Lateral fixation of open AO type-B2 ankle fractures: the Knowles pin versus plate

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Abstract Forty-seven patients with open lateral malleolar (AO type-B2) fractures treated with copious irrigation and radical debridement, reduction, and immediate fixation by Knowles pins or lateral plates were retrospectively reviewed with an average follow-up period of 29 months. The 47 patients were divided into two groups, based on the method of treatment. The Knowles pin group included 25 patients. The plate group included 22 patients. There was no difference between the Knowles pinning and lateral plating with respect to the rate of good reduction (96% vs. 95.5%, $p=1$). Both of the groups were similar in good and excellent results (92% vs. 86.4%, $p=0.65$). However, Knowles pinning had significantly shorter operation time, smaller wound size, less symptomatic hardware, and lower complication rate than lateral plating (all p values <0.04). In conclusion, lateral fixation of open AO type-B2 ankle fractures by the Knowles pin is recommended due to its efficacy, simplicity, and low complication rate.

Résumé Quarante sept patients avec une fracture ouverte de la malléole externe (type AO: B2), traités par débridement, réduction et fixation par broches de Knowles ou par plaque étaient étudiés rétrospectivement avec un recul moyen de 29 mois. Les patients étaient divisés en deux groupes: le groupe des broches incluait 25 patients et le

groupe des plaques incluait 22 patients. Le taux de bonnes réductions n'était pas différent (96% vs 95,5%, $p=1$). Les deux groupes étaient similaires pour le taux de bons résultats (92% vs 86,4%, $p=0,65$). Cependant la synthèse par broches avait un temps opératoire plus court, une incision plus petite, moins de gêne liée au matériel et un taux de complication plus faible que la synthèse par plaque. En conclusion l'ostéosynthèse externe par broches des fractures ouvertes de la cheville type AO-B2 est recommandée pour son efficacité, sa simplicité et son faible taux de complication.

Introduction

For an OTA 44-B2 (AO type-B2) ankle fracture (a trans-syndesmotomic fibular fracture with medial lesion), open reduction and internal fixation is recommended because the fracture is either unstable or the talus tends to shift in the mortise [1, 2, 4, 6].

Operative treatment for open lateral malleolus fractures becomes more complicated, leading to an increased risk of wound problems. Soft tissue management of the open wound is the most important step for an optimal result. Fracture stabilisation increases the ability of the soft tissues to heal and resist infection [2, 4, 6]. Although a lateral plate is commonly used to treat an open lateral malleolar fracture, more soft tissue dissection may result in skin complications [20]. Internal fixation with minimum dissection that can achieve stable fixation is preferable [6]. Knowles pinning of distal fibula is an intramedullary technique that can achieve stable fixation with minimum soft tissue dissection, and is the author's preferred means to stabilise most of the open lateral malleolar fractures. To our knowledge, there are only a few reports dealing with Knowles pinning for the treatment of

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open lateral ankle fractures. The purpose of this study was to compare the clinical outcomes of the Knowles pin fixation and lateral plating in open AO type B2 ankle fractures, to assess the technique's applicability to these injuries.

Patients and methods

Between 2000 and 2007, 69 adults who had open lateral malleolar fractures classified as AO type B2 ankle fractures were surgically treated in our institution. Inclusion criteria for this study were: (a) OTA 44-B2 fractures (AO type B2 ankle fractures), (b) acute fractures, (c) internal fixation with either a Knowles Pin or a tubular plate, and (d) patients with the ability to walk without any assistance before injury. Exclusion criteria for this study were: (a) severe open fractures such as Gustilo grade III [7], (b) severe comminuted fractures (>75%), and (c) patients with syndesmosis instability. There were 51 patients who met the inclusion criteria. However, four patients could not be followed-up due to relocation, and they were excluded. Therefore, 47 patients with an average age of 38.6 years (range, 19–67) were followed-up more than 12 months after discharge from the hospital and were included in this study. The average follow-up was 29 months (range, 12–63). Twenty-six of the patients had Gustilo type I open fractures and 21 patients had type II. Twenty-eight of the 47 patients had medial malleolar fractures and 19 had medial tenderness associated with a medial clear space >4 mm, consistent with a ruptured deltoid ligament. There were eight surgeons involved in our study. Five surgeons favoured the Knowles pin and the remaining three surgeons favoured the tubular plate to treat lateral malleolar fracture.

The 47 patients were divided into two groups, based on the method of treatment. The Knowles pin group included 25 patients with an average age of 40.1 years. Twenty-three patients (92%) suffered from vehicular trauma. The open fractures included 13 type I and 12 type II. The tubular plate group included 22 patients with an average age of 36.9 years. Nineteen patients (86.4%) suffered from vehicular trauma. The open fractures included 13 type I and nine type II. The injury mechanisms and fracture patterns related to the groups are shown in Table 1.

Operations on the ankle fractures were always performed under spinal anaesthesia. In five cases, the open wounds were transverse and needed to be extended for adequate exposure. A vertical incision at the end of these transverse wounds created a Z-shape, which provided adequate exposure for debridement and fixation of the fractures. When a medial malleolar fracture was present, a separate incision was made for open reduction and internal fixation. This fixation was either by Kirschner wires augmented by a screw or by two screws. If the medial malleolus was intact

Table 1 Preoperative data of the two groups

	Knowles pin (number of patients)	Tubular plate (number of patients)	<i>p</i> value
Injury mechanism			
Vehicular trauma	23	19	0.65
High-energy falls	2	3	0.65
Gustilo open type			
I	13	13	0.77
II	12	9	0.77
Fracture pattern			
Deltoid ligament ruptures	9	10	0.56
Medial malleolar fractures	16	12	0.56
Transverse fractures	2	1	1.0
Oblique & spiral fractures	16	17	0.36
Comminuted fractures	7	4	0.51
Demographics			
Gender (F/M)	10/15	6/16	0.54
Mean age (years)	40.1	36.9	0.29
Compounding medical conditions			
Hypertension	1	2	0.59
Diabetes	2	1	1.0
Heavy smoker	2	2	1.0

and the deltoid ligament was ruptured, the deltoid ligament was not repaired.

In the Knowles pin group, a lateral skin incision from 1 cm below the distal fibular tip to 1 cm above the fracture site was made after the open wound was debrided. After identifying that there was no syndesmosis instability by using the stress test or intraoperative roentgenograms, a Knowles pin of 4-mm threaded diameter and 3.2-mm shaft diameter (Zimmer, Warsaw, IL), with threads capable of passing the fracture site, was directly inserted by hand drilling. For a comminuted fracture, fixation by cerclage wires or sutures was permitted in addition to the Knowles pin. This procedure could hold the distal fibular alignment before the Knowles pins were inserted. The surgical technique has been described by Lee et al. [12, 13]. In the tubular plate group, lateral plating was used to stabilise the distal fibula. In both groups, the open wound was sutured loosely to cover most of the exposed bone. Prophylactic antibiotics were administered for 48 hours.

Plain films were taken immediately postoperatively to evaluate reduction. A scale by McLennan and Ungersma [15] was used to grade the reduction. Good reduction was defined as no fibula shortening, a posterior displacement less than 2 mm, and less than a 1 mm increase in the medial clear space. A fair reduction represented a fibula shortening of 2 mm, posterior displacement of 2–4 mm, and a 1–3 mm increase in the medial clear space. A poor reduction was defined as a fibula shortening in excess of 2 mm, posterior displacement of over 4 mm, and a greater than 3 mm increase in the medial clear space.

Fig. 1 Knowles pin stabilisation of the Gustilo type II open lateral malleolar fracture associated with a medial malleolar fracture. **a** Preoperative anteroposterior radiograph of a 48-year-old male patient. **b** X-rays taken immediately postoperatively show a good reduction.

The medial malleolar fracture was treated with two Kirschner wires augmented by one screw. **c** X-rays at three months shows fracture healing with excellent restoration of the fracture alignment and the ankle joint

A short leg cast with the ankle in a neutral position was applied for four weeks for soft tissue healing. The postoperative rehabilitation process consisted initially of partial weight bearing. Full weight bearing was permitted two weeks after cast removal or when union was evident radiographically. Patients were reviewed at two, four, eight, 12, 16, and 24 weeks after the operation. Anteroposterior (AP) and lateral roentgenograms were taken for all patients at each follow-up appointment for evaluation of implant position and fracture healing. Radiographic healing was defined as evidence of bridging callus across the fracture sites or the obliteration of the fracture lines on both AP and lateral views.

At the last follow-up, the results were evaluated according to the ankle scoring system of Baird and Jackson [1], which was modified from that of Weber [18]. In this system, the subjective and objective clinical data are combined with radiographic results, with the maximum score being 100 points. The maximum clinical score is 75 points. Pain, stability of the ankle, ability to run, ability to walk, and motion of the ankle were evaluated. Maximum radiographic results contribute 25 points. An overall score of 96–100 points ranks as excellent, 91–95 points as good, 81–90 points as fair, and 0–80 points as poor results. The Mann-Whitney U test, chi-square test with Yates' correction, and Fisher's exact test were used to compare the two groups. The statistic software SPSS vs 10.0 (SPSS Inc., Chicago, IL) was used to analyse the data; p values below 0.05 were considered significant.

Results

Both groups were similar with respect to injury mechanisms, open fracture grade, fracture pattern, demographics,

and compounding medical conditions (all p values >0.29) (Table 1).

All ankle fractures healed radiographically within six months (Fig. 1). Evaluation of immediate postoperative roentgenograms for adequacy of reduction by one set of criteria [14] produced a good reduction in 24/25 (96%) in the Knowles pin group and 21/22 (95.5%) in the tubular plate group. No difference in the good reduction rate between the two groups was noted ($p=1.0$). However, the Knowles pin group had a significantly shorter operation time ($p<0.001$) and significantly smaller wound size ($p<0.001$), as compared to the tubular plate group (Table 2).

The Knowles pin group had fewer complications than the tubular plate group ($p=0.04$). The Knowles pin group had no complications, and the plate group had four complications (18.2%), consisting of two superficial infections and two cases of skin necrosis. The superficial infections were diagnosed clinically at the first follow-up visit seven days after surgery. A seven-day regimen of oral antibiotics resolved the infection and wound healing occurred uneventfully. The other patients experienced skin

Table 2 Clinical results in the two groups

	KP (M $\pm$ SD)	TP (M $\pm$ SD)	p value
Union in six months	25/25	22/22	1.0
Fracture reduction result			
Good	24/25	21/22	1.0
Fair	1/25	1/22	1.0
Poor	0	0	1.0
Surgical data			
OR time (min)	34 $\pm$ 5.6	52 $\pm$ 7.1	<0.001
Wound size (cm)	4.5 $\pm$ 0.46	8.2 $\pm$ 0.79	<0.001

KP Knowles pin, TP tubular plate, M mean, SD standard deviation

necrosis 10–14 days after surgery. They had a secondary operation to remove the plate and then received a split-thickness skin graft after granulation tissue surrounded the wound. Their fractures healed after cast immobilisation.

One patient (4%) in the Knowles pin group complained of symptomatic hardware problem. Removal of the Knowles pin was easily accomplished by making a 1 cm skin incision along the old scar under regional anaesthesia. Twenty-two patients (88%) asked to have the hardware removed. In the tubular group, ten patients (45.5%) complained of prominent feeling plates and screws. Twenty-one patients (95.5%) asked to have the hardware removed. The Knowles pin group had fewer hardware symptoms ($p < 0.001$). However, elective hardware removal did not significantly differ between the two groups ($p = 0.61$).

At the final follow-up, the ankle scoring system of Baird and Jackson [1] was used for functional outcome evaluation. Good to excellent results were obtained in 92% of the Knowles pin group and 86.4% of the tubular plate group. The functional results showed no significant difference between the two groups ($p = 0.65$). However, a single poor result was noted in the plate group. This patient was relatively elderly (62 years old), had diabetes mellitus, and displayed skin necrosis around the wound of the Gustilo open type II fracture. The major symptoms of the patient were pain, stiffness, and marked decrease in motion of the ankle. All 47 patients were free of radiographic signs of arthrosis.

Discussion

Although there are many surgical techniques for lateral fixation of the AO type B2 ankle fractures, there are only a few reports about intramedullary nailing [8, 12, 13, 15–17]. Intramedullary fixation provides stable fixation without prominent subcutaneous hardware, allows for dynamic compression at the fracture site, and facilitates healing of a fracture [12, 13, 15, 17]. In our study, Knowles pin fixation provided stable fixation and allowed early weight bearing. The half-threaded Knowles pins with a rectangle head can exert an axial compression force at the fracture site, like the lag screw effect when the screw is tightened during the final few turns. The compressive force of the Knowles pin can make the contact of an oblique or spiral surface of cancellous bone stable enough to resist proximal migration or rotation at the fracture site. This could explain the observance of a good radiographic reduction rate of 96%, predominant good and excellent results (92%), and a high union rate (100%).

Extramedullary techniques for lateral fixation of the AO type B2 ankle fractures are commonly used [3, 10, 11]. One

or two lag screws were recommended by Kim et al. [10]. However, this technique is only used in oblique or long spiral fractures, as damage to the peroneal tendons by an overly long screw is possible [8]. Although tubular plating is a popular technique, it carries the disadvantages of palpable hardware and increased dissection [11]. In one study, 31% of the 126 patients had lateral pain overlying their fracture hardware and nearly 50% continued to have pain even after hardware removal [3]. In our study, 45.5% of the patients who were treated with a lateral plate had lateral pain and skin tightness. In contrast, only one patient (4%) in the Knowles pin group complained of this problem.

Open ankle fractures are frequently the result of high-energy trauma. All of our patients were injured in either vehicular trauma or a high fall. Operative treatment of such fractures is preferred by most orthopaedic surgeons. Immediate wound debridement followed by stable internal fixation of the fracture is advised [2, 5, 9, 20]. In an open lateral malleolar fracture, lateral plating may result in complications of skin and soft tissue due to the double contour of the lateral malleolus and the small amount of overlying subcutaneous tissue [14]. For an open ankle fracture, immediate internal fixation with minimal apparatus provides acceptable results and is preferred by most traumatologists [5, 9]. We determined that fibular plating needs a larger skin incision and more extensive soft tissue stripping compared to Knowles pinning. This could explain why lateral plating of lateral malleolus is associated with increased complications such as infection and skin necrosis.

White et al. found that a systemic disease such as diabetes mellitus associated with an open wound has a high risk of infection and can even be life-threatening, with high amputation and wound complication rates despite prompt irrigation and debridement [19]. In their study, one patient had Gustilo type I open ankle fracture and five patients had open type II. Three of the six patients had wound complications and two required below knee amputation. In our study, three patients had diabetes mellitus associated with open ankle fractures. Two of the patients treated with the Knowles pin had no wound complications, while the third patient who was treated with the lateral plate developed skin necrosis.

Our study had various limitations: (a) it was a retrospective study and could produce a selection bias, (b) it was performed in a teaching institution where the resident was the operating surgeon and the surgeons' level of experience could influence the outcomes, and (c) it was not a large series and when we calculated the power of this study, most were only 80–90%. If the null hypothesis (no difference between the groups) was accepted in our study, the false-negative rate was as much as 10–20%.

In conclusion, Knowles pinning for the treatment of an open lateral malleolar fracture requires a shorter operation

time, small wound size, less symptomatic hardware, confers less soft tissue damage, and produces fewer complications compared to lateral plating. The fixation conveyed by a Knowles pin is as good as a plate. Therefore, use of the Knowles pin for an open AO type B2 lateral malleolar fracture is a recommended option.

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