Original Article

Nonunion of greater trochanter following total hip arthroplasty: Treated by an articulated hook plate and bone grafting

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Abstract

Background: Trochanteric osteotomy still has an important role in hip arthroplasty in cases of (1) preexisting developmental hip dysplasia with superior subluxation, (2) revision arthroplasty, specifically with acetabular component revision in the face of well-fixed femoral component, and (3) recurrent dislocation without component loosening or malalignment, in treatment of complicated trochanteric fixation in osteoporotic bone and nonunions may be difficult. This study reports the clinical outcomes of trochanteric fixation following total hip arthroplasty (THA) utilizing a hook plate construct in a cohort of ten patients.

Materials and Methods: The Arbeitsgemeinschaft für Osteosynthesefragen (AO) articulated hook plate was used in nine cases of established approach related nonunion following THA and in one case of osteopenic bone during primary THA. All ten patients returned for interviews and clinical examination. The average time for clinical followup was 35 months (range 5–48 months). The mean age of the study cohort was 65 years (range 56–74 years). Time to union and incidence of postoperative complications were assessed.

Results: Union occurred in all ten cases at an average of 3.3 months postoperatively. One patient developed symptomatic trochanteric bursitis and required plate removal. Another patient developed a superficial infection which was successfully treated with local wound debridement and antibiotics. A third patient developed a symptomatic neuroma at the site of the iliac crest bone harvest and was successfully treated with excision of the neuroma. No catastrophic implant failures occurred.

Conclusions: The articulated design of the plate allows for ease in application and functional construct stability. The articulated hook plate is an option for fixation of osteopenic bone fragments and established nonunions of the greater trochanter.

Key words: Total hip arthroplasty, trochanter, fixation, fracture, hook plate
MeSH terms: Hip fractures, arthroplasty, replacement, hip, bone plates

Introduction

Greater blood loss[1,2] and prolonged operative duration[3-5] have been reported in patients undergoing hip arthroplasty via a transtrochanteric approach. Furthermore, trochanteric nonunion rates, ranging from 5% to 17%,[6,7] have discouraged surgeons from using the transtrochanteric approach in routine primary arthroplasty. However, trochanteric osteotomy still has an important role in hip arthroplasty in cases of (1) preexisting developmental hip dysplasia with superior subluxation, (2) revision arthroplasty, specifically with acetabular component revision in the face of well-fixed femoral component, and (3) recurrent dislocation without component loosening or malalignment,[8] in which the trochanter can be advanced for abductor tightening.

Failure of the trochanter to unite may be attributed to the strong anterior to posterior shearing forces which are poorly neutralized in a uniplanar fixation of a trochanteric

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osteotomy. A chevron biplanar osteotomy has been described by several authors.[9,10] Berry and Müller published the technique of biplanar osteotomy in detail and reviewed their results in cases of primary and revision surgery.[11] In 53 primary hip arthroplasties, the trochanteric union rate was 98%, whereas in 74 revision cases, union occurred in 97% of the osteotomies. One must be reminded that not all nonunions are symptomatic or disabling. Stable nondisplaced fibrous nonunions will often be diagnosed on the radiographs of asymptomatic patients. However, abductor weakness is well correlated with displacement of the nonunion beyond 2–3 cm.[6,7]

Trochanteric nonunion remains a challenging problem. In revision surgery, it is not uncommon that a displaced poorly vascularized trochanteric bony shell is present. In our experience, a monoblock hook plate construct is excellent for difficult trochanteric fixation. Distally, the plate is identical to a broad 4.5 mm Arbeitsgemeinschaft für Osteosynthesefragen (AO) dynamic compression plate, and controlled compression across the 4 nonunion can be readily achieved. Improved construct modifications have resulted in a modular, articulated design (Synthes, Chur, Switzerland). This configuration allows disassembly and removal through a small incision with minimal trauma to the soft tissues and abductor mass. This study reports the clinical outcomes of trochanteric hook plate fixation in a cohort of ten patients.

Materials and Methods

The hook plate was utilized for fixation of a trochanteric osteotomy in ten patients over an 18-year period. The mean age of the study cohort was 65 years (range 56–74 years). Nine patients were female and one patient was male. Nine cases had established, symptomatic nonunions presented at a mean 34 months (range 8–77 months) following total hip arthroplasty (THA). The symptoms were pain with ambulation and a moderate to severe limp. The remaining case was in THA patient with severe osteoporosis following failed internal fixation of an intertrochanteric hip fracture. There were two cases with nondisplaced trochanteric nonunions, three cases with mild displacement between 1 and 2 cm, two cases with moderate displacement between 2 and 3 cm, and two cases with severe displacement beyond 3 cm. In nine patients, the trochanteric bone stock was graded according to the system of Scher and Jakim.[12] Six patients were graded as fair, whereas the remaining, three were rated poor. Seven of ten operations were performed exclusively for trochanteric fixation. The articulated hook plate was used at the time of revision hip arthroplasty in two patients [Table 1].

Operative procedure

The patient is positioned supine on the operating table. A transtrochanteric approach with the patient in the lateral decubitus position can be done as well according to the preference of the surgeon. A straight lateral incision is placed equidistant between the anterior and posterior margins of the proximal femur and greater trochanter. The interval between the tensor fascia latae and the gluteus maximus is developed proximally, and the incision is carried along the iliotibial band distally. The site of the nonunion is identified, and any prior hardware is removed if present. The anterior and posterior borders of the greater trochanter are determined with the aid of a blunt tipped instrument. A sharp osteotome is used as an elevator to open the plane of the nonunion. The bony shell of the nonunited trochanter is elevated from the site as gentle traction is applied to its undersurface with a bone hook. Iliac crest bone graft is harvested after synovectomy and revision of the components as needed. Before trochanter fixation, a determination is made regarding the need for advancement or re-fixation of the trochanter *in situ*.

It is common to be faced with contracted abductors attached to a thin, poorly vascularized shell of bone. One can perform small releasing incisions in the tendinous portion to elongate the tendon. Placing the leg in the abduction and advancing the trochanter too far distally can result in excessive traction on the repair when the patient attempts adduction. The trochanteric bed is freshened with a sharp osteotome to expose bleeding bone. In most of our patients, the trochanteric bed was nonexistent, and one is faced with only cement mantle or prosthesis. Cancellous graft is applied to the bed and gently impacted. A small longitudinal incision is made at the midportion of the tendinous insertion into the trochanter to allow passage of the hook. Temporary fixation of the proximal hook into the trochanter with a unicortical screw simplifies the subsequent steps; although, it is not necessary. The composite formed by the greater trochanter-proximal hook can then be easily articulated with the distal plate. Tension can be applied to the AO articulated traction device while the plate is held to the bone by a clamp. At this point, the further cancellous bone graft is impacted in the nonunion site. Finally, the plate is fixed to the femur, starting distally and finishing proximally. Traction can be enhanced by the self-compressing features of the distal plate. The temporary unicortical screw applied earlier is usually exchanged to improve the compression across the nonunion site [Figures 1a-d]. Postoperative rehabilitation typically consists of partial weight bearing from 10 to 25 kg in the operated extremity with support on two crutches for 1–3 months. The weight of the patient determined that amount of partial weight bearing as approximately 20% of the patient's weight was deemed allowable for weight

Table 1: Clinical details of the patients

Patient	Age (in years/ Sex)	Diagnosis	Primary THA	Complications	Other procedures	Grading of trochanteric bone stock	Hook plate operation	Complications	Final outcome	Latest followup (months)	Clinical exam preoperative	Clinical exam postoperative	Other Dx
1-SH	56/female	AVN	Right	Acute trochanteric fixation failed after fall	Trochanteric re-fixation	3 (fair)	For nonunion 1-2 cm of displacment	Trochanteric bursitis. Plate removed at 13 mo postopeartive	Healed at 3 months	48	One leg stand <4 s Trenedelenburg + Duchenne negative Mild to moderate pain	One leg stand >4 s Trenedelenburg-Duchenne negative No pain after removal	Spondylolisthesis L5/S1
2-BE	74/female	DJD bilateral	Left	Trochanteric bursitis Aseptic loosening Disloation	Synovectomy Revision THA with trochanteric osteotomy Closed reduction	3 (fair)	For nondisplaced nonunion	-	Healed at 4 months	20	One leg stand <4 s Trenedelenburg + Duchenne positive Moderate pain	One leg stand <4 s Trenedelenburg + Duchenne positive No pain	Sarcoidosis, polymyalgia, temporal arteritis on prednisone
3-EG	68/female	Hip Fx left Bilateral DJD	Bilat	Multiple left hip dislocations	Left hip revision, antiluxation acetabulum and trochanteric advancement	4 (poor)	For trochanteric fixation failure. Nonunion with >3 cm of displacement	-	Healed at 3 months	18	One leg stand <4 s Trenedelenburg + Duchenne negative Mild pain	One leg stand >4 s Trenedelenburg-Duchenne negative No pain	
4-NM	74/male	DJD	Right at outside institution	Dislocation secondary to acetabular component malposition	Acetabular revision with trochanteric osteotomy	4 (poor)	For nonunion displaced 2-3 cm exchange of femoral head at the same time	Superficial wound sepsis managed with debridement and antibiotics	Healed at 3 months	18	One leg stand <4 s Trenedelenburg + Duchenne negative Severe pain	One leg stand >4 s Trenedelenburg-Duchenne negative Mild to no pain	
5-DG	68/female	DDH bilateral	Bilat	Bilat acetabular revisions with trochanteric osteotomy. Developed right nonunion	-	4 (poor)	Second revision of acetbaulum using Burch-Schneider ring. Hook plate for nonunion 1-2 cm of displacement	-	Healed at 3 months	6	One leg stand <4 s Trenedelenburg + Duchenne positive Mild to moderate pain	One leg stand >4 s Trenedelenburg-Duchenne negative No pain	
6-MM	65/female	DJD left	Left	Limb length discrepancy left < left by 1 cm and severe limp	-	3 (fair)	For displaced nonunion >3 cm	-	Healed at 4 months	36	One leg stand <4 s Trenedelenburg + Duchenne positive mild pain	Slight limp. One leg stand >4 s Duchenne negative Mild to no pain	

Contd...

Table 1: Contd...

Patient	Age (in years/ Sex)	Diagnosis	Primary THA	Complications	Other procedures	Grading of trochanteric bone stock	Hook plate operation	Complications	Final outcome	Latest followup (months)	Clinical exam preoperative	Clinical exam postoperative	Other Dx
7-BE	67/female	Intertrochanteric hip Fx sip dynamic hip screw	Right THA requiring trochanteric osteotomy	-	-	-	At the time of primary THA	-	Healed at 3 months	24	One leg stand <4 s Trenedelenburg + Duchenne positive	One leg stand >4 s Trenedelenburg + Duchenne negative	
8-MR	46/female	DJD light	Left	-	Left acetabular revision with trochanteric osteotomy. Developed nonunion	3 (fair)	For nondisplaced nonunion	-	Healed at 3 months	50	One leg stand <4 s Trenedelenburg + Duchenne negative Moderate pain	One leg stand >4 s Trenedelenburg + Duchenne negative Minimal pain	Asthma, bradycardia
9-ND	64/female	DJD right	Right	-	-	3 (fair)	Nonunion 1-2 cm of displacement	-	Healed at 3 months	60	One leg stand <4 s Trenedelenburg + Duchenne negative	One leg stand >4 s Trenedelenburg-Duchenne negative Mild pain	
10-CL	63/female	Bilateral DDH	Right acetabular bone grafting with autologous Femoral head	-	1st acetabular revision with trochanteric osteotomy followed by 2nd acetabular revision with trochanteric osteotomy which developed nonunion	3 (fair)	For nonunion displaced 2-3 cm	Illiohypogastric nerve neuroma at the site of iliac crest bone harvest. Required neuroma excision	Healed at 3 months	5	One leg stand <4 s Trenedelenburg + Duchenne negative Moderate pain	One leg stand >4 s Trenedelenburg-Duchenne negative Minimal pain	

DJD=Degenerative joint disease, AVN=Avascular necrosis, DDH=Developmental dysplasia of the hip, THA=Total hip arthroplasty, Fx=Fracture

bearing. The security of the fixation, as well as the quality of the bone, determined the rate of progression from partial to full weight bearing. Subsequently, the patient graduates to single cane support as needed for 3–5 months.

All ten patients returned for interviews and clinical examination. Time to union and incidence of postoperative complications were assessed. Union was determined radiographically when bridging callus was noted on two radiographic views. All cases documented in this study were in accordance with the ethical standards of the Helsinki Declaration of 1975, revised in 2000.

Results

All ten patients healed their trochanteric fixation on both radiologic evaluation and clinical exam at an average of 3.3 months, with a range of 3-4 months. The average time for clinical followup was 35 months, with a range of 5–48 months. In our clinical series, only two patients demonstrated delayed healing beyond 3 months with no clear correlation between the severity of the displacement or the quality of the trochanteric bone stock with healing time. There were no major complications associated with the use of the articulated hook plate. The plate was removed in one patient who developed symptomatic trochanteric bursitis. The osteotomy had healed at the time of the exploration of the hip joint. In addition, there was one case of superficial infection treated successfully with local wound debridement and antibiotics. In one patient, a painful neuroma of the iliohypogastric nerve developed at the site of the iliac crest bone harvest. The patient successfully underwent operative excision of the neuroma.

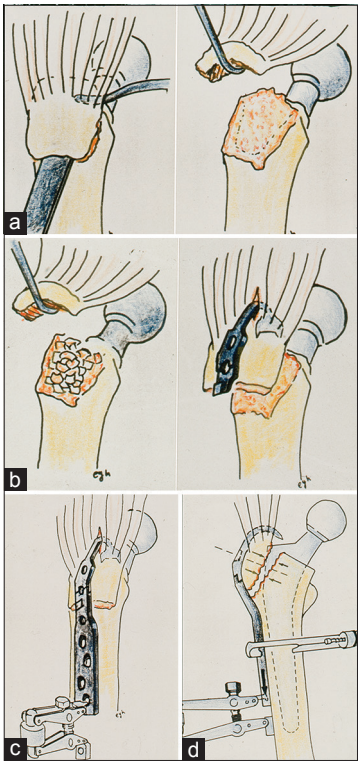

Figure 1: Diagrammatic representation of surgical sequence. (a) Opening of the fibrous nonunion or pseudoarthrosis with a sharp osteotome after the anterior and posterior borders of the abductor mass have been delineated with a blunt instrument. Gentle elevation of the trochanter with a bone hook. (b) Following component revision as needed, the trochanter bed is freshened and bone grafted. Application of the proximal hook by a small incision on the tendinous insertion. The proximal hook can be temporarily fixed with a unicortical screw, creating a composite which facilitates the subsequent steps. (c) The proximal hook is articulated with the distal plate. (d) The plate is held against the bone with a clamp. Further bone grafting is applied prior to tensioning. Preliminary tensioning along the shaft of the femur with the Arbeitsgemeinschaft für Osteosynthesefragen articulated tensioning device is used. The plate is fixed starting at the most proximal dynamic compression plate hole in compression mode

The sequence in Figure 2 illustrates a case of a trochanteric nonunion with 2–3 cm of displacement and grade 4 (poor) trochanteric bone stock. Trochanteric reconstruction was undertaken because of moderate to severe pain and limping. At the 3 months followup, the patient's complaints were resolved.

Discussion

Müller has long advocated total hip arthroplasty without trochanteric osteotomy.[13] The notion of the "functional unit" between the gluteus minimus, gluteus medius, and the vastus lateralis was first conceived by McFarland and Osborne[14] in 1954. Bauer *et al.*[15] in 1979 and Hardinge[16] in 1982 independently described transgluteal approaches to the hip to avoid osteotomy of the trochanter. The authors of the current study prefer the transgluteal approach for uncomplicated primary hip arthroplasty.

A trochanteric osteotomy is a useful tool in the armamentarium of the orthopedic surgeon. Charnley used the transtrochanteric approach for THA to gain superior exposure and to improve the biomechanics on the prosthetic joint by distal and lateral reattachment of the trochanter together with medialization of the socket.[17,18] Osteotomy of the greater trochanter has many modifications,[19,20] yet nonunion continues to raise concerns. Abductor weakness, as well as higher component loosening and revision rates in patients with trochanteric nonunion, has been reported.[6,7,21] With trochanteric osteotomy still being performed and the clinical significance of nonunion, an improved method of fixation would be ideal.

Dall and Miles have advocated the use of a braided cable system in trochanteric fixation,[22] however there is significant evidence of adverse performance of this particular fixation mode. Silverton *et al.*[23] identified nonunion of the

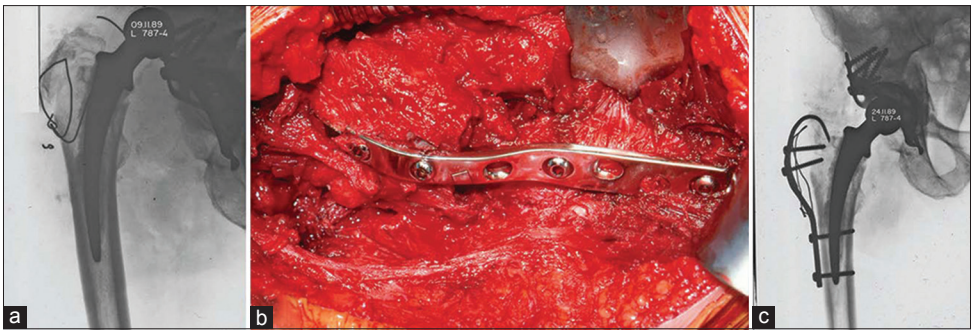

Figure 2: A 74-year-old male patient underwent a primary right total hip arthroplasty for severe degenerative joint disease. (a) X-ray hip joint with proximal thigh anteroposterior view showing an acetabular revision via a transtrochanteric approach for dislocation secondary to acetabular component malposition, the patient developed a symptomatic nonunion of the greater trochanter. (b) Peroperative photograph showing that the trochanteric nonunion of 2–3 cm of displacement with poor bone stock was fixed because of moderate to severe hip pain and limping. (c) Intraoperative fluoroscopy imaging following trochanteric reconstruction with the articulated hook plate and iliac crest bone grafting demonstrated good positioning of the implant

trochanter in 25% of their patients and noted significant osteolysis in the area of the lesser trochanter, along with significant amounts of metallic debree from the cables. Kelley and Johnston[24] found a higher rate of acetabular loosening associated with cable fixation and confirmed the presence of particulate debris and marked tissue reaction at the time of revision.

Charnley described a staple clamp[18] designed to improve fixation by resisting shearing forces in the anterior-posterior direction. The malleable fixator described by Scher[12] was used for trochanteric nonunions, but no dynamic compression can be obtained with this implant. Volz and Brown[25] described a technique of a bolt which is drilled and cemented in the lateral proximal cement mantle and to which a clamp-nut is affixed to compress the trochanter. Five patients underwent a successful operation with this technique.

After repeated operations, the quality of the soft tissue envelope surrounding the greater trochanter worsens. It is not infrequent to face fibrotic, contracted abductor musculature. Trochanter reconstruction with reattachment of the abductor mass may not restore a normal gait but will minimize pain and improve balance during ambulation. Such limited goals justify the operation, especially when we consider elderly patients who may often have lumbar spondylosis and are unable to compensate for the loss of abductor function. In our series, the most challenging cases were four displaced trochanters in the form of eggshell-like bone combined with an absent trochanter bed. All four cases healed successfully demonstrating bony union with clear reconstitution of the trochanter and its bone stock. Although not seen in our series, hip adductor contractions may also be present secondary to patient compensation to offload a painful arthritic hip. Adductor release may be considered in these cases to avoid the distraction of the greater trochanter fixation.

In our experience, removal of the trochanteric hook plate is simple when required. A smaller incision at the level of the proximal femur suffices to remove the plate. The screws fixing the proximal hook are removed, and the hook is easily disarticulated from the distal plate. The design of the articulated plate allows for ease of removal with minimal damage to the abductor muscle mass, as compared to the monoblock hook plate. The distal plate portion is then easily retrieved.

There are some limitations to our study. First, our study cohort is relatively small and may not identify possible outcomes demonstrated in larger cohort studies. Next, our study was a case series and did not feature a control cohort for comparison. Finally, our findings represent the outcomes of a single surgeon operating at the same hospital and may reduce the generalizability of our results. However, we believe this also is a strength of our study in that it demonstrates uniformity of patient evaluation, surgical treatment, and postoperative treatment.

In summary, the currently articulated hook plate facilitates tension along the shaft of the femur with the use of the AO articulated distraction-compression device and the self-compressing features of the plate. The articulated hook plate offers the surgeon the possibility of controlled reconstruction of trochanteric nonunions with cancellous iliac crest bone grafting. The use of this technique appears to be justified in the face of persistent or displaced trochanteric nonunions which may be limited by the local healing biology and current fixation technology. Other definite advantages of the articulated hook plate over other devices include the ease of application and removal when necessary. In our experience, the articulated hook plate is a good option for fixation of osteopenic bone fragments and established nonunions of the greater trochanter.

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Conflicts of interest
There are no conflicts of interest.

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