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Tubular vs Profile Plate in Peroneal or Bimalleolar Fractures: is There a Real Difference in Skin Complication? A Retrospective Study in Three Level I Trauma Center

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ABSTRACT

Introduction: Not enough literature is available to evalute the wound complication rate of plates type in distal fibular fractures. **Aim:** The aim of our study was to compare wound complications of using a third tubular plate compared to LCP distal fibula plate. **Material and Methods:** This study is a retrospective single-centre study in which was performed plating of fibula in closed ankle fractures. 93 patients were included in our study and assigned in two groups, based on using of different implant : in group A 48 patients were treated with one-third tubular and in group B 45 patients were treated with LCP distal fibula plate. There were no significant differences in the baseline characterisctics. Patients received the same surgical procedure and the same post-operative care, then they were radiologically evalueted at 1-3-12 months and clinical examination was made at 12 months using AOFAS clinical rating system. Categorical data, grouped into distinct categories, were evalueted using Chi-square test. We considered a *p* value < 0.05 as statistically significant. **Results:** The wound complications rate of the overall study group was 7.6%. There were no statistical differences in the rate of wound complications between the two groups. There were no differences between both group in percentage of hardware removal at follow-up (overall 5.4%); plate removal was performed earlier in the locking plate because of wound complications. **Conclusions:** Our study has shown no difference in radiographic bone union rate, no significant differences in terms of clinical outcomes, in time of bone reduction and wound complication rate between the LCP distal fibula plate and conventional one-third tubular plate. Controversy still exists about the best method for the fracture reduction.

Key words: closed ankle fractures, distal fibular fractures, third fibular plate, distal fibular plate.

1. INTRODUCTION

Ankle fractures account for about 9% of all the fractures, with an incidence of 187 fractures for 100.000 people each year in the U.S. (1, 2). They frequently occur in a relatively young and active population as a result of a minor injury. To date, there is no agreement on the best method for treating lateral malleolus fractures. Surgery of these fractures is associated with complications such as non-union, mal-union, post-traumatic osteoarthritis and especially skin problems ranging from wound healing delay to the exposure of the plaque (3). Therefore, different studies were conducted the incidence of skin complications in relation to the means of synthesis used for the fixation (4, 5). The most common used synthetic means are the LCP metaphyseal plate and the LCP distal fibula plate. They can serve as bridging plates, compression plates, tension band plates or neutralization plates (6). Another plate used for osteosynthesis is the non-locking plate. This device exploits the friction force between the plate and the bone and is frequently used as a neutralization device, but it has a theoretical disadvantage of a periosteal compression and a negative interference in blood drawing, unfavorable condition for bone union (7). Literature evaluating the wound complication rate of locking plate in distal fibular fractures is
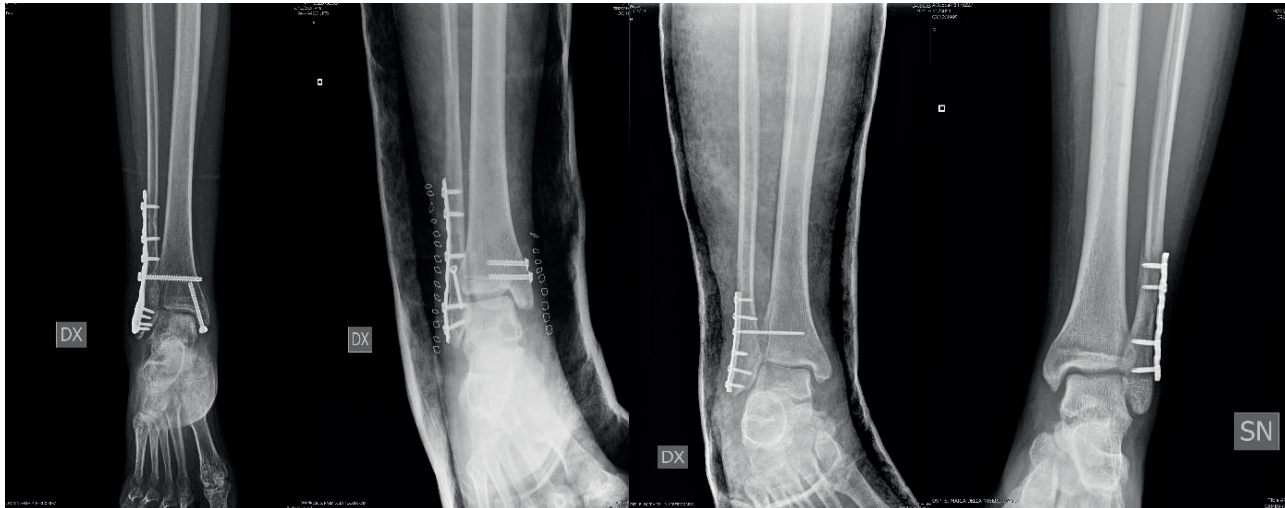
Figure 1. Different type of plates used in the current study: A) LCP distal fibula plate, B) conventional one-third tubular plate

poor. Although, in recent years, different studies demonstrated the advantages of the locking system in different anatomical areas like distal radius, distal femur, cervical spine (8, 9, 10), there is no clear evidence of the real effectiveness of a type of plate compared to another in ensuring proper anatomical reduction and absolute stability in the fixation of the lateral malleolar fractures (11). The aim of our study is to compare two types of plates, one third tubular plate and LCP distal fibula plate, evaluating the clinical outcome and the skin complications associated with their use.

2. MATERIALS AND METHODS

The present study is a retrospective single-center study, carried out between the January 1st 2012 and December 31st 2015. We collected the data of 122 consecutive unimalleolar or bimalleolar fractures treated by internal fixation for a closed, displaced distal closed fibular fracture. Exclusion criteria were: 1) open ankle fractures; 2) trimalleolar fractures; 3) previous ankle fractures; 4) severe venous insufficiency; 5) ankle osteoarthritis previous to surgery; 6) associated ankle dislocation. Eleven patients were excluded because of previously radiologically diagnosed osteoarthritis, seven patients for open fractures, six patients because of severe venous insufficiency, five patients for ankle dislocation. Ninety-three patients were included in our study and assigned to two different groups, based on the surgical implant used for synthesizing the peroneal fracture: 48 patients, treated by with one-third tubular plate (Synthes GmbH, Switzerland), were assigned to group A, and, 45 patients, treated with LCP distal fibula plate (Synthes GmbH, Switzerland) to group B. Patients characteristics (age, gender, smoking habits), fracture features (side, Weber classification) and the surgical procedure (type of plate, use of torniquet and duration of surgery) were recorded from the patient file. The fractures were Weber A (32,3%), B (45.2%) and C (22.5%) types; 60.3% of the cases were unimalleolar, 39.7% were bimalleolar. In the group A there were 13 Weber A, 24 Weber B, 12 Weber C, whereas in the group B we had 17 Weber A, 18 Weber B and 9 Weber C. Patients were followed up in our orthopaedic department and radiographically evaluated at 1 month, 3 months and at 12 months; the clinical assessment at one year was assessed by surgeon from functional questionnaire American Orthopaedic Foot & Ankle Society (AOFAS) clinical rating system.

Surgical procedure and post-operative care

All the patients received lumbar anaesthesia and an antibiotic prophylaxis with intravenous 2 g cefazoline within 30 minutes prior to skin incision. In all the cases surgery was performed within 48 hours from injury. The surgeons used a conventional lateral approach and the tourniquet was used in all the patients at 100 mmHg above systolic blood pressure; anteroposterior and lateral x-rays were taken before wound closure to confirm anatomical reduction of the fracture site. In 73% of the patients of group A (35 patients) we used an interfragmentary screw for the fracture fixation. In the bimalleolar fractures we used two distal screws for the fixation of the medial malleolus (Figure 1). The wound was washed out with saline solution. The subcutaneous was sutured using Vicryl® and the skin using Ethylon®. Identical postoperative care was provided to both groups: we left a valve pinstripe for 7 days, then we removed the stitches at 15 days after surgery. The patients were recommended active a passive mobilization of the operated ankle without weight bearing for 5 weeks, then weight bearing was allowed with a bivalve brace for two weeks. Then the patients were clinically and radiographically evaluated.

Statistical analysis

Statistical analysis were performed by SPSS version 18.0 (SPSS Inc, Chicago, IL USA); categorical data, grouped into distinct categories, were evalueted using Chi-square test. We considered a p value <0.05 as statistically significanct. Numeric data are expressed as medians with P25-P75; percentages represent ordinal and nominal data.

3. RESULTS

Ninety-three patients were eligible for our study. The baseline characteristics of study group are shown in Table 1. The age ranged from 18 to 65 years (average 46), males and females were equally represented, 5% were

Figure 2. Example of wound complications in patients treated with the different plates type in the current study.

diagnosed with diabetes and 19 % of patients were smokers. There were no significant differences in the baseline characteristics in terms of age, plate length and time of surgery between the two groups. A total of 48 patients received a one-third tubular plate in group A and 45 patients were treated with locking plate in group B, both with stainless stain and titanium. The operation time of surgery in group A was 55.6±7.8 minutes, in group B was 57.6 ± 12.3 minutes, no statistical difference found in the groups. At the final 12-month follow-up a comparison between the two groups showed no statistical significant differences in reduction accuracy and bone union ratio at radiological examination (Table 2). The mean standard deviation time for bone healing at the fracture site was 4,1±1,8 weeks in the LCP distal plate and 4,2±1,6 weeks one-third tubular plate (p=0.72, Student's t-test); in terms of ROM no differences were detected (mean deviation standard 54.3± 8.3° vs 53.9±8.6 °, p<0,740) and no statistical differences in clinical score AOFAS rating system found in the two groups. The skin healing time was similar in both groups. The wound complications rate of the overall study group was 7.6%. At the final follow-up we found 2 deep infections, 2 wound dehiscence and 3 superficial infections. In the group A occurred 1 deep infection, 2 superficial infection, no wound dehiscence; in group B occured 1 deep infection, 1 superficial infection and 2 wound dehiscence. There were no statistical differences in the rate of wound complications between the two groups (p=0.70; Fisher exact test). There were no differences between boths group in percentage of hardware removal at follow-up, overall 5.4 %; plate removal was performed earlier in the locking plate because of wound complications (Table 3). None developed tromboembolic complications or superficial peroneal nerve injury during the study.

4. DISCUSSION

The aim of our study was to compare wound complications after osteosynthesis with a third tubular plate compared to LCP distal fibula plate. Although contro-versy still exists about the best method for the fracture reduction. Locking malleolar fractures have improved surgical outcomes with surgical stabilization and a more appropriate anatomical reduction. Locking plates were developed to combine internal fixation and dynamic compression principles, functioning as a fixed-angle de-

	Overall population	One-third tubular plate	Locking plate	p-Value
Patients (n)	93	48	45	-
Male (%)	47 (50.6)	29 (60.5)	18 (40)	0.06 a
Age (years)	46.5 (31.6-64.7)	48.2 (33.5-61.0)	48.4 (33.5-60.9)	0.9 2 c
Smokers (%)	18 (19,4)	11 (23)	7 (15.6)	0.36 b
Diabetic (%)	5 (5.4)	3 (6.3)	2 (4.5)	0.69 b
Right sided (%)	*45 (48,4)*	25 (52.1)	20 (44.5)	0.53 a
Weber classification (%)				
A	30 (32.3)	13 (27)	17 (37.8)	0.53 b
B	42 (45.2)	23 (48)	19 (42.2)	
C	21 (22.5)	12 (25)	9 (20)	
Fracture type (%)				
Unimalleolar	56 (60,3)	27 (56.3)	29 (64.5)	0.41 b
Bimalleolar	37 (39,7)	21 (43.7)	16 (35.6)	

Table 1. Patient and fracture characteristics for both patient groups. Data are presented as number with the percentage between brackets (categoric data) or as mean with the P25 and P75 between brackets (numeric data). a) Data were analysed using the Fisher's exact test. b) Data were analysed using the Chi-square test. c) Data were analysed using the Mann_Whitney U-test

	Overall population	One-third tubular plate	Locking plate	p value
Operation time (min)	56.8 ± 6.5	55.6 ± 7.8	57.6 ± 12.3	0.67 b
Plate lenght (holes)	7 (6-7)	7 (6-7)	7 (6-7)	0.34 b
Reduction accuracy(%) Anatomical	83 (89,2)	43 (89.6)	40 (88.9)	1 a
Zero to 2 mm	10 (10.8)	5 (10.4)	5 (11.1)	
More than 2 mm	0 (0)	0 (0)	0 (0)	

Table 2. Surgical details of both plate groups. Data are presented as number with the percentage between brackets (categoric data) or as mean with the P25 and P75 between brackets (numeric data). a) Data were analysed using the Fisher's exact test. b) Data were analysed using the Mann_Whitney U-test

	Overall population (n= 93)	One-third tubular plate (n= 48)	Locking plate (n= 45)	p value
Wound complication(%)	7 (7.6)	3 (6.3)	4 (8.9)	0.70 a
Complication type (%)				
Deep infection	2 (2.2)	1 (2.1)	1 (2.3)	0.32 b
Superficial infection	3 (3.2)	2 (4.2)	1 (2.3)	
Wound dehiscence	2 (2.2)	0 (0)	2 (4.4)	
Plate removal	5 (5.4)	2 (4.2)	3 (6.7)	0.67°
Plate removal (months)	8.5 (5.2-13.4)	9.4 (7.5-14)	6.2 (5.4-9.2)	0.06 c

Tabela 3. Complications rates between both patient groups. Data are presented as number with the percentage between brackets (categoric data) or as mean with the P25 and P75 between brackets (numeric data). a) Data were analysed using the Fisher's exact test.. b) Data were analysed using the Chi-square test. c) Data were analysed using the Mann_Whitney U-test

vice and converting shear stress to compressive forces at the screw bone interface. Studies comparing locking and non-locking plate in a single fracture type are poor. Since the first experience of Hess et al (12), who evaluate the osteosynthesis with locking compression plate with MIPO technique, few studies assessed the clinical feasibility and the advantages of ostheosynthesis of distal fibula with a minimally invasive plate. This technique, used firstly for femur, tibia and humerus, was developed as a prevention for periostal devascularization and major soft tissue dissection, it allows internal fixation with a small incision and an accurate bone healing rate with few complications, comparable with ORIF technique. Different studies compare the using of locking plates vs the traditional one third tubular plate evaluating the healing bone ratio, incidence of wound complications, clinical and radiographic outcomes. Huang et al. (13), compared LCP metaphyseal and LCP distal fibular plate to one third tubular plate, using MIPO technique for both locking systems. They found a less bone healing time and significant higher functional scores OMS and AOFAS for fractures treated with LCP distal plate than those treated with LCP metaphyseal plate and the one third tubular plate for Weber A and Weber B ankle fractures; they found no statistical differences in reduction accuracy, anatomical reduction and in terms of the ROM among three groups. In a randomized controlled trial of Tsukada et al. (14) no differences in functional scores, radiological (bone union rate), clinical outcomes and wound complications were observed between the use of locking plate and non-locking plate for the treatment of lateral malleolar fractures. According to this results, our study showed no differences in radiographic bone union rate between the LCP distal fibula plate and conventional one-third tubular plate, as the neutralization plate for treatment of lateral malleolar fractures. Moreover, time of bone healing at the fracture site or wound complication rate, in our case series, showed no significant difference. Lateral plating is the most common and easiest method of fixation, however the biomechanical characteristics of various plates and screw constructs have not been elucidated. In some human cadaveric studies, biomechanical comparisons were developed between locking and non-locking neutralization plates. Takemoto et al. concluded that no

advantage was found in using a locking plate when lag screw could achieve stable fracture fixation; we agree with this conclusion (15). We believe that the main successful factor is the anatomical reduction and the proper lag screw insertion. Eckel et al. demonstrated no significant differences in plate performance (16): they found positive correlation between bone mineral density and bending stiffness, a negative correlation between BMD and the amount of angulation at the peak bending moment for all plates; one-third tubular plates showed the most high resistance to bending forces. No differences were found in rotational and bending forces, torsional stiffness in external rotation exceeded stiffness in internal rotation; this study did not identify a superior plate. Kim et al. demonstrated that the locking plates were biomechanically equivalent to standard plates, they were not dependent on BMD and may be advantageous in patients with severe osteoporosis; they found that the locking plate provide higher torque to failure in specimens that had diminished BMD (17). No differences were found by Nguyetant et al. in the fixation of trimalleolar fractures, high energy fractures, multiple fractures, rotational fractures; they found that LCP do not provide a biomechanical advantage in individuals with normal bone density and in absence of fracture comminution (18). The wound complication rate in our study was equivalent between the two groups, no statistical differences were found in using of traditional plates (Figure 2). Instead, the rate of wound complication observed by Schepers et al. with the use of locking plate was higher than that with the non-locking plate. They found a significant increase in wound complications in the use of locking plate in distal fibula fractures, because of the increased thickness of the locking plates (2,8-3,3mm) and no compression to periostium, that could increase subcutaneous volume of fracture site no statistically influence of titanium versus stainless steel (19). Soohoo et al. (5) highlighted the importance of the specific patient comorbidities of diabetes and peripheral vascular disease in predicting the risks of the short-term complications of mortality, infection, reoperation, and amputation. An important conclusion of this study was that hospital-related factors, including volume, rural location, and teaching status, were relatively less important as significant predictors of the short or intermediate-term complications that were analyzed. In according to Miller et al. (20) we found significant associations between wound complications and diabetes, peripheral neuropathy, postoperative non compliance and wound-compromising medications; no relationship found between wound outcome, age and time to surgery.

There are limitations of this study: although this is a retrospective analysis of available information, the choice of plates was left at the discretion of attending surgeon, the number of cases in our study did not support a more rigorous comparison between the two groups.

5. CONCLUSION

The study demonstrated no significant differences in the use of locking plate compared with the conventional plates. Furthermore, there were no differences between non LCP and LCP plates in terms of radiographic bone ratio and clinical outcomes in the treatment of distal fibular fracture. The data currently available, however, do not yet allow for definitive conclusions about the appropriate treatment and the best choice of the plate for peroneal and bimalleolar fractures regarding skin complications and clinical outcomes. In our opinion is mandatory a multifactorial approach regarding all possible patient comorbities like age, diabetes or neuro-vascular disease in order to have a fair predictable risk factors and the complication rates. Furthermore, we need of more studies with a statistical validity and an increased number of patients to provide more evidence for the type of plate that can be chosen with a better clinical outcomes and a decreased skin complications risk, RCT or metanalasys are in this case useful to improve scientific evidence and give more information for the correct surgical treatment of ankle fractures.

- **The authors contribution in senteces:** The study's conception and design were did by Giuseppe Rinonapoli, Giuseppe Rollo, Gabriele Falzarano, Auro Caraffa. Rosario Petruccelli, Paolo Ceccarini, Michele Bisaccia and Marco Giaracuni gave a contribution to acquisition of data. The analysis and interpretation of data and the article drifting were did by Luigi Meccariello, Michele Bisaccia, Olga Bisaccia and Rosario Petrucelli. Finally criticaly revising the article was did by Giuseppe Rinonapoli, Giuseppe Rollo, Gabriele Falzarano, Auro Caraffa, Luigi Meccariello, Michele Bisaccia.
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- **Human and animal rights:** For this type of study is not required any statement relating to studies on humans and animals. All patients gave the informed consent prior being included into the study. All procedures involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments.

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