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Complications - Other

Trochanteric Fixation With a Third-Generation Cable-Plate System: An Independent Experience

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ABSTRACT

Background: Greater trochanteric fracture/nonunion can be a devastating complication with significant functional impact after total hip arthroplasty, and their fixation remains a challenge because of the significant forces being transmitted as well as the poor bone quality often associated with these fractures. The objective of this study is to investigate the rates of reoperation and trochanteric nonunion using a third-generation cable-plate system at one center.
Methods: Thirty-five patients, mean age 72.9 years (range 46-98 years) with 24 women and 11 men, underwent fixation of their fractured greater trochanter using a third-generation cable-plate system. The indications were: periprosthetic fracture (n = 17), complex primary arthroplasty (n = 5), and complex revision arthroplasty (n = 13). Primary outcomes included rates of reoperation and radiographic union.
Results: At a mean follow-up of 2.5 years, trochanteric union rate was 62.9% with nonunion rate of 31.4%, and fibrous union in 5.7%. In regard to quality of initial apposition, only 40% achieved a perfect bone on bone reduction. Ten patients (28.6%) had evidence of wire breakage. Five patients (14.3%) required reoperation and removal of the internal fixation because of lateral hip pain.
Conclusion: Fixation of the trochanteric fractures remains a challenge with a relatively high reoperation rate. Poor bone quality and capacity to maintain a stable reduction continue to make this complication after total hip arthroplasty a difficult problem to solve.

The greater trochanter (GT) is a site of attachment for multiple anatomic structures, most importantly, the abductor mechanism proximally, the vastus lateralis distally, and the short external rotators posteriorly [1,2]. In the setting of a GT fracture, all these muscle attachments apply competing biomechanical forces on the GT fragment. These forces need to be neutralized at the time of fixation to achieve mechanical stability at the fracture site. Therefore, surgical stabilization of GT fractures can be quite challenging, and may require multiple operations. The rate of radiographic nonunion post-GT reattachment has been reported as high as 39% [3]. Functional disabilities secondary to GT nonunion has been mainly attributed to proximal migration of the GT fragment >1 cm, which can lead to abductor insufficiency [4]. Some GT nonunions have been characterized as stable fibrous unions that cause minimal functional limitations. Patients with GT nonunion can experience significant lateral hip pain, abductor lurch, as well as component loosening and instability of their total hip arthroplasty [5,6].

To enhance the potential for GT union at the fracture site, surgical fixation should be strong enough to convert the shear and pulling forces on the GT fragment into compression forces [4]. There are a variety of surgical techniques and implants described to reattach the GT. The cable-plate system is one of the implants commonly used to stabilize GT fractures which has undergone multiple evolutions in its design to improve its outcome [7–10].

The first generation of cable-plate system was introduced over 40 years ago, developed by Dall and Miles and consisted of an H-shaped gripping device with 2 transverse bridges to secure the trochanteric fragment [1]. Although this construct has been shown to be biomechanically stronger than cable or wire constructs alone [11], the rates of nonunion and hardware failure remained as high as 42% [12]. The second generation of cable-plate system combined a plate to a trochanteric claw, to hook the tip of the GT with the

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plate secured to the proximal femur with cables and screws [13,14]. The overall union rate with this design was reported to be 70% [14]. The third-generation cable-plate system incorporated new advancements in cable engineering to enhance rigidity and decrease fatigue failure, as well as to improve anatomic conformity of the proximal femur to decrease the incidence of lateral hip pain.

The primary objective of this study is to evaluate the reoperation and radiographic outcome of fixation of the GT during total hip arthroplasty using a third-generation cable-plate system. The secondary objective is to assess complication rates associated with this device.

Methods

Patient Selection

A retrospective chart review was performed by a single reviewer of all cases that required GT fixation using a third-generation cable-plate system. From 2008-2014, 52 trochanteric fixations were performed in 51 patients using this third-generation cable-plate system at our institution. To assess radiographic union, only patients with minimum 6 months clinical and radiographic follow-up were included. Of the 51 patients identified, 35 satisfied the inclusion criteria. There were 11 male and 24 female patients. The average age at the time of trochanteric fixation was 72.9 years (range 46-98 years). Sixteen patients were lost to follow-up: 7 deaths, 3 unreachable by phone, and 6 unable to return for clinical and radiographic assessment.

Indications for GT reattachment were subdivided into three broad categories: (1) periprosthetic fracture, (2) difficult primary total hip arthroplasty, and (3) revision total hip arthroplasty (see Table 1 for more details).

Surgical Technique and Postoperative Care

All procedures of GT reattachment were performed by 6 arthroplasty surgeons using the ACCORD Cable Plate system (Smith and Nephew, Memphis, TN). This implant is available in lengths from 75-265 mm, with the option of a small or standard sized trochanteric hook. The size of the plate correlates with the maximal number of cables it can accommodate, and ranges from 3-11. Provisional reduction of the GT fragment was performed and secured with a large AO clamp or 2 k-wires. Then plate trials were used to select the most appropriate size that conforms to the proximal femoral anatomy. The final implant was inserted, using the claws at the proximal end of the implant to capture the trochanteric fragment and apply compression at the fracture site. Standard sized hooks were used in 20 cases, whereas small hooks were used in 15 cases. Light impaction was used to embed the claws in the trochanter. Cerclage cables were used to fix the plate to the trochanter. A mean of 3.9 cables were used per implant (range 2-8). The first cable placed was located from the central section of the plate to the inferior pole of the lesser trochanter. The accompanying tensioning device was used to compress the trochanter to its femoral bed, after which the clamp screw was tightened with the torque limited tensioner. This procedure was repeated for each additional implanted cable, after which the flush cutter was used to remove excess cable.

All patients received systemic antibiotics preoperatively as well as minimum 24 hours postoperatively. Chemical thromboprophylaxis was administered for minimum 3 weeks postoperatively. Physiotherapy was consulted for rehabilitation on the first postoperative day. Postoperative activity restrictions were surgeon-dependent, but all patients were restricted to no active abduction and toe touch-/non-weightbearing for a minimum of 6 weeks postoperatively, with progressive increased activity based on clinical and radiographic healing.

Table 1
Indication for Trochanteric Fixation.

Indication	No. of Cases
Periprosthetic fracture	17/35
Vancouver A	8
Vancouver B1	0
Vancouver B2	8
Vancouver B3	1
Complex primary THA	5/35
Trochanteric advancement	0
Failed ORIF for hip #	4
Native hip #	1
Complex revision THA	13/35
Trochanteric nonunion	6
Trochanteric advancement	0
Extended trochanteric osteotomy	3
Reconstruction with structural allograft	4

THA, total hip arthroplasty; ORIF, open reduction internal fixation.

Radiographic Analysis

Standard anteroposterior (AP) pelvis and lateral radiographs of the operated hip was performed at postoperative day 1 or 2, as well as at each subsequent follow-up visit. The method of radiographic analysis was performed as previously described [9] by a single independent observer. Initial apposition of the GT fragment on its femoral bed was assessed on the initial postoperative AP pelvic radiograph. Apposition was graded as "good" if there was no gap, "fair" if the gap was <3 mm, and "poor" if the gap was ≥3 mm. Union of the trochanter was assessed on serial follow-up AP pelvic radiographs. Bone union was defined by the presence of a stable position of the GT fragment, osseous continuity between the GT fragment and the underlying femoral bed, as well as absence of plate fracture. Similarly, fibrous union was defined by the presence of a stable GT fragment with intact plate, but the assessment of osseous continuity was blocked by overlying hardware. Nonunion was defined by any displacement of GT fragment, absence of osseous continuity, or plate fracture. Hardware failure including cable fraying/breakage, clamp screw slippage, and plate fracture were also recorded.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel 2007. A Pearson chi-square test was used to demonstrate significance of surgical indication or initial trochanteric apposition with resulting trochanteric nonunion or reoperation. A P value of less than .05 was considered significant.

Results

At a mean follow-up of 2.5 years, 22 patients achieved union (62.9%), 2 patients fibrous union (5.7%), and 11 patients nonunion (31.4%). Union was first identified on follow-up radiographs at mean 6.4 months postoperatively (range 1.7-39.3 months). On the initial postoperative radiographs, 14 of the 35 (40%) had "good" apposition with no gap between GT fragment and its proximal femoral bed, 15 cases (42.9%) had "fair" apposition (<3 mm), and 6 cases (17.1%) had "poor" apposition (>3 mm) (Table 2).

Factors Associated With Nonunion

There were not any nonunions in complex primary total hip arthroplasty, whereas the rates of nonunion for periprosthetic

Table 2
Nonunion Rate as Correlated With Initial Apposition.

Initial Bony Apposition	Union	Fibrous Union	Nonunion	%Nonunion
Good (no gap)	11	1	2	14.3
Fair (<3 mm gap)	9	0	6	40
Poor (>3 mm gap)	2	1	3	50

fracture and complex revision total hip arthroplasty were significantly higher at 35.3% (6/17) and 38.5% (5/13), respectively ($P = .016$).

The nonunion rate was only 14.3% if "good" initial apposition was achieved, but increased to 40% and 50% if initial apposition was rated "fair" or "poor", respectively ($P = .21$). Because of limited sample size, this correlation was unable to reach significance (statistical significance defined as $P > .05$).

Cable Plate Failure

Ten of the 35 patients had evidence of implant failure (28.6%). Six instances of broken wires had occurred, and 4 instances of cable slipping from the clamp screw with no fraying or cable damage visible. Cable plate failure was first identified on follow-up radiographs at mean 17.5 months postoperatively (range 4.8-36.6 months). Six of the 10 patients with implant failure had radiographic evidence of nonunion, of which 4 patients had the cable-plate system removed.

Reoperations

Fifteen of the 35 patients underwent repeat surgery of which 5 were because of failure of the cable-plate device with patients complaining of functionally limiting lateral hip pain. At the time of intraoperative assessment, 3 had united their trochanter, whereas 2 were left with a long-term nonunion.

Ten revisions were deemed not related to failure of the cable-plate device. Of these patients, 7 had their cable-plate system removed during revision. Three were removed for infection, 1 for periprosthetic fracture, and 3 for revision arthroplasty. Three patients who underwent revision total hip arthroplasty with the cable-plate system left in place, 2 were for femoral component loosening and 1 was for recurrent hip dislocation (Tables 3 and 4).

Discussion

Despite an evolution of strategies to fix GT fractures, nonunion remains a common complication that can cause patients significant functional limitations. Although using modified trochanteric osteotomy is not a common surgical approach, it is still used in complex primary and revision hip arthroplasty to improve exposure [16]. Historically, transtrochanteric approaches to the hip were used routinely in primary total hip arthroplasty, after which the trochanter was fixed with multiple wire and cable configurations. These constructs performed poorly with fatigue failure and subsequent nonunion in as high as 33.2% of primary arthroplasty cases [17]. Using a so-called third-generation device, the present study demonstrated a nonunion rate of 31.4% all occurring in the periprosthetic fracture and revision situations, with rates of fibrous and osseous union of 5.7% and 62.9%, respectively. There was a 14.3% reoperation rate directly related to failure of the cable-plate device, with patients complaining of functionally limiting trochanteric bursitis.

In the presence of a femoral implant, conventional method of fixation using interfragmentary screw compression is not feasible. Therefore, fixation using cerclage-type design is necessary. Dall and Miles [1] introduced the first cable-plate construct over 40 years ago to combat the high rate of nonunion and subsequent associated complications. Biomechanical testing revealed a significantly increased rigidity of this construct, with nearly twice the force required for 1 cm of displacement relative to wire or cable fixation alone [11]. Clinically, this implant initially reported excellent results in primary hip arthroplasty, with a nonunion rate of 1.5% and cable breakage of 3.1% [1]. But, its success in complex revision arthroplasty was less impressive, with reported rates of nonunion and cable fraying at 37.5% and 32.5%, respectively [12]. Subsequent generations of cable-plate systems built on this original design. The third-generation cable-plate system, incorporates increased anatomic conformity to decrease the incidence of lateral hip pain, and increased rigidity to decrease micromotion and subsequent implant fatigue failure. Hodgkinson et al [7] prospectively compared a group of 52 trochanteric osteotomies reattached using double crossover wire with a compression spring and showed an increased union rate relative to a historic population treated with wires alone (81% compared with 14%, $P < .0001$). The authors concluded that compression was crucial in the treatment of an ununited trochanter. The third-generation cable-plate system incorporates this element of compression by using large-diameter cables in a 19 × 7 configuration (7 × 7 in prior generations). Biomechanical studies have shown that these cables retain 90% of their tension after 30 minutes, where the prior design retained only 30% of their tension in the same period [18]. Only one prior study has reported outcomes using this third-generation cable-plate system. Patel et al [15] prospectively followed 47 uses of a third-generation cable-plate device over a minimum 3-year period. They observed 2 nonunions (4.3%), 2 reoperations (4.3%), and no instances of hardware failure including cable breakage, fretting, or fraying. The present study used identical surgical technique and radiographic analysis. Taking a closer look at comparing our patient population to Patel et al, both studies enrolled approximately 1/3 male and 2/3 female patients. Implant indications were also quite comparable between periprosthetic fracture (47% vs 49%), complex primary arthroplasty (21% vs 14.3%), and complex revision arthroplasty (32% vs 37.1%). However, a noticeable difference between the two study populations is the average age—the present study's population was on average a decade older (72.9 vs 61.4 years). The expected higher incidence of osteoporosis in the elderly may be a confounding factor, especially as bone quality is an important determinant for successful union of the trochanteric fragment. In terms of follow-up period, Patel et al was successful in achieving longer term follow-up at minimum 3 years, with a mean time to union of 11.4 weeks which helped guide cut off for the present study.

Table 3
Nonunion Rate as Correlated With Indication for Trochanteric Fixation.

Indication	Union	Fibrous Union	Nonunion	%Nonunion
Periprosthetic Fracture	10	1	6	35.3
Complex Primary THA	4	1	0	0
Complex Revision THA	8	0	5	41.7

THA, total hip arthroplasty.

Table 4
Nonunion Rate as Correlated With Generation for Trochanteric Fixation.

Generation	Third (Present Study), %	Third (Patel et al, 2012 [15]), %	Second (Barrack et al, 2005 [14]), %	First (Ritter et al, 1991 [12]), %
Nonunion	31.4	4.3	14.6	37.5
Reoperation	14.3	4.3	Not reported	Not reported
Implant failure	28.6	0	19	32.5

To help interpret the results of the present study, nonunion rates were correlated with indications for trochanteric fixation as well as degree of initial trochanteric apposition. We did not observe any nonunions with use of this implant for difficult primary THA (n = 5), whereas significantly higher rates of nonunion were observed after periprosthetic fracture and complex revision arthroplasty (35.3% and 38.5%, respectively, $P = .016$). This higher rate of trochanteric union in primary arthroplasty can be related to the presence of better bone stock. In the presence of previous total hip arthroplasty and subsequent osteolysis, trochanteric fixation has a poor rate of healing. Appropriate implant use, as measured by initial trochanteric apposition, also appears to play a role in the success of trochanteric fixation. This study demonstrated nearly a third of the nonunion rate if initial bony apposition is rated as "good" (14.3%), relative to both "fair" (40%) and "poor" (50%), ($P = .21$). Patel et al reported a perfect initial apposition rate of 78.7%, whereas our series only had perfect apposition in 40% of cases. This may have contributed to the higher observed nonunion rate in our series. Thus, we propose that perfect anatomic trochanteric reduction is crucial to optimize union potential.

The present study has several limitations. It is retrospective with a small patient cohort with no comparison group using an alternative implant for trochanteric fixation as well as a relatively short minimum follow-up of 6 months. Although trochanteric union is often protracted because of decreased bone density and compromised vascularity, previous studies have used 6 months as a cut off to define trochanteric nonunion [7]. This study also does not report clinical outcomes as the vast majority of patients had no preoperative questionnaires. Having said that, our primary objective was to assess the rate of union with this device as well as associated complications/reoperations. Finally, there were 16 patients who were lost to follow-up and therefore did not meet this study's inclusion criteria. Despite these limitations, this study adds to the literature on trochanteric fixation using a third-generation cable-plate system, because there is only a single report published on this implant [15].

Achieving bone union after GT fixation, GT relies on rigid stable fixation that can resist the distracting biomechanical forces applied by the different muscle attachments, especially the hip abductors. The most significant shear force is in the anteroposterior plane, reaching up to four times an individual's body weight during stair climb. Forces in the vertical plane can double an individual's body weight during normal walking [2]. Finally, the anterosuperior insertion of the gluteus medius and minimus on the GT create a rotational force that is not countered by the short external rotators [1]. Rather than combat the massive forces from abductor contraction, Chin and Brick [19] reported success in their case series of 4 hips treated with advancement of the abductor muscles, through subperiosteal release of the gluteus minimus, medius and maximus off the iliac wing. This allowed for a tension free trochanteric reattachment, and subsequent healing in all 4 cases. The authors advise this technique only if the fragment cannot be reattached to its femoral bed with the hip in <20 degrees of abduction, as detachment of the gluteus musculature origin severely affects trochanteric vascular supply [20].

One of the shortcomings of cerclage-only trochanteric fixation is the lack of translational and rotational stability. As illustrated by case 1D (Appendix A), the cable-plate device on postoperative films is almost always angled anterior or posterior to the proximal femur. This can be attributed to the flexion and rotatory forces applied to the GT, which are not adequately counteracted by the compressive frictional forces of a cerclage-type device. Advancements in locked fixation have shown promise in the ability to counteract these forces. Biomechanical testing of Y-shaped locking plates with anterior and lateral unicortical locking screws to fix the GT has shown improved trochanteric stability over cerclage cable fixation [21]. Furthermore, locking plate fixation oriented anterolaterally significantly reduces trochanteric anterior migration compared with direct lateral plate positioning [22–24]. In the present study, we observed a 28.6% rate of cable fraying, breaking or clamp screw release, concerning for limited long-term implant longevity [25]. Hop et al [26] reported the 10-year follow-up results of a large series of patients that underwent cable vs wire fixation of the trochanter. They observed accelerated polyethylene wear, increased osteolysis and component loosening in the cable fixation group with a reduced survival rate of 10% when compared with the wire reattachment group [27].

In conclusion, this study showed a high incidence of nonunion, reoperation, and implant failure at a minimum 6-month follow-up using the third-generation cable-plate device. Further well designed randomized studies are necessary to determine if there is added benefit in using this more expensive third-generation cable-plate device for the management of the GT.

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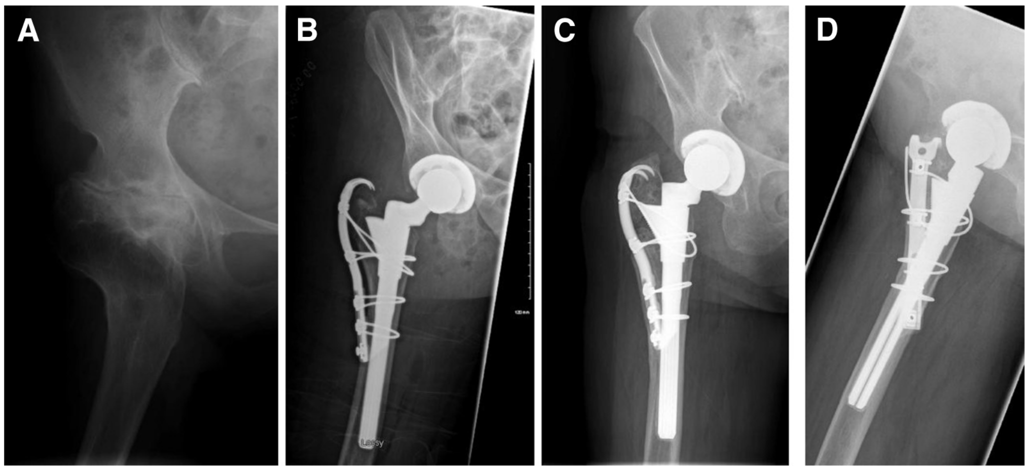
Appendix

Appendix A. Case—Successful union. Case 1. One of the first uses of the Accord system at TOH. 70-year-old female who presented to TOH with a history of right hip pain. (A) Significantly deformed right hip with end-stage arthritis due to underlying dysplasia. (B) THA with trochanteric advancement—fair bony apposition with ~2 mm gap. (C) Over 1-year follow-up with trochanteric union. (D) Lateral image.



Appendix B. Case—Failed union. Case 2. (A) 52-year-old male with a history of resurfacing arthroplasty with trochanteric advancement complicated by painful trochanteric nonunion. (B) Revision to THA with Accord cable-plate GT fixation—poor bony apposition with large gap. (C) 7 months later, continued to have significant lateral hip pain and radiographic nonunion, so taken to the OR for Accord removal. (D) 5-year follow-up, mild lateral hip pain with obvious trochanteric nonunion.