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Technical note and surgical outcomes of percutaneous cable fixation in subtrochanteric fracture: A review of 51 consecutive cases over 4 years in two institutions

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ABSTRACT

Background: The main purpose of this study is to introduce our surgical technique and report surgical outcomes for percutaneous cable fixation in the treatment of subtrochanteric femoral fractures.
Methods: Between May 2013 and April 2017, 51 patients with subtrochanteric femoral fractures treated with closed intramedullary nailing and percutaneous cable fixation were enrolled in this study. Postoperative angulation, union rate, time from injury to union, and femoral shortening were also evaluated to assess radiologic outcomes. Clinical outcomes, including range of hip flexion, walking ability, and Harris hip score at the last follow-up were evaluated.
Results: Average coronal and sagittal angulation after surgery were 0.9 (range 0–5) and 0.3 (range 0–5), respectively. There was no postoperative angulation of more than 5°. Average shortening of the femur at 1-year follow-up was 2.7 mm (range 0–15). Bone union was achieved in 50 patients (98.0%) and average time to union was 18.6 weeks (range 12–48). Hip flexion, walking ability and Harris hip score at the last follow up were 115.6° (90–120), 7.9 (5–9), and 88.3 (65–100), respectively.
Conclusion: Percutaneous cerclage cable fixation can provide a greater likelihood of achieving anatomical reduction and increased stability of fracture, while preserving biology around the fracture site. Thus, percutaneous cerclage cable fixation can be an effective surgical technique for the treatment of complex subtrochanteric fractures.

Introduction

Cerclage wiring for treatment of subtrochanteric femoral fractures with long oblique or spiral fracture lines has been accepted as a good surgical technique to minimize fracture gap and improve fracture stability [1–6]. In particular, introduction of a percutaneous cerclage wire passer system has made it possible to perform this technique percutaneously, which can preserve blood supply around the fracture site without extensive soft tissue dissection [2,7]. However, cerclage wiring technique is at risk for wire breakage or difficulty achieving full compression of the fracture site in high-energy subtrochanteric femoral fractures because of the relatively lower biomechanical properties of wire [8–10]. Cable is known to have higher mechanical strength and provides better fixation stability than single looped wire [11]. However, since a percutaneous wire passer system does not allow direct passage of cables without the use of specially designed cable passing tube, more extensive soft tissue dissection may be inevitable for the application of cable when the passing tube is not available or a conventional cable passer is used.

We devised a simple method to pass cable percutaneously using a percutaneous cerclage wire system (Depuy Synthes, Oberdorf, Switzerland) and have applied this technique for treatment of complex subtrochanteric femoral fractures with long oblique or spiral fracture lines. This technique preserves biology around the fracture, improves the quality of reduction, and provides greater stability than wire fixation, which maximize the load sharing properties of an intramedullary nail [11–13]. Thus, we hypothesized that this technique can improve surgical outcomes in patients with complex subtrochanteric femoral fractures. The main purpose of this study is to introduce our surgical technique and report surgical outcomes for percutaneous cable fixation in the treatment of subtrochanteric femoral fractures.

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Materials and methods

Study population

This study followed the guidelines of the Declaration of Helsinki and institutional review board approval was obtained. This multicenter, retrospective observational study was conducted in two tertiary university hospital with a level I trauma center. Between May 2013 and April 2017, 51 patients with subtrochanteric femoral fractures treated with closed intramedullary nailing and percutaneous cable fixation were enrolled in this study. We excluded those with simple subtrochanteric fractures that would not be suitable for cable fixation, such as transverse and short oblique fractures. Open fractures, pathologic fractures, and patients with less than one year of follow-up were also excluded. A subtrochanteric fracture was defined when the main fracture line was located within the subtrochanteric region, defined as the area from the lesser trochanter to 5 cm distal [14]. The indications for percutaneous cable fixation were a long spiral or oblique fracture, fracture with a large wedge fragment, and some comminuted fractures [2].

Surgical technique and postoperative care

All operations are performed with the patient in supine position on a radiolucent fracture table with proper traction under fluoroscopy. In order to achieve rotational alignment of the femur, the patella should be positioned neutrally or slightly medially. In the majority of cases, it would be difficult to achieve adequate closed reduction of flexed, externally rotated, and abducted proximal fragments using only simple traction. Thus, minimally invasive reduction technique should be applied using a long Kelly

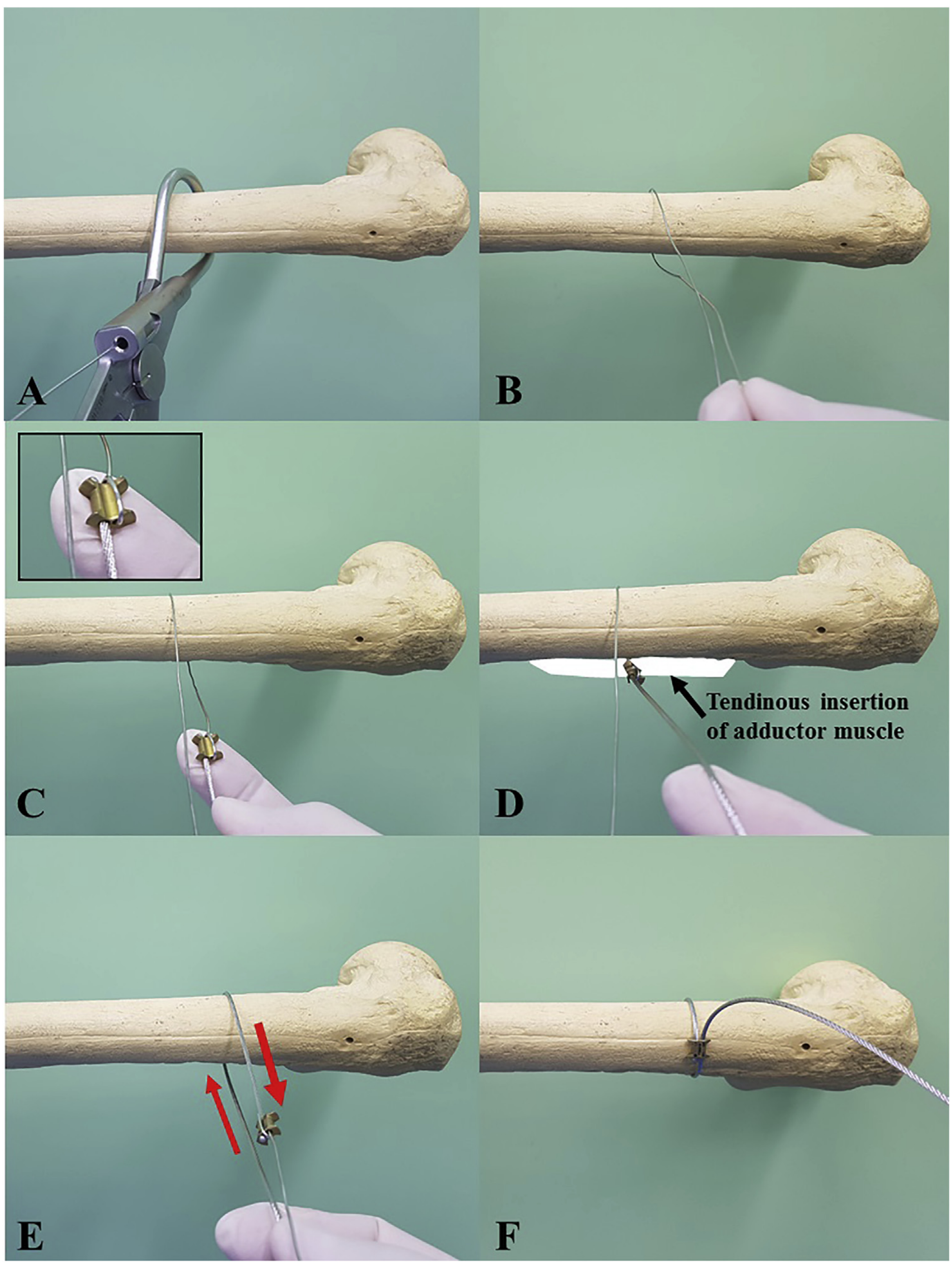

Fig. 1. Surgical techniques for percutaneous cerclage cable fixation. (A, B) After the two connecting parts of percutaneous wire passer system have been brought together, wire is pushed through the tube of the closed cerclage passer. (C, D, E) Cable can be passed using this wire percutaneously. (F) Cable is tensioned using the cable tensioner.

Forceps, Hoffman retractor, Schanz screw, bone holding clamp, and collinear clamp.

Percutaneous cable fixation should be conducted after proper reduction of a proximal fragment, because rotational alignment is the key to achieving accurate compression of fracture site. The initial step in percutaneous fixation is to determine the best location for the cable under fluoroscopy. The cable should be positioned in the middle of the long fracture line. The cerclage tunneling device is inserted both dorsally and ventrally around the femur to prepare the way and facilitates the passage of the percutaneous cerclage wire passer. One-half of the cerclage passer is inserted, then the other by following the prepared soft tissue tunnels. After the two connecting parts have been brought together, wire is pushed through the tube of the closed cerclage passer. Cable can be passed using this wire percutaneously. The dorsal end of the wire is temporarily tied with the crimp of the cable. After the crimp is placed just lateral to the linea aspera, which is the insertion site for the thick adductor thigh muscles, cable can be taken out ventrally by pulling over the wire. If the ventral end of the wire is tied with the crimp of the cable, it would be difficult to pass the crimp through the thick tendinous insertion of adductor thigh muscles. After inserting the end of the cable through the free hole of the crimp, cable is tensioned by turning the fluted knob on the cable tensioner. For more accurate reduction of a fracture and insertion of intramedullary nail, tension applied to the cable fixation should not be too tight (Fig. 1). Closed intramedullary nailing is performed according to the manufacturer's guideline and conventional fracture fixation concept. We used Expert Antegrade Femoral Nail (A2FNs) with two recon screws (Depuy Synthes, Oberdorf, Switzerland), long proximal femoral nail antirotation (PFNA; Depuy Synthes, Oberdorf, Switzerland), and long cephalomedullary nails (CM nail; Zimmer, Warsaw, USA) based on the fracture geometry and canal width. After confirmation of proper rotational alignment and reduction of fracture using fluoroscopy or the surgeon's reduction finger, cable is finally tensioned for full compression of the fracture site. Finally, distal locking screws for intramedullary nailing are inserted (Figs. 2 and 3).

All patients were encouraged to perform quadriceps-strengthening and straight-leg-raising exercises postoperatively. After removal of drains at 48 h postoperatively, passive knee and hip range of motion exercises were initiated. Partial weight bearing using crutches was allowed as tolerated for the first 6 weeks, and weight bearing was gradually increased based on evidence of callus formation on follow-up radiography.

Radiologic and clinical assessment

Preoperative characteristics, including age, sex, American Society of Anesthesiologists (ASA) class, fracture type, injury severity score (ISS), and walking ability before injury were assessed. Postoperative data included operation time, number of cerclage cables used, types of intramedullary nails, and blood loss. Coronal and sagittal angulation was assessed on anteroposterior (AP) and lateral plain radiographs obtained immediately after surgery. Union rate, time from injury to union, and femoral shortening were also evaluated to assess radiologic outcomes. Clinical outcomes, including range of hip flexion, walking ability, and Harris hip score at the last follow-up were evaluated. Two orthopedic surgeons confirmed fracture union defined as full painless weight bearing with bridging callus across at least three cortices on AP and lateral views of the femur. Orthoroentgenography was used at the 1-year follow-up to measure shortening of the femur [15]. Walking ability was graded from 0 to 9 using the mobility score of Parker and Palmer, which reflects the sum of the ability to walk indoors and outdoors and to participate in social activities [16].

Result

Preoperative characteristics of all patients are presented in Table 1. Of 51 patients enrolled in this study, 34 were men (66.7%) and their mean age was 57.8 years (range 17–86). Average follow-up period was 18.8 months (range 12–36). There were 22 long spiral fractures, 14 fractures with a large wedge fragment, 8 comminuted fractures, and 7 long oblique fractures. Average ISS was 21.0 (range 9–41) and mobility score before injury was 8.6 (range 7–9).

Single cerclage cables were used in 29 patients (56.8%), with 2 cables used in 20 patients (39.2%), and 3 cables in 2 patients (3.9%).

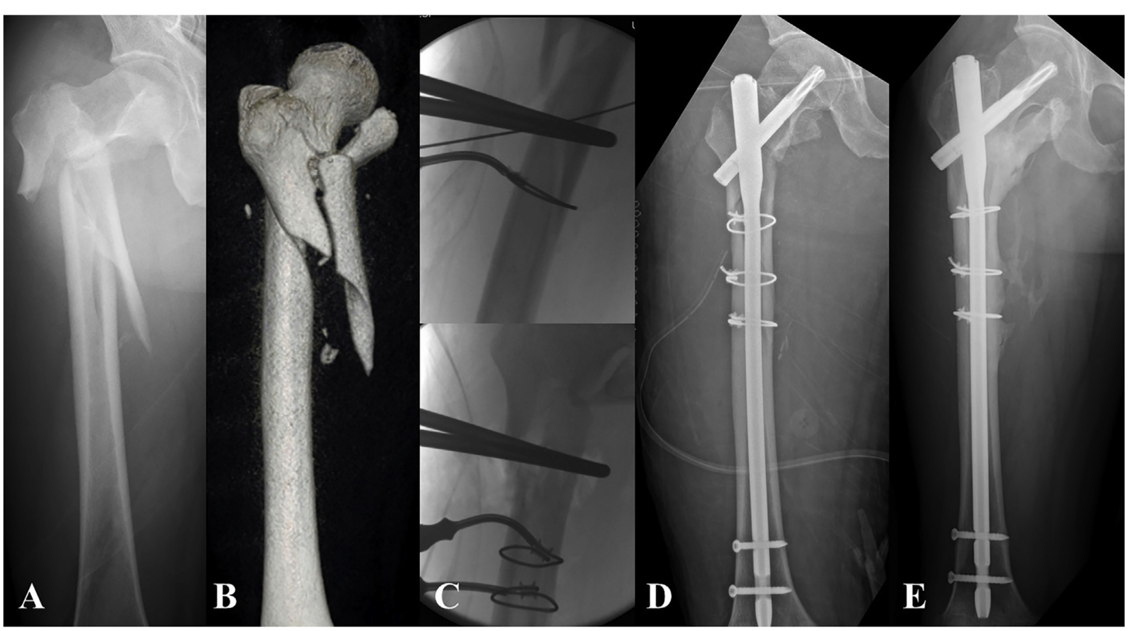

Fig. 2. (A, B) A 47-year-old male patient with subtrochanteric fracture with large spiral wedge fracture and intertrochanteric fracture. (C) Intraoperative fluoroscopic imaging showing the percutaneous cerclage cable fixation using percutaneous wire passer system. (D) Postoperative radiograph. (E) Fracture union with callus formation at 10 months after surgery.

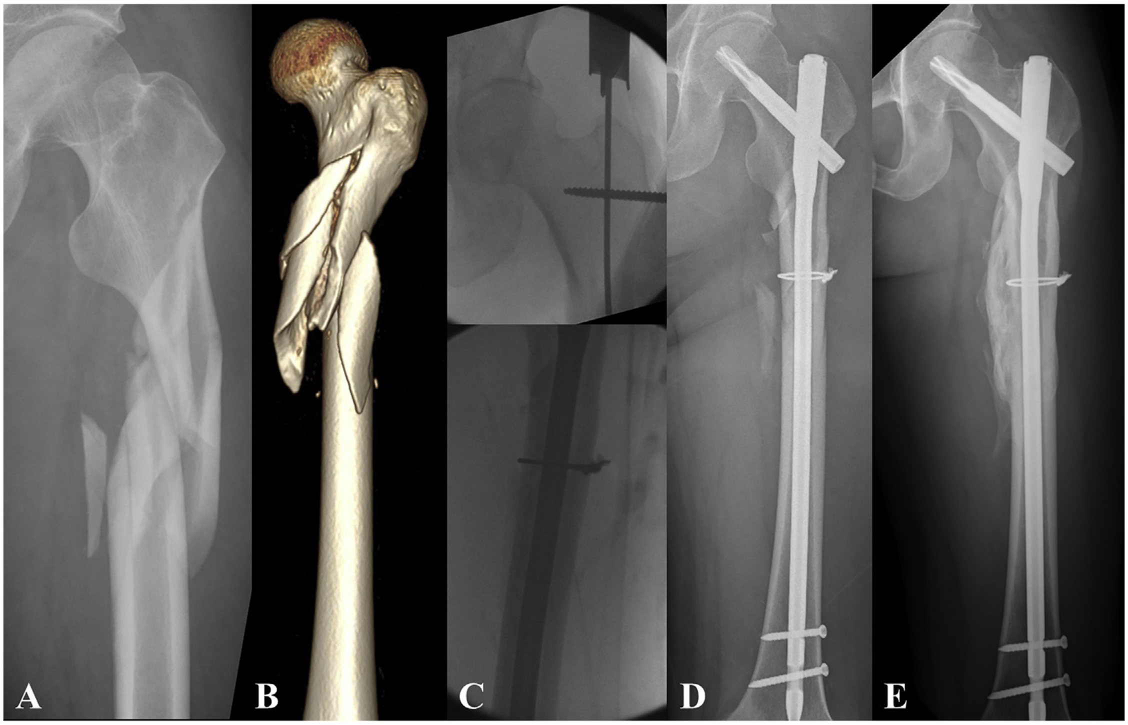

Fig. 3. (A, B) A 68-year-old male patient with subtrochanteric fracture with comminution. (C) Intraoperative fluoroscopic imaging showing the percutaneous cerclage cable fixation after reduction of proximal fragment using minimally invasive technique. (D) Postoperative radiograph. (E) Fracture union with callus formation at 9 months after surgery.

Table 1
Preoperative characteristics of all patients with subtrochanteric fracture treated with closed intramedullary nailing and percutaneous cable fixation.

Variables	Union
No. of patients	51
Sex, female, No. (%)	17 (33.3)
Age at the surgery, year	57.8 ± 19.1 (17 - 86)
Follow up period, month	18.8 ± 7.1 (12 - 36)
Affected hip, Right, No. (%)	29 (56.9)
ASA, No. (%)	37 (72.5)
I, II	14 (27.5)
III, IV	
Type of fracture No. (%)	22 (43.1)
Long spiral fracture	14 (27.5)
Frsssacture with large wedge fragment	8 (15.7)
Comminuted fracture	7 (13.7)
Long oblique fracture	
Injury severity score	21.0 ± 9.2 (9 - 41)
Preinjury mobility score	8.6 ± 0.7 (7 - 9)

Values are presented as mean (range), or number (%).
ASA; American Society of Anesthesiologists.

Long PFNAs were used in 44 patients (86.3%), with long CM nail used in 4 patients (7.8%), and A2FN in 3 patients (5.9%). Average operative time was 149 min (range 40–265) and average intra-operative blood loss was 500 cc (range 100 – 1000). Average coronal and sagittal angulation after surgery were 0.9 (range 0–5) and 0.3 (range 0–5), respectively. There was no postoperative angulation of more than 5°. Average shortening of the femur at 1-year follow-up was 2.7 mm (range 0–15). Bone union was achieved in 50 patients (98.0%) and average time to union was 18.6 weeks (range 12–48). Hip flexion, walking ability and Harris hip score at the last follow up were 115.6° (90–120), 7.9 (5–9), and 88.3 (65–100), respectively (Table 2). Complications, including infection, cut-out, or cut-through of a helical blade or hip screw were not identified during the follow-up period.

Table 2
Surgical outcomes, including postoperative data, radiologic outcome, and clinical outcomes in patients with subtrochanteric fracture treated with closed intramedullary nailing and percutaneous cable fixation.

Variables	Outcomes
Number of cerclage cables used, no. (%)	29 (56.8)
1	20 (39.2)
2	2 (3.9)
3	
Types of intramedullary nail, no. (%)	44 (86.3)
Long PFNA	4 (7.8)
Long CM nail	3 (5.9)
A2FN	
Time of operation, min	149.0 ± 52.1 (40 - 265)
Intraoperative blood loss, cc	500 ± 236.5 (100 - 1000)
Postoperative angulation, °	0.9 ± 1.6 (0 – 5)
Coronal angulation	0.3 ± 1.0 (0 – 5)
Sagittal angulation	
Shortening at 1 year follow up, mm	2.7 ± 3.9 (0 – 15)
Union, no. (%)	50 (98.0)
Time to union, week	18.6 ± 7.1 (12 - 48)
Walking ability at the last follow up	7.9 ± 1.4 (5 - 9)
Harris hip score at the last follow up	88.3 ± 10.4 (65 - 100)

Values are presented as mean (range), or number (%).
PFNA; Proximal femoral nail antirotation, CM; cephalomedullary, A2FN; expert Asian femoral nail.

Discussion

We performed closed intramedullary nailing and percutaneous cerclage cable fixation in 51 patients with long spiral or oblique subtrochanteric fracture and subtrochanteric fracture with large wedge fragment, and comminuted subtrochanteric fractures that were considered suitable for cerclage cable fixation. In this study, we observed 98% bone union without any complication at an average 18.6 week of follow-up.

Table 3
Comparative results with previous studies published.

Authors	Age	Number	Enrollment	Surgical methods	Non-union	Time to union
Kenedy et al. [1]	35.4	16	Long oblique fracture	Closed nailing with conventional cerclage cable	1 (6.2%)	within 6 months except one nonunion
Ban et al. [12]	82.0	60	A2 (22, 23) 18 A3 (31, 33) 35 A32 7	Closed nailing with conventional wires or cables	8 (13.1%)	–
Jang et al. [17]	58.7	28	31 A (31/32/33) 3/1/3 32 A (1/2/3) 3/3/6 32B (1/2/3) 2/0/1 32C (1/2/3) 0/1/5	Biologic plating with locking compression plate	1 (3.6%)	5.4 months
Kim et al. [2]	48.3	12	Long oblique or spiral fracture, comminuted fracture considered to be suitable for cable fixation	Closed nailing with percutaneous cerclage wiring	0 (0%)	19.1 weeks
Our study	57.8	51	Long oblique or spiral fracture & fracture with larger wedge fracture, comminuted fracture considered to be suitable for cable fixation	Closed nailing with percutaneous cerclage cable	1 (2.0%)	18.6 weeks

We believe that percutaneous cerclage cable fixation has definite advantages, especially in the treatment of complex subtrochanteric fractures. First, cable can provide greater fixation stability than wire fixation. This was demonstrated in a report by Mark et al. that cable cerclage showed higher fixation strength compared to wire cerclage [11]. Kim et al. reported a technical note with clinical results for percutaneous cerclage wiring followed by intramedullary nailing for the treatment of subtrochanteric femoral fractures [2]. Although they reported that all 12 cases healed without a bone graft at an average of 19.1 weeks after surgery, there still exist serious concerns that wire can be broken or provide inadequate stability to achieve full compression of a fracture especially in high-energy injury or young patients. Broken wire or insufficient fractrure fixation may cause instability around the fracture site, which is directly associated with hypertrophic nonunion.

Conventional cable fixation technique is at risk for damage of biology around the fracture site due to excessive soft tissue dissection and vascular disruption. However, Apivatthakakul et al demonstrated that percutaneous cerclage wiring showed minimal disruption of the femoral blood supply in their cadaveric injection study [13]. In addition, our technique allowed the cable passage percutaneously with minimal soft tissue dissection, which can preserve biology around the fracture and aid undisturbed fracture healing. In this study, 98% of patients achieved bone union at an average of 18.6 weeks after surgery. Although it is not possible to directly compare this result to that of other studies, we believe that our surgical results are remarkable considering that most cases are high-energy injuries with mean ISS of 20.0. Further, it seems that our study showed better outcomes compared with that of some previous studies in which conventional open techniques were used [1,12] (Table 3).

Stronger biomechanical properties of cerclage cable fixation can enhance compression of fracture sites. This advantage can make it possible to achieve nearly anatomical reduction and provide maximum stability at the fracture site. Average coronal and sagittal angulation values after surgery in our study were only 0.9 and 0.3, respectively. This excellent postoperative alignment can minimize the possibility of fixation failure, which can allow early rehabilitation after surgery. Mean shortening of the femur was 2.7 mm and 3 patients showed significant shortening more than 10 mm. However, this is because we enrolled 8 patients with comminuted fractures; there were no cases with femoral shortening more than 10 mm in other type of subtrochanteric fracture.

The major limitations of our study are as follow. We could not prove the superiority of our surgical technique regarding the use of cables, types of intramedullary nail used, and closed or open procedures, because this study used non-comparative design. However, this study showed comparable or better surgical outcomes than that of some previous studies regarding bone union, postoperative alignment of the femur, and clinical score, even though we enrolled many high-energy injuries, including 8 comminuted fractures, with mean ISS of 20.0 [2,17]. Further, this study was conducted in two tertiary university hospitals with a level I trauma center, which made it possible to collect 51 consecutive subtrochanteric fractures with the same treatment protocol over a period of 4 years. We believe that the numbers of enrolled cases in the present study are relatively larger than that of previous case series about subtrochanteric fractures treated with closed intramedullary nailing and cerclage wiring [1,2,12,17].

Although there are some previous reports on cerclage wire or cerclage cable for the treatment of subtrochanteric fracture, to the best of our knowledge, this is the first study to report the surgical outcomes of percutaneous cable fixation. We not only reported surgical outcomes of our technique but also focused on introducing our surgical technique with a detailed demonstration. Because this is a simple, easy, and practical surgical method that can even be used when a cable passing tube is not available, we expect that many orthopedic surgeons can apply this technique for the treatment of complex subtrochanteric femoral fracture.

Conclusion

This study demonstrated that closed intramedullary nailing and percutaneous cerclage cable fixation showed good surgical outcomes in patients with complex subtrochanteric femoral fractures. Percutaneous cerclage cable fixation can provide a greater likelihood of achieving anatomical reduction and increased stability of fracture, while preserving biology around the fracture site. Although further comparative study is needed, percutaneous cerclage cable fixation can be an effective surgical technique for the treatment of complex subtrochanteric fractures.

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

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

References

[1] Kennedy M.T., Mitra A, Hierlihy TG, Harty JA, Reidy D, Dolan M. Subtrochanteric hip fractures treated with cerclage cables and long cephalomedullary nails: a review of 17 consecutive cases over 2 years. Injury 2011;42(11):1317–21.

[2] Kim JW, Park KC, Oh JK, Oh CW, Yoon YC, Chang HW. Percutaneous cerclage wiring followed by intramedullary nailing for subtrochanteric femoral fractures: a technical note with clinical results. Arch Orthop Trauma Surg 2014;134(9):1227–35.

[3] Hoskins W, Bingham R, Joseph S, Liew D, Love D, Bucknill A, et al. Subtrochanteric fracture: the effect of cerclage wire on fracture reduction and outcome. Injury 2015;46(10):1992–5.

[4] Tomas J, Teixidor J, Batalla L, Pacha D, Cortina J. Subtrochanteric fractures: treatment with cerclage wire and long intramedullary nail. J Orthop Trauma 2013;27(7):e157–60.

[5] Muller T, Topp T, Kuhne CA, Gebhart G, Ruchholtz S, Zettl R. The benefit of wire cerclage stabilisation of the medial hinge in intramedullary nailing for the treatment of subtrochanteric femoral fractures: a biomechanical study. Int Orthop 2011;35(8):1237–43.

[6] Kilinc BE, Oc Y, Kara A, Erturer RE. The effect of the cerclage wire in the treatment of subtrochanteric femur fracture with the long proximal femoral nail: a review of 52 cases. Int J Surg 2018;56:250–5.

[7] Apivatthakakul T, Siripipattanamongkol P, Oh CW, Sananpanich K, Phornphutkul C. Safe zones and a technical guide for cerclage wiring of the femur: a computed topographic angiogram (CTA) study. Arch Orthop Trauma Surg 2018;138(1):43–50.

[8] Perren SM, Fernandez Dell'oca A, Regazzoni P. Fracture fixation using cerclage, research applied to surgery. Acta Chir Orthop Traumatol Cech 2015;82(6):389–97.

[9] Leonardi F, Rivera F. Intravascular migration of a broken cerclage wire into the left heart. Orthopedics 2014;37(10):e932–5.

[10] Ritter MA, Lutgring JD, Davis KE, Berend ME, Meding JB. A clinical, radiographic, and cost comparison of cerclage techniques: wires vs cables. J Arthroplasty 2006;21(7):1064–7.

[11] Lenz M, Perren SM, Richards RG, Muckley T, Hofmann GO, Gueorguiev B, et al. Biomechanical performance of different cable and wire cerclage configurations. Int Orthop 2013;37(1):125–30.

[12] Ban I. Circumferential wires as a supplement to intramedullary nailing in unstable trochanteric hip fractures. Acta Orthop 2013;84(2):227-.

[13] Apivatthakakul T, Phaliphot J, Leuvitoonvechkit S. Percutaneous cerclage wiring, does it disrupt femoral blood supply? A cadaveric injection study. Injury 2013;44(2):168–74.

[14] Robinson CM, Houshian S, Khan LA. Trochanteric-entry long cephalomedullary nailing of subtrochanteric fractures caused by low-energy trauma. J Bone Jt Surg Am 2005;87(10):2217–26.

[15] Corrales LA, Morshed S, Bhandari M, Miclau 3rd T. Variability in the assessment of fracture-healing in orthopaedic trauma studies. J Bone Jt Surg Am 2008;90(9):1862–8.

[16] Shin WC, Moon NH, Jang JH, Lee HJ, Suh KT. Comparative study between biologic plating and intramedullary nailing for the treatment of subtrochanteric fractures: is biologic plating using LCP-DF superior to intramedullary nailing? Injury 2017;48(10):2207–13.

[17] Jang JH, Ahn JM, Lee HJ, Moon NH. Surgical outcomes of biologic fixation for subtrochanteric fracture using locking compression plates. Hip Pelvis 2017;29(1):68–76.