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Original Research

Greater Trochanteric Fixation Using Cable Plate Devices in Complex Primary and Revision Total Hip Arthroplasty

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ABSTRACT

Background: Successful fixation of the greater trochanter (GT) in total hip arthroplasty (THA) is a challenging task. A wide range of clinical results are reported in the literature despite advancements in fixation technology. Previous studies may have lacked adequate sample sizes to detect differences. This study evaluates nonunion and reoperation rates and determines factors influencing successful fixation of the GT using current-generation cable plate devices.

Methods: This retrospective cohort study included 76 patients who underwent surgery requiring fixation of their GT and had at least 1-year radiographic follow-up. Indications for a surgery were periprosthetic fracture (n = 25), revision THA requiring an extended trochanteric osteotomy (n = 30), GT fracture (n = 3), GT fracture nonunion (n = 9), and complex primary THA (n = 3). Primary outcomes were radiographic union and reoperation. Secondary objectives were patient and plate factors influencing radiographic union.

Results: At a mean radiographic follow-up of 2.5 years, the union rate was 76.3% with a nonunion rate of 23.7%. Twenty-eight patients underwent plate removal, reasons for removal were pain (n = 21), nonunion (n = 5), and hardware failure (n = 2). Seven patients had cable-induced bone loss. Anatomic positioning of the plate ($P = .03$) and number of cables used ($P = .03$) were associated with radiographic union. Nonunion was associated with a higher incidence (+30%) of hardware failure due to broken cable(s) ($P = .005$).

Conclusions: Greater trochanteric nonunion remains a problem in THA. Successful fixation using current-generation cable plate devices may be influenced by plate positioning and number of cables used. Plate removal may be required for pain or cable-induced bone loss.

Introduction

Successful fixation of the greater trochanter (GT) can be a challenging task due to the significant multiplanar forces that are exerted across the proximal femur in activities of daily living [1]. A variety of methods are currently used for GT fixation including wires, cables, and cable plate devices, but there is no consensus on a superior mode of fixation among arthroplasty surgeons. Cable plate devices have been shown to be the strongest trochanteric fixation option biomechanically [2,3]. However, this has not translated to consistent superior clinical results [3].

Previous studies using current-generation cable plate devices have shown nonunion rates ranging from 5% to 31% [4–7]. This wide range of results may be due to multiple factors including technique, indication for surgery, patient factors, device factors such as plate length, the number of cables used, and initial reduction. To date, it is unclear which factors truly influence successful trochanteric fixation using current-generation cable plate devices. Currently, the largest series analyzing trochanteric fixations using current-generation cable plate devices contains only 47 patients [4]. We sought to perform a larger analysis of nonunion and reoperation for plate-related complications as well as uncover factors that may influence successful union when using current-generation cable plate devices for GT fixation in conjunction with

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THA. We hypothesized that our nonunion rate would fit within the range reported in previous studies and that the incidence of nonunion would be greater in patients with nonanatomic placement of the plate/GT, and lastly utilization of longer plates and more cables would be associated with a reduced incidence of nonunion.

Material and methods

All procedures reviewed in this investigation were approved by the institutional review board for research involving human subjects. A retrospective chart review was performed of all GT fixations in conjunction with total hip arthroplasty using current-generation cable plate devices. From 2012 to 2021, 111 cases were performed at our institution. Only cases with at least 1 year of radiographic follow-up were included, leaving 76 cases. Patient demographics, comorbidities, American Society of Anaesthesiologists' scores, plate type, and plate length were recorded from the electronic medical record (Table 1). Indications for trochanteric fixation were recorded from the operative note and subdivided into the following categories: periprosthetic fracture, revision THA requiring an extended trochanteric osteotomy, complex primary THA requiring an osteotomy, GT fracture, and GT fracture nonunion (Table 2). If a patient required a reoperation, the indication was recorded (Table 3).

Surgical technique

All cases were performed by 3 fellowship-trained hip and knee arthroplasty surgeons at 1 institution using a traditional posterolateral approach to the hip and femoral shaft. Plate type was selected by the surgeon. In general, plate length was chosen based on the size of the GT fragment. Sharp towel clips are used to reduce and hold the GT fragment to the proximal femur. Cerclage cables are placed through the plate from a posterior to anterior direction. Two longitudinal slits are then made through the abductor musculature to facilitate placement of the claw tines anatomically. The claw portion of the plate is then placed through the muscle into the GT fragment with light impaction. The handle attachment of the plate is used to rotate the plate to reach the femoral shaft. An assistant holds the plate in this position as a cable passer is used to pass cables around the femur. The cables are sequentially tightened. An intraoperative radiograph is taken to confirm anatomic positioning of the plate and GT; where the claw portion of the plate fully captures the GT fragment; if the fragment is reduced to the proximal femoral bed; and if the plate secured against lateral femur. The cables are then cut flush with the plate.

Table 1
Patient demographics.

Patient demographics	Union	Nonunion
Female	35 (60%)	12 (67%)
Male	23 (40%)	6 (33%)
Age (y)	69 ± 13	63 ± 9
Body mass index (kg/m^2)	27.7 ± 6.8	28.7 ± 7.9
American Society of Anaesthesiologist (ASA) Score	2.8 ± 0.5	3.1 ± 0.5
Radiological follow-up (d)	987 ± 659	778 ± 491
Comorbidities		
Smoking	12%	17%
Osteopenia/osteoporosis	12%	17%
Diabetes	24%	28%
Inflammatory arthritis	7%	22%
Hypothyroidism	26%	17%

Data are presented as means ± SD for patient demographics and frequency of comorbidities. No statistically significant differences detected between Union and Nonunion groups.

Table 2
Patient frequency for reason for needing plate.

Indication for plate	Union		Nonunion	
Vancouver type A	12	20.69%	4	22.22%
Vancouver type B1	0	0.00%	0	0.00%
Vancouver type B2	6	10.34%	1	5.56%
Vancouver type B3	1	1.72%	1	5.56%
Revision THA	30	51.72%	6	33.33%
Greater troch fracture	3	5.17%	0	0.00%
Greater troch nonunion	3	5.17%	6	33.33%
Complex primary THA	3	5.17%	0	0.00%

Postoperative regimen

In addition to standard preoperative antibiotic prophylaxis, the patients are given intravenous antibiotics for 24 hours postoperatively and standard deep vein thrombosis prophylaxis for 1 month postoperatively. Physical therapy commences on the day of surgery. Patients are counseled to refrain from active abduction for 6 weeks.

Radiographic analysis

A standard anterior-posterior pelvis radiograph was taken postoperatively and was used to evaluate anatomic positioning of the plate and GT on the anterior-posterior radiograph. The plate and GT were determined to be in an anatomic position if the claw portion of the plate fully captured the trochanteric fragment, the fragment is reduced to the proximal femur, and the plate was secured flush with the femur (Fig. 1a). The plate and GT were determined to be nonanatomic if any of the aforementioned requirements were not satisfied (Fig. 2a). The number of cables and the presence of a proximal cable were recorded from the immediate postoperative image. Follow-up imaging was reviewed for radiographic union. Radiographic union was defined as complete osseous continuity of the GT to the proximal femur. Nonunion was defined as absence of complete osseous continuity of the GT fragment with the proximal femur at 1 year. Nonunions were further characterized as stable if there was no displacement of the fragment from the initial postoperative position or escape from the plate (Fig. 3) and unstable if there was displacement of the fragment compared to the postoperative radiograph or escape from the plate (Fig. 2b). Presence of heterotopic ossification, broken cables, and instances of cable-induced bone loss were also recorded. Radiographs were initially reviewed by a hip and knee arthroplasty fellow and then were subsequently reviewed and confirmed by a senior author.

Statistical analysis

An independent samples *t*-test was used for comparison of continuous data between union and nonunion cases. A chi-square

Table 3
Indications for reoperation.

Indication for reoperation	Union		Nonunion	
No reoperation	30	51.72%	6	33.33%
Deep infection	3	5.17%	1	5.56%
Superficial infection	2	3.45%	1	5.56%
Painful hardware	18	31.03%	3	16.67%
Periprosthetic fracture	3	5.17%	1	5.56%
Dislocation	1	1.72%	0	0.00%
Other type of fracture	0	0.00%	0	0.00%
Hardware failure	1	1.72%	1	5.56%
Heterotopic ossification	0	0.00%	0	0.00%
Nonunion	0	0.00%	5	27.78%

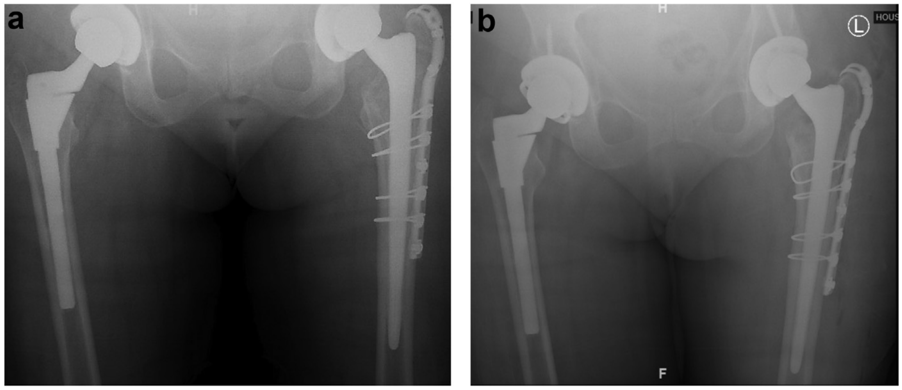

Figure 1. Anatomic positioning of plate GT/construct (a) resulting in successful union (b).

test was used for comparison of frequency-based data between union and nonunion cases and Fisher's exact test in instances where there were fewer than 5 observations. For all significant comparisons between groups, effect size (ES) was calculated using either a Cohen's *d* statistic (*t*-test comparison) or a phi statistic (chi-square analysis) whereby ES were interpreted as follows: 0.0-0.1, negligible (N); 0.1-0.3, small (S); 0.3-0.5, moderate (M); 0.5-0.7, large (L); >0.7, very large [8–10].

Results

At a mean radiographic follow-up period of 29 ± 18 months (range 12-89 months), the radiographic union rate was 76.3% with a nonunion rate of 23.7%. Twelve of the nonunions were stable, and six were unstable. The overall reoperation rate was 52.6%, and the reoperation rate for plate-related complications was 36.8%. Twenty-one patients required plate removal for pain. Five patients required reoperation for repeat fixation for nonunion (Table 3). There were 15 patients who formed heterotopic ossification and 16 patients with broken cables; 2 were symptomatic and required removal of hardware. Seven patients had cable-induced bone loss.

Factors influencing nonunion

No difference was observed between the union and nonunion groups for patient age, body mass index, ASA score, comorbidities, and indication for a surgery (Tables 1 and 2). In 48 cases, there was anatomic positioning of the plate/GT, and in 28 cases, there was nonanatomic positioning. Anatomic positioning of the plate/GT ($P = .031$; Fig. 4a) and number of cables used (union 4.2 ± 0.2, nonunion 3.7 ± 0.3, $P = .0350$, ES 0.44) were significantly associated with radiographic union. A proximal cable around the GT fragment was present in 68.4% of the cases that went on to radiographic union and 66.6% of nonunion cases. The Smith and Nephew Accord system (Memphis, TN) was used in 58 cases, Zimmer Biomet (Warsaw, IA) cable ready system was used in 11 cases, and Stryker Dall Miles system (Mahwah, NJ) was used in 7 cases. The average plate length was 152 ± 44 mm in the union group and 146 ± 36 mm in the nonunion group. Presence of a proximal cable, plate type, and plate length did not show a significant association with radiographic union or nonunion. Although no significant differences were detected between union and nonunion groups regarding plate length, a significant positive correlation was observed between plate length and the number of cables used ($r = 0.421$, $P < .001$). Lastly, nonunion cases were observed to have a significantly higher incidence of hardware failures involving broken cables ($P = .005$; Fig. 4b).

Discussion

Our study includes 76 patients, which is, to our knowledge, the largest series to date using current-generation cable plate devices for GT fixation across a wide range of surgical indications in THA. Cable plate devices for trochanteric fixation were developed with the goal of improving union rate and decreasing complications related to loosening and breakage of wires and/or cables seen with older devices and techniques [2,3]. Although cable plate devices have been shown to be biomechanically superior to cables or wires

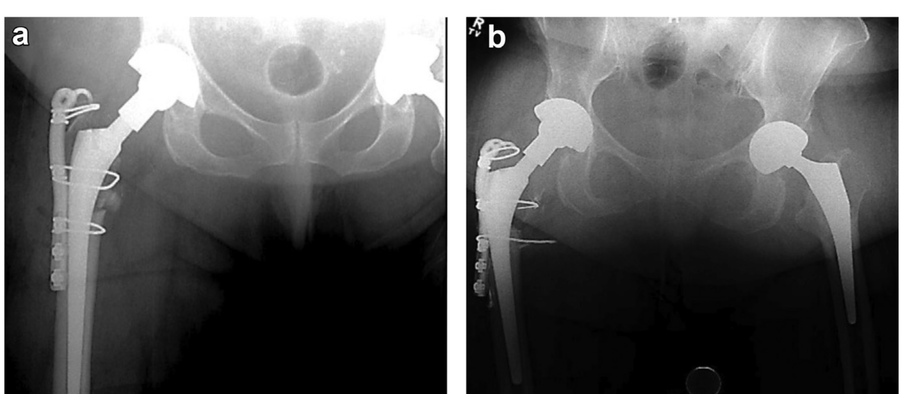

Figure 2. Nonanatomic positioning of the GT/plate construct (a) resulting in hardware failure and unstable nonunion (b).

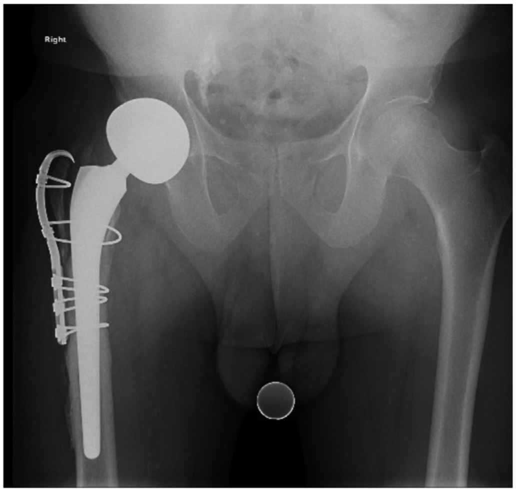

Figure 3. Stable nonunion.

alone, previous studies show a wide range of clinical results [2–7]. Previous investigations have demonstrated nonunion rates ranging from 5% to 33% [7].

To date, it is known that cable plate fixation of the GT can lead to successful union in a majority of patients. However, there is room for improvement, and it is unclear what factors may influence success and could be used to improve results going forward. At this time, the largest series analyzing GT cable plate fixations across all surgical indications in THA comprises 47 patients [4]. It is likely that the smaller sample sizes of previous studies have failed to uncover important factors that could influence successful fixation of the GT. Our study includes 76 patients, which is, to our knowledge, the largest series to date using current-generation cable plate devices for GT fixation across a wide range of surgical indications in THA. We hypothesized that our nonunion rate would fit within the range reported in previous studies, that the incidence of nonunion would be greater in patients with nonanatomic placement of the plate/GT, and that utilization of longer plates and more cables would be associated with reduced incidence of nonunion.

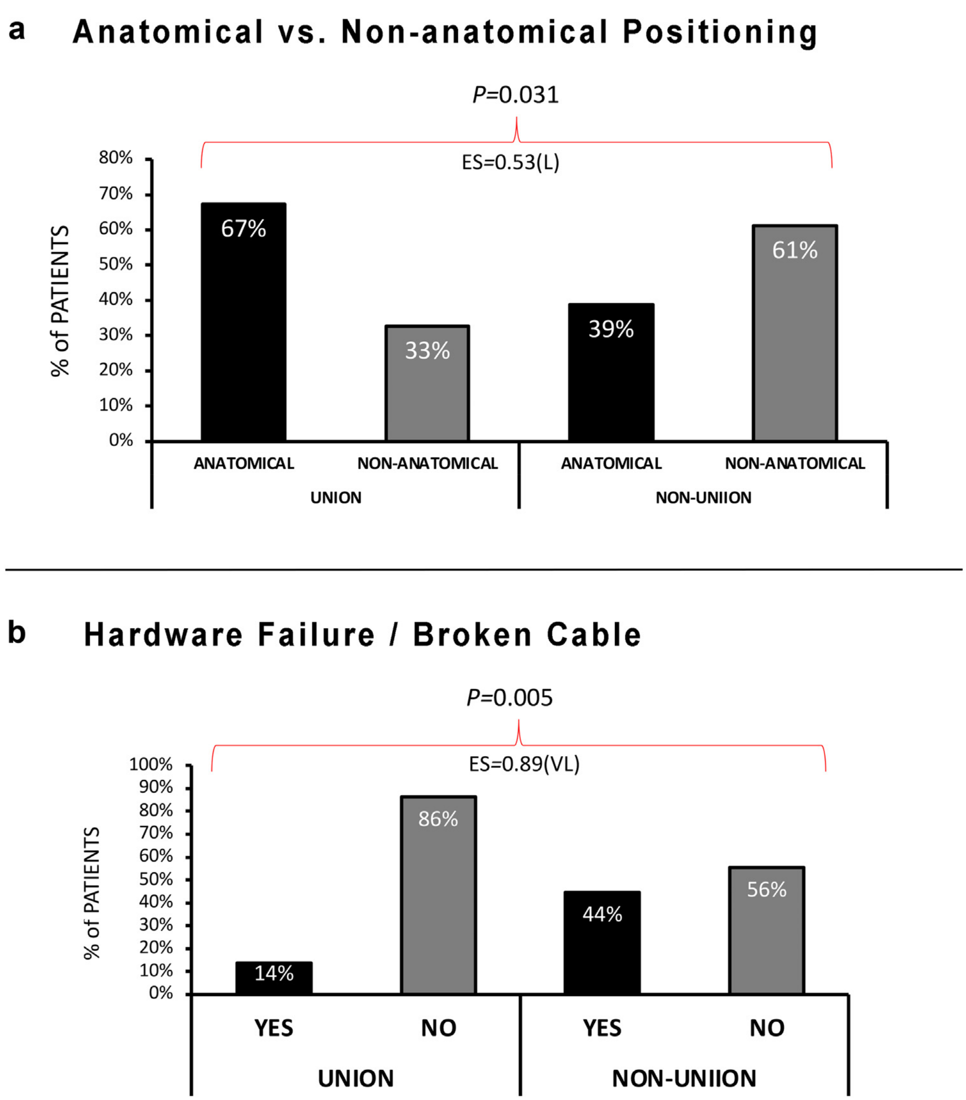

Figure 4. (a) Data are presented as frequency of anatomical vs nonanatomical plate positioning. (b) Values are presented as frequency of hardware failure. Type-I error set at $\alpha = 0.05$. Effect sizes (ES) are presented as either a Cohen's d statistic (a) or a phi statistic (b) and interpreted as follows: <0.1, negligible (N); 0.1-0.3, small (S); 0.3-0.5, moderate (M); 0.5-0.7, large (L); >0.7, very large (VL).

In the present investigation, we observed a nonunion rate of 23.7%, which is lower than that of multiple previously reported studies but still a relatively high rate. Trochanteric nonunion can cause pain and long-term functional limitations, so it is important to determine factors that may improve union rate when using these devices [9–12]. Previous studies have concentrated on initial reduction of the GT fragment by measuring fracture gap in millimeters. Stewart et al. noticed a trend toward improved union rate with perfect or near-perfect bony apposition (<3-mm gap), but this was not statistically significant [5]. In our experience in using these devices, we have found both anatomic reduction of the fragment and anatomic positioning to be important. We chose to analyze the anatomic position of the plate and GT because the plate is designed to capture the fragment and stabilize it to the proximal femur. If the fragment or the plate is not in an optimal position, stability of the construct may be compromised, which will likely result in increased strain at the fracture site. It is known that controlling the magnitude of interfragmentary strain is an important aspect of fracture healing, and when the magnitude of strain is not optimized, healing is impaired, and nonunion may occur [13–15]. Therefore, it is important to provide adequate stability needed for successful bone healing. Our definition of anatomic positioning is when all the following criteria are met: The claw of the plate completely captures the GT fragment with no gaps, the fragment is in continuity with the proximal femur, and the plate is in intimate contact with the GT and the shaft of the femur. In the present study, we found a significant association between anatomic positioning of the plate/GT and number of cables with radiographic union. These results suggest that the deforming forces exerted through the GT may be less likely to increase strain and negatively influence bony union when the construct is in proper position and tightened down with an adequate number of cables. Also, of the 6 patients with unstable nonunions, 4 had nonanatomic positioning of the plate/GT construct, which conveys that in the case of nonunion, anatomic positioning might prevent displacement and/or escape of the trochanter from the plate. This could have clinical implications as it has been reported in the literature that displacement of the GT of greater than 2 cm can result in significant weakness of the abductors [12]. There were no statistically significant differences in plate type or length between union and nonunion cases. However, there was a statistically significant correlation between plate length and number of cables used, which is likely the result of more options being available for cables on longer plates. Of the reoperations for plate-related complications, 21 patients required plate removal for lateral hip pain, and 7 required repeat fixation for nonunion/hardware failure. Fifteen patients developed heterotopic ossification postoperatively, and none of them required any further treatment. There were 7 instances of bone resorption beneath the cables, and in these cases, plate removal was recommended. There were 16 patients with broken cables, and there was a higher frequency of broken cables in patients with nonunion than in patients who achieved radiographic union (Fig. 4b). The higher frequency of broken cables in nonunion cases is likely the result of suboptimal stability of the initial construct, resulting in motion and eventual failure of the cables.

The not insignificant nonunion rate in this, and other, series demonstrates that fixation of GT fractures is a demanding procedure. Anatomic reduction, which may be difficult to achieve, and sufficient plate length and number of cables should improve the union rate. New plate designs with locking screws may improve results [16–18].

Although this study has improved statistical power compared with the previous smaller studies, it is not without limitations. It is a retrospective study at a large tertiary referral center, and inconsistent patient follow-up is an issue that led to the exclusion of over 40 patients. Despite this limitation, we were still able to obtain 1 year of radiographic follow-up in 76 patients. There were multiple surgeons performing the trochanteric fixation procedures, and while 3 different cable plate devices were used, all were based on the same principal of capturing the GT, as we described in the technique section, and reducing this to the native position whenever possible. A large majority of our fixations were done in periprosthetic fracture and revision THA (55/76). We preferred to have more complex primary THA patients, but with the retrospective nature of this study, we were unable to control for many of the aforementioned variables.

In conclusion, current-generation cable devices can be used for GT fixation successfully in a large majority of patients (>75%); however, nonunion remains an issue, and the hardware can be painful, requiring removal. Ensuring anatomic positioning of the plate and GT as well as increasing the number of cables used may increase the likelihood of radiographic union.

Conflicts of interest

T. A. Clyburn is in the speakers' bureau of or gave paid presentations for Intellijoint, is a paid consultant for Flexion Therapeutics, and has stock or stock options with Conformis Inc. S. J. Incavo receives royalties from Innomed, Kyocera Medical Corporation, MicroPort Orthopedics Inc., Osteoremedies, Smith & Nephew, and Zimmer Inc.; is a paid consultant for Kyocera Medical Corporation and MicroPort Orthopedics Inc.; and has stock or stock options with Ryann Surgical. B. Lambert receives research support as a principal investigator from Delfi Medical Innovations. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101103.

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