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Simple Approach to the Management of Aseptic Non-union of the Shaft of Long Bones

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ABSTRACT

Aim: Internal fixation with a plate in the management of non-union for shaft of long bones has been condemned but the review of the literature does not provide such unequivocal evidence. Also there are certain situations where it is either technically not feasible or contraindicated to do closed intramedullary nailing. This study was done to see the outcome of plate-fixation for the treatment of non-union of the shaft of long bones.

Method: The non-union was treated by freshening the fracture ends, opening the medullary canal, re-aligning and stabilizing the fracture with a plate and packing autogenous cancellous bone grafts around the non-union site. There were 25 patients with an average age of 35 years. The non-union involved 7 femurs, 8 humerii and 10 tibiae. The initial treatment was operative in 11 patients, by plaster cast in 5, by traction in 1 and by traditional practitioner in 8. There was no pathological fractures or infected cases. The average delay prior to operation was 14 months and the average follow up was 30 months.

Results: All non-unions healed on an average in 18 weeks. There was neither incidence of infection nor any complications at the bone graft donor site. Three cases of transient nerve paralysis recovered spontaneously. One femoral plate broke at 12 weeks, which required replating. In another patient the distal screws of the femoral plate pulled out, this was managed successfully with a cast brace.

Conclusion: Plate fixation is useful and effective in the management of non-union, more so in situations where it is technically not feasible to do closed intramedullary nailing. The incidence of infection, success of union and time to union are comparable with other methods.

Keywords: aseptic non-union, shaft of long bones, plating and bone grafting

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INTRODUCTION

The incidence of non-union following post traumatic fractures is reported to be between 5 and 10 percent[1]. Treatment by internal fixation with a plate has been condemned. Opening the non-union site further damages the blood supply, increases the risk of infection and there is frequent implant failure[2,3], although the review of the literature does not provide such unequivocal evidence. The other implant commonly used is a locked intra-medullary nail. However there are situations where it is technically not possible to do closed nailing and opening the non-union site becomes necessary eg. to remove the implants from previous operations, or when it is not possible to negotiate the reamer into the distal medullary canal by closed method[4] or when mal-alignment needs to be corrected. Moreover, in developing countries, cost of the implant is an important consideration in deciding the choice of treatment.

Presented are the results of 25 cases of non-union of the shaft of femur, tibia and humerus treated with plate fixation and autogenous cancellous bone grafting.

PATIENTS AND METHOD

Between January 1990 and November l997, twenty-five patients with aseptic un-united fracture of the shaft of femur, tibia and humerus were treated by compression plate fixation and autogenous cancellous bone grafts from the iliac crest. Their average age was 35 years (range 17 to 66 years). There were seven femora, eight humerii and ten tibiae involved. Only six patients attended our hospital after the initial injury; eleven patients were referred from other hospitals and eight patients had consulted the bone setters.

The initial fracture was closed in sixteen and open in nine patients. There was one femur and one tibia with open grade I, one humerus with open grade III A and six tibiae with open grade III B. Twenty fractures were in the mid-shaft region and the other five were in the shaft near the metaphyseal region. Ten patients had angulatory mal-alignment. No patient had bone loss exceeding one centimetre i.e. Type A of Paley et al[5].

Table I. Patient's characteristics.

No	Sex M/F	Age (yrs)	Inital fracture open/closed	Bone involved and Previous treatment	Interval from Injury to operation (months)	Type of non-union Atrophic/ hypertrophic	Time to union following operation (weeks)	Length of follow-up (months)
1.	M	17	closed	femur-plating	6	atrophic	16	38
2.	F	52	open I	femur-traction	12	atrophic	20	40
3.	M	35	closed	femur-IMN	9	atrophic	16	24
4.	M	66	closed	femur-IMN	31	atrophic	18	24
5.	F	61	closed	femur-traditional	12	atrophic	18	25
6.	M	23	closed	femur-traditional	9	atrophic	16	22
7.	M	24	closed	femur-traditional	6	atrophic	24	22
8.	M	21	closed	humerus-traditional	6	atrophic	14	36
9.	M	26	closed	humerus-traditional	6	atrophic	24	24
10.	M	49	closed	humerus-plaster	9	atrophic	16	24
11.	M	40	closed	humerus-plaster	6	atrophic	20	36
12.	M	28	closed	humerus-plaster	6	hypertrophic	20	24
13.	M	59	closed	humerus-traditional	96 (8 Years)	atrophic	16	26
14.	M	30	open III A	humerus-external fixator	12	atrophic	12	48
15.	M	58	closed	humerus-plating	6	atrophic	16	36
16.	F	26	open I	tibia-plaster	15	atrophic	14	24
17.	M	27	closed	tibia-plaster	6	hypertrophic	12	22
18.	M	30	open III B	tibia-external fixator	6	atrophic	18	42
19.	M	48	closed	tibia-traditional	6	atrophic	16	40
20.	M	17	closed	tibia-traditional	6	hypertrophic	24	32
21.	M	21	open III B	tibia-external fixator	22	atrophic	20	31
22.	M	38	open III B	tibia-external fixator	12	atrophic	32	36
23.	M	22	open III B	tibia-external fixator	6	atrophic	16	24
24.	M	18	open III B	tibia-external fixator	19	atrophic	18	24
25.	M	65	open III B	tibia-external fixator	7	atrophic	28	24

The primary treatment was by external fixator in seven patients, intramedullary nail in two, plating in two, plaster cast in five, traction in one and by traditional methods in eight patients. The 'traditional' treatment by the bone setters consisted of repeated massage and application of unspecified herbs, to the skin over the site of fracture. There were 22 atrophic and 3 hypertrophic non-unions. The average interval between the initial fracture and treatment of the non-union was 14 months (range 6 to 96 months). There were no patients with pathological fractures. (See Table I). Non-union was defined as absence of clinical and radiological signs of union at 6 months after injury.

All the non-unions were internally fixed using a compression plate. The bone was exposed only on the side of proposed placement of the plate. Clinical non-union and mobility of the bone ends was confirmed. The intervening fibrous tissue was excised to correct the mal-alignment and the medullary canal was reopened. The cortex was refreshened and rose petalled. A compression plate of appropriate size was applied subperiosteally on the tension side unless it was difficult to place it so because of scars from the previous operation or because of the situation of the fracture. This problem was encountered in the distal tibial non-unions. Occasionally, the plate was contoured to match the altered local anatomy at the site of non-union (Fig. 1a, b, c, d and e). Autogenous cancellous grafts harvested from the iliac crest were packed around the non-union filling any gaps between the bone ends. All patients were given a course of antibiotic for prophylaxis.

Post-operatively, active exercises were started after 2 to 3 days. After the wound had healed, the leg was put in patellar-tendon-bearing cast for the tibial fractures, plaster gaiter cast around the thigh for the femoral and around the upper arm for humeral fractures, for 4 to 6 weeks. Non-weight bearing crutch walking was started at 2 to 3 weeks post-operatively. Gradual, partial to full weight bearing was advised according to the progress of healing as judged clinically and radiologically.

All patients were reviewed at regular intervals. The outcome was assessed with regards to deep infection, time to union, range of motion in adjacent joints, shortening, nerve injury, complications due to iliac bone grafting and implant failure. Union was judged clinically by the absence of pain on full weight bearing for the lower limb and ability to lift 4 to 5 kg weight to the elbow height for humeral non-unions and on radiographs by evidence of bridging callus .The average length of follow up was 30 months (range 22 to 48). The plate was removed electively in 7 patients at 18 months or later.

RESULTS

All wounds, both at the fracture site and the graft donor site, healed primarily. All non-unions healed on average in 18 weeks (range 12 to 32). There were 5 cases of

Fig. 1a Radiograph showing segmental fracture of tibia and fibula open grade IIIB, on admission. This was initially treated by surgical debridement and external fixator.

Fig. 1b Antero-posterior and lateral radiographs of the same tibia showing established non-union at the distal end of the segmental fracture at 19 months after injury.

Fig. 1c Antero-posterior and lateral radiographs showing union of the distal fracture after plating and bone grafting. The plate was contoured to fit the non-union site.

transient nerve palsy, 3 of the radial nerve and 2 of the common peroneal nerve. All patients had spontaneous recovery of the nerve palsy. Mal-alignment was corrected in all and on an average the lower limb shortening was 1 cm (range 0.5 to 1.5 cms). No patient requested or was prescribed a shoe raise. The upper limb length was not recorded nor did any patient complain of shortening.

All patients regained the pre-op range of motion at the knee, ankle and shoulder. The knee flexion was limited to 100º in one patient with femoral non-union and the other 6 had either full flexion or limitation of last 10° of flexion. One patient with tibial non-union had limitation of dorsiflexion at the ankle and one had 5° equinus. All patients with the humeral non-union had regained sufficient range of shoulder and elbow movements so as not to cause any impediment in their work or pleasure activities.

One femoral plate broke at 3 months, before union had occurred. Replating was done and it healed at 6 months. In another patient, the distal screw of the femoral plate pulled out at 5 weeks following surgery. A cast brace was applied and union occurred in 5 months. None of the 7 patients who had elective removal of the plate had refracture. There were no problems related to the bone graft donor site in any patient.

Fig. 1d, e Clinical photographs of the leg. Note the extensive skin grafting required to cover the wounds after initial debridement. The necessary manipulation required for closed nailing could have caused wound breakdown. Plate fixation avoided that.

Table II. Indications for plate fixation.

Indication	No. of patients (percentage)
Removal of previous implant	4 (16%)
Initial treatment with external fixator	7 (28%)
Mal-alignment*	10 (40%)
Fracture nearer the end of the shaft*	5 (20%)

* One patient common to both indications

DISCUSSION

Fear of infection following an open method[3,6,7] has persuaded many surgeons to advocate a closed technique, but review of the literature shows there is little difference in the reported incidence of infection, which is between 5 to 10% irrespective of the type of implant or technique used[6-10]. In the present study there was no incidence of infection, even though 11 (44%) patients had previous treatment either by an external fixator or an implant.

Another reason for reluctance to open the non-union site is the presumed reduction of the blood supply to the bone ends following stripping of the soft tissues[2]. This was not found to be true by Barron et al[11], who in their study on dogs' ulnae noted the blood flow in general was similar in both the rod or plate fixed ulnae and the end result in terms of healing of the fracture was also similar in both. Further Rand et al[12] compared the effects of compression plating and open nailing after reaming at the fracture site in tibia of dogs. They concluded that there was no decreased vascularity of the cortex after plate fixation but there were higher values for blood flow at the fracture site after reaming and rod-fixation due to some compensatory mechanism but inspite of that the rate of union and maturation of the fracture was slower with rod-fixation. In clinical practice following plating, Wiss et al[9] and Weber et al[13] reported union in 96% and 99% respectively for tibial non-unions and Ring et al[10] reported union in 97% for femoral non-unions. In the present study all 25 non-unions healed following plating.

There are certain limitations for closed reamed intramedullary nailing e.g. difficulty to get the guide rod and reamers past the fibrous tissue into the medullary canal of the distal fragment (Fig. 1a and b). Inability to correct the mal-alignment and removal of implants from previous operations also necessitates opening the non-union site[6,7,14,15]. Further, intramedullary nailing is a poor choice in cases initially treated with external fixator because of the risk of flare up of infection[8,9], or when the fracture is situated in close proximity of the distal locking holes because of increased risk of implant failure[16,17]. In the present study 4 patients (16%) required removal of the previous implant, 7 patients (28%) had had prior treatment with external fixator, 5 patients (20%) had fracture more towards the distal part of the shaft and 10 patients (40%) had mal-alignment (1 patient with metaphyseal fracture also had mal-alignment). See Table II. Mal-alignment was common especially when the previous treatment was non-operative or by traditional practitioner. With regards to the humerus, recent studies using locked intramedullary nailing have reported non-union rates between zero to 50 percent[18]. Moreover the geometry of the distal humerus as well as the design of certain nails does not provide adequate torsional stability[18,19].

Breakage of plate is another reason for its condemnation. As an added precaution, plaster gaiter cast was applied to the thigh, leg or arm upon discharge from hospital. This way the patients feel they are still under supervision and perhaps refrain from experimenting with premature weight bearing against advice - the common reason for a broken plate. In this study non-weight bearing crutch-walking was commenced at 2 to 3 weeks and 1 femoral plate broke at 3 months. Other implants also break on early weight bearing[16,17]. Boenisch et al[20] reported 30% breakage of the interlocking bolts of unreamed nails in 66 patients with a fresh fracture of tibia, even though partial weight bearing was advised at 8 to 10 weeks.

Autogenous cancellous bone grafting has been deemed unnecessary, as the bone dust from reaming of the medullary canal is considered sufficient to promote union[6]. Powered reaming produces necrotic debris and micro-squestrae along with some osteogenic material[1]. Cancellous bone has superior osteogenic properties[21] and helps to achieve union in less time[8] and is advocated for atrophic non-unions[2,13,22]. Further, open additional bone grafting is recommended if there is a gap or bone loss at the non-union site[23,24]. There were 22 atrophic non-unions in the present study and

Table III. Average time to union with and without open bone grafting as reported by various authors.

No	Authors	Type of internal fixation used	Union in weeks With bone graft	Union in weeks Without bone graft
1.	Clancey et al[6] 1982	48 tibial non-unions		
		30 closed Kuntscher nailing		28
		18 open Kuntscher nailing		44
2.	Johnson et al[8] 1987	22 tibial non-unions – open nailing	12.5	
3.	Wiss et al[9] 1992	50 tibial non-unions – compression plating		
		39 (78%) out of 50 required bone grafting	28	
4.	Court-Brown et al[23] 1995	33 tibial non-unions – exchange intramedullary nailing		
		15 closed		16.1
		18 open – of which 11 were bone grafted	15.2	
5.	Ring et al[10] 1997	42 femoral non-union – wave plate combined with bone grafting		
		41 (97%) healed	24	
6.	Furlong et al[24] 1999	25 femoral non-unions – exchange reamed nailing		
		12 cases additional bone grafting	24.6	
		13 cases no bone grafting		36.2
7.	Present study	25 cases – plating and bone grafting	18	

all non-unions healed on an average in 18 weeks. Webb et al[15] reported union at an average of 20 weeks in 101 patients of tibial non-union treated mostly by closed reamed nailing. Clancey et al[6] reported 28 weeks (7 months) as the average time to union after closed nailing and 44 weeks (11 months) after open nailing without cancellous grafts in 48 tibial non-unions, compared to 12.5 weeks following open nailing and cancellous grafting in 22 fractures of the tibia as reported by Johnson et al[8]. Furlong et al[24] reported that union was earlier when additional bone grafts were used along with reamed intramedullary nailing for non-union of femur. The mean union time was 24.6 weeks in 12 cases (48%) when grafting was done as compared to 36.2 weeks in 13 non-grafted cases. See Table III.

The study could be criticised for lack of comparison with the other commonly used implant ie. closed locked intramedullary nailing. The intention was not comparison. Closed nailing has its place. Plating is still useful and indicated where closed nailing is not feasible or contraindicated. Plating does not deserve to be condemned outright, it requires minimal instrumentation and equipment, post-operatively patients can be discharged from the hospital as early with crutches and is less expensive, an important consideration in developing countries.

CONCLUSION

Plate fixation is useful and effective in the management of non-union of the shaft of long bones in situations where closed intramedullary nailing is not possible for technical reasons or the high cost involved is not acceptable. All 25 patients treated with plating and autogenous cancellous bone grafts united on an average in 18 weeks. There was no incidence of infection. One femoral plate broke which required replating. The average shortening was 1 centimetre. Review of the literature reveals that the incidence of infection and success of union following plating was comparable with that obtained by closed intramedullary nailing.

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