Treatment of 84 cases of femoral nonunion

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Eighty-four femoral nonunions were treated with Küntscher nailing, Grosse-Kempf locked nailing, plating, and Huckstep nailing, and were followed-up for a median of 34 months. Küntscher nailing and locked nailing were superior, with fewer complications, less operation time, and less blood loss. A Küntscher nail was preferred for the isthmic region when there was no shortening of the bone, and a locked nail was preferred above or below this region or when lengthening was indicated.

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Reamed intramedullary nailing has been the treatment of choice for femoral shaft fractures (Rothwell and Fitzpatrick 1978, Shaffer and Rechtine 1985). A Küntscher nail can only be used for mid-third transverse or short oblique fractures. Outside of the isthmic region, a plate or a Huckstep (1986) nail can be chosen. The introduction of interlocking nails has extended the indications for reamed intramedullary nailing. Femoral shaft fractures from below the lesser trochanter to the supracondylar area can now be stabilized without supplementary devices (Kempf et al. 1985, Browner 1986, Klemm and Borner 1986).

We made a retrospective study of femoral nonunions treated with these above-mentioned four different techniques.

Patients and methods

From January 1986 to June 1989, excluding nonunions, which were treated with only a cancellous bone graft, there were 105 consecutive patients with 107 aseptic nonunions of the femoral shaft treated with new internal fixation at our orthopedic department. Included in this study were 84 nonunions in 82 patients that were followed up for at least 1 year. The median age was 32 (17–63) years, with a male to female ratio of 6 to 1. The majority of patients had had from one to three previous internal fixations. The period of nonunion was from 1 to 4 years. A locked Grosse-Kempf nail was used in 46 cases, a Küntscher nail in 24 cases, a plate in 21 cases, and a Huckstep nail in 16 cases.

The principle of revision was replacement of the previous implant with a new, different implant. A Küntscher nail was used only in the isthmic region when lengthening was not indicated. For a nonunion above or below this region or nonunions associated with shortening, a plate, a Huckstep nail, or a locking nail was chosen. Concomitantly, a cancellous bone graft from the iliac crest or ipsilateral tibial condyle was used in all the cases where the fracture was opened. All the patients were treated with cephalosporin for 3 days.

We used the following surgical technique for locked nailing. Under general intubation anesthesia, the patient was placed in a lateral position on a fracture table. A 2.4-mm Kirschner wire was inserted through the femoral condyle for traction. First, a cancellous bone graft was taken from the posterior iliac crest. Next, the previous implant was removed through a lateral approach. The area of nonunion was thoroughly debrided and decorticated, and the traction was tightened until the intended length was obtained. A flexible guide wire was inserted from the piriform fossa and directed into the distal fragment under direct vision. Then, a cancellous bone graft was placed in situ, and the wound was closed with or without Hemovac drainage. After reaming the medullary canal, a statically locked nail was inserted.

For the insertion of a Küntscher nail, a Huckstep nail, or a plate, an ordinary operation table was used. The lengthening was performed with a distraction device. Knee stiffness was treated with quadricepsplasty together with removal of the implant when bony union had ensued.

Postoperatively, partial weight bearing was permitted after Küntscher nailing and nonweight bearing after locked nailing, Huckstep nailing, and plating. The patients were followed up at 4–6-week intervals until there was bony union—i.e., when there was no

Table 1. Clinical data for 105 cases of femoral nonunion

A	B	C	D	E	F	G	H	I	J	K
1	40	1	3	1	2	3	3	–	–	52
2	32	1	3	2	2	3	L			
3	42	1	5	1	1	1	4	–	–	48
4	42	1	5	3	1	1	L			
5	19	1	5	2	1	2	5	–	–	46
6	28	2	5	1	1	1	3	–	–	46
7	30	1	3	1	2	3	3	–	–	44
8	50	1	3	1	2	3	L			
9	38	1	5	1	1	1	5	–	–	44
10	36	1	4	2	2	3	5	–	–	42
11	45	1	5	1	1	2	L			
12	40	1	5	1	1	1	4	–	–	42
13	41	1	5	2	1	1	L			
14	40	1	3	4	2	3	N	N	4	41
15	54	1	5	1	1	1	3	–	–	41
16	34	1	5	1	1	1	L			
17	48	1	5	1	1	2	5	–	–	41
18*	26	1	3	1	1	1	4	–	–	41
19	52	2	5	3	2	2	N	N	4	41
20	17	1	1	2	2	3	L			
21	18	1	2	2	2	2	6	–	–	40
22	35	1	5	1	1	1	5	–	–	40
23	19	1	3	1	2	2	L			
24	28	1	5	2	1	2	4	–	–	40
25	21	2	1	1	1	3	7	–	–	40
26	30	1	5	1	1	2	L			
27	48	1	5	1	1	2	5	–	–	39
28	25	1	3	2	1	4	N	Q	1	39
29	46	1	5	1	1	4	3	–	–	39
30	34	1	3	1	2	3	4	–	–	38
31	26	1	4	2	1	4	3	–	–	38
32	40	1	3	1	1	4	3	–	–	38
33	32	2	3	1	1	2	L			
34	24	2	3	1	2	2	N	P	3	38
35	24	1	4	2	2	4	N	Q	2	38
36	40	1	3	2	1	3	4	–	–	37
37	58	1	1	1	1	2	N	N	4	37
38	22	1	3	2	1	2	L			
39	28	1	2	1	2	1	L			
40	31	1	5	1	2	1	N	N	1	37
41	45	1	5	1	1	2	7	–	–	37
42	30	1	5	1	1	1	7	–	–	37
43	34	1	3	3	2	4	3	–	–	36
44	38	1	5	1	1	1	N	P	3	36
45	24	1	5	1	1	2	3	–	–	36
46	54	1	3	1	2	4	L			
47	28	1	5	1	1	2	3	–	–	36
48	56	2	1	2	2	4	3	–	–	36
49	31	1	5	1	1	4	3	–	–	35
50	23	1	5	1	1	4	L			
51	19	1	5	1	1	2	N	Q	1	35
52	41	1	5	2	1	4	6	–	–	35
53	48	1	4	2	2	1	6	–	–	35
54	32	1	3	1	2	4	3	–	–	35
55	22	2	3	1	2	4	3	–	–	34
56	30	1	5	2	1	1	3	–	–	34
57	42	1	5	1	1	4	3	–	–	34
58	26	2	3	1	2	4	3	–	–	33
59	54	1	3	2	2	4	3	–	–	33
60	36	1	3	1	2	4	L			
61	45	1	3	1	2	4	5	–	–	33
62	20	1	3	1	2	3	L			
63	18	1	4	1	2	4	4	–	–	33
64	21	1	3	1	2	4	L			
65	33	1	4	2	2	1	3	–	–	32
66	25	1	5	1	1	1	N	Q	1	32
67	30	2	3	1	2	4	3	–	–	32
68	63	1	5	1	1	1	6	–	–	32
69	52	1	5	2	1	1	L			
70	44	1	5.5	1	2	4.4	3.3	–	–	31
71	32	2	3	1	2	3	3	–	–	31
72	28	1	5	1	1	4	3	–	–	30
73	20	1	3	1	2	3	6	–	–	30
74	30	1	3	1	1	4	7	–	–	30
75	26	1	3	1	1	4	L			
76	40	2	5	2	2	4	N	N	4	29
77	26	1	3	1	2	3	3	–	–	29
78	30	1	4	2	2	3	3	–	–	28
79	22	1	3.3	2	2	3.3	3.3	–	–	28
80	44	1	5	1	1	4	N	N	4	28
81	61	1	5	1	1	4	6	–	–	28
82	33	1	2	1	1	3	5	–	–	27
83	24	1	3	1	2	4	7	–	–	27
84	26	2	3	1	2	4	3	–	–	27
85	28	1	5	1	2	4	3	–	–	24
86*	50	1	4	1	2	4	3	–	–	21
87	32	1	3	2	1	3	N	N	1	21
88	24	1	3	1	2	4	3	–	–	20
89	30	1	3	1	2	4	3	–	–	20
90*	41	1	3	1	2	3	3	–	–	18
91	42	2	3	1	1	4	3	–	–	18
92	22	1	5	2	2	4	L			
93	20	1	5	1	2	4	5	–	–	17
94	50	1	5	1	2	4	N	N	4	17
95	34	1	3	1	1	3	3	–	–	16
96	33	2	5	1	1	4	3	–	–	16
97	38	1	3	2	1	3	3	–	–	14
98	36	1	4	1	1	4	4	–	–	14
99	42	2	2	1	2	4	L			
100	30	1	5	1	2	4	L			
101	32	1	5	1	2	4	3	–	–	13
102	20	1	1	1	1	3	4	–	–	13
103	29	1	5	1	1	3	3	–	–	13
104	31	1	5	1	2	4	L			
105	18	1	5	1	2	4	3	–	–	12

A Case number
B Age, years
C Sex
  1 male
  2 female
D Previous treatment
  1 casting
  2 external fixation
  3 plate
  4 Huckstep nailing
  5 Küntscher nailing
  6 locked nailing
E Time elapse from fracture to treatment, years
F Type of nonunion
  1 hypertrophic
  2 hypotrophic
G Treatment (Antibiotics with a cancellous bone graft were used in every open method case.)
  1 plate
  2 Huckstep nailing
  3 Küntscher nailing
  4 locked nailing
H Result, union period, months
  N nonunion
  L lost to follow-up
I Complications
  N nonunion
  P deep infection
  Q implant failure
  – without
J Reoperations
  1 locking nail
  2 plate
  3 external fixator
  4 only bone graft
  – without
K Follow-up, months
* Complications of ipsilateral neck and shaft fractures

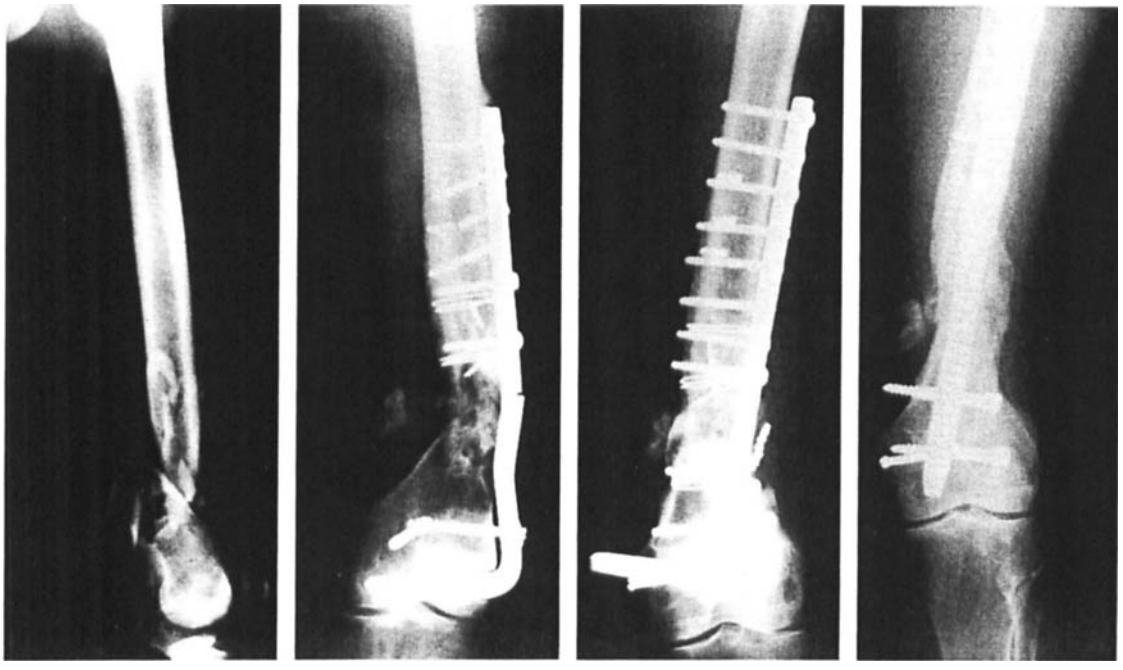

Figure 1. Case 43. A 34-year-old man sustained a left femoral supracondylar comminuted fracture. An angle blade plate was inserted, but nonunion with plate breakage was noted. Revision with a new angle blade plate with a supplementary cancellous bone graft failed. After revision with a locking nail and a supplementary cancellous bone graft, bony union ensued.

pain or tenderness, when the patient could walk without support, and when a radiograph showed solid bridging callus between the fragments (Chan et al. 1984, Kempf et al. 1985). Nonunion was defined as a fracture that still had not united after 1 year (Seinsheimer 1980).

For statistical calculations, the Student's *t*-test was used.

Results

For the Küntscher nail, the locked nail, the plate, and the Huckstep nail, the union rates were respectively 18/20, 32/37, 12/16, and 8/11, and the union times were 3 (3–7), 3 (3–7), 4 (3–7), and 5 (3–7) months. ($P < 0.05$ between the locked and the Huckstep nail; Table 1).

The operation time for the Küntscher nailing was 1 (0.8–3) hour, for the locked nailing 2 (1–3) hours, for the plating 2.5 (1.5–4) hours, and for the Huckstep nailing 3.5 (2–4) hours ($P < 0.001$ between locked nailing and plating or Huckstep nailing). The blood loss with Küntscher nailing was 0.2 (0.15–0.3) L, with locked nailing 0.4 (0.2–0.7) mL, with plating 1.5 (0.8–2.2) L, and with Huckstep nailing 1.5 (1.0–2.2) L ($P < 0.01$ between locked nailing and plating or Huckstep nailing).

Complications

Nonunion was noted in Küntscher nailing (2/20), locked nailing (5/37), plating (4/16), and Huckstep nailing (3/11). After repeated operations, most of the nonunions united (Figure 1). There were 2 cases of deep infection—1 after plating and 1 after Huckstep nailing. The plate and nail were removed and replaced with a Hoffmann external fixator. Two locked nails, one plate, and one Huckstep nail failed. After repeated locked nailing and cancellous bone grafting, the fractures healed and bony union ensued.

There was no significant leg-length discrepancy (> 2 cm) or malalignment (rotation or angulation > 10°).

Discussion

The union rate after closed reamed intramedullary nailing is very high (Rothwell 1982). Nonunion after

Küntscher nailing may be due to open reduction with too extensive periosteal dissection, deep infection, or inadequate mechanical stability. Moreover, the load-sharing effect of Küntscher nails (Schatzker 1980) can produce bone shortening whenever the fracture fragment undergoes resorption. The treatment of Küntscher nail-fixed nonunion can be with a bone graft only in the hypovascular type (Weber and Brunner 1981) or revision with another implant and bone grafting when lengthening is indicated. Even for a hypervascular nonunion, open reduction and revision with a plate or a Huckstep nail will destroy periosteal vascularity; therefore, it is better with a supplementary bone graft to promote healing (Crenshaw 1987).

In the past, few implants could be used in non-isthmic fractures. A plate or a Huckstep nail needs an extensive dissection, with great risk of infection and nonunion. Moreover, high stress concentration and insufficient cortical quality in the subtrochanteric area (Fielding 1973, Seinsheimer 1978) and a widening canal, thin cortex, and poor bony stock in the distal femur (Pritchett 1984) can produce inferior results. The mechanical characteristics of a locked nail have been well studied. Johnson et al. (1986) found that 3–4 times the body weight can be withstood with a femoral segmental defect. Theoretically, it should be better than a plate or a Huckstep nail. Our series also confirms that a Küntscher nail or a locked nail gives a higher union rate and a shorter healing time. The cause may not be only mechanical: viz., for plating and Huckstep nailing, extensive exposure of the femur is necessary.

The success rate of nonunion treatment will decrease after repeated operations (Crenshaw 1987). The direct cause can be repeated local periosteal destruction, with reduced nutrition as a result. Moreover, disuse osteoporosis produces less stability for implant fixation. For this reason, we support cancellous bone grafting whenever the fracture is opened. The treatment of knee stiffness can be postponed until the implant is removed; the extensive dissection with quadricepsplasty will greatly increase the infection and nonunion rate.

We observed 3 cases of implant failure. The slot end and nail hole produce stress concentration and weaken the implant (Bucholz et al. 1987). This can be avoided by protected weight bearing.

Our investigation confirms that on the basis of theoretic and clinical considerations an aseptic nonunion is best treated with limited open Küntscher or interlocked nailing. With adequate indications, each technique will give satisfactory results.

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