Trochanteric claw plate fixation for greater trochanteric fracture or osteotomy in total hip arthroplasty

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Research Article

Abstract

Background: Fixation of greater trochanteric fractures or osteotomy in total hip arthroplasty pose technical challenges. This study aimed to evaluate the results of trochanteric claw plate fixation.

Methods: This study retrospectively evaluated 41 consecutive open reductions and internal fixations following primary or revised total hip arthroplasty, which required trochanteric claw plate fixation for greater trochanteric fracture or osteotomy between January 2008 and December 2020. The mean duration of clinical follow-up was 4.2 years (range, 1–13 years). The patients included 13 men and 28 women, with a mean age of 68 years (range, 32–87 years). The indications for intervention included trochanteric osteotomy, intraoperative fracture, and non-union including postoperative fracture in 6, 9, and 26 cases, respectively.

Results: The mean Merle d'Aubigné clinical score improved from 9.4 points (range, 5–15 points) pre-operatively, to 14.3 points (range, 9–18 points) at the last follow-up. Bone union occurred in 35 cases (85%), while implant breakage occurred in 4 cases. At the last follow-up, the mean Merle d'Aubigné Clinical Score of bone union and non-union were 15.3 and 14.1 points, respectively (p = 0.48). The Kaplan-Meier survival rate, with the endpoint being revision surgery for pain, non-union, dislocation, or implant breakage, at 10 years was 80.0% (95% confidence interval: 62.6–97.4%).

Conclusions: Greater trochanteric fixation using a trochanteric claw plate yielded successful results.

Background

Periprosthetic fractures (PPFs) that occur intra- and postoperatively following total hip arthroplasty (THA) result in considerable morbidity and dysfunction in patients [1, 2]. The number of PPFs is currently increasing, and it is the third most common reason for revision surgery in the United States and the second in the United Kingdom [3–5]. Although greater trochanter fracture (Vancouver type A_G) is the leading type of PPF, there are few reports of Vancouver type A_G compared to Vancouver type B and C fractures [6, 7]. Vancouver type A_G fractures are often neglected because greater trochanter fractures that are minimally displaced have been treated nonoperatively. However, a greater trochanter fracture involving the abductor lever arm can be a devastating complication leading to persistent pain, a Trendelenburg gait pattern, chronic dislocation, and reduced quality of life. The indication for fixation of the united greater trochanter following THA depends largely on functional impairment and the magnitude of proximal migration of the trochanteric fragment [8]. Hence, fixation after trochanteric osteotomy is also similar to a greater trochanter fracture.

Trochanteric fractures or non-unions remain a challenging problem. Furthermore, technical difficulties include the small size of the bone fragment, which is an important site for the gluteus medius muscle attachment, and requires fixation with muscle. Although various methods for trochanteric fixation have been developed, the most common being monofilament wires, multifilament braided cables, cable-plate systems, or locking plates, it is difficult to support one implant over another [9]. Therefore, we have used a trochanteric claw plate (CMK Trochanteric plate, Zimmer Biomet Holdings Inc., Warsaw, USA) for greater trochanteric fracture or osteotomy following THA. A trochanteric claw plate has the following advantages: (1) the large hooks allow bone fragments to be captured with muscles, (2) no screw fixation around the greater trochanter produces less irritation, and (3) the plate can be bi-cortically fixed at the diaphysis. This study aimed to reintroduce this technique and retrospectively evaluate clinical results. The hypothesis was that the trochanteric claw plate would be effective for the fixation of the greater trochanter.

Methods

Forty-six consecutive open reductions and internal fixations following primary or revised THA, which required fixation using a trochanteric claw plate for greater trochanteric fracture or osteotomy, were performed at our institution between January 2008 and December 2020. Of these, 5 patients (5 hips) were lost to follow-up (follow-up rate, 89%). The subjects included 13 men and 28 women, with a mean age of 68 years (range, 32–87 years) at the time of surgery. The mean duration of clinical follow-up was 4.2 years (range, 1–13 years). The trochanteric claw plate was used for trochanteric osteotomy in 6 hips, intraoperative fracture in 9 hips, and non-union, including postoperative fracture in 26 hips (Table 1). Non-union included dislocation in 8 hips, pain in 4 hips, transposition of fragment in 2 hips, limp in 1 hip, and fixation of the existing displaced trochanteric fragment from unrelated revision in 11 hips. The indication for managing a united greater trochanter was decided according to the Hamadouche's algorithm, primarily based on the degree of limp, the magnitude of proximal migration of the greater trochanter, and pain (Fig. 1) [8]. Our institutional review board (2021152) approved this prospective cohort study. Each patient also provided informed consent for inclusion in the published findings.

Table 1
Pre-operative patient characteristics

Patient Demographics	Value
Number of hips	41
Mean age at surgery, years (range)	68 (32 – 87)
Sex, male:female	13:28
Mean follow-up period, years (range)	4.2 (1 – 13)
Reason for the use of a trochanteric claw plate	6
Trochanteric osteotomy	9
Intra-operative fracture	26
Non-union including post-operative fracture	

The trochanteric claw plate characteristics are as follows: 1) the proximal end has two hooks that capture the trochanteric fragment, and 2) the distal end has two convex flanges that appose to the femoral cortex (Fig. 2) [10]. In addition, each of these arms has one hole for flexible fixation to the femur with a 4.5 mm screw. The device is available in three sizes (80 mm, 90 mm, and 100 mm).

The transgluteal approach in the lateral position was used in all the patients. Furthermore, in revised THA, a longitudinal incision was made after incision through the skin and tensor fascia latae. Dislocation of the prosthesis was usually not required, and the trochanteric fragment and its femoral bed were cleaned of all fibrous or granulation tissue. Although the fixation of the trochanteric claw plate was performed according to previous reports [8, 11], we used an ultra-high molecular weight polyethylene fiber cable (UHMWPE fiber cable; NESPLON Cable System, Alfresa Pharma Co., Osaka, Japan) [12]. The hooks were pushed into the thickness of the gluteus medius tendon until they were in anterior contact with the trochanteric fragment. The claw plate in close contact with the trochanteric fragment was pulled down toward the distal, and the vastus lateralis was longitudinally incised to expose the subtrochanteric region. The UHMWPE fiber cable was circled around the claw plate. The plate was pulled down to the distal at the position of 20° of abduction, and then a 2.0 mm Kirshner wire was temporally fixed into the distal central hole. In cases of instability between the hooks and trochanteric fragment, a second UHMWPE fiber cable was circled over the hooks and trochanteric fragment. After the temporal fixation, the UHMWPE fiber cable was firmly tightened to a tension strength of approximately 20 kg. The cable was tied using a tensioning device (Alfresa Pharma Co.) with a double loop-sliding knot technique [13]. The fixation was then completed with two 4.5 mm bi-cortical screws placed anteriorly and posteriorly to the femur (Fig. 3). In our experience, the screw was sometimes fixed only in the posterior hole because the anterior femoral bone is narrow. Finally, a temporal Kirschner wire was removed, and the rigidity of the fixation was confirmed. Full weight-bearing was allowed as soon as possible, although the patients were encouraged to use a cane for up to 3 months.

After surgery, patients were followed-up at 2 weeks, 3 months, 6 months, 1 year, and annually thereafter. A retrospective analysis was performed by two blinded orthopedic surgeons. For clinical assessment, the Merle d'Aubigné and Postel grading system was used preoperatively and at the last follow-up [14]. Intraoperative and postoperative complications were also recorded. For radiological assessment, anteroposterior radiographs of the pelvis were evaluated using a ruler (Carestream Health Japan Co., Ltd., Tokyo, Japan). Trochanteric non-union was defined as visible migration of the trochanter. Union was considered to be complete when no residual radiolucent line was visible on the most recent anteroposterior views of the radiograph [10]. The apposition was considered good if the contact was perfect and there was no gap, fair if the gap was < 3 mm, and poor if it was ≥ 3 mm [8]. Statistical analysis was performed using nonparametric tests, with a p value < 0.05 considered statistically significant. Prosthesis survival was determined using the Kaplan -Meier method with 95% confidence intervals; end points were repeat revision surgery for implant breakage, non-union, dislocation, or pain. Data were analyzed using SAS 9.2 (SAS institute Inc., Cary, NC, USA).

Results

The mean Merle d'Aubigné Clinical Score improved from 9.4 points (range, 5–15 points) pre-operatively to 14.3 points (range, 9–18 points) at the last follow-up ($p < 0.05$) (Table 2). In abductor weakness, the mean active abductor range increased from 10.4° (range, 0–20°) pre-operatively to 22.8° (range, 5–40°) at the last follow-up ($p < 0.05$). Repeat revision surgery was performed in 8 patients for the following indications: pain in 4 hips (10%), periprosthetic fracture in 2 hips (5%), recurrent dislocation in 1 hip (2%), and periprosthetic infection in 1 hip (2%). Four patients who experienced an implant breakage were treated nonoperatively because of the absence of symptoms. A typical case was shown in the Fig. 4.

Table 2
Mean Merle d'Aubigné Clinical Score

Demographics	Preoperative	Last follow-up	p value[a]
All cases (41 cases)	9.4 ± 2.9	14.3 ± 2.3	< 0.05
Total	2.6 ± 1.2	5.3 ± 0.8	< 0.05
Pain	4.4 ± 1.4	5.2 ± 1.1	< 0.05
Mobility	2.4 ± 1.4	3.8 ± 1.8	< 0.05
Ability to walk			
Reason for the use of a trochanteric claw plate	7.0 ± 1.3	14.2 ± 3.3	< 0.05
Trochanteric osteotomy (6 cases)	7.3 ± 2.1	13.8 ± 2.1	< 0.05
Intra-operative fracture (9 cases)	10.9 ± 2.6	14.7 ± 2.2	< 0.05
Non-union (26 cases)			
Bone union at the last follow-up	9.6 ± 2.9	15.3 ± 2.8	< 0.05
Non-union (6 cases)	9.3 ± 2.9	14.1 ± 2.2	< 0.05
Union (35 cases)			
[a] Student t-test			

Bone union occurred in 85% (35/41 cases), with a mean duration of 1.4 years (range, 0.3–5 years). The rates of bone union in trochanteric osteotomy, intraoperative fracture, and non-union was 100% (6/6), 89% (8/9), and 81% (21/26), respectively. In postoperative bone contact, 20 hips were categorized as good, 8 as fair, and 13 as poor. At the last follow-up, the mean Merle d'Aubigné Clinical Score of bone union and non-union were 14.1 and 15.3 points, respectively ($p = 0.48$). The 10-year survival rate, with the endpoint being revision surgery for pain, non-union, dislocation, or implant breakage, was 80.0% (95% confidence interval, 62.6–97.4%).

Discussion

There is a current overall worldwide increase in PPF incidence, and the cumulative probability is 3.5–4.0% at 20 years [1, 3, 4, 7]. The reason may be that the excellent results with THA have led to expanded indications for the procedure, including younger and more active patients, and more elderly patients [15]. Vancouver's classification is most commonly used for PPFs [6]. Type A fractures involve the trochanteric region and are subclassified into the A_G and A_L for the greater and lesser trochanter. Type B fractures are those around the stem, or slightly distal to the stem. Type C fractures are distal to the stem. Type B fractures are subclassified into B1 when the implant is stable, B2 when the implant is unstable, and B3 when the bone stock is inadequate. B2 and B3 fractures require revision to a longer stem, while B1 and C fractures can be commonly fixed with a locking plate. Although there are many reports of Vancouver type B or C fractures, Vancouver type A_G fractures are leading type of PPFs (Vancouver type A_G: 32.1%) [7]. Greater trochanter fractures mostly occurred with no known trauma; they were avulsion-type fractures treated non-operatively. However, the united greater trochanter following THA depends mainly on functional impairment and the magnitude of the proximal migration of the trochanteric fragment that requires fixation [8].

The fixation of the trochanteric fracture and non-union remains a challenge because a bone fragment is small despite being an important site for the attachment of the gluteus medius muscle. Various methods for trochanteric fixation after trochanteric fracture or osteotomy have been developed. Mei et al. [9], systematically reviewed 10,956 fixations following greater trochanteric osteotomies and fractures, and reported that the rate of non-union of a wire occurred in 4.2%, cable in 5.1%, the cable-plate system in 16.2%, claw or locking plate in 9.6%, and trochanteric bolt in 12.4%, respectively. However, this systematic review includes some reports of other "claw plates", and the trochanteric claw plate with the same concept as the current study was only reported from Cochin Hospital in France [11]. To the best of our knowledge, few other methods without the trochanteric claw plate have confirmed favorable results, including non-union, function, and pain. In particular, a small trochanteric fragment suits fixation using the trochanteric claw plate. Hamadouche et al. [11] demonstrated that the rate of non-union of the trochanteric claw plate occurred in 17%, only trochanteric claw plate in 25%, and trochanteric claw plate with vertical wires in 0%, respectively. Subsequently, Vastel et al. [10] also concluded that the unwanted effects of non-union can be minimized by trochanteric claw plate fixation, which significantly improves final hip function, even in cases of non-union of the greater trochanter. Although the trochanteric claw plate allows for more rigid fixation and earlier mobilization of patients (Table 3), other institutions have no reports. In this study, greater trochanteric fixation using a trochanteric claw plate after trochanteric fracture or osteotomy yielded successful results. However, in trochanteric fractures, the large hooks of a trochanteric claw plate sometimes result in postoperative pain, because a trochanteric claw plate was initially made for the non-union of the greater trochanter [16]. The hooks of a trochanteric claw plate are not fixated strongly, unlike screw fixations. Hence, it is essential to augment with UHMWPE fiber cables or others.

Table 3
Advantages and risks of fixation using a trochanteric claw plate

Advantages
(1) Large hooks allow a bone fragment to be captured with muscles
(2) No screw fixation around greater trochanter causes less irritation
(3) Plate can be bi-cortically fixed at the diaphysis
Risks
(1) Hook itself is not fixated strongly
(2) Large hooks sometimes result in postoperative pain

Trochanteric fracture and non-union have a relationship with surgical approaches in THA. Charnley popularized the use of trochanteric osteotomy, which was routinely performed in primary THA in 1960 and 1970 [17]. Currently, it is sometimes used for complex primary and revised THA. The reported rate of non-union following trochanteric osteotomy using steel wires ranges from 0.4–21% [18]. Consequently, many different wiring techniques have been developed. A trochanteric claw plate was developed to deal with non-union of the greater trochanter by Courpied from Cochin Hospital [16]. In addition, Dall [19] described the modified direct lateral approach, which retains a trochanteric bone fragment within the connection between the gluteus medius and vastus latralis. The reported rate of radiological complications after the modified Dall's approach was 13% [20]. Surgeons using a trochanteric osteotomy or its modifications routinely may have more experience with the fixation of non-union of the greater trochanter because they may encounter non-union following the osteotomy in practice. Furthermore, greater trochanteric fractures performed via direct anterior approach (DAA) have an incidence of approximately 29% [21]. This is because the greater trochanter is sometimes subjected to excessive load and stress due to the surgical procedure of lifting the femur to prepare for stem installation during surgery. There is no consensus on the treatment of greater trochanteric fractures following DAA. Intrinsically, post-operative fracture may be caused by intra-operative iatrogenic damage.

There were some limitations to this study. First, we retrospectively evaluated the patients without a control group. All the patients underwent the current technique. Furthermore, our follow-up period was limited to a minimum of 1 year. Continued follow-up will be required to establish the long-term outcomes of this procedure. Second, the sample size was relatively small, involving only 46 individuals. Third, all operations were performed by high-volume surgeons; the outcomes might have been difficult if the operations were performed by other surgeons. In addition, we used a modified Dall's approach in the primary THA and had some technical knowledge of the non-union of the greater trochanter.

Conclusion

Greater trochanteric fixation using a trochanteric claw plate yielded successful results, even though patients had non-union of the greater trochanter. However, some patients experienced pain and implant breakage following the fixation of a trochanteric claw plate.

Abbreviations

PPF
Periprosthetic fractures
THA
Total hip arthroplasty
UHMWPE
Ultra-high molecular weight polyethylene
DAA
Direct anterior approach.

Declarations

Ethics approval and consent to participate

As stated in the Methods section, Ethical approved of the study was provided by the Institutional Review Board (Kansai Medical University, date 06/09/2021/No. 2021152). All participants were informed of the study and signed a written informed consent. The study was conducted according to the ethical principles stated in the Declaration of Helsinki.

Consent to publish

Informed consent was obtained from all individual participants included in the study.

Available of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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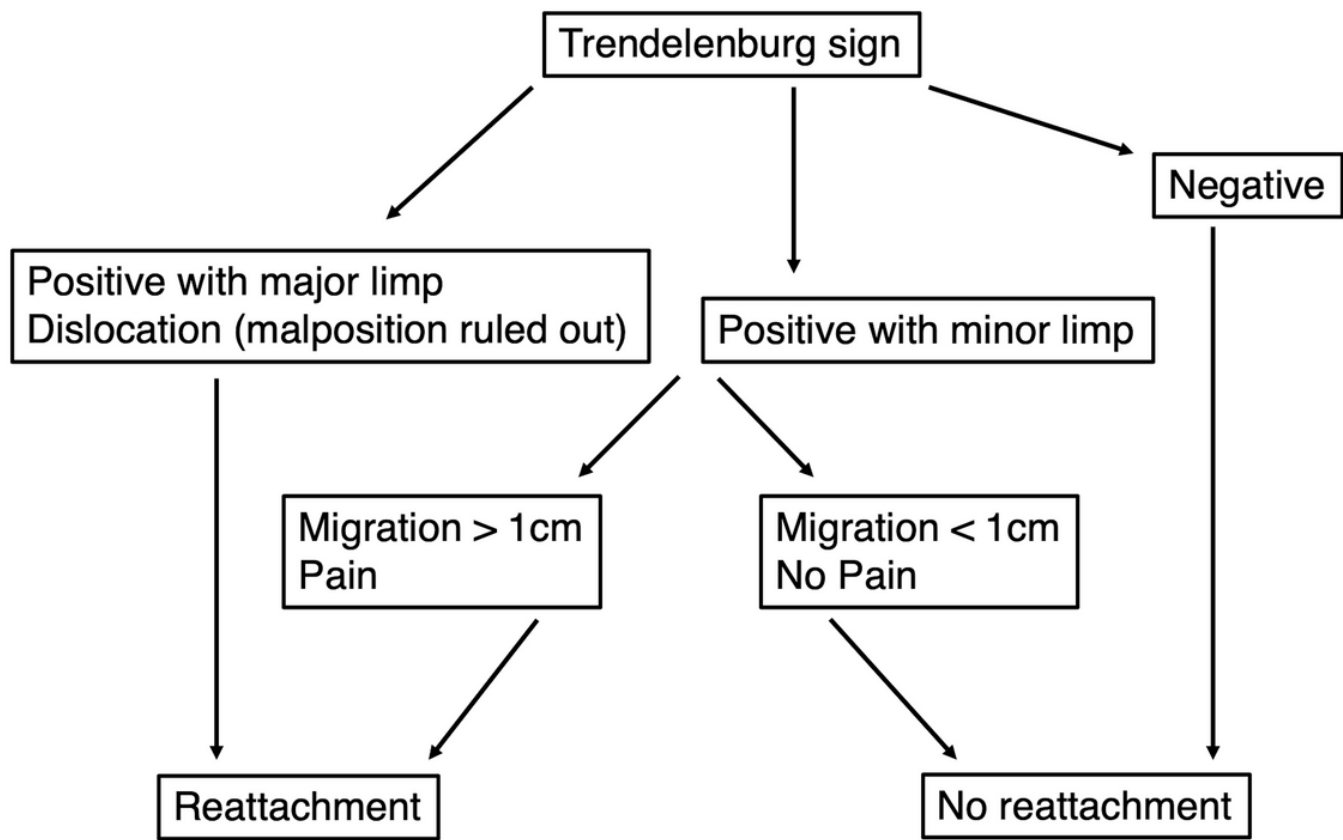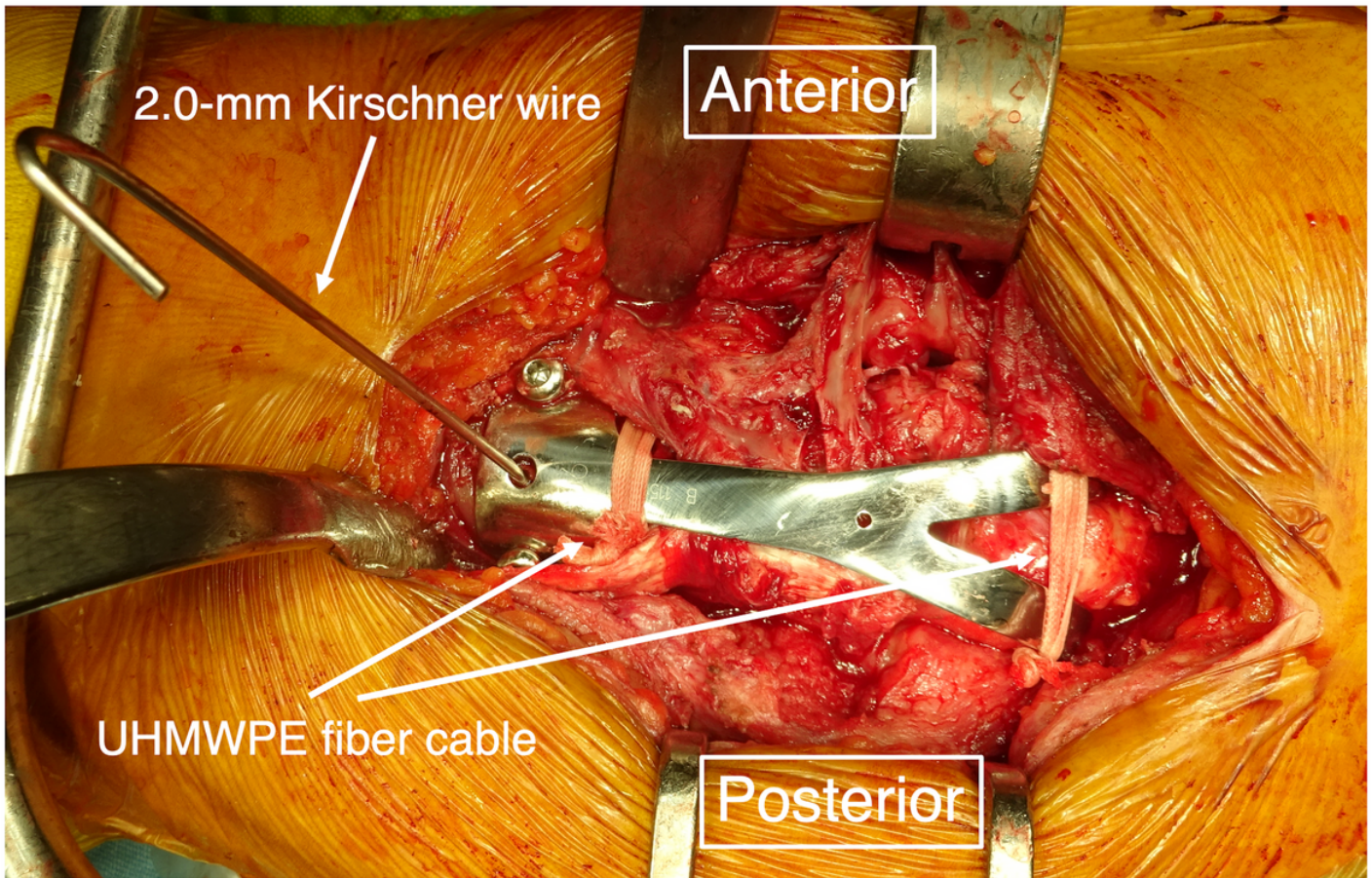
Figures

Figure 1

Treatment algorithm for non-union of the greater trochanter following total hip arthroplasty according to Hamadouche et al. [8]
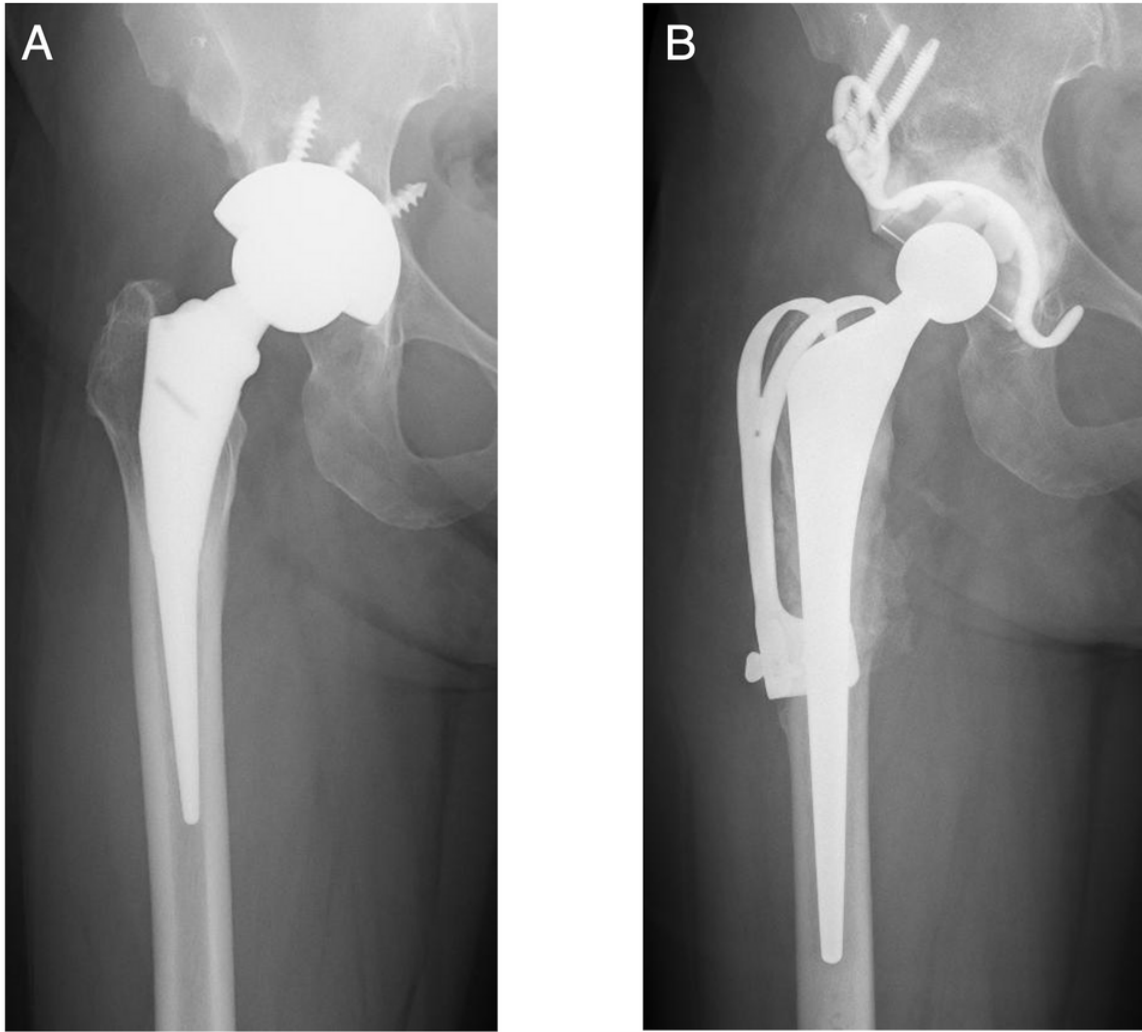
Figure 2

Photograph of the trochanteric claw plate (size: 80 mm). The proximal end of the trochanteric claw plate has two hooks that capture the trochanteric fragment, and its distal end has two convex flanges that appose to the femoral cortex

Figure 3

Intraoperative photograph of the left hip in the lateral position. An ultra-high molecular weight polyethylene (UHMWPE) fiber cable is circled around the femur with the claw plate, and another fiber cable is circled over the hooks and trochanteric fragment

Figure 4

Anteroposterior radiographs of a patient in whom a trochanteric claw plate was used for intra-operative fracture in a one-stage revision total hip arthroplasty (THA) because of periprosthetic infection. A: Primary THA was performed for secondary osteoarthritis 3 years ago. B: At 2 years after revision THA