Musculoskelet Surg (2013) 97:229–235
DOI 10.1007/s12306-013-0292-x

ORIGINAL ARTICLE

Minimally invasive plate osteosynthesis in type B fibular fractures versus open surgery

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Received: 10 September 2012 / Accepted: 17 July 2013 / Published online: 31 July 2013

Abstract

Background In traumatology, the search for better surgical access points has led to the increased use of the minimally invasive plate osteosynthesis (MIPO) technique. There are few studies on the treatment of distal fibular fractures with MIPO. Locking compression plates (LCP) for distal fibular fractures is generally applied after open reduction, but may involve complications to the surgical wound. In this study, we compared two groups of patients receiving either ORIF or MIPO, in order to analyse the advantages and disadvantages of the two techniques.

Materials and methods Two homogeneous groups of patients (18 + 18) received LCP for distal fractures of the fibula, type B, according to AO. Group A patients underwent open surgery, whereas Group B patients received plates applied with the MIPO technique. Both groups were examined physically and radiographically 1 and 3 months after the two types of procedure and then 1 year later, with functional assessment according to Olerud and Molander.

Results ROM Group A: 5° reduction in tibiotarsal extension in 8 patients and 5° in supination in 1 patient; Group B: 5° reduction in extension in 7 cases. Mean healing time: 3 months (range 2–4) in Group A and 2.9 (range 2–4) in Group B. Dehiscence of the surgical wound was observed in five Group A patients, but none in Group B. Functional assessment according to Olerud and Molander was 87.4 points in Group A (range 80–100) and 95.6 in Group B (range 82–100).

Conclusions We believe that the MIPO technique for distal fractures of the fibula should be used more often, especially if soft tissue is in a critical condition. Healing times should be reduced in the more complex cases. It is important that the learning curve should be improved, to minimize exposure to radioscopy and possible damage to the superficial fibular nerve.

Keywords MIPO · Fibular fractures · Osteosynthesis

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Introduction

In traumatology, the search for better surgical access points has led to the increased use of the minimally invasive plate osteosynthesis (MIPO) technique. Locking head screws are used, giving good stability, especially in osteoporotic bone [1, 2], and complete respect for the periosteum. The literature contains many works on the MIPO technique for fractures of the humerus [3] (proximal and shaft), femur [3–6] (proximal, distal and shaft) and tibia [3, 7–11] (proximal, distal and shaft), with good results. However, there are few studies on the treatment of distal fibular fractures with MIPO. LCP for distal fibular fractures is generally applied after open reduction, but may involve complications to the surgical wound, as reported in the literature [12–14], especially in elderly patients with critical soft tissue condition, because at this level, the bone is not covered with muscle and soft tissue coverage is thin. Siegel and Tornetta [15] reported a series of 31 unstable comminuted pronation–abduction ankle fractures. A direct lateral incision with extraperiosteal dissection was used to preserve the soft tissue sleeve surrounding the fracture. All fibular fractures healed within 10 weeks. Hess and Sommer [16] reported 20 distal fibular fractures with critical soft tissue conditions treated with the MIPO technique.

Seventeen fractures healed without complications in an average time of 9 weeks. Krenk et al. [17] reported that 19 ankle injuries were treated with the MIPO technique. All fractures healed without skin complications in an average time of 8.3 weeks.

In this study, we compared two groups of patients receiving either ORIF or MIPO, in order to analyse the advantages and disadvantages of the two techniques.

Materials and methods (Tables 1, 2)

We studied 36 patients, 16 males and 20 females, mean age 51 years (range 21–82), operated for distal fibular fracture. The right side was involved in 14 patients and the left in 22. Fractures were distinguished according to the AO classification. All patients had fractures of AO type 44 of the distal fibula. Patients with fractures of the tibial malleolus, previous fractures of the same-side ankle, or vascular or neurological pathologies that could delay healing or alter functional recovery, were excluded. Patients were subdivided into two groups, similar to the type of fracture: Group A was treated with open surgery and synthesis metaphyseal LCP, and Group B with MIPO and LCP. Both groups were composed of 18 patients (8 males, 10 females) with fractures of type B1 (16 cases) and B2 (2 cases). The plates were thinner in the more distal 2 cm and thicker proximally. Various kinds of plates were used in the two groups: 6 holes (length 86 mm), 7 holes (99 mm), 8 holes (112 mm) or 10 holes (138 mm). Screws were 3, 5 mm in diameter.

Surgical technique

Patients were in lateral decubitus. Group A was treated with open surgical access, laterally and slightly posterior to the fibula, with particular attention to the superficial fibular or sural nerves. In some cases, an anteromedial incision was also made. Once the area of the fracture had been exposed, it was reduced and a compression plate was applied according to the AO technique also adding locking head screws. In some cases, an interfragmentary screw was inserted and then locking head screws were added proximally and distally to the area of fracture. At the end of the surgery, a cast was positioned with the foot at 90° and was removed after 2 weeks, when physiotherapy and free mobilization of the ankle began. Load on the operated limb was generally allowed after 32 days on average (range 15–45) according to screw hold.

Group B was treated with the MIPO technique. Under fluoroscopic guidance, the apex of the fibular malleolus was identified and a small incision about 2 cm was made (Fig. 1). Tissue was detached from the fibula with suitable instruments, care being taken not to create false pathways that could have obstructed plate positioning. The plate was locked distally with Kirschner wires, and again under fluoroscopic guidance, the plate was identified proximally and a small incision at the more proximal

Table 1 ORIF technique cases

Patients	Gender years	Side R, right L, left	Trauma-surgery interval (days)	RX AO	Operation time (min)	Radioscopy time (s)	LCP 3,5 no holes	Full loading (days)
1. SA	M21	R	2	B1	85	8	7	40
2. CD	F60	R	3	B1	120	30	7	30
3. DM	M53	R	1	B1	60	14	7	45
4. FM	M48	L	1	B1	50	12	6	45
5. BG	F54	L	1	B2	105	6	7	45
6. BG	M63	R	5	B1	125	15	10	30
7. SR	M53	L	3	B2	125	10	8	15
8. DJR	M36	L	3	B1	70	8	8	21
9. CI	F56	L	4	B1	55	22	6	30
10. SA	F75	L	1	B1	140	6	6	30
11. PL	M82	R	3	B1	85	5	7	30
12. BC	F77	L	2	B1	115	10	7	30
13. FE	F54	L	1	B1	115	13	7	30
14. PR	F37	R	3	B1	120	30	6	15
15. MG	F48	R	1	B1	70	12	6	40
16. MR	M23	L	6	B1	70	15	6	30
17. SF	M37	L	1	B1	40	14	7	30
18. GI	F45	R	3	B1	60	20	7	40

Table 2 MIPO technique cases

Patients	Gender years	Side R, right L, left	Trauma-surgery interval (days)	RX AO	Operation time (min)	Radioscopy time (s)	LCP 3,5 no holes	Full loading (days)
1. HA	M36	R	5	B2	55	16	8	40
2. GE	M45	L	1	B1	60	82	6	45
3. CS	F35	L	3	B1	80	28	6	30
4. GS	M43	R	3	B1	50	30	6	15
5. CA	M46	R	1	B1	35	18	6	15
6. NG	M65	L	2	B1	35	6	6	20
7. NM	F59	L	1	B1	45	6	7	15
8. AM	F38	L	1	B1	40	12	6	15
9. CM	M29	L	1	B1	55	8	6	30
10. MA	F33	R	1	B1	45	45	6	15
11. BE	F59	L	1	B1	75	25	6	15
12. PG	M65	L	1	B2	80	95	7	15
13. MM	M73	L	3	B1	35	15	6	30
14. BB	M79	L	3	B1	55	65	8	45
15. DC	F54	R	1	B1	100	10	6	30
16. TA	F63	L	2	B1	90	90	6	15
17. BP	F68	L	1	B1	70	80	6	30
18. TC	F30	R	1	B1	43	30	6	30

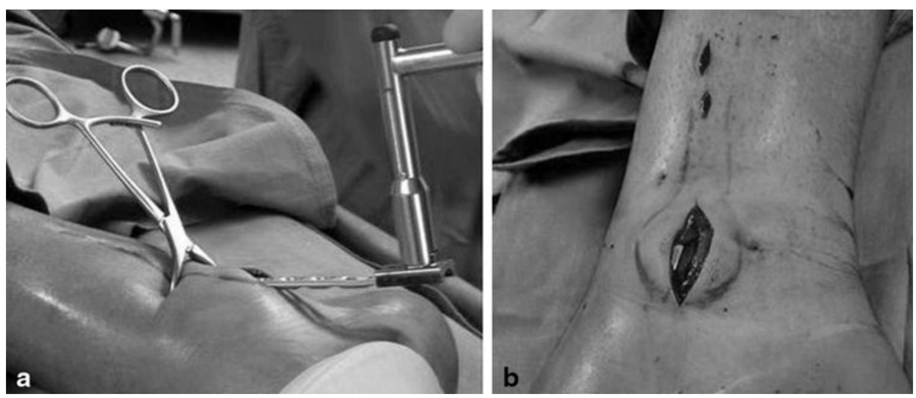

Fig. 1 MIPO of the distal fibula. The plate is placed through the distal incision

screw hole was made, great care being taken not to damage the superficial peroneal nerve, which may lie on the plate hole [18–24]. The locking drill sleeve was then positioned and used as a handle. The plate was inserted epiperiosteally and locked in place with Kirschner wires. Correct positioning of the plate was checked radioscopically, since at least two locking head screws proximally and distally to the point of fracture had to be applied. The technique required closed reduction in the fracture, which could be carried out in two ways: in the case of displaced fractures on frontal plane, a screw was placed proximally near the area of fracture, and under radioscopic guidance, the fibular plate was pressed until the fracture was realigned. For displaced fractures on the sagittal plane, with a tendency to posterior or proximal displacement of the distal fragment, a pointed reduction forceps were used percutaneously and checked radioscopically to ensure that reduction was correct. During reduction, any defects of rotation were corrected, as rotation of the distal fibula was crucial. After reduction, the plate was fixed with locking head screws (Figs. 2, 3). With the MIPO technique, quite short plates, with a maximum of 8 holes, were used. Lastly, a cast was applied with the foot at 90° and removed 2 weeks later, followed by physiotherapy and free movement of the ankle. Load on the operated limb was generally allowed on average after 25 days (range 15–45), according to screw hold.

Group A patients were operated on average 2.4 days after trauma (range 1–6), average duration of surgery was 89.4 min (range 40–140), and mean radioscopic time was

Fig. 2 C.M., male, aged 29, case 9 Tables 2, 3 and 4: **a**, **b** preoperative X-ray; **c**, **d** follow-up 6 months later

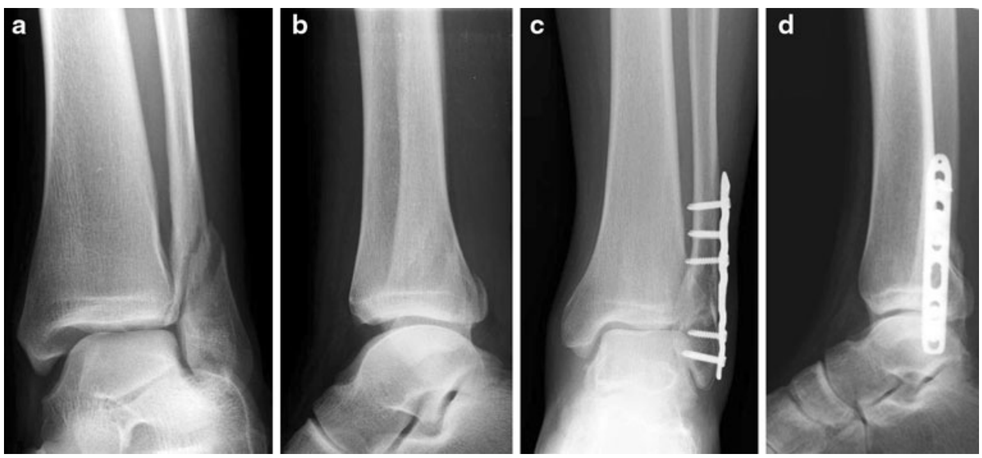

Fig. 3 M.M., male, aged 73, case 13 Tables 2, 3 and 4: **a**, **b** preoperative X-ray; **c**, **d** follow-up 8 months later

13.3 s (range 5–30). Group B patients were operated on average 1.7 days after trauma (range 1–5), average duration of surgery was 58.2 min (range 35–100), and mean radioscopic time was 36.7 s (range 6–95). The number of holes of the plates was recorded, as were any intra- or post-operative complications.

Both groups of patients were re-examined clinically and radiographically with functional assessment according to Olerud and Molander [25] (score 0–100), including pain, stiffness or swelling, and capacity for stair-climbing, running, jumping, squatting, using supports, and activities of daily living.

Results (Tables 3, 4)

In the days after surgery, 5/18 Group A patients (27.7 %) showed dehiscence of the surgical wound. In one case (no. 2; Table 1), dehiscence was minimal, with healing 1 month later. In the four other cases (7, 10, 11 and 14), 10–15 mm of exposure of the plate occurred (10, 11, 14). These were resolved 3 months later or (case 7) 4 months later, after consolidation and removal of the plate. No cases of dehiscence of the surgical wound occurred in Group B.

Average patient follow-up was 22 months (range 6–40) in Group A and 15 (range 6–39) in Group B. Bone healing was judged to be complete when X-ray examination (AP and LL) showed that at least three of the four cortices were bridged by visible callus in both anteroposterior and lateral views). ROM Group A: 5° reduction in tibiotarsal extension in 8 patients and 5° of supination in 1 patient; Group B: 5° reduction in extension in 7 cases. Mean consolidation time was 3 months (range 2–4) in Group A and 2.9 (range 2–4) in Group B. Dehiscence of the surgical wound was observed in 5 cases in Group A, but none in Group B. Functional assessment according to Olerud and Molander was 87.4 in

Table 3 ORIF technique results

Patients	Dehiscence of the wound	Follow-up (months)	Olerud and Molander scoring scale	ROM	Callus consolidation (months)	Removal of the plate	Fibular nerve injury
1. SA	No	22	100	Total	3	No	No
2. CD	Yes	22	80	Extension-5°	3	No	No
3. DM	No	6	96	Total	3	No	No
4. FM	No	31	100	Total	3	No	No
5. BG	No	32	94	Total	3	No	No
6. BG	No	6	92	Extension-5°	3	No	No
7. SR	Yes	6	88	Extension-5°	4	Yes	No
8. DJR	No	12	88	Supination-5°	3	No	No
9. CI	No	40	82	Extension-5°	3	No	No
10. SA	Yes	28	93	Extension-5°	3	No	No
11. PL	Yes	25	88	Extension-5°	3	No	No
12. BC	No	24	85	Extension-5°	3	No	No
13. FE	No	25	92	Total	3	No	No
14. PR	Yes	22	100	Total	2	No	No
15. MG	No	22	90	Extension-5°	3	No	No
16. MR	No	20	96	Total	3	No	No
17. SF	No	26	100	Total	3	Yes	No
18. GI	No	27	92	Total	3	No	No

Table 4 MIPO technique results

Patients	Dehiscence of the wound	Follow-up (months)	Olerud and Molander scoring scale	ROM	Callus consolidation (months)	Removal of the plate	Fibular nerve injury
1. HA	No	22	96	Extension-5°	3	No	No
2. GE	No	27	96	Extension-5°	2	No	No
3. CS	No	36	100	Total	3	No	No
4. GS	No	39	100	Total	3	No	No
5. CA	No	6	100	Total	3	No	No
6. NG	No	17	100	Total	3	No	No
7. NM	No	6	93	Extension-5°	4	No	No
8. AM	No	9	100	Total	3	No	No
9. CM	No	6	94	Total	3	No	No
10. MA	No	12	100	Total	3	No	No
11. BE	No	9	82	Extension-5°	3	No	No
12. PG	No	8	100	Total	2	No	No
13. MM	No	8	96	Extension-5°	3	No	No
14. BB	No	8	92	Extension-5°	4	No	No
15. DC	No	28	96	Total	3	No	No
16. TA	No	17	96	Total	3	No	No
17. BP	No	6	89	Extension-5°	3	No	No
18. TC	No	6	92	Total	2	No	No

Group A (range 80–100) and 95.6 in Group B (range 82–100). At the 1 year follow-up, functional assessment of patients operated at least 12 months previously was the same as during subsequent checks. Two removals of the plate in Group A were observed, but no removal in Group B. There was no fibular nerve injury in Groups A and B.

Discussion

This study was undertaken after examining the literature data on a certain percentage of complications of the surgical wound in ankle fractures treated with surgery and plating. El-Rayes et al. [12] reported 19 % of wound complications in 162 patients with ankle fractures. Höiness et al. [13] reported 22 % of such complications out of 152 patients. This problem occurs particularly in distal fibular fractures, surgically treated with lateral access at a point where soft tissues are thin. For such fractures, plate thickness was also examined and is discussed. Schepers et al. [14] reported 5.5 % of wound complications with conventional plates, but this figure rose to 17.5 % with LCP, presumably due to the increased thickness of the locking plates (2.8–3.3 mm) with respect to the one-third tubular plate (1 mm). To solve plate problems in the distal third of the fibula, already in 1982, Brunner and Weber [26] described the anti-glide technique, with application of the plate on the posterior surface of the fibula with a more posterior incision. This technique is particularly appropriate for oblique instable fractures with a tendency to posterior and proximal displacement of the distal fragment. It has also been used more recently by several authors [27–29]. Treadwell and Fallat [30] in fact report that the posterior plate caused peroneal tendinitis in 2 out of 71 cases. Ostrum [31] reported 4 cases of peroneal tendinitis, resolved in 4–8 weeks, in 32 cases treated with the anti-glide technique. Other solutions to the problem of soft tissues have been sought [32, 33] with the use of a single intramedullary screw for non-comminuted lateral malleolus fractures. These techniques, although interesting, can only solve some types of fractures. Recently, in the wake of the increasingly frequent use of MIPO for fractures of the humerus, femur and tibia [3–11], some published works [15–17] describe this technique for distal fibular fractures, although indications must still be clearly defined. Krenk et al. [17] used MIPO for complex fractures up to C3 according to AO, especially in patients with soft tissue damage, and Hess and Sommer [16] used it in carefully chosen complex cases, when soft tissues were in a critical state. In our experience of two homogeneous samples of patients, we limited our study to B1 and a few B2 fractures. An initial comparative analysis of the two groups showed that the mean trauma/surgery interval was greater in Group A (2.4 days) than in Group B (1.7 days). This indicates that the mini-invasive technique may be used earlier, even when the state of the patient's skin is still not completely satisfactory. The mean operation time was greater in Group A (89.4 min; Group B 58.2) and mean radioscopic time was lower (Group A 13.3 s; Group B, 36.7). Functional assessment, according to Olerud and Molander, although satisfactory in both groups, was lower in Group A (87.4 vs. 95.6). Data on the MIPO technique should be improved with improved learning curves, and possible reduction in operating and radioscopic times, and could be extended to more complex fractures. In our experience, skin complications only developed in patients subjected to open surgery. Healing times were almost equal in the two groups, although MIPO, which allows closed reduction without opening the area of fracture, is a more biologically friendly procedure. Extending the technique to more complex comminuted fractures would presumably reduce callus consolidation time. One limitation of MIPO with respect to open surgery is the risk of damage to the superficial peroneal nerve, the position of which may vary greatly, as reported in many works [18–24]. In our cases, no fibular nerve injury with MIPO technique was observed. In cadaver studies, Mirza et al. [22] have shown that the superficial peroneal nerve leaves the fascia of the lateral compartment at an average of 11.62 cm (range 6.8–18.2 cm) from the tip of the lateral malleolus and that it may be damaged by a longer plate with 9 holes. As the most frequently used plates have 6 holes (or, more rarely, 7 or 8, according to level of fracture), we believe particular care should be taken when using plates with 7–8 holes.

In conclusion, we believe that the MIPO technique for distal fibular fractures should be favoured, particularly when the condition of soft tissue is critical. Healing times could be reduced in the most complicated cases. It is important to improve learning curves, to minimize radioscopic exposure and possible damage to the superficial peroneal nerve.

Conflict of interest None.

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