Bridge plating osteosynthesis of 20 comminuted fractures of the femur

John P CHRISOVITSINOS[1], Theodore XENAKIS[2], Kostas G PAPAKOSTIDES[1], Nicholas SKALTSOYANNIS[1], Anastasios GRESTAS[1], Panayotis N SOUCACOS[2]

We retrospectively studied the outcome of 20 comminuted fractures (20 patients, 15 men) of the femur treated in accordance with the principles of indirect reduction and biological osteosynthesis technique. The patients were followed for mean 1.5 (1–4.5) years. 11 fractures were subtrochanteric (type C), 6 complex diaphyseal and the remaining 3 were supracondylar (2 type C3 and 1 type A3); 3 fractures were open (type I, II, IIIA). Subtrochanteric fractures were treated with either 95° dynamic condylar screw (DCS; 5 fractures) or with 135° dynamic hip screw (DHS; 6 fractures). Autocompression plates (ACP) implants were chosen for diaphyseal fractures in 4 fractures, and a limited contact dynamic compression plate (LC/DCP) implant in 2. The 3 supracondylar fractures were treated with a 95° DCS implant (1 fracture) and the Condylar Buttress Plate (2 fractures). 11 fractures were bone grafted.

There were no immediate postoperative complications. All fractures united on an average of 5 months, irrespective of use of bone grafts. Late complications consisted of mild knee stiffness (4 patients) and 1–2 cm shortening (4 patients).

[1]Orthopaedic Department, Hatzikostas General Hospital and the [2]Department of Orthopaedic Surgery, Unversity of Ioannina, School of Medicine, Ioannina, Greece. Correspondence: Dr. J P Chrisovitsinos, Director, Orthopaedic Department, Haztikostas General Hospital, Ioannina, Greece. Tel +30-651-80494. Fax - 31414

Clinical experience has shown that the early AO/ASIF method of plating comminuted fractures of the femur to ensure absolute stability and primary bone union was associated with a high risk of postoperative infection and nonunion (Wagner and Jakoob 1986, Kinast et al. 1989). Recent experience with closed locked intramedullary nailing strongly suggests that, leaving the fragments untouched preserves their blood supply and accelerates union (Tencer et al. 1984).

This new observations have led to a modified approach for internal plate fixation. Anatomical reduction of the fragments in comminuted diaphyseal and metaphyseal fractures of the femur are no longer the goal. Reduction aims at correct bone length and axial and torsional alignment (Perren 1991, Schatzker and Tile 1996). The reduction of fragments is indirect, usually by continuous skeletal traction on the fracture table or by application of a fracture distractor. The fragments are not directly manipulated and their soft tissue attachment is not disturbed, instead the area of comminution is bridged with a plate which is fixed to the proximal and distal fragments. The importance of preserving the viability and integrity of the soft tissue envelope of metaphyseal and diaphyseal fractures has is also supported by Schatzker and Tile (1996), who in comminuted fractures of the metaphysis and diaphysis found that a 2–3 week delay helps the soft tissue envelope to recover (Schatzker and Tile 1996). This type of indirect fixation is referred to as "bridge plating" and is part of the new concept of biological internal fixation (Perren 1991).

We retrospectively reviewed the results of the treatment of comminuted subtrochanteric, diaphyseal and supracondylar fractures of femur using indirect reduction and the bridge plating technique.

Patients and methods

The charts and radiographs of 39 patients treated between 1990 and 1995 with comminuted diaphyseal, subtrochanteric and supracondylar fractures of the femur were reviewed. 15 fractures had been treated with another technique and were excluded. The remaining 24 fractures had been treated with bridge plating. Of thess, 4 did not have adequate follow-up. The study is based on the remaining 20 patients (mean age 45 (18–83) years, 15 men), who all had a routine follow-up evaluation including regular clinical and radiographic documentation until bone union and full rehabilitation of the patient; follow-up aver-

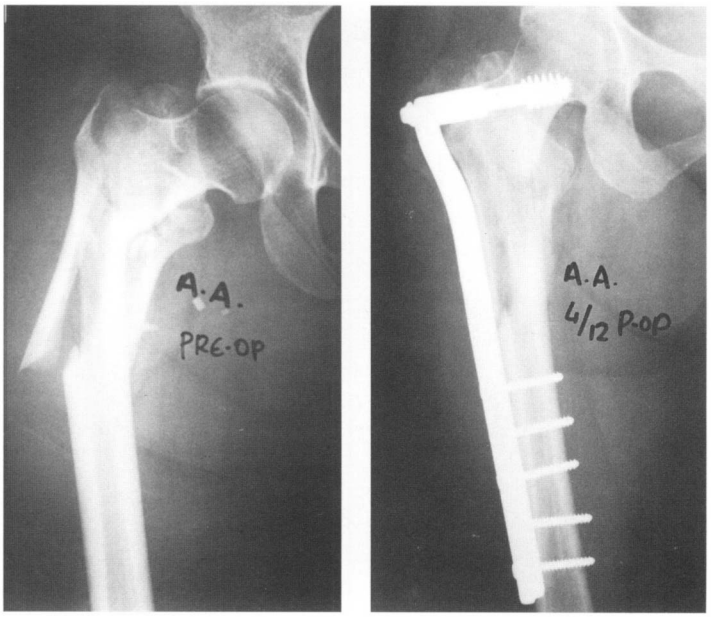

Figure 1. Type C subtrochanteric fracture of the femur (left). 4 months postoperative, excellent alignment and fracture healing following treatment with a 95° DCS plate (right)

aged 1.5 (1–4.5) years. 18 patients were involved in motor-vehicle accidents and 2 had a fall from a height. 12 of the 20 patients had multiple injuries. 17 fractures were closed and 3 open (I, II, IIIA). 11 were subtrochanteric type C, 6 complex diaphyseal and 3 supracondylar, 2 type C3 and 1 type A3 (AO classification).

All subtrochanteric and diaphyseal fractures were placed on skeletal traction at admission. Preoperative planning included radiographs of the opposite femur to determine the DHS or DCS entry site, and theproper length of the plate. A 135° DHS was used in 6 of the 11 subtrochanteric fractures, as the longest DCS available was too short to bridge the fracture of the diaphysis. 9 were operated between 1 and 4 days post injury, 8 patients between 5 and 15 days and 3 between 15 and 22 days. When no absolute indication for immediate fixation was present, the operation was delayed for 1 or 2 weeks with the leg length maintained by skeletal traction. In 8 multitrauma patients, the other fractures were fixed immediately and the fractured femur after 5–15 days.

Of the 3 patients who were operated on 15–22 days after injury, 2 had developed ARDS 2 days after trauma and the third (supracondylar type IIIA open fracture) had been treated initially at another institution with traction, where he had developed a superficial wound infection. All patients received pre- and postoperative antibiotics for 3 to 5 days and fractional Heparin.

Surgical technique: Subtrochanteric fractures were reduced indirectly by skeletal traction, checking the length, axial alignment and rotation clinically and under radiographic control (Figure 1). In subtrochanteric fractures, a standard lateral approach to the hip was performed. First, the screw of the 95° DCS was inserted in the predetermined position under image intensification. The vastus lateralis was then mobilized from the linea aspera and reflected anteriorly, revealing only the lateral aspect of the femur. Homan retractors were placed only on the proximal and distal main fragments and not in the area of fragmentation. The plate was connected with the DCS screw, tightened and secured to the distal fragment with bone holding forceps. The fragments lying medially were reduced indirectly by overdistraction and careful manipulation of the larger ones, aiming to approximate them to the plate and fix them, either by interfragmentary screws or by means of cerclage wiring. The small fragments were left undisturbed. Axial alignment, rotation and length was checked and the plate was fixed to the distal fragment by at least 4 screws. Autogenous bone was grafted in 3 of 11 subtrochanteric fractures.

In diaphyseal fractures, the vastus lateralis muscle was reflected anteriorly, the plate was fixed proximally and distally with at least 4 screws and large fragments were approximated to the plate by intrafragmentary screws and cerclage wiring. All 6 diaphyseal fractures were bone grafted (Figure 2).

The same technique was followed for the fixation of the 3 supracondylar fractures (Figure 3). The condylar fracture was reduced and fixed and then a 95° DCS or Condylar Buttress Plate was inserted, first, in the femoral condyle and then to the proximal

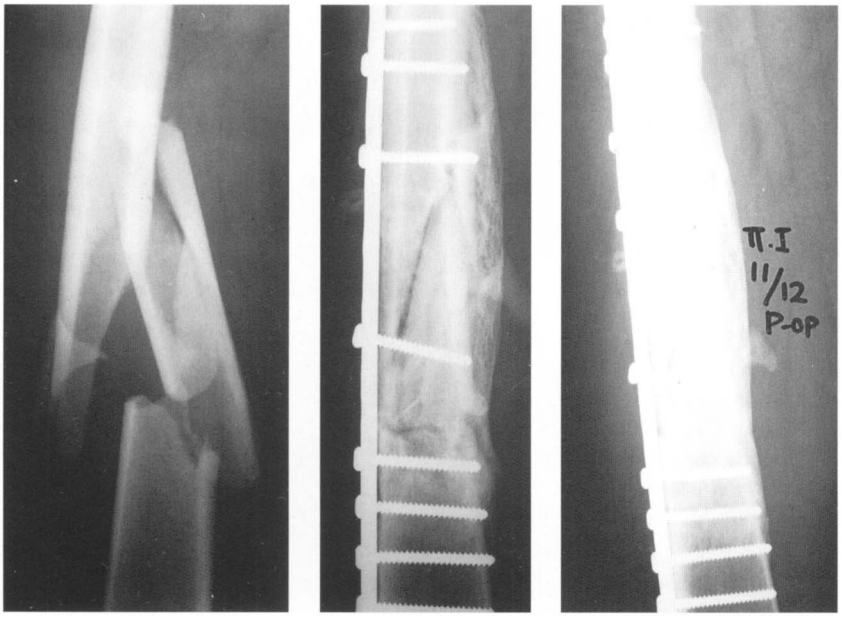

Figure 2. A segmental fracture of the shaft of the femur preoperatively (left) and 4.5 months following treatment by bridge plating and autogenous bone grafts (middle). (B) Postoperatively at 11 months solid heaing of the fracture is seen (right).

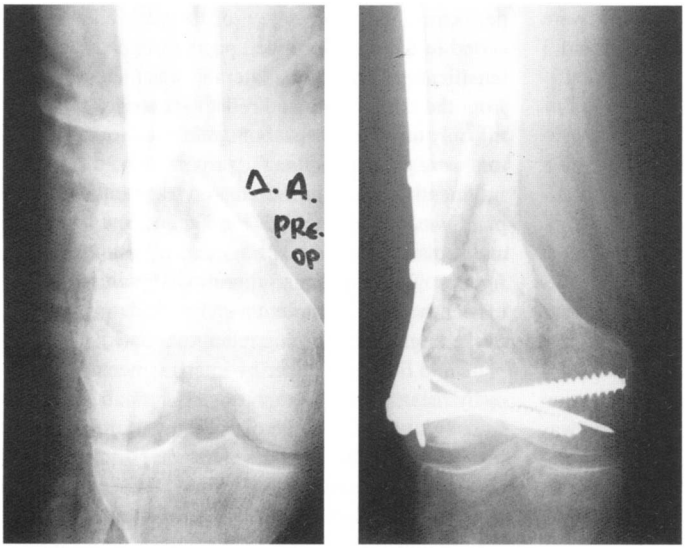

Figure 3. A supracondylar fracture of the femur with marked intraarticular and metaphyseal comminution (C3; left). A condylar buttress plate was used to bridge the area of comminution and restore intraarticular congruity. Healing of the fracture after 6 months (right).

fragment, leaving the area of fragmentation undisturbed. Alignment, length and rotation were checked before the insertion of the proximal screws. In 2 of the 3 supracondylar fractures bone was grafted to fill large metaphyseal defects.

The following implants were used: In the subtrochanteric fractures, the preferred implant was the 95° DCS (5 patients). In the remaining 6 patients, a 135° DHS was used in order to bridge very long fractures. In the diaphyseal fractures, 4 ACPs and 2 LC/DCPs and in the supracondylar fractures, 1 DCS and 2 Condylar Buttress Plates were used.

The postoperative regimen depended on the stability of the fixation of the fracture. Postoperative traction was maintained for 4–5 weeks in 6 patients. 4 of them had long subtrochanteric fractures which were fixed with 135° DHS. Because the proximal fragment could not be fixed to the plate with extra screws, they were considered unstable. The other 2 patients had supracondylar fractures fixed with condylar plates and the stability of the fixation was questionable because of poor bone. The remaining patients were mobilized from the third postoperative day. Weight bearing started when there was sufficient callus on radiographs, usually after the third post operative month.

Table 1. Data of each case

Case	Sex	Age	Injury [a]	Diag.[b]	Type [c]	Open	M.[d]	Time [e]	Method	Graft	Tract.[f]	U.[g]	FU [h]	Complications
1	M	70	MVA	ST	C	–	–	1	135-DHS	–	–	4	12	
2	M	23	MVA	D	X	–	+	3	LC-DCP	+	–	4	12	
3	M	40	MVA	ST	C	–	–	2	135 DHS	–	1	6	12	
4	M	23	MVA	ST	C	–	+	6	135 DHS	–	–	4	14	
5	M	48	MVA	ST	C	–	+	18	135 DHS	+	1	6	18	ARDS, 1.5 cm short. 8^0 varus
6	M	32	MVA	D	X	–	–	5	AC-Plate	+	–	6	14	
7	M	36	MVA	D	X	–	+	12	AC-Plate	+	–	4	11	
8	F	39	MVA	ST	C	–	+	2	95 DCS	–	–	3	14	
9	M	30	MVA	SC	C	–	+	2	135 DHS	+	–	4	12	1 cm short. / 10^0 varus
10	F	61	MVA	SC	C3	+ (II)	–	2	Cond. Pl.	+	1	6	16	2 cm short. Knee flex.: 0–90^0
11	M	38	MVA	D	X	–	+	12	LC-DCP	+	–	4	11	
12	M	18	MVA	ST	C	–	+	10	95 DCS	–	–	5	11	
13	F	33	MVA	D	X	–	+	2	AC Plate	+	–	6	11	
14	M	64	MVA	ST	C	–	+	14	135 DHS	+	1	6	48	
15	M	32	MVA	ST	C	–	–	8	135 DHS	–	1	4	36	
16	F	76	MVA	SC	A3	–	–	3	Cond. Pl.	–	1	5	12	Knee flex.: 0–110^0
17	M	83	Fall	SIT	C	–	–	1	95 DCS	–	–	4	12	
18	F	31	Fall	ST	C	–	+	8	95 DCS	–	–	5	14	
19	M	38	MVA	D	X	+ (I)	–	18	AC Plate	+	–	4	54	ARDS, Knee flex.: 0–80^0
20	M	29	MVA	SC.	C3	+ (III)	+	22	95 DCS	+	–	3	18	Infection (preop.) Knee flex.: 0-110^0 1.5 cm short.

a Injury: MVA motor vehicle accident.
b Diagnosis: ST subtrochanteric, D diaphyseal, SC supracondylar, SIT sub- and intertrochanteric fracture.
c Type: X complex.
d Multitrauma
e Timing in days.
f Months in traction postoperatively.
g Time to bone union in months.
h Follow-up in months.

Results

Immediate posttrauma complications occurred in 3 patients (Table 1). 2 of the multitrauma patients developed ARDS after 2 days; both recovered and were operated 18 days after injury. The third patient (C3, open IIIA supracondylar fracture) came to us 1 week after injury with superficial wound infection and was operated 22 days after injury. There were no infections in the post operative period nor any other complications.

All fractures healed after mean 4.6 (3–6) months. In most fractures the amount of the callus was impressive, most so in the patients operated 5–15 days after injury. Bone grafting did not influence the speed of union; the 11 bone grafted fractures united after average 4.8 months and the 9 nongrafted fractures after average 4.6 months.

4 patients had leg shortening, between 1 and 2 cm; the shortening was intentional in 2 patients with supracondylar fractures to obtain stability of the fracture, while the other 2 with subtrochanteric fractures had a 8–10° varus deformity of the femoral neck. Knee stiffness was observed in 4 patients: 3 with supracondylar fractures achieved a range of motion of 0°–90°, 0°–105° and 0°–110°, and 1 patient with a segmental fracture of the diaphysis had 0°–80°. No second operations were performed in any of our patients.

Discussion

We have evaluated the technique of bridge plating in the treatment of 20 difficult fractures of the femur. Of the 20 fractures, 11 were comminuted subtrochanteric, type C3. In 8 of them the trochanteric mass was involved by the fracture and, therefore, interlocking nailing was excluded. All 11 fractures united within 5 months. Two patients had 1–2 cm shortening of their leg and 7.5°–10° varus angulation of the femoral neck. Only 3 of the 11 fractures were bone grafted. Our results are in agreement with those of Kinast (1989) and Baugaertel (1994), who also used indirect reduction and biological plating, and emphasize the superiority of the indirect reduction to the direct reduction.

Today absolute stability is no longer the objective of internal fixation because of better understanding of bone physiology and the importance of preserved blood supply to the bone fragments (Perren 1991, Schatzker and Tile 1996). Biological internal fixation is perhaps most important for comminuted diaphyseal fractures of the femur. Best treatment of these fractures seems to be biological indirect reduction and splinting by an unreamed locked nail, as a first choice or a bridging plate as a second choice (Perren 1991, Schatzker and Tile 1996). Unreamed nails have reduced, but have not eliminated cardiopulmonary complications (Schatzker and Tile 1996). Thus, there still is debate whether to nail femur fractures in multitrauma patients, who have been in shock and have concomitant chest injury. It has been suggested that long bone fractures of these patients should be plated or stabilized with an external fixator.

There is a limited number of reports regarding the bridge plating technique in comminuted fractures of the femur diaphysis (Waddel 1979, Kinast et all. 1989, Mast et al. 1989, Gerber et al 1990, Schatzker and Tile 1996). In our series, 6 patients had a complex fracture of the diaphysis. The operation was delayed intentionally for an average of 9 days for the soft tissue envelope to recover, and indirect reduction by continuous skeletal traction and bridging was done with bone grafting. All fractures healed by 5 months, with only 1 patient developing an excessive callus anteriorly and knee stiffness.

Ostrum and Geel (1995) reported the results of 30 supra-intercondylar fractures treated by indirect reduction, where 26 had excellent or satisfactory results. This compares favorably with the results following direct reduction. In our study there were 3 supracondylar fractures, where 2 were supra-intercondylar, type C3, and the third was a supracondylar type A3. All fractures healed after indirect reduction and bridge plating with average 100° motion. It should be noted that 2 patients had 1 cm shortening. These excellent results are compatible with previous studies (Johnson 1987, Ostrum and Geell 1995).

Bone grafting did not alter the speed or rate of bony union which occurred on an average of 5 months in all patients. This finding is in agreement with current literature, stating that bone grafting is unnecessary in comminuted fractures treated with indirect reduction technique (Perren 1991, Schatzker and Tile 1996). In addition, bone union occurred within 3–6 months irrespective of immediate or delayed surgery. However, an effect of delay on bone union cannot be assessed, as the fractures of the two groups were not matched. It has also been reported that a delay in surgery and the subsequent soft tissue recovery allow for a technically easier and safer indirect reduction and plating (Charnley and Guindy 1961, Lam 1964, Schatzker and Tile 1996, Smith 1964).

In conclusion, our findings indicates that the bridge plating technique, with indirect reduction of the fracture, led to a rapid union of all comminuted fractures of the femur without major complications.

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