Secondary intramedullary nailing after distraction osteogenesis

30 patients followed for 2–12 years

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Submitted 03-04-10. Accepted 04-01-12

Background **There is no consensus about replacement of an external fixator by reamed intramedullary nailing in fracture cases.**

Patients and methods **We evaluated the outcome in 30 patients (33 segments) of secondary intramedullary nailing during the consolidation phase after callus distraction using an external device. The main reasons for nailing were docking site nonunion (17 patients), angular deformity or fracture of the lengthened area (8 patients) or intolerance of the external device (5 patients), in 11 patients combined with a delayed distracted callus maturation. The average follow-up time was 4 (2–12) years.**

Results **Intramedullary infection after nailing occurred in 1 case, and slight loss in callus length in 5 cases. Failure of union at the docking site with nail breakage occurred in 1 case. In the other patients, consolidation in the lengthened callus area and also union at the docking site were achieved on average 6 months after nailing.**

Interpretation **We believe that intramedullary nailing during the consolidation phase after bone lengthening or bone transport is a treatment option for delayed callus maturation or docking site nonunion, reducing prolonged use of the external fixator.**

Complications of distraction osteogenesis are common (Paley 1990, Aquerreta et al. 1994, Dahl et al. 1994). The duration of the callus consolidation phase is often twice as long as the lengthening phase in young people, and 3–4 times longer in adults and the elderly (Paley 1990, Fischgrund et al. 1994). Prolonged use of the external fixator may be difficult for the patient to tolerate, and increases the risk of pin track infections and joint complications. This may lead to premature removal of the fixator when the lengthened callus has not been consolidated. Premature removal may lead to plastic deformity of the callus with axial deviation, shortening, or fracture.

Another problem is delayed union or nonunion at the docking site after bone transport. After the end of distraction, healing takes about 2–3 months. Delayed union or nonunion is common when healing large post-traumatic bone defects with soft-tissue injuries.

We present our experience of intramedullary nailing during the consolidation phase after bone lengthening or bone transport, for further stabilization of the lengthened callus and enhancement of callus maturation and docking site union.

Patients and methods

Between 1991 and 2001, 210 patients were surgically treated with distraction osteogenesis, bone lengthening and/or bone transport, either with the standard Ilizarov frame or with a unilateral lengthening system with half pins. In 30 (14%)

Observations in 30 patients (33 segments) who had secondary intramedullary nailing during the consolidation phase after callus distraction

A	B	C	D	E	F	G	H	I	J	K
1	M/16	SN	T	2	44	BT	I	DSN	N	4
2	F/15	AN/A	T	4	37	BT	I	DSN	N	2
3	M/45	SN	T	2.5	41	BT	I	DSN	N	4
4	M/30	PBD	T	10	50	BT	I	DSN/DC	N	7
5	M/40	A	F	7	31	BL	U	PI	LL1.5cm	5
6	M/59	AN	T	2	34	BT	I	DSN	N	6
7	M/15	A	T	5	39	BL	I	PI	N	4
8	M/12	PH	T	12	30	BL	I	A/PI	N	3
9	M/25	A	F/F	8	25	BL	U	PI	LL1cm	5/5
10	M/29	CO	F	16	41	BT	I	DSN	N	12
11	M/32	SN	F	5	44	BT	I	DSN	SN	6
12	M/49	A	F/T	28	43	BL	I	DC/PI	N	10/8
13	M/30	CO	F/T	18	42	BLBT/B	I	DSN/PI	A	12/7
14	M/35	PBD	F/T12	20	31	BT	I	DSN	N	14
15	M/40	PBD	T	8	34	BT	I	DSN	N	12
16	M/40	PBD	T	12+5	39	BT	I	DSN	N	6
17	M/25	PBD	T	4	51	BT+BL	I	DC/PI	DI	5
18	M/45	A	T	5	33	BL	U	A	N	5
19	M/12	A	F	10	37	BL	I	A	N	3
20	M/68	PBD/SN	F	3.5	43	BT	I	A	SI	6
21	M/25	AN	T	2	39	BT	I	DSN	N	6
22	M/65	AN	F	10	34	BT	I	DSN	N	8
23	M/23	PBD	T	4	42	BT	I	DSN	N	3
24	M/22	A	T	2	37	BL	U	A	LL1cm	4
25	M/19	SN	F	4	37	BT	I	DSN	SI	3
26	F/18	SN	T	3	35	BT	I	DSN	N	6
27	M/30	PBD	F	4.5	44	BT	I	DSN	NU-NB	–
28	F/22	A	F	12	39	BL	U	F	LL1cm	3
29	M/10	PH	T	12	30	BL	I	F	LL2cm	3
30	F/17	A	T	4	36	BL	U	F	N	4

A Case no.
B Sex/age, years
C Treatment indication
- SN septic nonunion
- AN aseptic nonunion
- A anisoscelia
- PBD posttraumatic bone defect
- PH peroneal hemimelia
- CO chronic osteomyelitis

D Bone
- T tibia
- F femur

E Amount of lengthening, cm
F Length index, days/cm
G Distraction type
- BL bone lengthening
- BT bone transfer

H Distractor type
- I frame fixator (Ilizarov)
- U unilateral system

I Reason for nailing
- DC delayed callus consolidation
- DSN docking site nonunion
- PI patient's intolerance
- A angulation
- F fracture

J Complications
- N none
- SI superficial infection
- DI deep infection
- A arthritis
- NU nonunion
- NB nail breakage

K Time for ossification after IM, months

patients (27 men), the external device was replaced with a static intramedullary nail after the end of distraction. The mean age was 30 (10–68) years. The femur was involved in 13 cases and the tibia in 20; 3 patients had 2 bones involved at the same time. The main reasons for nailing were delayed union at the docking site (17 patients), discomfort due to prolonged use of the device (5 patients) and an angular deformity (> 10°) or fracture of the callus in the lengthened area (8 patients), in 3 patients combined with delayed maturation of the distracted callus (Table). Prerequisites for nailing were completion of bone lengthening, healed soft tissues, and no clinical and laboratory signs of

infection. 24 interlocked Grosse-Kempf and 9 AO-ASIF nails were inserted.

In 25 cases, all treated with the Ilizarov lengthening system, the nailing was performed immediately after frame removal. Under general anesthesia, the patient was placed on a traction table to maintain the length and axis of the lengthened callus during removal of the frame and insertion of the nail. After cleaning of the skin, of the device and of the transosseous pins, the frame and the pins were removed, the soft tissue pin tracks were debrided and filled with an antiseptic povidon iodine infusion. Then, in the same surgery, we tried to pass a guide wire through the lengthened area into the distal part of the bone under fluoroscopic guidance. This was easy if the callus was soft. Hard callus or hard bone ends at the docking site made this difficult, and in such cases we opened the canal by a long, straight and hard awl under fluoroscopic guidance. After limited reaming of the intramedullary canal and the callus area, the nail was inserted. The diameter of the nail for the femur was 11–12 mm, while for the tibia it did not exceed 10 mm. The patients received perioperative antibiotic prophylaxis with cefuroxime 750 mg (3 doses per day) for 2 days and thrombosis prophylaxis for 6 weeks.

In 5 cases with unilateral lengthening system, nailing was delayed for about 2 weeks after removal of the external device until granulation of the pin tracks was evident. During this time, the leg was stabilized by a long leg plaster. In 3 patients, nailing was performed because of fracture at the callus area some days or weeks after removal of the external device.

Partial weight bearing was recommended from the second postoperative day, when a rehabilitation program also started. Clinical and radiographic follow-up took place once a month. The callus was considered to be consolidated or the docking site healed when the patient could walk without pain, had no pain or movement at the callus area or the docking site at manual stress application, and when there were radiographic signs of ossification.

The average follow-up time was 4 (2–12) years. The external lengthening device remained for 11 (5–21) months on average, or 38 days per cm of the bone defect.

Results

Infection

Intramedullary infection after placement of the nail occurred in 1 patient (case 17). Initially an open fracture, Gustilo stage IIIb (bone defect 17 cm), it was first treated by 12 cm bone transport with the Ilizarov method and secondly by additional bone lengthening of 5 cm. The nail was placed 18 weeks after the end of bone lengthening, because of delayed callus consolidation and the discomfort of the patient with the Ilizarov device. Despite no preoperative signs of infection, pan-diaphysitis caused by staphylococcus aureus occurred. After an initial treatment with a fluid flow system and intravenous antibiotics, the nail was removed 8 weeks later followed by reaming of the intramedullary canal. Intravenous antibiotic administration followed for 6 weeks. The callus was finally consolidated after 10 weeks using a limited frame fixator, and no evidence of infection was found at follow-up 4 years later.

Docking site healing

In 1 patient (case 27) with a leg length discrepancy of 3 cm due to a supracondylar fracture, docking site nonunion failed to heal after insertion of the nail. Fatigue fracture of the nail occurred after 3 years, and revision using a new frame fixator was required. 10 of the docking site nonunions healed within 6 months of nail insertion. The other 6 cases had a delayed radiographic ossification, but no clinical symptoms (Figure 1). Dynamization of the statically interlocked nail was performed in 3 of these 8 weeks after the nail placement (Figure 2). In no case was additional bone-grafting required.

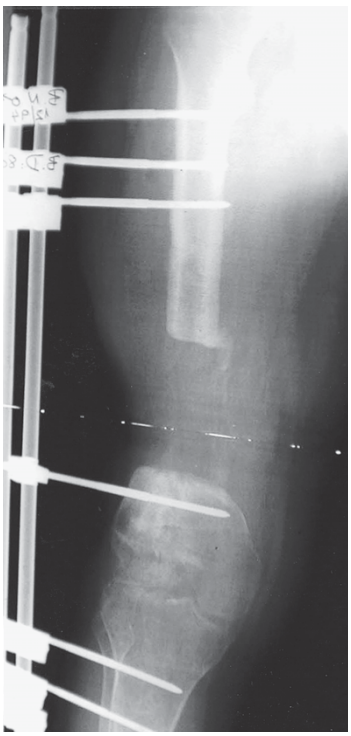
Limb alignment

In the 4 cases in which angular deformity of the lengthened area occurred (18, 19, 20, 24), axial deviation was corrected immediately after the correction osteotomy and placement of the nail. Overall, the tibia or femur alignment was kept straight (angulation $< 5°$), according to the nail axis, during the whole follow-up period (except for case 27, where there was nail breakage).

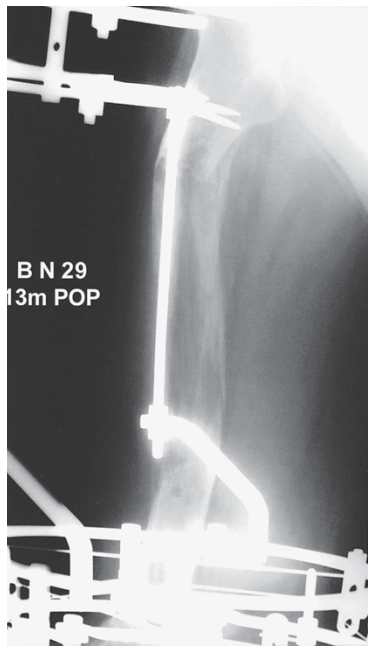
Callus length

In 27 cases, the final leg length discrepancy was

Figure 1. Case 10.



Bone defect of 16 cm after chronic osteomyelitis.



Bone transport with Ilizarov device.

Intramedullary nailing 2 years post-operatively.

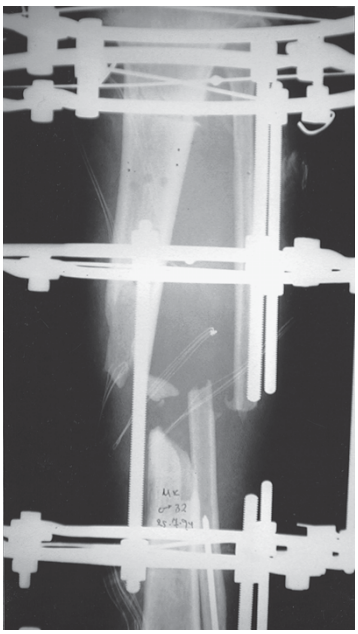
less than 0.5 cm. In 5 cases (5, 8, 24, 28, 29) 1–2 cm of callus shortening occurred during the cast period between the removal of the external fixator and the nailing.

In all of our patients, union at the docking site and consolidation of the newly formed bone were both clinically and radiographically evident on average 6 (2–14) months after the nail insertion. The condition of the skin and soft tissues progressively improved. There were no cases with neurovascular complications, compartment syndrome or pulmonary emboli. All the patients were satisfied (as judged by a subjective questionnaire), and their psychological condition improved immediately after removal of the external fixator and nail placement.

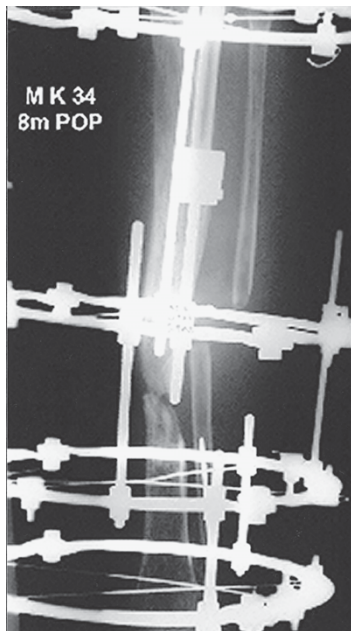
Discussion

There is no consensus about replacement of the external fixator by reamed intramedullary nailing in closed and open fracture cases. McGraw and Lim (1988) found nonunion in 50% of their patients who were treated by this method, and deep infection in 44%, and the method was therefore described as unacceptable. On the contrary, many authors (Maurer et al. 1989, Blachut et al. 1990, Johnson et al. 1990, Wheelwright and Court-Brown 1992, Antich-Adrover et al. 1997) consider the method to be the one of choice for loss of reduction, delayed consolidation or pseudarthrosis. The deep infection rate varied from 0–6% in the cases without pin-track infection. A waiting period of 1–2 weeks between the removal of the external device and the nailing was considered necessary. However, Bernat et al. (1996) and Nowotarski et al. (2000) recommended a 'one-stage conversion procedure' in patients in which there is a relatively short time with external fixator, no signs of systemic infection and no loosening of the external fixator pins, erythema or purulent drainage at the pin sites. The deep infection rate in these reports was less than 2%.

Figure 2. Case 14.



Post-traumatic bone defect of 12 cm and bone transport with an Ilizarov frame.



Docking site nonunion.

Interlocking nailing.

Callus consolidation and docking site union after nail dynamization.

Intramedullary nails have also been used during bone lengthening, in combination with an external distractor (lengthening over a nail, or as a static nail that stabilizes a direct limited elongation, or as a mechanical system of progressive bone lengthening (telescopic nail). However, the biology of distraction osteogenesis is disturbed by an intramedullary nail. We believe, therefore, that the advantages of intramedullary nailing are best utilized at the end of the bone-lengthening phase. Rommens and Hessmann (1999) found successful healing at the docking site after nailing in 11/12 patients, 2-cm loss of callus length in 1 case and deep infection in 1 patient. Lai et al. (2002) reported 27 patients who had docking site union on average 6 months after nail application. The callus shortening ranged from 0–2.5 cm and the deep infection rate was 2/27. One stage conversion was done in 7 cases. In a study in sheep (Papadopoulos et al. 2002), the Ilizarov device was replaced by a static unreamed intramedullary nail at the beginning of the consolidation phase, after the end of bone lengthening. The mobility of the sheep improved rapidly and the callus matured. No deep infection occurred.

Of course, we are aware of the probability of intramedullary infection after nailing, which is theoretically increased even if the nail placement has been done after removal of the external device. However, after completion of elongation and restoration of soft tissues, and in the absence of clinical and laboratory signs of infection, we believe that the one-stage replacement of Ilizarov frame by an intramedullary nail is a relatively safe procedure. We recommend a two-stage procedure only when large pins with screw threads have been used, as in unilateral elongation systems.

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