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COMPARISON OF TWO DIFFERENT PLATE TYPES IN THE MINIMALLY INVASIVE PERCUTANEOUS PLATE OSTEOSYNTHESIS OF DISTAL TIBIA FRACTURES

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Abstract

Distal tibia fractures present a unique challenge for the surgeon due to the subcutaneous position of the tibia with a thin soft tissue envelope. The development of the technique for minimally invasive percutaneous plate osteosynthesis (MIPPO) is a well-accepted step towards this direction.

In our study we explore the benefits and shortcomings of two different plate types used with this technique: the 3.5 mm anatomically pre-shaped titanium plate, and the 4.5 mm LC-DCP.

The study was a prospective – retrospective clinical intervention case control study of 100 patients with closed, unstable, extraarticular and partially articular fractures of the distal tibia and fibula, classified as AO type 43A1, 43A2 and 43A3. Patients were divided in two groups of 50 patients. Group A were patients prospectively treated with a 3.5 mm pre-shaped plate, and Group B were patients with retrospectively collected data treated with a 4.5 mm LC-DCP.

Patietns age was 38.15 years with 68 male and 32 female patients. Operation duration in Group A was 57.14 ± 8.30 and 66.67 ± 5.55, in Group B which was statistically significant. Partial and full weight bearing, as well as time to union in both groups was achieved within a similar timeframe. Functional according to Johner and Wruh's criteria and showed that most patients in both groups (61) had excellent results (Group A: 32, Group B: 29) and 21 had good results (Group A: 10, Group B:11).

Rate of complications were comparable between the two groups, in regard to superficial infection, deep infection and ankle stiffness. Only complication parameter which showed a significant difference between the two groups was rate of implant irritation, which was higher in the 4.5 mm LC-DCP group. Both 3.5 mm and 4.5 mm plates are reliable when used with a MIPPO technique.

This method is minimally invasive, preserves the periosteal blood supply and ensures optimal conditions for biological repair of distal tibia fractures, regardless of the type of plate used.

Keywords: Distal tibia fractures, MIPPO, Distal Tibia LC-LCP, LC-DCP, AO-classification,

Introduction

The most common cause of injure in tibial fractures are high energy, road trafiic accidents, [1] followed by falls, direct blows, and sports injuries.

Distal tibial fractures have a reported incidence of 0.6%, which is 10% to 13%of all tibial fractures [2]. Most tibial fractures are associated with a significant soft tissue injury. This is especially the case with distal tibial fractures, where the soft tissue envelope is thin and often compromised. This subcutaneous position of the tibia adds to the difficulty of treating them, due to higher incidence of complications such as wound infections and dehiscence, delayed union and nonunion.

When assessing a patient with a distal tibia fracture, the importance of the inspection must be emphasized. Open wounds as well as areas of contusions and abrasions must be noted. This is important for grading the injury, using the Gustillo – Anderson classification for open, and the Tscherne classification [3] for closed fractures. Minimally invasive plate osteosynthesis (MIPO) is a well-accepted and effective method of treating distal tibia fractures. Open reduction and plating cause severe disruption of the extraosseous blood supply in comparison to percutaneously applied plates such as MIPO [4].

Closed reduction using ligamentotaxis [5] and minimally invasive plating requires detailed pre-operative planning since it is inherently more difficult than open reduction internal fixation. In order to reduce operative times, spare the extraosseous blood supply and achieve sufficient stability lower profile, pre-shaped, anatomical plates have been developed. We present a study which compares the use of these plates, the 3.5 mm anatomic pre-shaped Distal Tibia Locking Plates to the 4.5 mm Limited Contact - Dynamic Compression Plates (LC-DCP)

Materials and Methods

The study was designed as a prospective – retrospective clinical intervention case control study of 100 patients with closed, unstable, extraarticular and partially articular fractures of the distal tibia and fibula.

The study group (Group A) comprised of 50 patients treated prospectively by the first author with Minimally Invasive Percutaneous Locking Plate Osteosynthesis (MIPLPO) using a 3.5 mm pre-shaped titanium plate in the period April 2014 till December 2018.

The control group (Group B) was comprised of 50 patients treated by the same surgeon as Group 1 in the period between 2003 and 2009 using stainless steel 4.5 mm Limited Contact - Dynamic Compression Plate (LC-DCP), with data retrospectively gathered and analyzed.

Fracture classification was performed using the AO Fracture and Dislocation Classification Compendium (6) and the study included extraarticular fractures of Type 43A1, 43A2 and 43A3.

Inclusion criteria were patients aged over 18, with fractures meeting the AO criteria, who signed an informed consent, who had competent neuro-vascular status of the affected limb, who can be operated within 6 hours of injury (for the prospective Group A), and patients who were operated within 6 hours (for the retrospective Group B). Patients with pathological fractures and patients who did not sign the informed consent.

The study was approved by the Ethical Committee and the Board of the University Clinic for Surgical Diseases “St. Naum Ohridski”, Skopje, North Macedonia. On admission standard antero-posterior and lateral radiographs were obtained, and the leg was splinted until surgery. After standard preoperative investigations were done, and anesthetic clearance obtained, patient was taken up for surgery.

Surgical technique

Patient was placed supine on a radiolucent table and the extremity was prepared and draped in a standard manner. A tourniquet was not used. To restore length, first step was open reduction internal fixation of the fibula, which also reduces the antero-lateral angle of the tibial plafond. For tibial plafond fractures we used manual traction. In cases where satisfactory reduction was unobtainable in this manner, a calcaneus Schanz pin was used to obtain length and control rotation and angulation. Once reduction was achieved, primary fixation was done using lag screws.

In cases where satisfactory reduction was not obtainable through ligamentotaxis and indirect manipulation, open reduction and fixation was performed, and the patient was excluded from the study. Plate length was determined using the plate-span ratio.

This means that the length of the plate used should be 2-3 times the length of the fractured segment in comminuted fractures, and 8-10 times the length of the fracture in simple fractures. In patients in Group A, a 3,5 mm Titanium pre-shaped limited contact locking plates LC-LCP were used. After marking the incisions and determining the plate length, the distal incision was made first, and through it a subcutaneous tunnel on the anteromedial aspect of the tibia was made with a curved forceps.

Upon reaching the marked position, the proximal incision is made. When making the subcutaneous tunnel, caution is advised to preserve the periosteum and thus avoiding excessive intraoperative bleeding, but most importantly preserving the blood supply, which is the main advantage of this technique. The plate is placed through the tunnel, and after a fluoroscopic confirmation of the plate position, it is fixed using screws proximally and distally. Wounds were sutured after placement of vacuum drainage.

Postoperative protocol

Physiotherapy was commenced on day 2, immediately after drainage removal. Initially only passive movement exercises of the ankle were performed, followed by active movements as tolerated. Patients were discharged on day three, reason being antibiotic prophylaxis and education for continuation of the exercises at home. Partial weightbearing was allowed after first clinical and radiological signs of healing were observed, usually at five weeks. Weightbearing was increased progressively as tolerated by the patient. Sutures were removed at 14 days.

Radiographs were obtained on postoperative day one, and afterwards at 5 weeks, then at 3, 6, 12,18 and 24 months.

We recorded operation duration, postoperative complications, time to union, time to partial and complete weight bearing. Functional outcome was measured using Johner and Wruh's criteria [7].

Results

In this study 100 patients with distal tibia fractures were selected, 50 treated with a 4.5 mm LC-DCP analyzed retrospectively (Group B), and 50 treated with a 3.5 mm LC -LCP prospectively (Group A).

All patients were operated within 3 to 8 hours (mean time 5.3 hours).

The mean age of the patients was 38.15 years with a range from 19 to 62 years. There were 68 male and 32 female patients. Injury was on the right extremity in 56 patients, 44 were on the left.

Fractures were classified according to the AO classification. There were 50 Type 43A1, 34 Type 43A2 and 16 Type 43A3.

Table 1. – Demographic data

Parameter	Total	Group A (3.5 mm LC-LCP)	Group B (4.5 mm LC-DCP)
Male	68	36	32
Female	32	14	18
Mean age	38.15	35.18 ± 9.23	38.91± 10.12
Mechanism of injury			
• Road Traffic Accident	64	32	32
• Fall	21	11	10
• Sports Injury	8	3	5
• Direct blow	7	4	3
AO Classification			
• Type 43A1	50	27	23
• Type 43A2	34	16	18
• Type 43A3	16	7	9
Injured side			
• Right	56	26	30
• Left	44	24	20

Operation duration in Group A ranged from 46 to 78 minutes (mean 57.14 ± 8.30), whereas in Group B it ranged from 50 to 91 (mean 66.67 ± 5.55). This showed a statistically significant ($P < 0.0001$)

Partial weightbearing in both groups was achieved within a similar timeframe. For Group A it was 6.90 ± 1.33 weeks, and for Group B 6.88 ± 1.38 weeks. The mean time for achieving full weightbearing in Group A was 13.37 ± 1.25 weeks, and in Group B 13.22 ± 1.34. Both parameters were found to be statistically insignificant.

Time to union in Group A was 21.22 ± 2.76 weeks, and in Group B 22.91 ± 3.12, which was also statistically not significantly different. Table 2.

Table 2. Compared parameters

Parameter	Group A (3.5 mm LC-LCP)	Group B (4.5 mm LC-DCP)	P
Duration of surgery (min)	57.14 ± 8.30	66.67 ± 5.55	<0.0001
Weight bearing (weeks)			
• Partial	6.90 ± 1.33	6.88 ± 1.38	0.9691
• Full	13.37 ± 1.25	13.22 ± 1.34	0.9505
Union time (weeks)	21.22 ± 2.76	22.91 ± 3.12	0.9583

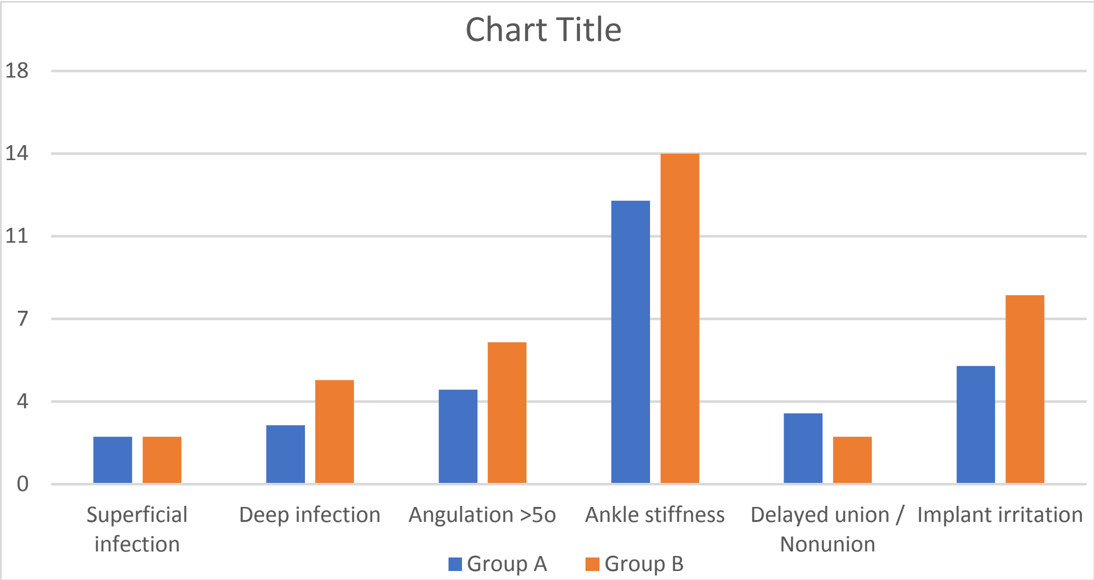
Functional results were measured by Johner and Wruh's criteria and showed that most patients in both groups (61) had excellent results (Group A: 32, Group B: 29) and 21 had good results (Group A: 10, Group B:11). The difference was not found to be statistically significant. Table 3.

Table 3. Johner and Wruh's criteria

	Excellent	Good	Fair	Poor
Non-Union, osteomyelitis, amputation	None	None	None	Yes
Neurovascular disturbances	None	Minimal	Moderate	Severe
Deformity				
• Varus / valgus	None	2-5^{o}	6-10^{o}	>10^{o}
• Anteversion / Recurvatum	0-5^{o}	6-10 ^{o}	11-20 ^{o}	>20 ^{o}
• Rotation	0-5^{o}	6-10 ^{o}	11-20 ^{o}	>20 ^{o}
• Shortening	0-5 mm	6-10 mm	11-20 mm	>20mm
Mobility				
• Knee	Normal	>80%	>75%	<75%
• Ankle	Normal	>80%	>75%	<75%
• Subtalar joint	Normal	>80%	>75%	<75%
Pain	None	Occasional	Moderate	Severe
Gait	None	Normal	Insignificant limp	Significant limp
Strenuous activities	Possible	Limited	Severely limited	Impossible

Rate of complications were comparable between the two groups, in regard to superficial infection, deep infection, malalignment and ankle stiffness. Six patients showed signs of a superficial infection, three in each group, and all were resolved with topical antiseptics and dressing changes, without requiring antibiotics. Morning stiffness was recorded in 25 patients and was treated successfully with NSAIDs.

Thirteen patients showed swelling and were investigated, and upon confirmation treated for superficial thrombophlebitis. Only complication parameter which showed a significant difference between the two groups was rate of implant irritation, which was higher in the 4.5 mm LC-DCP group.



In this study, using 3.5 mm pre-shaped titanium plates showed a significantly reduced operation times and reduced rate of implant irritation, while obtaining similar functional results, time to weight bearing, union, and complications when compared to the use of 4.5 mm stainless steel dynamic compression plates.

Discussion

Distal tibia fractures pose a challenge for the surgeon as the status of soft tissues and the comminution of the fracture require meticulous planning and skill. The concept of anatomic reduction is not so much of an issue here as it is in articular fractures, but proper alignment and length restoration are key goals, coupled with adequate stability.

This all should be achieved by methods which take into account the thin soft tissue envelope around the distal tibia, as well as the blood supply to the fracture fragments themselves.

With the development of anatomically pre-shaped locking plates, which relies on angular stability between the screw and plate, instead of compressive frictional force between the plate and bone, and thus preserving blood supply [8], we have been given an additional resource in the treatment of these fractures. In this study, patient’s age was in the range of 19 to 62 years, with a predominantly male involvement.

We assume this was because outdoor activities, heavier labour and driving are predominantly undertaken by men in comparison to women, which is also the case with other studies [9,15,16].

The most common cause of injury were road traffic accidents, followed by falls from height. Distal tibia fracture requires high energy in young healthy patients, hence the cause of injury distribution. Literature reports show a bimodal distribution favouring two groups of patients, young males injured through a high-energy mechanism, and women over 80 years of age who suffer low-energy fractures [10].

Operation duration difference can be explained by the need for intra-operative shaping and bending of the 4.5 mm LC-DCPs, whereas the 3.5 mm pre-shaped palates skip this step. Our results were 46 to 78 minutes for group A and 50 to 91 for Group B which was in line with the literature[11,12].

The beginning of partial weight bearing and full weight bearing in both groups in our study were similar. This shows that the choice of implant did not significantly influence healing, contrary to the theoretical assumption that pre-shaped locking plates have less impact on the fracture fragment blood supply.

Time to union in our study was was 21.22 ± 2.76 weeks for Group A, and 22.91 ± 3.12 for Group B.Similar numbers for weight bearing and union are shown in the literature as well [12, 13]. In our study, acceptable alignment according to Johner and Wruh`s criteria [7], was obtained in 88 patients.

Mallalignment was found in 5 patients in Group A, and 7 patients from Group B. We found the pre-shaped anatomic plates aid the reduction when fixed with a cortical screw at first, which compresses the plate to bone, thus aligning the tibial fragments to the shape of the plate. We believe this to be a significant advantage of the pre-shaped plates, especially when used with a MIPPO technique.

Ankle stiffness and implant irritation were by a margin the most numerous complications in our study. Ankle stiffness was comparable in both groups, whereas implant irritation was found to be significantly higher in the 4.5 mm implant group [8], compared to the 3.5 group [5]. This can be explained by the lower profile of the 3.5 mm anatomically pre-shaped plates. Similar numbers can be found in the literature as well [14].

Conclusion

The use of both 3.5 mm, as well as 4.5 mm plates, with a MIPPO technique is a reliable method of fixation with a high success and low complication rate.

This method is minimally invasive, preserves the periosteal blood supply and ensures optimal conditions for biological repair of distal tibia fractures, regardless of the type of plate used.

In theory the 3.5 mm pre-shaped locking plates should have lower impact on the bone vascularity compared to 4.5 mm plates due to the fact that they act as an internal fixator and have a lover area of contact with the bone, but our study was unable to provide evidence towards this.

Bone healing times were similar, and rates of union and non-union were comparable.

Our study showed an advantage in the use of 3.5 mm pre-shaped plates compared to 4.5 mm LC-DCPs, in two categories> operation time and complications.

Operation time is significantly reduced when using pre-shaped plates.

Having an anatomic plate, already molded to fit the irregular antero-medial surface of the tibia saves the surgeon time which would be lost in manually bending and shaping a 4.5 LC-DCP.

Regarding complication rate, although similar in both groups, we must take notice of the fact that 3.5 mm pre-shaped plates showed a lower rate of malalignment and implant irritation. As a conclusion, we can state that 3.5 mm anatomically pre-shaped locking plates are somewhat a better implant choice compared to 4.5 mm LC-DCPs for the treatment of distal tibia fractures. One factor we have not taken into consideration during our study was the significantly higher price of the 3.5 mm titanium implants, and whether this might offset its advantages. Further studies are needed in order to determine this impact.

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