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SECTION II
ORIGINAL ARTICLES

Treatment of the Late Sequelae of Septic Arthritis of the Hip

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Numerous salvage procedures have been proposed for the treatment of late sequelae of septic arthritis of the hip. Despite this, there are no reports in the literature discussing treatment with simultaneous hip reconstruction and femoral lengthening using the hybrid advanced Ilizarov method. The authors reviewed their experience with this technique, and present 15 patients treated between 1982 and 1997. The average age of the patients was 21.1 years and the average limb length discrepancy was 6.5 cm. All the hips were classified according to the classification of Choi et al. The time the external fixator was worn was 225.5 days and the average followup was 108 months. The results were classified based on pain relief, residual deformity, range of motion, Trendelenburg sign, and limb length discrepancy. Ten patients had a good or excellent result, three patients had a fair result, and only two patients had a poor result. Major complications included a common peroneal nerve palsy in one patient, loss of angulation of the proximal femoral osteotomy in two patients, and a mild knee subluxation in three patients all of whom responded to treatment. At the latest followup, 13 patients were satisfied with the treatment, all had returned to their previous occupations, and no patient had a total hip arthroplasty.

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Acute childhood septic arthritis involves the hip in 23% to 75% of patients and the pathogenesis and treatment have been reported previously.[10,19,21] The long-term effects differ depending on the age of the patient, the infecting organism, and the timing and adequacy of surgical and pharmacologic treatment. In patients with severe sequelae, a destroyed and deformed femoral head can result in subluxation

or dislocation of the hip often associated with a leg length discrepancy caused by the dislocation and by a septic growth arrest.[3,12,13,23]

Many primary and secondary treatments have been proposed for the late sequelae of septic arthritis of the hip including simple observation, contralateral epiphysiodesis, hip arthrodesis, trochanteric advancement, pelvic osteotomy, acetabuloplasty, femoral osteotomy, femoral head and neck reconstruction with a free vascularized iliac bone graft, and total hip arthroplasty.[4,6,12,16,17,19,20] An angulated subtrochanteric osteotomy of the femur to support the acetabulum and stabilize the hip was proposed by Froelich[9] and Bayer.[1] More recently, Cheng and Lam[7] suggested femoral lengthening for treatment of the most severe sequelae of neonatal septic arthritis of the hip with a limb length discrepancy greater than 5 cm. However, none of these procedures was able to treat the hip instability and leg length discrepancy concurrently.

Ilizarov[14] combined a proximal femoral osteotomy and distal limb lengthening using a circular external fixator. He proposed an angulated proximal osteotomy of the femur to support the pelvis and achieve dynamic stabilization of the hip by retensioning the trochanteric muscles. In addition, he did a distal femoral osteotomy to lengthen the femur and correct the mechanical axis. This procedure allowed simultaneous treatment of the hip instability and limb length discrepancy thereby avoiding multiple operations.

The hybrid advanced fixator is a modification of the classic Ilizarov technique replacing Kirschner (K) wires with half-pins and full rings with arches.[5,11] The purpose of the current study was to present the results of simultaneous treatment of limb discrepancy and deformity together with hip instability in severe sequelae of septic arthritis of the hip using the hybrid advanced Ilizarov method.

MATERIALS AND METHODS

Between 1982 and 1997, 36 patients with a history of septic arthritis of the hip in childhood were referred to one of the authors' institutions (Fig 1). Fifteen of the 36 patients were treated with a simultaneous hip reconstruction and leg lengthening using the hybrid advanced Ilizarov method. These 15 patients are included in this study. Tables 1 and 2 show patient details including age and gender, previous operations, hip deformity, amount of shortening, associated treatment, and type of pelvic support planned. The average age of these patients was 21.1 years (range, 14–36 years). There were 10 females and five males. Four patients had previous surgery before being referred to the authors. All patients were in general good health. A residual deformity of the hip and femur was seen in all patients. These deformities were classified according to Choi et al.[8]

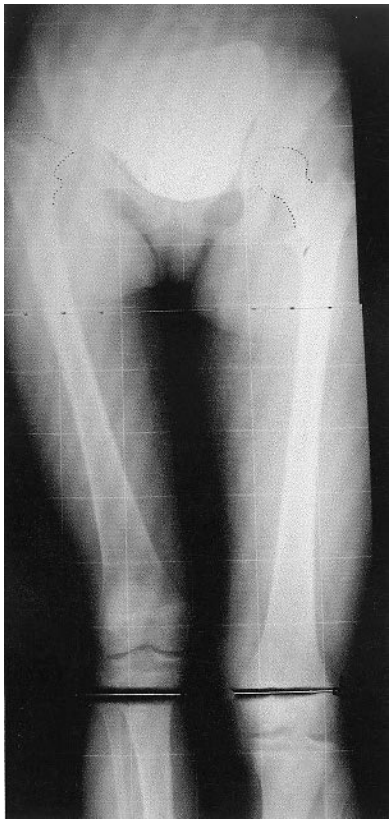

Fig 1. An AP radiograph of the lower limbs shows the late sequelae of septic arthritis of the hip, the femoral head deformity is associated with limb length discrepancy.

The average amount of femoral shortening was 6.1 cm (range, 3–11 cm) and the average limb length discrepancy was 6.5 cm. All patients had a positive

TABLE 1. Preoperative Data of the 15 Patients

Patient Number	Age/Gender	Previous Operations	Type of Deformity (Choi)	Amount of Shortening	Femoral Deformity
1	14 years/Female	Leg lengthening Pelvic osteotomy Femoral lengthening Leg lengthening	IVB	4 cm	None
2	32 years/Female	Resection of femoral head	IVB	6 cm	None
3	14 years/Male	None	IVB	8.5 cm	None
4	36 years/Male	None	IIIA	4.5 cm	None
5	15 years/Male	Unknown	IIIA	6 cm	None
6	17 years/Female	None	IVB	11 cm	None
7	18 years/Female	Unknown	IVA	6 cm	None
8	32 years/Female	None	IVA	5.5 cm	None
9	18 years/Female	None	IIA	6.5 cm	None
10	15 years/Male	Pelvic osteotomy Proximal femoral osteotomy	IIIA	7 cm	15° varus
11	16 years/Female	None	IVA	5 cm	None
12	16 years/Male	None	IIA	6 cm	None
13	25 years/Female	Unknown	IVA	6.5 cm	None
14	14 years/Female	None	IIB	3 cm	40° external rotation
15	23 years/Female	Pelvic osteotomy	IVA	6 cm	None

Trendelenburg sign and hip pain exacerbated by ambulation. No patient needed a walking aid. Eight patients had additional surgical procedures on the affected limb. A tibial frame was added in four patients to achieve additional lengthening, in two patients to treat knee subluxation, and in one patient to correct a preoperative equinus deformity. In addition, an Achilles tendon lengthening was combined with the tibial frame in two patients. A calcaneal procedure to correct a planovalgus foot was combined with the hip reconstruction and femoral lengthening in a final patient.

TABLE 2. Preoperative Data and Procedural Details of the 15 Patients

Patient Number	Associated Treatment	Pain	Trendelenburg Sign	Type of Support
1	Tibial frame	Yes	Positive	Subacetabular
2		Yes	Positive	Acetabular
3	Ipsilateral calcaneal procedure	Yes	Positive	Acetabular
4	Achilles tendon lengthening and tibial frame	Yes	Positive	Pubic ramus
5	Proximal tibial lengthening	Yes	Positive	Acetabular
6		Yes	Positive	Acetabular
7	Tibial frame	Yes	Positive	Acetabular
8		Yes	Positive	Acetabular
9		Yes	Positive	Subacetabular
10	Distal tibial lengthening	Yes	Positive	Acetabular
11	Knee extension brace	Yes	Positive	Acetabular
12	Distal tibial lengthening	Yes	Positive	Subacetabular
13		Yes	Positive	Subacetabular
14	Achilles tendon lengthening and distal tibial lengthening	Yes	Positive	Acetabular
15		Yes	Positive	Subacetabular

Clinical evaluation of the patients was done at the latest review by two surgeons. Neither of these surgeons was involved in the surgical procedures. The results were classified based on pain relief during walking or laying down, residual deformity, hip and knee range of motion (ROM), Trendelenburg sign, and limb length discrepancy. An excellent result was one in which the patient had no pain, no residual deformity, a postoperative ROM equal to or better than before surgery, no joint instability, and no limb length discrepancy. Patients with a good result had no pain or joint instability but had a persistent limb length discrepancy less than 2.5 cm, deformity less than 10°, or reduced hip and/or knee ROM less than 10°. Patients with fair results had a leg length discrepancy greater than 2.5 cm, deformity greater than 10°, decreased hip and/or knee ROM between 10° and 20°, a positive Trendelenburg sign, or mild pain. Patients with a limb length discrepancy greater than 5 cm, deformity greater than 10°, loss of hip and/or knee ROM greater than 20°, or continuous pain were classified as having a poor result. The patient was considered to be satisfied with the outcome of the treatment if on questioning he or she had returned to employment and would have had the same procedure again. Furthermore during the latest review, symptoms of osteoarthritis were scored by a Normalized Likert-scaled Western Ontario-McMaster University osteoarthritis index.[2]

Progressive bone fusion and lower limb alignment were evaluated on serial radiographs. Pin site infections were identified on clinical examination and divided into Grade 1, soft tissue inflammation; Grade 2, soft tissue infection; and Grade 3, bone infection according to the classification of Paley.[18] Early partial weightbearing was permitted a few days after discharge from the hospital and physiotherapy was begun the day after surgery to regain hip and knee motion. Full weightbearing was allowed at the end of the lengthening and the frame was removed when the radiographs showed cortical bone bridging on at least two projections at both osteotomy sites.

Surgical Technique

Preoperative planning involved anteroposterior (AP) radiographs of the pelvis and full length AP and lateral radiographs of the lower limbs obtained with the patient standing. Using the AP radiograph of the pelvis with the involved limb in maximum adduction the osteotomy level was identified. The AP radiographs of the pelvis also were used to determine the optimal position for femoral support on the pelvis (acetabular, subacetabular, or superior pubic ramus). The full length AP and lateral radiographs of the lower limbs obtained with the patient standing were used to assess axial deviation and limb length discrepancy.

Under general anesthesia and after administration of parental antibiotics, the patient was placed supine on a fracture table. The involved leg was draped free with a support under the knee providing circumferential access to the entire lower limb.

A proximal femoral osteotomy was done first. A 5- or 6-mm half-pin was inserted laterally just distal to the tip of the great trochanter and directed medially to exit the opposite cortex just below the lesser trochanter. The exact angle and the level of this half-pin was determined by the radiographs obtained preoperatively and was based on the amount of angulation at the osteotomy site needed to obtain pelvic support. A second half-pin then was inserted 15 cm distal to the first half-pin and angled 15° and 20° caudal to a perpendicular line with the femoral shaft to achieve an overdisplacement at the osteotomy site, which reduces the risk of loss of correction caused by bone remodeling. Finally, a smooth 1.8-mm K wire was inserted into the soft tissue laterally down to the bone at the approximate level of the osteotomy. An intraoperative radiograph confirmed the proper orientation and placement of both half-pins and the correct level of the osteotomy (Fig 2). A 90°-arch was attached to each of these half-pins and a second half-pin was added to each ring. A 3-cm incision was made laterally at the osteotomy site and deepened to the lateral cortex of the femur. A transverse osteotomy then was done. The correct angulation of the proximal femur was accomplished through the osteotomy site by bringing the arches parallel. The arches then are connected using threaded rods. Additional tensioning of the gluteal muscles was achieved by ensuring mild anterior angulation at the osteotomy site.

The distal construct was preassembled and consists of two connected rings, which were passed over the leg. The distal ring was placed at the level of the superior pole of the patella and attached to the femur with a transepicondylar 1.8-mm tensioned K wire and two half-pins passed obliquely in an anterolateral and anteromedial direction. The proximal ring was fixed using two half-pins inserted at two different levels. These two rings must be parallel to the joint line. They were connected to each other by two medial hinges centered on the distal femoral osteotomy site. The distal construct

Fig 2. An intraoperative AP radiograph of the hip confirms the proper orientation and placement of the proximal half-pins and the correct level of the proximal femoral support osteotomy.

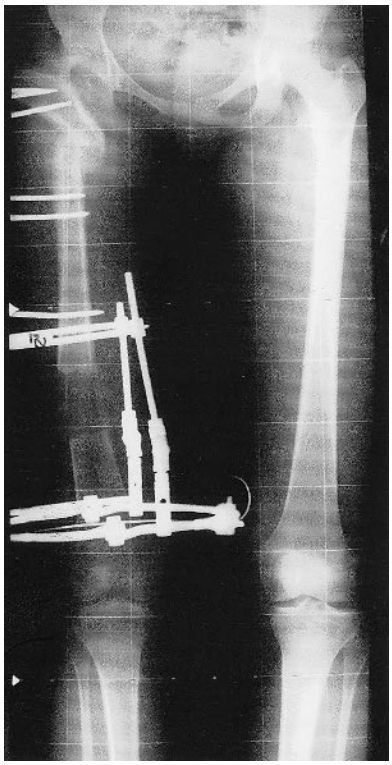

Fig 3. A full length AP radiograph of the lower limbs obtained with the patient standing shows the proximal femoral support osteotomy and distal lengthening in progressive correction to a gradual varus using the medial hinges.

was connected to the hip construct with threaded rods. A transverse distal osteotomy then was done percutaneously at the junction between the metaphysis and the diaphysis of the distal femur with multiple drillings temporarily disconnecting the distal two femoral rings.

After a latency period of 5 to 7 days, gradual lengthening at the distal osteotomy site was done at a rate of 0.25 mm four times a day (Fig 2). The initial lengthening was along the anatomic axis of the femur and as a consequence, a mild valgus deformity occurred. When the patient ambulated, this forced the extremity that was operated on into adduction and additionally stabilized the proximal femur by bringing it in contact with the pelvis. Near the end of lengthening, gradual varus angulation of the distal osteotomy was done using the distal hinges to obtain a physiologic mechanical axis as determined from the previous radiographs (Fig 3).

RESULTS

The average followup from frame removal was 108 months (range, 38–178 months). A stable hip reconstruction and completion of leg lengthening was achieved after a mean external fixation time of 225.5 days (range, 135–370 days). The average amount of femoral lengthening was 5 cm (range, 1.5–10 cm). The leg lengths were equalized in 11 patients and within 2 cm of the other limb in four patients (Table 3). In eight patients, the postoperative ROMs of the hip and knee were unchanged or improved compared with before surgery. All the hips were stable without radiographic signs of subluxation (Fig 4). The postoperative Trendelenburg sign was negative in nine hips. Ten patients had good or

TABLE 3. External Fixation Time, Followup, and Results

Patient Number	External Fixation Time (Days)	Followup (Months)	Residual Leg Length Discrepancy	Postoperative Deformity	Hip Range of Motion	Knee Range of Motion
1	135	42	None	None	Improved	Worse (< 10°)
2	235	156	None	None	Worse (< 20°)	Same
3	265	87	None	None	Same	Same
4	270	84	None	None	Improved	Same
5	160	91	None	None	Improved	Same
6	370	178	1 cm	10° varus	Worse (20°)	Same
7	250	149	None	None	Improved	Worse (< 10°)
8	212	156	None	None	Worse (< 10°)	Same
9	340	163	None	None	Improved	Same
10	190	78	1 cm	None	Improved	Same
11	180	77	None	None	Improved	Same
12	195	38	2 cm	15° femoral internal rotation and 15° valgus	Same	Worse (< 20°)
13	212	155	None	None	Improved	Improved
14	154	79	0.5 cm	20° femoral external rotation	Same	Same
15	215	89	None	None	Worse (< 20°)	Same

excellent results, three had fair results, and two had poor results (Table 4). The average Normalized Likert-scored Western Ontario-McMaster University osteoarthritis index was 1.94 (range, 0.44–5.76).

All patients had superficial pin-site infections (Grades 1 and 2). These infections were more common in the proximal femoral pin sites and occurred with increasing frequency the longer the patient's extremity was in the frame. Most of these infections responded to local pin-site care and oral antibiotics. However, three patients were admitted to the hospital for proximal half-pin replacement because of recalcitrant infections.

During femoral lengthening, three patients experienced a mild knee subluxation but all responded to treatment. In one patient, this occurred late in the lengthening phase, and as a result was treated with a knee extension brace connected to the femoral frame. In the other two patients, knee subluxation occurred earlier, just at the beginning of the lengthening and was treated by frame extension to the tibia. Only one of these patients experienced 10° loss of knee motion.

In two patients, a progressive loss of the angulation of the proximal osteotomy site occurred with loss of support and a persistent Trendelenburg gait. One of these patients had a revision procedure for correction of the angulation and a residual leg length discrepancy of 2 cm. In one patient, complete correction of a 15° varus femoral deformity was achieved, but only partial correction of a femoral external rotation deformity was achieved. A common peroneal nerve palsy occurred in one patient, which was associated with a 10° varus femoral deformity. This patient refused additional treatment. A final patient had an undisplaced femoral fracture at the distal lengthening site a few days after frame removal. This patient's extremity was placed in a long leg spica cast. The fracture healed after 30 days; the patient did not have any hip or knee stiffness.

All the frames were removed in the outpatient clinic without anesthesia. Ten patients used a hinged knee brace for 30 days after frame removal. At the latest followup, all the patients had returned to their previous occupations. Thirteen patients were considered satisfied with the results of the operation and would

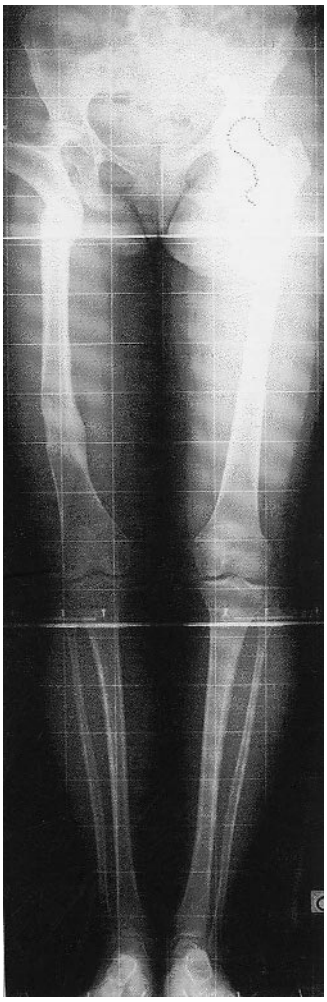

Fig 4. A full length AP radiograph of the lower limbs was obtained with the patient standing at the end of the treatment.

have the same procedure again. Two patients were considered not satisfied because they would not have the same procedure again.

DISCUSSION

The late sequelae of septic arthritis of the hip in childhood vary in severity. In severe cases, two of the major clinical problems are hip instability and limb shortening.[2,10,21,23] A patient with a floating hip with a Trendelenburg gait is difficult to treat and some authors advocate treatment of the hip as a priority.[6–8] Many treatments have been suggested to deal with the hip instability including femoral or pelvic osteotomy, hip reconstruction, arthrodesis, and total hip arthroplasty.[1,4,9,12,13,16,17,19,20] Successful femoral lengthening without additional hip dislocation has been reported.[7] However, some patients had an early proximal femoral reconstruction with a vascularized graft.[6,7]

The surgical technique suggested by Ilizarov is unique because it simultaneously addresses the hip instability and the limb length discrepancy in one operation.[14] By combining an angular proximal femoral osteotomy and a distal femoral lengthening, both problems can be treated concurrently avoiding the need for multiple surgical procedures. The proximal femoral osteotomy places the proximal femur in maximum adduction in relation to the pelvis. The effect of this osteotomy is to place the femur under the pelvis and as a result to support the pelvis. In addition, the gluteal muscles are stretched maximally and the pelvis is stabilized during the single limb stance phase of gait. This results in resolution of the Trendelenburg gait and sign. A second osteotomy in the distal metaphyseal area of the femur is used to lengthen the limb by distraction osteogenesis and restore the normal mechanical axis. After the proximal osteotomy, the distal ⅔ of the femur is placed in relative abduction. A gradual varus angulation at the distal femoral osteotomy returns the final mechanical axis to normal.

The hip reconstruction and leg lengthening technique described by Ilizarov has numerous advantages.[14] In particular, it allows treatment of two of the major late sequelae of septic arthritis of the hip with one operation. The aesthetic aspects of this reconstruction also are satisfying. The surgery involves only small scars. Angulation of the proximal femur is well-masked by the soft tissue bulk of the proximal thigh and displaces the large soft tissue mass of the proximal thigh laterally, which provides a more normal appearance to the limb. The functional abduction obtained on the surgically treated side aids perineal hygiene and sexual function in women. The Ilizarov

TABLE 4. Complications, Clinical Outcomes, and Patient Satisfaction

Patient Number	Complications	Trendelenburg Sign	Pain	Patient Satisfaction	Clinical Result	Normalised WOMAC score
1	Knee subluxation	None	None	Satisfied	Good	1.98
2	None	Reduced	None	Unsatisfied	Fair	4.26
3	Progressive loss of support	Reduced	None	Satisfied	Good	0.44
4	Pin substitution	None	None	Satisfied	Excellent	0.58
5	None	None	None	Satisfied	Excellent	0.44
6	Common peroneal palsy Pin substitution	Reduced	None	Satisfied	Poor	3.52
7	Knee subluxation	None	None	Satisfied	Good	1.69
8	None	None	None	Satisfied	Good	1.69
9	Pin substitution	Reduced	None	Satisfied	Good	1.98
10	None	None	None	Satisfied	Excellent	0.44
11	Knee subluxation	None	None	Satisfied	Good	0.44
12	Progressive loss of support	Reduced	Mild	Satisfied	Poor	3.63
13	Distal regenerate fracture	Reduced	None	Satisfied	Good	0.58
14	Foot external rotation	None	Mild	Satisfied	Fair	1.69
15	None	None	None	Unsatisfied	Fair	5.76

WOMAC = Western Ontario-McMaster University osteoarthritis index

fixator can be used independent of the status of the surrounding soft tissues because application of the frame involves minimal disruption to the local blood supply. It is a relatively safe technique in the presence of previous infection. The frame provides the opportunity to modify alignment during treatment and allows, by application of distraction and compression forces, a progressive mechanical stimulus for bone formation. Finally, using a hybrid advanced construct immediate and full ROM of the hip and the knee is possible.[5,11]

Disadvantages of this technique include the cost and labor intensive nature of the treatment. However, the treatment of patients with these complex, long-standing problems is demanding on resources irrespective of the treatment modality chosen. Hip reconstruction and leg lengthening with an Ilizarov fixator can be demanding technically and involves a lengthy period wearing the frame. However, for many patients the time weaning the fixator is relatively short when compared with the time already spent coping with the disability. The Ilizarov fixator can cause some patient inconvenience and discomfort especially when applied to the proximal thigh, but using the hybrid advanced technique, this problem can be minimized.

A subsequent total hip arthroplasty would be much more difficult after this hip reconstruction and leg lengthening procedure. The altered anatomy of the proximal femur after this operation would significantly increase the difficulty in doing a total hip arthroplasty. However, a total hip arthroplasty in these young patients is a challenging problem especially with previous septic arthritis and the inevitable revision procedures may be equally difficult.

Using a hybrid advanced Ilizarov fixator and distraction osteogenesis, simultaneous hip reconstruction and leg lengthening was achieved in all 15 patients. Normal lower limb length was restored in 11 patients, with a residual limb length discrepancy of 2 cm or less in the other four patients. The frame used, substituting arches for rings and reducing the number of wires, contributed to the patient's level of comfort. None of the patients described any difficulties with the frame and 10 good or excellent results were achieved. Thirteen patients indicated that they would have the procedure again.

Eight patients had improved or unchanged hip and knee ROM at the end of treatment.

Two patients were not satisfied with the outcome. Both wanted significant improvement in hip motion. When these patients were referred to the authors, they had stiff hips because of previous surgeries. However, in this procedure, the priority was to stabilize a floating hip with a significant leg length discrepancy and not to regain full ROM of the hip. The literature supports this emphasis on correcting the hip instability showing joint ROM is not an important determinant for a successful outcome in a joint that already is compromised.[6,7]

Despite the majority of patients having a complex hip deformity according to the classification of Choi et al,[8] nine patients had significant improvement in lower limb function with resolution of Trendelenburg sign and gait postoperatively. Although two patients had a poor result based on the authors' clinical criteria, both stated they would have the same procedure again and refused corrective surgery. The first patient had a common peroneal nerve palsy, 10° residual varus angulation of the femur, and a stiffer hip. The second patient, a 16-year-old boy had progressive loss of angulation at the proximal femoral osteotomy and consequent loss of pelvic support. As a result, he had persistent mild Trendelenburg gait and moderate pain. This problem also was seen to a lesser degree in a second patient and probably reflects progressive bone remodeling of an inadequate initial angular correction.

Numerous pin-site infections occurred during treatment, the majority of which were superficial and responded to local pin-site care and antibiotics. Although no patient had hip subluxation or dislocation develop during treatment, three patients had mild knee subluxation. This complication is well-recognized in the literature; careful evaluation during lengthening and intensive physiotherapy to maintain knee extension is recommended.[14,15,18,22] All three patients responded to treatment.

Even though the results of the current study are encouraging, a longer followup of patients having this technique is needed. This especially is true in view of the significantly increased difficulty the proximal femoral osteotomy presents for subsequent total hip arthroplasty. The authors think hip reconstruction and femoral lengthening by the Ilizarov method is a viable salvage procedure for the late sequelae of septic arthritis of the hip particularly in young patients.

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