Technical Considerations In Difficult Primary Total Hip Arthroplasty

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Total joint replacement has become one of the more common orthopaedic operations, with approximately 240,000 major joint arthroplasties performed annually in the United States, a large percentage of these being of the hip.[1] The vast majority of hip replacements are for the diagnosis of degenerative arthritis and are performed in patients greater than 60 years of age. Less commonly the procedure is performed for other diagnoses (eg, developmental disorders of the hip, inflammatory arthritis, and post-traumatic arthritis) and in younger patients. Each of these diagnoses are associated with unique characteristics posing an array of technical challenges for the surgeon. The purpose of this manuscript is to highlight the more common of these processes with emphasis on the technical difficulties encountered when reconstructing these hips.

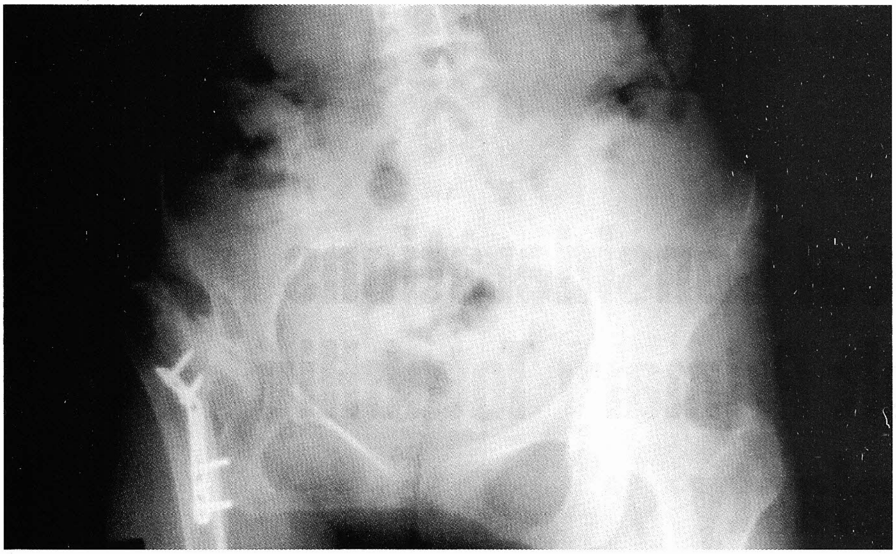

Figure 1a. The preoperative AP X-ray of a 39 year old female with congenital dysplasia of the right hip. The right femur was treated with a femoral osteotomy at age 8.

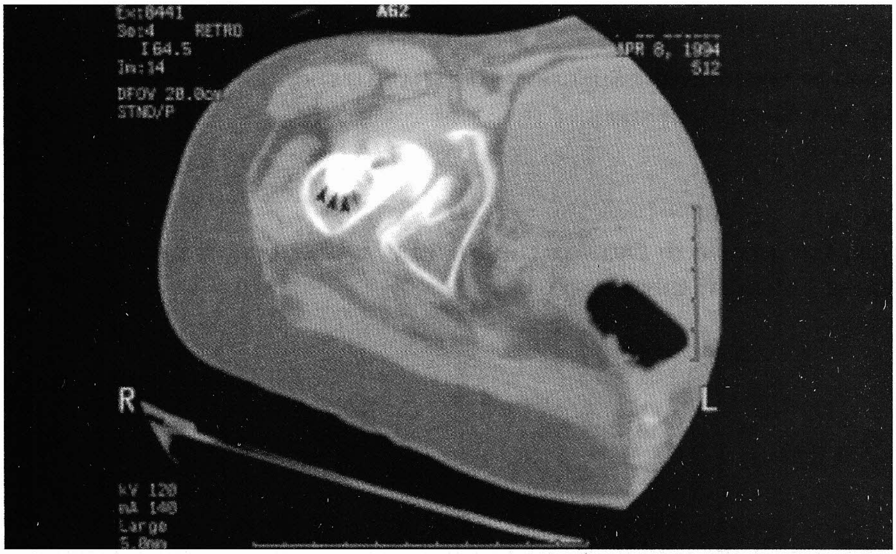

Figure 1b. CT scan demonstrates intramedulary position of the retained hardware (arrows).

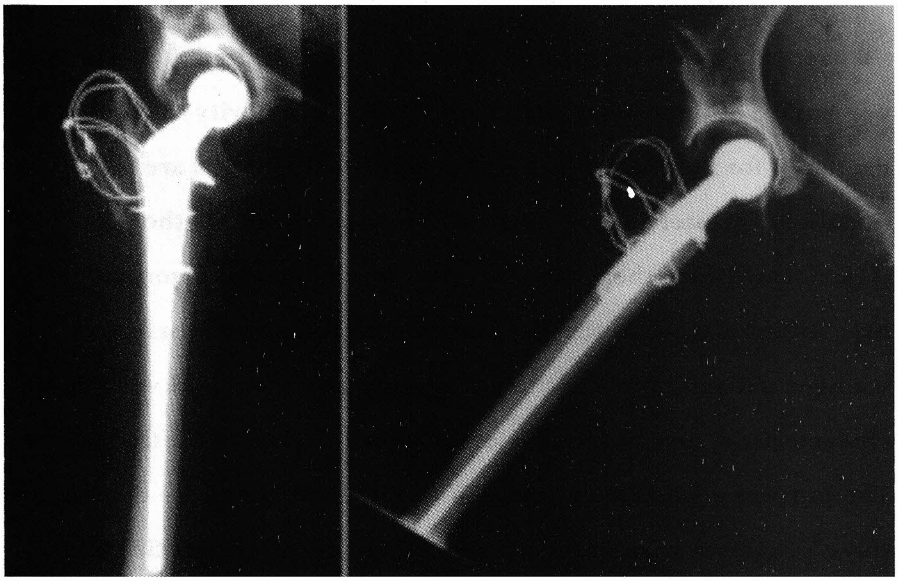

Figure 1c. AP and lateral X-rays of the left hip after total hip arthroplasty with CDH components. The distal portion of the plate was intracortical allowing for stem placement without total plate removal.

CONGENITAL OR DEVELOPMENTAL HIP DYSPLASIA

Congenital and developmental deformities of the hip most commonly result in disabling arthritis for patients in their fourth or fifth decade of life, and rarely occur sooner.[2] Reconstruction of the hip in these patients is only remotely similar to total hip arthroplasty for other diagnoses. The anatomy is significantly altered making surgical exposure and prosthetic placement much more difficult. The developmental or congenital abnormalities also apply to neurovascular structures which are more likely to be injured at the time of surgery. The preoperative considerations in these patients include previous surgeries, retained implants, muscle strength, limb length inequality, and bone stock remaining for reconstruction. Patients must be informed of the higher risks of surgery and have a clear understanding of the benefits.

Previous surgeries result in stiffened, non-compliant tissue, possibly altered anatomy, and the potential for retained hardware, which may be difficult to remove (Figure 1). Wide exposure and trochanteric osteotomy are recommended to help combat the difficulty of surgery in these patients. Trochanteric osteotomy also allows the surgeon to place the trochanter more laterally, thus preventing trochanteric impingement on the pelvis and enhancing abductor mechanics. A Watson-Jones or a posterior approach are alternatives if minimal deformity is present. Component placement is dependent on bony architecture and limb length inequality. Anatomic acetabular placement is indicated when bone quality and quantity permits, because hip biomechanics are best restored when the acetabulum is placed in this position.[3]

Crowe et al previously classified the severity of dysplasia based on the migration of the hip.[4] In types I and IV, anatomic acetabular placement may be possible without bone graft. All of these patients, especially type IV or high iliac dislocation, frequently require small (35-42 mm), all polyethylene components because of the anatomic constraints. Patients with moderate dysplasia, Crowe II or III, are most likely to require posterior or posterior superior bone graft. The patients femoral head is ideal in these cases. In general, a bone graft is indicated when less than 75% of the acetabulum is in contact with host bone.[5] An alternative to an anatomic acetabular reconstruction is high iliac placement of the acetabular component, particularly when iliac bone stock is greater in this position compared to that of the true acetabulum.[6]

The femoral reconstruction is equally as challenging. Shortening of the limb to prevent excessive lengthening and undue stress on the neurovascular structures may require resection of the femur at or below the level of the lesser trochanter. Alternatively, subtrochanteric resection with preservation of metaphyseal bone can be performed. Additional problems are the straight, narrow canal with a thin cortex. Often, the proximal femur is in excessive anteversion and the femoral neck is short. Special care must be taken when preparing the canal so the cortex is not violated or fractured. Because of these anatomic constraints, a trochanteric osteotomy is helpful in exposure and to assure the appropriate placement of the stem within the canal. Without special implants, reconstruction is virtually impossible. Custom implants for developmental dysplasia or miniature components, with 22 mm diameter heads, are available for this problem.

JUVENILE CHRONIC ARTHRITIS

Reconstruction in Juvenile Chronic Arthritis (JCA) can be challenging because of altered anatomy, previous surgeries, anatomical deficiencies including acetabuli protrusio, and physcosocial issues inherent in this patient population. Special components, which most resemble those in congenital or developmental dysplasia of the hip, are often necessary for these reconstructions. Patients with JCA frequently have brittle bone and marked soft tissue contractures.[7] It is usually necessary to release the severe soft tissue contractures to prevent intraoperative fractures, allow reconstruction the hip, and restore range of motion. Petty notes that adequate release of these tissues includes resection of the entire capsule, iliopsoas release, and sometimes gluteus maximus tendon release.[8]

Physcosocial problems are common in this patient population, and may interfere with or contraindicate surgery.[9] These patients must be closely evaluated, for they often have unrealistic expectations regarding there postoperative results. Good outcomes, however, have been noted in patients with favorable psychosocial profiles.[10,11]

PAGET'S DISEASE

Paget's disease, or osteitis deformans, affects approximately 15% of the elderly.[12] Although the pelvis is the most frequently involved site, proximal femoral involvement is not uncommon. Graham and Harris estimated that 10% of those with pagetic hips are symptomatic.[13] Total hip arthroplasty presents a unique challenge in these patients secondary to coxa vara, acetabuli protrusio, femoral bowing, sclerotic and soft bone, increased blood loss, and increased operative time.

Coxa vara, defined as a femoral neck angle $< 120°$, has been noted to occur in 16-38% of pagetic hips.[14,15,16,17] In the presence of coxa vara, there is a tendency to place the femoral component in a varus alignment (Figure 2). McDonald and Sim noted 22 of 91 components to be in varus positioning postoperatively, 10 of these in patients

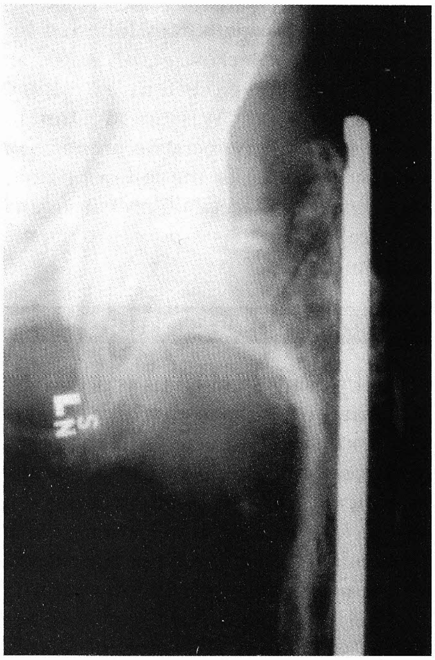

Figure 2a. AP X-ray of the left hip in a 71 year old male with Paget's disease. The patient suffered a midshaft femur fracture five years prior which was treated with an intramedulary rod. He presented with a minimally displaced femoral neck fracture with the joint preserved.

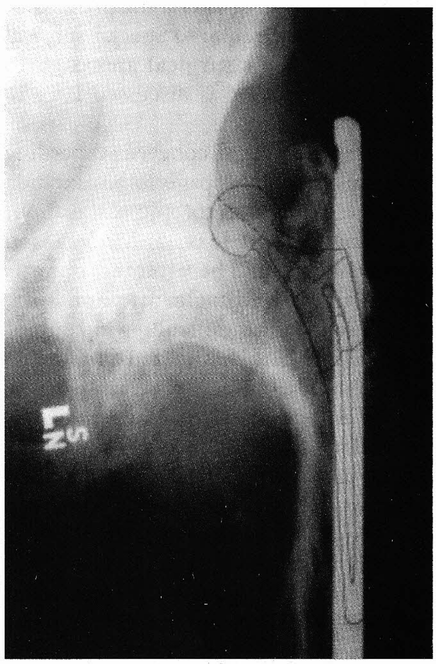

Figure 2b. This X-ray demonstrates the difficulty in placing a femoral component. Despite mild varus position of the stem, offset is not restored and the limb would be lengthened.

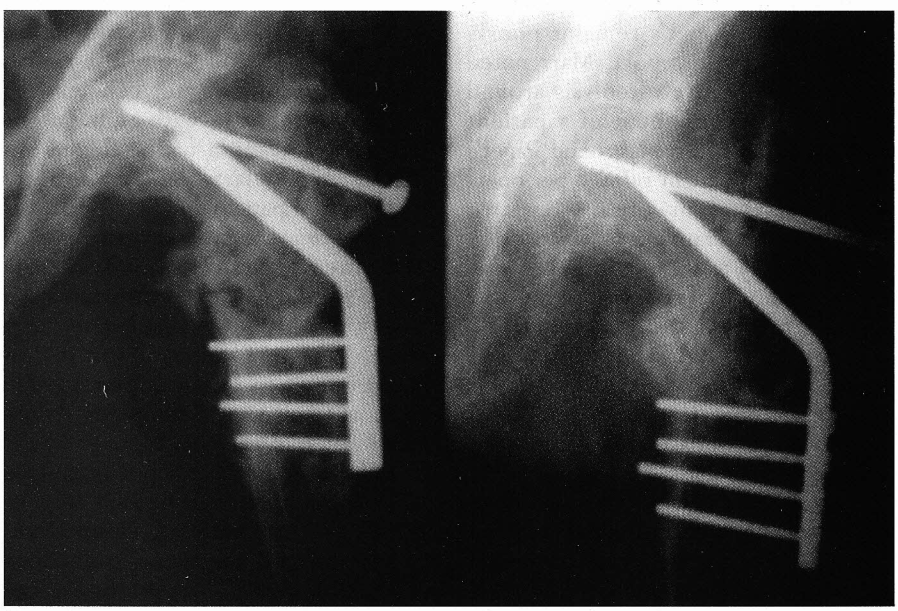

Figure 2c. AP view of the hip postoperatively and 1 year after valgus osteotomy. The patient ambulated pain free without assistive devices.

with preoperative coxa vara.[15] Merkow et. al. also noted 6 of 21 femoral components to be placed in varus, all in femurs with preoperative coxa vara. Two of these patients required revision arthroplasty for loosening of the femoral component.[16]

Protrusio acetabuli is also common in hip disease associated with Paget's, occurring in 16 - 35% of the cases.[13,14,15,16,17,18] Usually protrusio is mild, within 5 mm of Kohler's Line.[13] Merkow et. al. noted a 24% incidence of acetabuli protrusio, none of which required special surgical measures.[16] Our surgical approach to acetabuli protrusio is discussed later in this chapter.

Other technical concerns regarding arthroplasty in the pagetic hip include sclerotic bone, heterotopic ossification, increased blood loss, and increased operative time. The affected bone is noted to be both sclerotic and soft, which can lead to difficulties in component placement. Estimated blood loss has been noted to be significantly higher in hip arthroplasty for these patients, secondary to the increased vascularity of the pagetic bone.[16] Heterotopic ossification is more common in total hip arthroplasty in patients with Paget's, with an incidence as high as 65%.[14] Stauffer and Sim noted a significant decrease in post operative range of motion and a 15 point Harris Hip Score differential in postoperative patients with marked or severe heterotopic ossification versus those with minimal or no heterotopic ossification.[19] The role of perioperative calcitonin and diphosphonates in total hip arthroplasty in patients with Paget's remains poorly defined. In a case report, Marr noted rapid postoperative osteolysis around the femoral component of a patient with total hip arthroplasty and Paget's disease.[20] This patient refused perioperative treatment originally, but two months postoperatively received calcitonin therapy with and demonstrated no further osteolysis and some new bone formation. Although frequently recommended, the therapeutic effects of calcitonin and diphosphonate on blood loss, operative time, or heterotopic ossification have not been conclusively demonstrated.

Overall, the results of treatment of the pagetic hip with total hip arthroplasty are satisfactory. Roper demonstrated only marginal results in the treatment of these patients with intertrochanteric osteotomy.[21] In a 44 month follow-up on 7 patients with total hip arthroplasty for Paget's, Ha'eri noted an improvement in the Harris Hip Score from 39 preoperatively to 91 postoperatively, with complete pain relief in 6 of the 7 patients.[22] McDonald and Sim reported a good or excellent result in 74% of their patients, but demonstrated that the probability of having a revision after 10 years was greater in patients with Paget's versus those undergoing total hip arthroplasty for primary osteoarthritis.[15] In a series of total hip arthroplasties in 21 pagetic hips followed for over 5 years, Merkow et. al. noted an 85% good or excellent results.[16] Ludkowski and Wilson-McDonald noted that the preoperative presence of two out of three of the following findings; coxa vara, acetabuli protrusio, and femoral bowing, is a poor prognostic indicator.[14]

ANKYLOSING SPONDYLITIS

Ankylosing spondylitis is a chronic inflammatory disease which affects approximately one person in 2000, with a male predominance.[23] Clinically significant hip involvement has been noted in up to 42% of patients with ankylosing spondylitis.[24] Special considerations in this group of patients include analysis of other joint involvement, evaluation of comorbid factors associated with this disease, anesthetic concerns, surgical positioning difficulties, altered surgical anatomy, and postoperative heterotopic ossification and reankylosis.

Hip disease in ankylosing spondylitis is often associated with fixed flexion. This fixed flexion, combined with kyphosis of the spine, can lead to marked difficulties with ambulation. Surgical correction of the flexed hip during arthroplasty can significantly improve the patients ambulatory function.[25] Often patients may have ipsilateral knee and ankle involvement. Correction of flexion contractures the ankle (i.e. Achilles tendon lengthening) should be performed prior to hip replacement to obtain a plantegrade foot, where as knee arthroplasty should follow hip replacement.[26]

It is essential that a perioperative team approach is used in joint surgery in this group of patients. Preoperative pulmonary and anesthesia evaluations are mandatory. Because of cervical spine involvement in these patients, awake or fibrooptic intubation is usually performed, and even tracheostomy is sometimes necessary. Pulmonary function must be monitored carefully postoperatively.

Because of associated deformities, surgical positioning of these patients is often difficult, and may require special supports.[27] Surgical anatomy may be significantly altered, particularly in the ankylosed hip. In the completely fused hip, the femoral neck osteotomy may have to be done *in situ*.[26] One group of authors reported ischial and pubic fractures in a patient with altered anatomy secondary to an osteotomy that was done to far proximally. They recommended the use of guide pins and intraoperative X-rays in such cases.[28] The ankylosed hip is often associated with limb length shortening. Care to avoid comprising local neurovascular structures must be considered, as always, in correcting the length deficiency.

Heterotopic ossification and reankylsosis are major postoperative concerns. The incidence of heterotopic ossification after total hip arthroplasty in ankylosing spondylitis has been reported up to 67%.[25] Sundaram and Murray reported an overall incidence of 39%, but noted an incidence of 63.3% in patients with trochanteric osteotomy and 55% in patients with previous surgery.[29] Reankylosis of the reconstructed hip was first reported by Wilde in 1972.[30] Since that time, numerous reports of reankylosis have been noted.[25,31,32,33] Although not universally agreed upon, perioperative medical or irradiation therapy should be considered in total hip arthroplasty in patients with ankylosing spondylitis. This is particularly true in patients with previous surgeries, trochanteric osteotomy, a previous history of heterotopic ossification after surgery, or prolonged preoperative ankylosis of the effected hip.

ACETABULI PROTRUSIO

Protrusio acetabuli can be idiopathic, but more commonly is secondary to other diseases such as rheumatoid arthritis, ankylosing spondylitis, Paget's disease, or trauma.[34] It is reported that protrusio is present in as high as 20-30% of patients with rheumatoid arthritis undergoing total hip arthroplasty.[35] The approach to the challenges in these hips have been addressed by lateral placement of a standard acetabular component, special custom designed acetabular components (i.e. protrusio shells, protrusio rings, and wire mesh), and bone grafting for medial acetabular deficiencies. Restoring the anatomic position of the acetabulum is the prime objective in reconstruction of these hips (Figure 3).[36] Cases of failure when cement alone is used to fill the medial acetabular defect and lateralize the acetabulum have been reported.[34,37] The role of protrusio appliances is to redistribute the forces on the acetabulum and reinforce the medial wall. In the protrusio shell, the flanges, which rest on the acetabular rim, act to transfer the medial forces to the ilium, ischium, and pubis.[38]

Although numerous opinions exist on the management of protrusio, we follow the recommendations of Ranawat and Zahn. These authors recommend that when protrusion is less than 5 mm and the medial wall is strong, no bone graft or appliances are necessary. In protrusio greater than 5 mm with a thin but intact medial wall, bone graft is indicated but appliances are not.[39] In patients with marked deficient medial walls, our preference is to use larger, non-cemented components with acetabular rim contact as well as medial bone grafting of the acetabulum. Anatomic position of the component is accomplished by medial bone grafting. It is important, however, not to rely on the medial bone graft as the only stabilizing force of the acetabular component, but rather the rim of the acetabulum should be loaded. Many authors agree that the use of bone grafting and a protrusio appliance are most successful in reconstruction in severe protrusio acetabuli.[34,39,40,41,42]

ACETABULAR FRACTURES

Degenerative arthritis after fracture of the acetabulum or fracture dislocation of the hip is well described.[43,44,45,46,47,48] Prognosis of these patients depends on several variables, including location of fracture, fracture pattern, amount of displacement, and associated fracture of the femoral head. Rowe noted a 20% incidence of post-traumatic arthritis after central fracture dislocation of the hip.[43] Because of the significant incidence of post-traumatic hip disease, total hip arthroplasty often must be considered in these patients.

Previous operations, the presence of internal fixation devices, inadequate or poor bone quality of the acetabulum, persistent acetabular defects, and fibrous unions of the acetabular fracture complicate total hip arthroplasty in these patients.[49] Retained hardware that directly interferes with component placement must be removed (Figure 4). Anatomic placement of the acetabular cup may be more difficult, secondary to the previous trauma. Persistent or fibrous nonunions must be stabilized and bone grafted. Bone grafting also may be required in patients with markedly deficient acetabuli.

Reported results of hip reconstruction in acetabular fractures vary considerably, but overall are less satisfactory than those in primary total hip arthroplasty. In 19 patients with total hip arthroplasty for dysfunction after central fracture dislocation of the hip, Pritchett and Bortel reported excellent results, with a mean Harris Hip Score of 84 postoperatively. They found no radiologic evidence of loosening, and no revision surgeries were required. Mean follow-up, however, was limited to 34 months.[50] Boardman and Charnley also report good results with hip reconstruction in 66 patients, most of which had central or posterior fracture dislocations. Again, mean follow-up was limited to 3.5 years .[49] In series with longer reviews, the results have not been as promising.[51,52] Romness and Lewallen reported on 55 total hip arthroplasties following acetabular fractures with a mean follow-up of 7.5 years. Their incidence of femoral component loosening and revision compared favorably to the incidence in their primary hip arthroplasties. The acetabular failure rate was significantly higher, however, with an incidence of radiographic loosening of 52.9%, symptomatic loosening of 27.5%, and revision of 13.7%. The authors felt this high failure rate to be secondary to poor acetabular bone stock, and suggested that reconstruction of acetabular fractures may help provide better bone quality for later arthroplasty, even if the procedure is unsuccessful in preventing hip degenerative disease.[52] These results must be weighted against those of Helfet et al in primary open reduction and internal fixation of acetabular fractures in

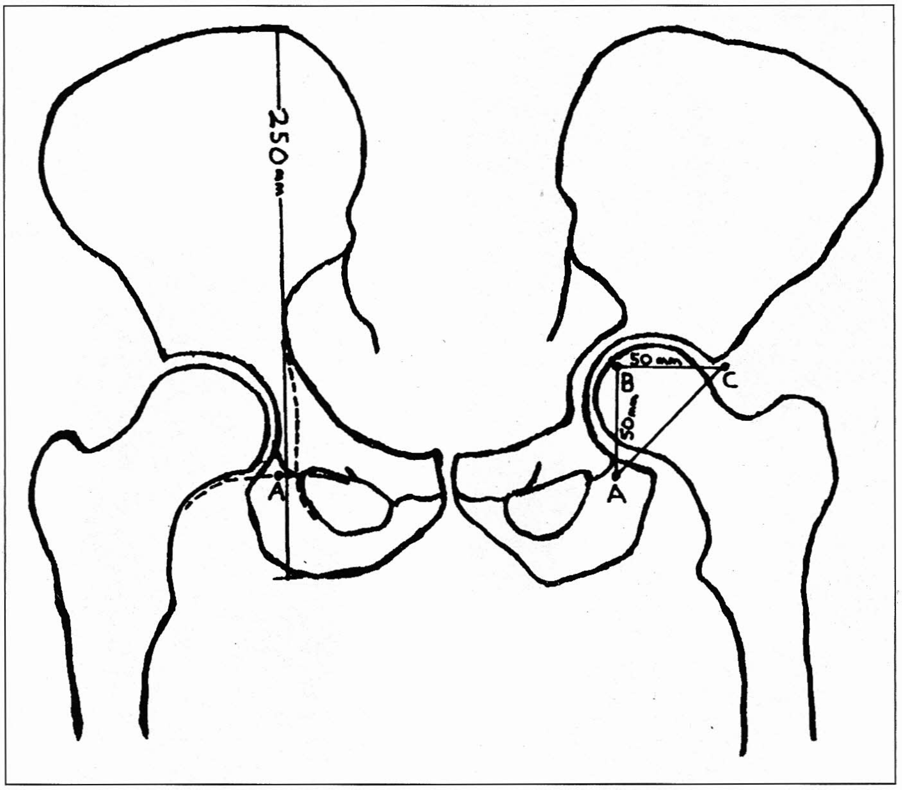

Figure 3: Diagram of the pelvis with acetabuli protrusio on the left. The height of the pelvis is measured at 250 mm. The height of the acetabulum is approximately 1/5 that of the pelvis (50 mm in this case). On the right, point "A" is determined by finding the intersection of Kohler's and Shenton's lines, and is marked 5 mm lateral to the intersection of these lines. Point "A" is marked at the same location of the left. A vertical line 1/5 the pelvic height (50 mm) is drawn from point "A" and point "B" is marked at the end of this line. A horizontal line is drawn 1/5 the pelvic height laterally from point "B" to create point "C". Points "A" and "C" are connected to complete the isosceles triangle. The isosceles triangle represents the ideal location of the reconstructed acetabulum.

patients over 60 years of age. These authors reported an average Harris Hip Score of 90 in 17 of 18 patients after at least a two year follow-up.[53] The above authors support primary fixation in most patients with significantly displaced acetabular fractures, with total hip arthroplasty reserved as a salvage procedure.

FEMORAL OSTEOTOMY AND POST-TRAUMATIC FEMORAL DEFORMITIES

Femoral osteotomy is frequently used as an initial surgical treatment in childhood hip disorders, avascular necrosis of the femoral head, traumatic hip arthritis, and rarely in osteoarthritis. Patients often note excellent relief from these procedures, albeit temporary, and further reconstructive procedures are frequently necessary. Altered proximal femoral anatomy, retained hardware, and partial or complete obliteration of the femoral canal all confront the surgeon during reconstruction of these hips.

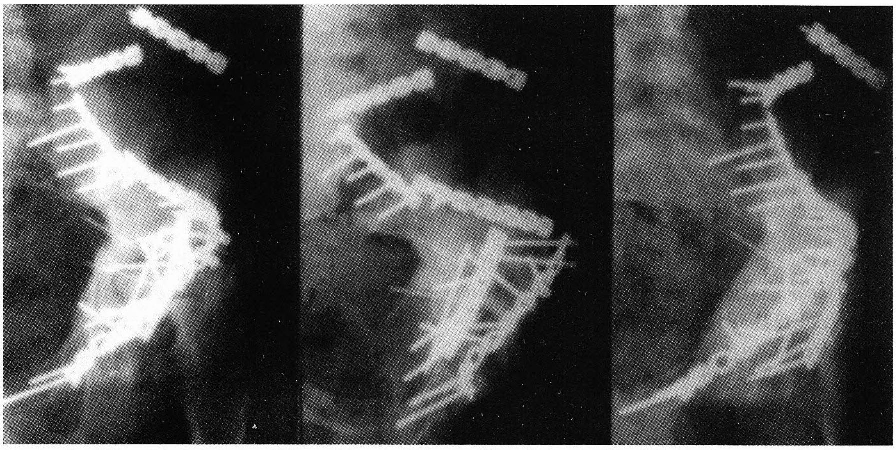

Figure 4a. AP and Judet views of the pelvis of a 39 year old male treated in 1981 with open reduction and internal fixation of a complex acetabular fracture. He presented with severe pain, stiffness, and limb shortening secondary to aseptic necrosis of his femoral head.

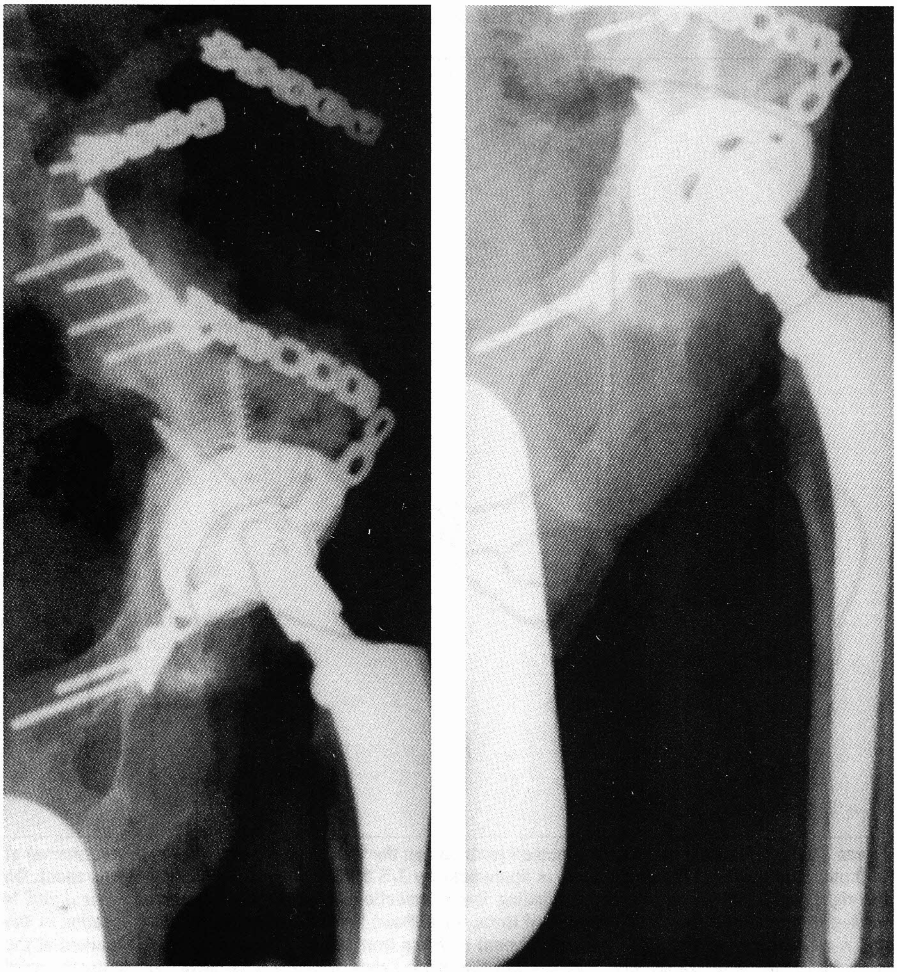

Figure 4b. AP of the left hip after total hip arthroplasty. At the time of surgery, the fracture was found to be healed, and hardware interfering with component placement was removed.

Soft tissue and bony landmarks are often altered in these patients secondary to previous operations. As in other complex reconstructions, a wide surgical exposure and possibly a trochanteric osteotomy are necessary in these cases. Internal fixation devices must be removed, and care must be taken as to avoid fracture of the cortex during hardware removal. The continuity of the intramedulary canal may be partially or completely obliterated, depending upon the degree of displacement at the time of the original osteotomy. In patients with mild displacement and a restorable femoral canal, routine surgical techniques and a standard femoral component can be used (Figure 5). In marked displacement, however, insertion of a standard prostheses can result in intraoperative femoral shaft fractures or varus placement of the femoral component.[54] The use of a custom prosthesis may be necessary in such cases.[55] Another alternative in patients with severe displacement is a corrective osteotomy, either concurrently with hip reconstruction or as a two staged procedure.

Good results have been reported for total hip arthroplasty after femoral osteotomy, particularly in patients with minimal displacement during the original procedure. Soballe et. al. compared 112 hip reconstructions in patients with previous osteotomies to 262 patients with primary total hip arthroplasty at an average of 56 months follow-up. They noted good pain relief, but found that the femoral component in the osteotomy group was more likely to be in varus ($p<0.05$). They also noted an increased risk of intraoperative fracture in patients with a previous osteotomy, which correlated with the amount of displacement of the proximal femur.[56] Benke et. al. had excellent results and concluded that femoral osteotomy did not jeopardize future total hip arthroplasty in their series of 105 hips. It was necessary, however, to use nine custom prosthesis. Very few of their patients had severe displacement.[54] The use of concurrent osteotomy during hip replacement has been described, particularly for patients with marked displacement at the time of the original osteotomy. Decoster et al described the use of a biplanar wedge osteotomy at the level of the lesser trochanter to correct the previous surgical deformity in three patients. There results were satisfactory at 3 years follow-up.[53] In a series with concurrent osteotomy during hip reconstruction in 31 patients, Papagelopoulos et. al. noted several complications, including 7 intraoperative fractures, 4 cases of aseptic loosening, 4 osteotomy nonunions, and a 26% reoperation rate, including 6 revisions.[57] Because of the high complication rate associated with simultaneous hip reconstruction and osteotomy, our approach has been to cement the femoral component without osteotomy when possible. If this is not feasible, it may be wisest, based on the increased complication rate, to reconstruct these hips in two stages. The first stage reestablishes the femoral canal, followed by a second stage total hip arthroplasty after the osteotomy has healed.

ARTHRODESIS

Hip arthrodesis is performed surgically for trauma or degenerative disease, or occurs spontaneously secondary to tuberculosis, sepsis, or ankylosing spondylitis. Patients with hip arthrodesis often present with complaints of effected or contralateral hip pain, back pain, and ipsilateral knee pain. Sponseller et. al., in a 38 year follow-up in 53 patients with surgically arthrodesed hips, noted a 57% incidence of back pain, and a 45% incidence of ipsilateral knee pain.[58] Total hip replacement in these individuals often can alleviate some of these symptoms. Considerations in this group of patients include altered anatomy, function of abductor musculature, presence of retained hardware, and limb length discrepancy.

In both spontaneously and surgically arthrodesed hips, surgical anatomy may be significantly altered. Trochanteric

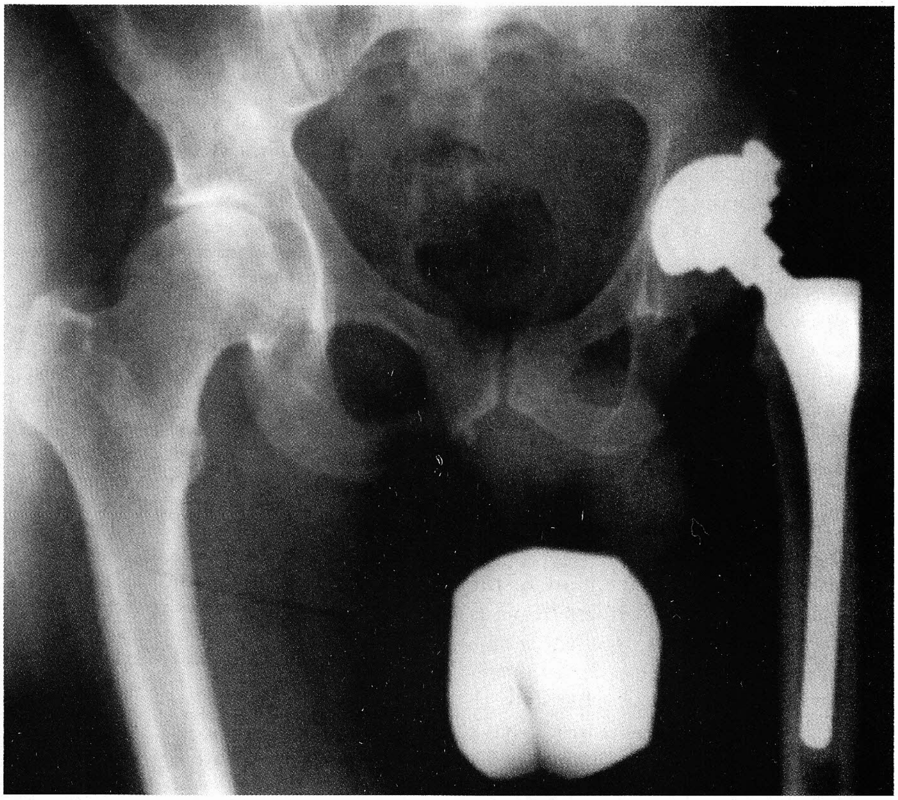

Figure 5a. AP X-ray of the pelvis of a 42 year old male with the history of a left hip fracture status-post pinning and subsequent osteotomy as an adolescent. The patient underwent left total hip arthroplasty in 1990, and presented with clinical and radiological evidence of loosening of his cementless components.

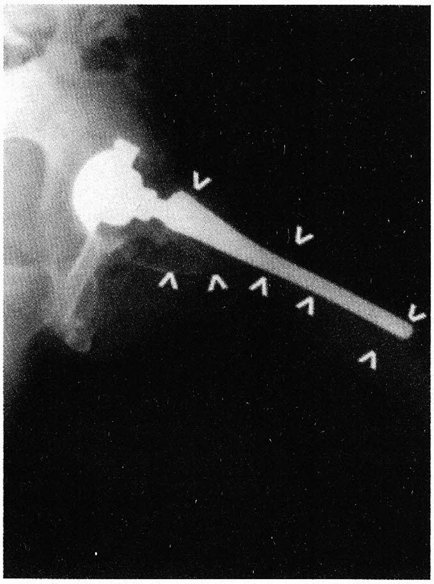

Figure 5b. Lateral pre-operative X-ray of the left hip reveals an angulatory deformity (arrows) of the proximal femur which prevented ideal positioning of the cementless stem.

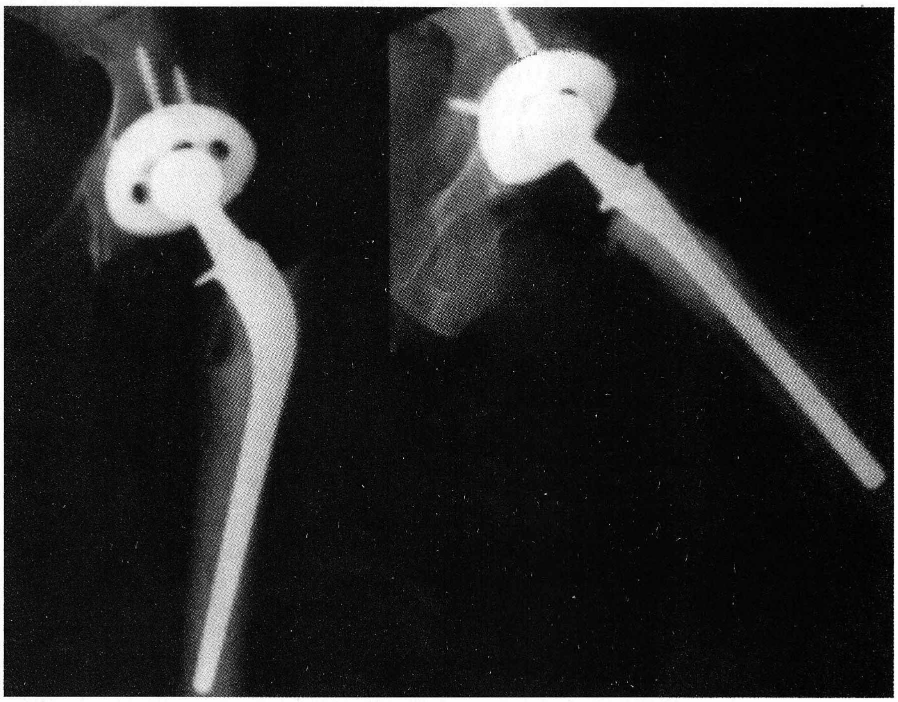

Figure 5c. At the time of his repair, we elected to revise this to a cemented femoral component.

osteotomy is usually necessary, and if the greater trochanter is poorly developed, cutting into the femoral neck may be necessary to obtain sufficient strength for wire fixation.[59] Internal fixation devices are often present in the surgically arthrodesed hip, and these must be removed. Strength of the gluteal musculature postoperatively depends on preoperative function, level of compromise from previous surgeries, length of immobilization after arthrodesis, and reconstruction of the abductor mechanisms of the hip.[60] Kilgus et al. noted function returned surprisingly well, but slowly, for up to 2 to 5 years.[61] Brewster et. al. noted some recovery in gluteal function postoperatively, and good results even in the absence of gluteal musculature if the patient was willing to use a cane.[62] Shortening of the effected limb is usually present in this group of patients, particularly in those with an infectious etiology. Additional limb length can be obtained with increased neck length, but care must be taken to avoid stretching the neurovascular structures.

Results of hip replacement in the arthrodesed hip have been less than satisfactory. Strathy noted excellent results in patients with spontaneous arthrodesis, but poorer results in patients with surgical arthrodesis ($p<0.05$).[63] Back pain and ipsilateral knee pain can be relieved with joint replacement in the arthrodesed hip, particularly in those with hips ankylosed in an unacceptable position.[64] Lubahn et al reviewed conversion of an arthrodesed hip to total hip arthroplasty and found that 12 of 13 patients with back pain, all patients with ipsilateral knee pain, and 7 of 10 patients with contralateral knee pain noted relief.[65]

CONCLUSION

In this chapter we have described several diseases with unique hip problems resulting in disabling arthritis. In contrast to patients with primary degenerative arthritis, these patients are younger, more active, and at times have unrealistic expectations of the surgery. If the surgeon provides appropriate preoperative care and is careful in his patient selection, good results can be achieved in these challenging reconstructive arthroplasties. STI

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