip Arthrodesis

Arthrodesis, although uncommonly carried out, is indicated for young patients with end-stage unilateral hip arthritis who have contraindications for both joint preserving and joint replacement procedures. Hip arthrodesis preserves bone stock and can provide pain relief indefinitely[125]. The ultimate goal for these patients is a return to an active lifestyle with minimal restrictions. The ideal candidate is an adolescent or young adult (less than thirty years of age) with a history of multiple hip surgeries, posttraumatic arthritis, and/or postinfectious hip disease. Activity demands are high, and the patient should not have preexisting disease of the lumbar spine, ipsilateral knee, or contralateral hip[126]. The surgical approach chosen for the fusion should attempt to minimize trauma to the abductor muscle mass[127] in case total hip arthroplasty is subsequently performed. With proper patient selection and with the hip fused in an optimal position, the onset of notable pain in adjacent joints can be delayed for up to twenty-five years[126,128].

VII. Overview

The care of hip disease in adolescent and young adult patients has engendered recent interest associated with a number of factors, which include an improved understanding of the mechanical etiology of disease in many patients and of the effectiveness of mechanically based treatment in many situations. This realm of orthopaedics is now experiencing rapid growth and high levels of interest because of the improved understanding of hip disease and innovation in surgical techniques. It is imperative that the orthopaedic community educate other health-care providers regarding the diagnosis and treatment of early hip disease. Specifically, we should target pediatricians, primary care physicians, radiologists, and physical therapists with the message that early diagnosis and referral for specialized care may optimize clinical outcomes and alter the natural history of these disorders. Surgical strategies for joint preservation should be viewed as desirable alternatives compared with persistent hip dysfunction and progressive joint degeneration. As we move forward, it is critical that these interventions be evaluated with sound clinical research. Specifically, hip arthroscopy and surgical techniques in joint preservation need to be analyzed with respect to symptom relief, activity tolerance, quality of life, and survivorship. Low-wear implant bearings and resurfacing implants need to be followed for longer terms in order to distinguish their clinical benefit and wear characteristics.

There is great need for improved validated activity and quality-of-life scores for these high-demand patients. In addition, determining the role of genetic factors in hip disease and developing effective screening protocols for various hip disorders may lead to an earlier diagnosis and preventive care. Collectively, progress in these areas will lead to continued improvements in the orthopaedic care of this traditionally underserved patient group.

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The Journal of Bone & Joint Surgery · jbjs.org
Volume 90-A · Number 10 · October 2008

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