Locked Nailing for Shortened Subtrochanteric Nonunions

A One-stage Treatment

Chi-Chuan Wu MD

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Abstract Subtrochanteric nonunions may involve considerable shortening. A convincing method of concomitantly treating both combined disorders has not been reported. Twenty-three consecutive patients with these combined disorders were treated by femoral condylar skeletal traction, one-stage lengthening to 4 cm maximum, static locked nail stabilization, and corticocancellous bone grafting. Indications for this technique included subtrochanteric aseptic nonunions, patient younger than 60 years, and 2.0 to 5.0 cm shortening. Postoperatively, protected weightbearing ambulation was encouraged as early as possible. Twenty-one patients were followed for a minimum of 1.2 years (mean, 3.2 years; range, 1.2–6.7 years). All nonunions healed with a union rate of 100% (21 of 21) and a median union period of 4.0 months (range, 3.5–11 months). One nonunion healed at 11 months despite nail breakage. In all patients, hip function improved from unsatisfactory grades preoperatively to satisfactory grades at latest followup. Knee function grade remained satisfactory throughout the treatment course in all patients. Although no surgical technique has clearly proven superior in treating subtrochanteric nonunions associated with

considerable shortening, the described approach may be the optimal treatment alternative. Protected weightbearing to reduce nail stress throughout the treatment course improves the success rate.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Subtrochanteric nonunions normally caused by failed treatment of subtrochanteric fractures are seldom reported [2, 5]. The anatomic boundary of the subtrochanteric region of the femur has not been concordantly defined. A study by Fielding classified subtrochanteric fractures into three types: Type 1, fracture between the upper and lower borders of the lesser trochanter; Type 2, fracture within one inch distal to Type 1; and Type 3, fracture within one inch distal to Type 2 [7]. Biomechanically, the femur immediately distal to the subtrochanter sustains maximal bending stress in daily activity [12]. Plating or intramedullary nailing reportedly achieves high union rates in subtrochanteric fractures [16, 20]. However, once subtrochanteric nonunions occur, implants in place are likely to fail.

Subtrochanteric aseptic nonunions are treatable by either plating or intramedullary nailing [9]. Treatment of subtrochanteric aseptic nonunions is rarely reported and sample sizes in published studies have been small [2, 4, 5, 9]. Each technique offers unique clinical advantages and disadvantages, and neither has clearly proven superior. In subtrochanteric aseptic nonunions associated with considerable shortening (greater than 2 cm) [21], concomitantly treating combined disorders may be very complex. Simultaneous treatment of these combined disorders,

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C.-C. Wu (✉)

Department of Orthopedics, Chang Gung Memorial Hospital,
Chang Gung University, 5 Fu-Hsin Street, 333, Kweishan,
Taoyuan, Taiwan
e-mail: ccwu@mail.cgu.edu.tw

regardless of techniques used, is rarely reported. Biomechanically, traditional plates generally cannot be used in the lengthening procedure as a result of loss of the abutment of the medial cortex [1, 8]. Without following the tension band principle, plates easily break. Although locking plates also may be used in the lengthening procedure, the effectiveness for combined disorders has not been evaluated. Biomechanically, intramedullary nailing should be feasible for treating combined disorders. In the medical literature, one-stage lengthening using locked nails to treat combined disorders in femoral shafts has been reported to be successful [21]. This technique also might be applied in the subtrochanteric region with combined disorders. The purpose of this retrospective study was to evaluate the success rate, complications, and degrees of difficulty using locked nailing to treat combined disorders in a one-stage approach. Ideally, a viable surgical technique for concomitantly treating combined disorders could be developed.

Materials and Methods

From February 1998 to May 2004, 23 consecutive adult (older than 15 years) patients with subtrochanteric aseptic nonunions and shortening of 2.0 to 5.0 cm were treated by the described technique at my institution. Twenty-one patients were followed for at least 1 year (median, 3.2 years; range, 1.2–6.7 years). Two patients could not be contacted and were excluded from this study and the remaining 21 patients constituted the study group. All the procedures were performed by the author. Patients' ages were 19 to 56 years (median, 36 years) and the male-to-female ratio was three to one (Table 1).

All subtrochanteric nonunions resulted from failed treatment of acute subtrochanteric fractures and all fractures were the result of motor vehicle accidents. All fractures remained unhealed after one to six surgical treatments. No deep infection had occurred. Eleven nonunions were Fielding Type 2 and 12 were Type 3. No Type 1 nonunions were noted. Time from injury to revision surgery was 1.2 to 6.5 years (median, 1.8 years). Shortening was 2.0 to 5.0 cm (median, 2.5 cm). I evaluated leg-length discrepancy by spinomalleolar distance with or without a scanogram [21]. Prior implants included sliding compression screws and locked or unlocked intramedullary nails. Seven patients had a history of failed implants. All patients had nearly normal range of motion (ROM) in the hip and the knee. Although none required regular use of walking aids, all patients had various degrees of limping and proximal thigh pain.

Indications for the described technique included subtrochanteric nonunions, absence of deep infection, age

Table 1. Clinical data for 23 patients

Patient number	Gender	Age (years)	Time since injury (years)	Operating times	Preoperative shortening (cm)
1	M	22	1.6	2	2.5
2	F	56	6.5	6	4.5
3	M	42	2.3	1	3.0
4	M	36	2.0	2	5.0
5	M	27	1.4	3	3.5
6	F	38	1.8	2	2.5
7	M	30	2.0	2	3.0
8	M	52	2.2	3	3.0
9	M	33	1.8	1	2.5
10	M	46	1.5	3	4.0
11	F	48	2.0	2	2.0
12	M	44	2.4	2	3.5
13	F	36	1.8	2	3.0
14	F	28	1.6	1	2.5
15	M	42	2.2	2	2.0
16	M	22	2.2	1	2.5
17	M	19	1.4	1	2.5
18	M	21	1.8	2	2.0
19	M	38	2.2	3	3.0
20	F	28	1.2	1	2.5
21	M	43	3.2	3	3.0
22	M	32	1.8	2	2.5
23	M	36	1.5	1	2.0

M = male; F = female.

younger than 60 years, and shortening of 2.0 to 5.0 cm. Shortening exceeding 5.0 cm was considered unsuitable for one-stage lengthening, and therefore, patients with this amount or greater shortening were excluded from the study [21]. Patients older than 60 years were advised against lengthening and also were excluded.

The leukocyte count, erythrocyte sedimentation rate, and C-reactive protein were examined routinely in all patients. Patients with nonunions with suspected latent infection were treated by external fixation and excluded from this study. In this study, all of the described laboratory tests in the 23 study patients were within the normal range.

After general anesthesia by endotracheal intubation, patients were positioned on a fracture table in the lateral decubitus position. A 2.4-mm Kirschner wire was inserted in the femoral condyle for skeletal traction. A massive corticocancellous bone graft was procured from the posterior iliac crest first. The outer table of the posterior iliac crest was peeled off with an osteotome and cancellous bone graft was harvested with a gouge. The volume of graft obtained varied between individuals but ranged from 25 to

30 mL. The subtrochanteric nonunion site was approached directly. Prior implants were removed as completely as possible and the nonunion site was thoroughly débrided. A spinal spreader was placed between bony fragments to aid lengthening. Traction was increased gradually as the femur was lengthened. The increased bony gap determined the extent of lengthening. After achieving the desired length, traction was fixed and the spinal spreader was removed. A flexible guide wire was inserted from the piriformis fossa to the distal fragment under direct vision. The marrow cavity was reamed as widely as possible using strong resistance as the criteria for adequate reaming. The locked nails were overreamed by 1 mm (Grosse-Kempf locked nail; Howmedica, Kiel, Germany; or Russell-Taylor locked nail; Smith & Nephew, Memphis, TN). Nail sizes were 12 to 14 mm ensuring the use of the larger size of locked screws. The static mode of nailing was used with one proximal and two distal locked screws inserted under visual guidance by an image intensifier. Corticocancellous bone graft was packed (morselized) in the nonunion site and the wound was closed with nonabsorbable sutures. A closed drain might be inserted depending on the amount of local bleeding.

Postoperatively, patients were encouraged to ambulate with protected weightbearing as early as possible. Physical activity involving full hip and knee ROM was encouraged. Patients were followed up at the outpatient department at 4- to 6-week intervals. Clinical and radiographic examinations were performed to assess healing. The author performed all followups independently. Use of crutches was advised until the nonunion healed. Patients then were followed up annually and whenever necessary.

A fracture union was defined as clinical lack of pain and tenderness, ability to walk without aids, and radiographic evidence of solid callus bridging the fracture site [11]. A nonunion was defined as a fracture remaining unhealed 1 year after treatment or requiring additional surgery to achieve a union [14].

Hip function was evaluated using the Epstein scoring system [6], and knee function was evaluated by the scoring system described by Mize et al. [13]. A satisfactory result included an excellent or good grade. Both scoring systems were used because of their simplicity and relative practicality. An excellent grade in hip score included no pain, full ROM, and no limp. A good grade included no pain, 75% ROM, and a slight limp. An excellent grade in knee score included flexion loss less than 10°, full extension, no angular or rotational deformity, and no pain. A good grade included no more than one of the following: greater than 20° flexion loss, greater than 10° extension loss, greater than 10° angular or rotational deformity, or minimal pain.

The McNemar test was used for statistical comparison of a union rate or hip function outcome between presurgery and postsurgery. A probability < 0.05 was considered statistically significant.

Results

A high union rate was achieved. The union rate was 100% (21 of 21) with a median union period of 4.0 months (range, 3.5–11.0 months; Fig. 1). All 21 nonunions healed within 1 year.

Fig. 1A–D (A) A 56-year-old woman had six unsuccessful surgical procedures to correct a left Type 3 subtrochanteric nonunion with shortening of 4.5 cm for 6.5 years. (B) The combined disorders were treated successfully using the described technique, and (C) the nonunion healed at 4.0 months. (D) Satisfactory hip and knee function were observed at the 5.8-year followup.

All surgical procedures were completed without intraoperative complications or delays. Median operating time was 2.2 hours (range, 1.8–2.8 hours) and median blood loss was 600 mL (range, 300–1200 mL).

The complication rate was low (4.8%). One locked nail breakage occurred, but it did not affect the treatment course. All patients required hospitalization for approximately 1 week. No patients required additional surgery. No nonunions, deep infections, malunions (shortening greater than 2 cm, rotational or angular deformity greater than 10°), or neurologic injuries were noted [19]. One patient sustained nail breakage at the proximal end of the nail slot (Fig. 2). This was attributable to the patient discontinuing the use of crutches 5 months postoperatively as a result of a working requirement. Nail breakage was found at 8 months during clinical followup. Because this patient had no symptoms, restriction of activity was advised, as was continued followup. The nonunion healed 3 months later without a second surgery. At latest followup, no complications of the bone graft donor site were noted.

Leg-length discrepancy and function of the hip and knee were corrected as planned. At latest followup, femoral shortening in all patients had been corrected to 0 to 1.0 cm (Table 2). All hips and knees exhibited almost full ROM. Hip flexion-extension averaged 138° with a range of 120° to 150°. Hip adduction-abduction averaged 65° with a range from 50° to 75°, whereas internal-external rotation averaged 62° with a range from 50° to 75°. Knee flexion-extension was maintained at an average of 130° (range,

120°–140°) throughout the treatment course [10]. Before revision surgery, hip function in all patients was graded unsatisfactory as a result of regular pain and limited walking ability. At latest followup, hip pain had subsided and all patients had resumed normal daily activities. The improvement of hip function between before and after surgery was statistically significant ($p < 0.001$). Knee function was satisfactory in all patients before and after revision surgery. All patients had achieved a normal gait at latest followup.

Discussion

In this study, subtrochanteric aseptic nonunions with shortening of 2.0 to 5.0 cm were treated effectively by one-stage lengthening using a locked nailing technique. Both combined disorders were corrected concomitantly and satisfactorily.

According to some reports, one-stage femoral lengthening should not exceed 4 cm to minimize neurovascular complications [17, 18, 21]. Therefore, in this study, femoral shortening was limited to 5 cm. A normal gait usually can be restored if shortening by revision surgery is limited. Shortening exceeding 5 cm normally requires gradual lengthening with external fixation.

Because similar techniques have not been reported for subtrochanteric lengthening, surgical results of the technique described cannot be comparatively evaluated.

Fig. 2A–E (A) A 27-year-old man (Patient 5) sustained a (B) right Type 2 subtrochanteric nonunion with shortening of 3.5 cm for 1.4 years. (C) One-stage lengthening with a static locked nail was performed. (D) Although the nail broke at the proximal slot end (arrow) at 8 months, (E) the nonunion healed 3 months later without a second surgery.

Table 2. Clinical data for 23 patients

Patient number	Last implant	Type of nonunion (Fielding)	Union period (months)	Final shortening (cm)	Followup (years)
1	S	2	4.5	0	6.7
2	L	3	4.0	1.0	5.8
3	K	3	4.0	0	5.2
4	L	2	T	T	T
5	L	2	11.0	1.0	4.8
6	K	3	3.5	0	4.6
7	S	2	4.0	0	4.4
8	L	3	4.5	0	4.3
9	S	2	4.0	0	3.8
10	L	3	5.0	0.5	3.5
11	K	3	5.0	0	3.4
12	S	2	4.5	0.5	3.2
13	L	2	5.5	0	3.1
14	L	3	T	T	T
15	K	3	4.0	0	2.8
16	L	2	4.0	0	2.7
17	K	3	4.5	0	2.6
18	L	3	4.0	0	2.4
19	L	2	4.5	0	2.2
20	L	2	3.5	0	1.9
21	S	2	4.5	0	1.6
22	K	3	4.0	0	1.5
23	L	3	4.0	0	1.2

S = sliding compression screw; L = locked nail; K = Küntscher nail; T = lost to followup.

Furthermore, concomitant treatment of combined disorders has not been reported. Even so, the current study clearly shows static locked nails are highly effective for treating combined disorders in a one-stage approach.

All subtrochanteric nonunions treated in this study were distal to the lesser trochanter. As such, first-generation locked nails were indicated [3, 20], and a 100% success rate was achieved. For more proximal combined disorders, reconstruction locked nails or other cephalomedullary nails may be needed [2, 4, 9]. Whether these nails will affect the success rate using this technique requires further study. Theoretically, despite added technical difficulty, the success rate should remain high. One-stage lengthening of the femur usually requires a longer operating time and produces more blood loss than techniques without lengthening. Therefore, elderly or physically unhealthy patients may be less tolerant of this type of procedure. In this study, 60 years was set as the upper age limit for performing the procedure. In patients unable to tolerate lengthening, a shoe lift is suggested after union is achieved [21]. Nerve palsy associated with one-stage femoral lengthening less than 4 cm usually is not problematic [17, 18, 21]. The nerves in

the thigh generally tolerate lengthening up to 4 cm well. No neurologic complications occurred in this series. One patient in this study sustained nail breakage at the proximal end of the nail slot before the fracture healed. Fortunately, the nonunion spontaneously healed 3 months later.

Donor site morbidity has been reported as much as 20% including infection, wound drainage, hematomas, prolonged pain, sensory loss, and keloids [15]. However, no evident morbidity occurred in my series of patients. Careful procurement of grafts should be able to greatly reduce these complications.

The limitations of this study include lack of Type 1 subtrochanteric nonunions, which may require cephalomedullary nails to stabilize the proximal fragment. However, although the patient is operated on in the lateral decubitus position, inserting two proximal locked screws into the femoral head under the guidance of an image intensifier is not technically difficult. There were no controlled studies as a comparison with other techniques (eg, locking plates). Therefore, only a theoretical comparison was made to support the superiority of the described technique. All followups were done by me. Evaluation of clinical and functional outcomes might have some variations by different observers. Additional studies are needed to support the described technique.

Locked nailing is an excellent one-stage treatment for subtrochanteric aseptic nonunions associated with considerable shortening. A high success rate generally can be predicted. Because the surrounding area sustains high bending stress, patients need protected weightbearing throughout the treatment course. The described technique is recommended as preferential treatment in patients with appropriate indications and good cooperation.

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