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ORIGINAL STUDY

Surgical treatment of ankle fractures by pneumatic stapling : Clinical experience and review of the literature

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Between June 1987 and December 2002, 237 cases of malleolar fractures were treated at Erasme hospital using pneumatic stapling, alone or combined with another type of fixation. This retrospective study addresses 176 well-documented cases. The mean follow-up period was 36 months. The results indicate that pneumatic stapling is an effective technique with a very low rate of failure. Comminuted fractures are not a contraindication.

Keywords : ankle ; fractures ; pneumatic stapling.

INTRODUCTION

Surgical treatment of ankle fractures is now widely accepted (*6, 15, 17, 18, 21, 27, 41, 45, 46, 48, 53*). The use of metal staples as an osteosynthesis technique dates back to Albin Lambotte (*49*). Shapiro adapted industrial pneumatic staplers to be used as orthopaedic tools (*43*). The orthopaedic literature unanimously agrees to restrict pneumatic stapling to cancellous bone fragments with less than 2 mm of cortical bone thickness (*16, 30, 43, 44*). The technique is well suited for ankle fractures. The relative ease of staple placement incited us to use it on a regular basis. We assessed the results retrospectively after a period of more than ten years.

Biomechanics of staple fixation

A few experimental studies were performed on different models of staples in bone tissue (*22, 29*). Pneumatic stapling is more accurate than manual insertion as staples are inserted in one shot (*22*). For Shapiro (*43*) manual insertion, in several hits, with minor oscillations of the staple holder, creates a penetration cone around the legs of the staples, thus reducing the bone-implant interface. The slight divergence of the prongs in pneumatic stapling induces some interfragmentary compression (*29*) which increases the implant stability against shear stress (fig 1). To optimise fixation, the staples should be long, considering the local anatomical conditions (*22*). Staples with a curved profile are slightly more efficient than square or rectangular profiles (*23*).To increase resistance to flexion or traction, the number and length of staples must be increased (*24*).

Surgical technique

The decision whether or not to use staples was left to the surgeon's judgment. Patient positioning

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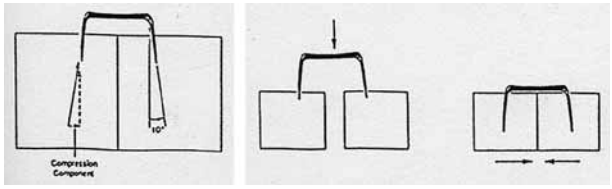

Fig. 1. — Interfragmentary compression due to divergence of the prongs of the staples (from Krackow and Mecherikunnel, 1991) (*29*).

and surgical incisions are similar to classical techniques. Fractures to be stapled mostly involve cancellous bone, with a fracture line large enough to accommodate several parallel staples (fig 2). The technique is suitable for medial and posterior malleoli, also for distal, inter-ligamentous, or oblique lateral malleolar fractures. The incision needed for reduction and stapling is significantly smaller than for insertion of other types of fixation material. The longest possible staples not protruding into the joint are used (the length of the staples is estimated preoperatively on radiographs) and the width of the staple must leave enough bone between both legs, to prevent cut out. The most frequently used staples are 13×10 and 13×13 mm. Smaller staples are used for distal medial malleolar, lateral malleolar fractures, or small comminuted fragments. The strength of the pneumatic stapler is set according to the degree of osteoporosis : in osteoporotic bone that is easily penetrated, hard impact could fragment the bone. It is set higher for strong bone in young patients and, if necessary, a second pneumatic hit is given without recharging the stapler. We usually implant three staples. The first staple is perpendicular to the midpoint of the fracture line. Two other staples are then placed at a distance on each side of the first one. They are inserted perpendicular to the bone surface and the fracture line. The shape of the staples is roughly cylindrical, and the arms of the staples converge towards each other. An intraoperative radiograph is made to check fracture reduction and proper length of the staples. The skin is closed and the leg is immobilised in a plaster cast in the majority of cases.

Fig. 2. — Medial malleolar fracture fixed by staples in an adequate convergent juxtaposition.

MATERIAL AND METHODS

Between June 1987 and December 2002, 237 patients with malleolar fractures underwent staple fixation in the Department. In this retrospective study, 176 cases were available for review : 102 patients were recalled, and 10 reached by telephone. Sixty-four patients had a complete outpatient record and were included in the study. Sixty-one patients were lost to follow-up. For each case, we collected pre- and postoperative serial radiographs. Preoperative radiographs were analysed and fractures classified according to the classifications of Weber (*50*) and Burwell *et al* (*11*). The quality of reduction was assessed according to Weber *et al* (*51*), on immediate postoperative films. On follow-up radiographs, reduction, healing and possible osteoarthritis were assessed according to Magnusson's criteria (*32*). Objective postoperative clinical data consisted in range of motion (ankle, subtalar, and mediotarsal), oedema, and deformity. Subjective data included pain, stability, walking perimeter, ability to use stairs, patient satisfaction and

Table I. — Ankle fracture classification

Fracture type	Weber A 12 cases	Weber B 102 cases	Weber C 35 cases	Medial malleolus (Burwell and Charnley, 1965) (*11*) 27 cases	Total
Lateral malleollus	7	22	1		28
Medial malleollus				27	27
Bimalleolar	5	39	18		62
Trimalleolar		41	16		57
Total	12	102	35	27	176

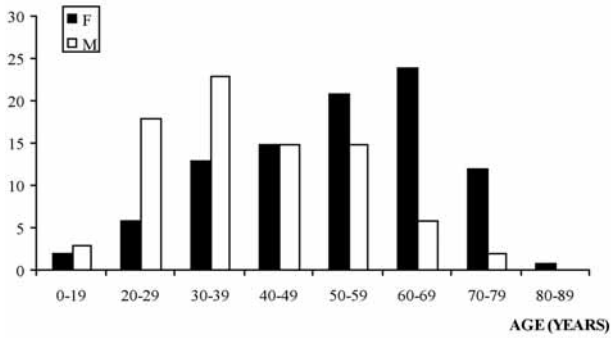

Fig. 3. — Age and sex distribution

Fig. 4. — Equivalent of a bimalleolar fracture, stapling of the fracture of the distal fibula.

basic quality of life. The mean follow-up period is 36 ± 5.6 months (range : 2 to 131). Radiographic follow-up averages 47 ± 8 months (range : 3 to 131) for the 102 recalled patients, 26 ± 5 months (range : 2 to 125) for the 10 patients contacted by telephone, and 12 ± 2.7 months (range : 2 to 55) for the patients studied on records only.

Description of the series

The sex ratio was practically even (94 females, 82 males), as well as the side of the fracture (84 left, 92 right). The mean age was 46.5 ± 2.4 years (range : 15 to 89). A histogram (fig 3) demonstrates peaks in young males (mean 40 ± 3.1 years) and older women (mean 52 ± 3.2 years) ($p < 0.001$). Domestic accidents are more frequent in females ; motor vehicle, work, or sport accidents are more common in males.

Our series consists of 12 Weber A fractures (6.8%), 102 Weber B fractures (58%), and 35 Weber C fractures (20%). There were 27 isolated fractures of the medial malleolus (Burwell classification, table I). Thirty-two patients (18.2%) presented a talo-tibial dislocation.

Thirty-eight patients (25.5%) had comminuted fractures : isolated medial malleolus fractures in 8, another 8 medial fractures in bi-malleolar lesions (all 16 were stapled). Of the 22 comminuted lateral malleolus fractures, 1 was treated by stapling, 3 by combined stapling and plating, and the remaining 18 by plating alone.

Lateral malleolar fractures were stapled in 33%, including 4 comminuted fractures. Medial malleolar fractures were stapled in 75% of the cases (fig 4, 5). All 16 comminuted medial fractures were stapled, in association with screw fixation in one. Posterior marginal fractures including more than one-third of the joint surface (16 cases) were treated by internal fixation, 56% of these by stapling. Seven fractures (4%) were open (*26*) : 3 were Gustilo I, 2 Gustilo II, 1 Gustilo IIIA and 1 Gustilo IIIC. Four patients were polytrauma patients as a result of motor vehicle accidents (mean age :

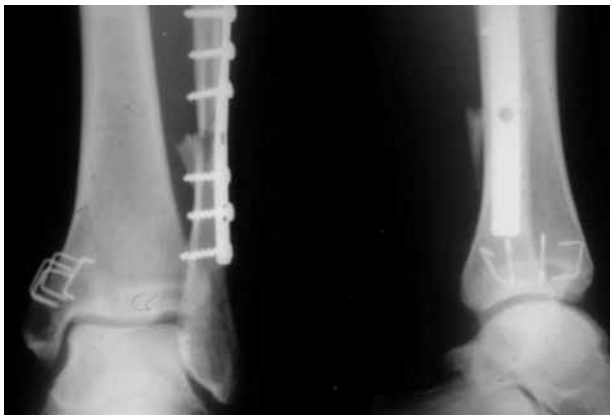

Fig. 5. — Rigid plate fixation of fibula, staple fixation of the medial malleolus (Weber C).

40 years). Eleven other patients presented with associated fractures but were not considered as a polytrauma, as the injury severity score was under 20 (*35*).

Out of the 176 cases, 165 (94%) were immobilised for a period of 5 weeks in a non-weight bearing cast, followed by 4 weeks in a walking cast. The average delay for free mobilisation was 65 ± 3.2 days (range : 31 to 147), a delay not influenced by associated fractures, except for the polytrauma patients. An external fixator was used in 5 out of 7 open fractures (71.4%) and 6 closed fractures with skin defects. The mean delay before full weight bearing was 92 days.

RESULTS

Subjective criteria

Out of 176 cases, 125 (71%) had no pain at follow-up. Twenty-five patients (14%) suffered slight pain upon effort, 19 (12%) moderate pain during normal activity, 6 (3.4%) pain on standing. Only one patient (0.6%) described constant pain. One hundred thirty-four patients (76.1%) had no ankle oedema, 34 (19.3%) had a painless oedema, and 8 (4.6%) a painful oedema. In patients with postoperative oedema, a significant proportion had post-traumatic osteoporosis ($p < 0.05$, table II). One hundred thirty-eight patients (78%) were satisfied, 32 (18%) moderately satisfied, and 6 (4%) unsatisfied. No patient considered the operation a failure.

Table II. — Oedema and algodystrophy

Oedema		Follow-up (months)	Algodystrophy
none	134 (76.1%)	37.8	12/134 (8.9%)
indolent	34 (19.3%)	43.4	9/34 (26.5%)
painful	8 (4.6%)	31.7	4/8 (50%)
Total	176		25

Objective criteria

Ninety seven percent of the fractures were anatomically reduced (Weber criteria, 1985) (*51*). The remaining 3% were considered acceptable. At follow-up 54% of anatomically reduced fractures had normal radiographs (grade 0, Magnusson, 1944) (*32*), 36% had osteoarthritis grade 1, 9% grade 2, and 1% grade 3. In the “acceptable reduction” subgroup, four patients (80%) developed grade 2 osteoarthritis, and 1 patient (20%) developed grade 3 osteoarthritis ($p < 0.001$, table III).

Implant removal

Staple removal was indicated in 13 cases for discomfort (table IV). Forty-seven patients requested removal. In isolated lateral malleolar fractures (30 cases), no implant was removed because of pain or discomfort, and in 5 patients the implants were removed on request (16.6%). In the 27 isolated medial malleolar fractures, 2 patients (7.4%) required removal because of discomfort and 3 (11%) on request**.** Out of the 62 bimalleolar fractures, ablation was performed on demand in 21 bimalleolar fractures (34%), for pain or discomfort in 8 (13%), and for a broken metal plate in one (1.6%). In 32 cases (51.4%), the material was left in place. In the triple malleolar subgroup (57 cases), removal was performed on principle in 22 (38.6%), for pain or discomfort in 3 (5.2%). Three patients had only the lateral malleolar metal plate removed (5.2%). The staples were not removed in 29 patients (51%).

Table III. — Relationship between osteoarthritis and anatomic reduction

Radiograph osteoarthritis	Grade 0	Grade 1	Grade 2	Grade 3	Total
Anatomic reduction	98	58	13	1	170
Acceptable reduction	0	0	5	1	6
Poor reduction	0	0	0	0	0
	98	58	18	2	176

Table IV. — Implant removal

Implant removal	Isolated lateral (30)	Isolated medial (27)	Bimalleolar (62)	Trimalleolar (57)	
pain (staple)	0	2	8	3	13
out of principle	5	3	21	22	51
Implant failure	0	0	1 (plate)	0	1
	5	5	30	25	65

Complications

The complication rate (20%) includes 25 cases of algodystrophy (14.2%), 5 superficial wound infections (2.8%), 4 implant failures (2.2%), one deep venous thrombosis (0.6%). Out of the 128 medial malleolar fractures treated exclusively by stapling, we observed 2 implant failures : one explained by a suboptimal staple placement, the second as a result of secondary displacement. There were no implant failures in the comminuted fractures, the 45 lateral malleoli, or the 10 posterior marginal fractures, treated by staples alone (2 failures out of 183 stapled fractures : 1%). We observed one secondary medial malleolar screw migration and one lateral malleolar metal plate fracture.

DISCUSSION

In Europe, ankle fracture is the third most common fracture after wrist and hip fractures (*7, 8*). Since 1950, the incidence and severity of ankle fractures in older females and in young, middle-aged males seem to have increased (*4, 5, 40*). Most authors agree that a stable anatomical reduction is the key to a good clinical end result (*11, 15, 27, 34, 48*). The current trend is towards surgical repair. Ligament lesions must also be taken into account. The medial, or deltoid, ligament must only be explored and sutured if a talotibial diastasis persists after proper reduction of the fibula (*1, 3, 4, 20, 33*). Lesions of the inferior transverse tibio-fibular ligament should be treated by a tibio-fibular screw if an instability persists after a proper malleolar osteosynthesis (*9, 20, 34, 36*). It should be removed before allowing weight bearing (*15, 19, 37, 47*).

Fractures of the posterior malleolus should be surgically fixed if more then 25% to 30% of the tibial articular surface is involved. It has also been shown that surgery within 24 hours of the trauma decreases morbidity (*14*).

Authors are unanimous in saying that stapling is only indicated for cancellous bone with a cortex less than 2 mm thick (*16, 30, 43, 44*). Published series report fairly good results. Advantages of the technique include rapidity and simplicity of placement (*16, 25, 30, 31, 38, 42, 52*) and the possibility of a minimal surgical incision (*13, 28, 31, 38*). They also report few complications and implant ablations. Staple removal is deemed unnecessary by most authors (*2, 12, 13, 16, 28, 39, 42*) as the staples are small (*42*). Pneumatic staples insertion is more accurate than manual insertion and improves bone fixation (*22*). Shapiro stresses that sufficient manual pressure should be applied when firing the stapler to counter the recoil force and prevent inadvertent displacement that would result in an improper insertion of the staple (*44*).

Between June 1987 and June 1998, 202 cases of malleolar fractures were treated at Erasme hospital using pneumatic stapling, alone or in association. In a retrospective study, 176 cases were available. The mean follow-up period was 39.5 months. Radiological results were deemed excellent in 93.8% of the cases. We agree with different authors promoting this technique in comminuted fractures.

We regret a 20% complication rate. The most frequent complication, algodystrophy (14.2%), however did not affect the final outcome. Mechanical failure only involved two staple fixations. These represent 1% of the 184 malleoli (lateral and medial malleoli) treated by staples alone. The rate of mechanical implant failure is seldom reported in large series (over 100 cases). Brodie and Denham (*10*) detected 4 cases of secondary displacement out of 298 ankle fractures treated by screws and plates (1.3%). Klossner (*27*) observed 11 mechanical complications out of his 215 cases treated with screws and plates (5.1%).

Staple removal was performed in 13 cases (7.1%) for discomfort. Removal on patient's request was done in 47 cases (25.7%). We were not able to find data on staple removal in the literature.

CONCLUSION

Our results demonstrate the efficacy of pneumatic stapling in ankle fractures, with a low rate of implant failure (1%). Complications are comparable to those of traditional surgical techniques. The method is applicable to comminuted fractures. Advantages include the minimal approach and the ease and rapidity of staple placement. Implant removal was performed in only 13 out of the 184 cases of isolated stapling (7.1%). If the indication for stapling is correct (cancellous bone with a cortex less than 2 mm thick), the technique is an attractive alternative to traditional ankle fracture osteosynthesis.

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