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Original article

MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS OF THE DISTAL TIBIA - COMPARISON OF TWO DIFFERENT IMPLANTS

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Abstract

Minimally invasive percutaneous locking plate osteosynthesis (MIPLPO) enables widening of indication area for using locking plates in the distal tibia region. Timing of surgery, appearance of deformity on X-ray, postoperative pain and the loss of range of motion were analyzed between two groups of patients. Preliminary results showed statistically significant advantage in shortening the operative time, appearance of deformity on X-ray, as well as improving the range of motion in patients treated with MIPLPO technique. Patients treated with MIPLPO technique showed statistically significantly better results compared to those treated with MIPPO technique.

Keywords: MIPLPO, timing of surgery, deformity, range of motion

Introduction

Fractures of the lower leg are the most common injuries in the general population; among them distal tibial fractures are of particular importance due to the high percentage of complications. They can be closed or open. The most common complications are infections, delayed union, malunion and non-union. According to MacKenzie, this type of injury has a very bad end result, as many as 43% of the injured at a certain period of their lives change their workplace or do not return to work at all[1].

The importance of soft tissues and their condition in open fractures has long been established and has been talked about for a long time in scientific circles. But the importance of the condition of the soft tissues in closed fractures was highlighted by Tscherne and Gotzen in 1984. They go so far as to claim that the condition of the soft tissues is more important than the condition of the injured bones, as the consequences can be catastrophic [2].

The concept of minimally invasive percutaneous plate osteosynthesis (MIPPO)[3] refers to the preservation of the bone blood supply, especially small fragments, during the surgical procedure, thus ensuring their vitality, achieving axial alignment with relative stability resulting in endosteal fracture healing and reduction in postoperative complications[4]. The basic principles on which this concept is based are indirect reposition[5] and bridging osteosynthesis[6].

In this study, we compared two modalities of the same surgical technique - minimally invasive percutaneous osteosynthesis with a plate.

Materials and methods

The study was designed as a monocentric clinical trial comprising 100 patients with closed, unstable, extraarticular and partially articular fractures of the distal tibia and fibula. The study group included 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 between April 2014 and December 2018. The control group (MIPPO) comprised 50 patients treated by the same surgeon 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 Comprehensive Classification of Fractures of Long Bones[7] and the study included extraarticular fractures of type A (43A1.1,43A1.2, 43A2.1, 43A2.2, 43A2.3, 43AA3.1, 43A3.2, 43A3.3) and partial-articular type B (43B2.1). The comparison was made between the definitive degree of deformity in each type of fracture separately, the occurrence of delayed, poor or nonunion, the occurrence of complications related to the soft tissues, the appearance of infections, the first radiological signs of healing, the appearance of a callus, the healing time, as well as the range of motion in the ankle joint during the healing process, as well as after its completion.

Data was statistically analyzed with the SPSS software package, version 26.0 for Windows (SPSS, Chicago, IL, USA). The qualitative series were processed by determining the coefficient of relations, proportions, and rates, and were shown as absolute and relative numbers. Quantitative series were present as mean, and standard deviation. Pearson Chi square test and Fisher exact test were used to determine the association between certain attributive dichotomies. Differences between groups related to operative time was calculated with *T*- test for independent samples. A two-sided analysis with a significance level of $p<0.05$ was used to determine the statistical significance.

Results

The study analyzed 100 patients with distal tibia fractures, 50 treated with a 4.5 mm LC-DCP analyzed retrospectively (Group MIPPO), and 50 treated with a 3.5 mm LC-LCP analyzed prospectively (Group MIPLPO) (Table 1).

The operative time with the MIPLPO ranged from 40-60 minutes, while the intervention with the MIPPO technique ranged from 45-85 minutes.

The average length of the intervention performed with the MIPLPO technique was 50.4±4.7 minutes, and was significantly shorter compared to the average operative time with the MIPPO technique which was 57.2±8.2 minutes ($p=0.000002$) (Table 2).

The control X-ray presented the existence of deformity in 18% (9) of patients from the group operated by the MIPLPO technique and in 46% (23) of patients from the group operated by the MIPPO technique. The X-ray finding of deformity significantly associated ($p=0.0027$) with patients from the MIPPO group (Table 3).

Table 1. Demographic data

Parameter	n	Group MIPLPO n(%)	Group MIPPO n(%)
Male	76	41(82)	35(70)
Female	24	9(18)	15(30)
AO Classification	**n**	**MIPLPO n(%)**	**MIPPO n(%)**
A 1.1	9	3(6)	6(12)
A 1.2	14	5(10)	9(18)
A 2.1	8	0	8(16)
A 2.2	16	2(4)	14(28)
A 2.3	11	11(22)	0
A 3.1	9	7(14)	2(4)
A 3.2	9	7(14)	2(4)
A 3.3	20	15(30)	5(10)
B 2.1	4	0	4(8)

Table 2. Operative time

Group	Operative time Statistical parameter		p-level
	mean±SD	min - max	
MIPLPO	50.4±4.7	40-60	t=5.06***p=0.000002
MIPPO	57.2±8.2	45-85	

MIPLPO- study group (Student t-test);***p<0.0001, MIPPO- control group

Table 3. Deformity

Deformity	n	Group MIPLPO n (%)	Group MIPPO n (%)	p-level
none	68	41(82)	27(54)	X^2=9.01 **p=0.0027
present	32	9(18)	23(46)	

MIPLPO-study groupX^2 (Pearson Chi-square);**p<0.01, MIPPO-control group

Early postoperative complications in terms of infection were registered only in 1 patient from the MIPPO group (Table 4).

Table 4. Infection rate

Infection rate	n	Group MIPLPO n (%)	Group MIPPO n (%)	p-level
Yes	1	0	1 (2)	Yates X^2=0.16 p=0.92
No	99	50 (100)	49 (98)	

MIPLPO-study groupX^2 (Pearson Chi-square), MIPPO-control group

On the control X-ray 5 weeks after surgery, the appearance of callus was diagnosed insignificantly (p=0.372) more often in patients from the MIPPO group - 90% (45) than in MIPLPO group - 84% (42) (Table 5).

Three months after surgery, the X-ray findings of callus significantly associated (p=0.027) with patients from the MIPPO group - 14% (7) (Table 5).

Table 5. Callus appearance 5 weeks postop

Callus appearance – 5 weeks postop	n	Group MIPLPO n (%)	Group MIPPO n (%)	p-level
Yes	13	8(16)	5(10)	X^2=0.8 p=0.37
No	87	42(84)	45(90)	
Callus appearance – 3 monthspostop	**n**	**Group MIPLPO n (%)**	**Group MIPPO n (%)**	**p-level**
Yes	92	49(98)	43(86)	X^2=4.9*p=0.027
No	8	1(2)	7(14)	

MIPLPO- study groupX^2 (Pearson Chi-square);*p<0.05, MIPPO-control group

Five weeks after surgery, difference was confirmed between the two operative techniques and in terms of the distribution of patients with a normal range of plantar extension, with a deficit in the range of 5˚, 10˚, 20˚ and 30˚. Deficit in the range of plantar extension of 5 degrees had 4% (2) of patients from the MIPLPO group, 52% (26) of patients from the MIPPO group; 6% (3) of patients from the MIPLPO group had a deficit of 10 degrees, 24% (12) of patients from the MIPPO group; 14% (7) of patients from the MIPLPO had a deficit of 20 degrees, 20% (10) of patients from the MIPPO group; only 4% (2) of patients operated with the MIPPO technique had a deficit of 30 degrees (Table 6).

Table 6. Deficit in plantar extension

5 weeks postop	Group			p-level
	n	MIPLPO n (%)	MIPPO n (%)	
0	38	38(76)	0	Exact test ***p=0.000
5	28	2(4)	26(52)	
10	15	3(6)	12(24)	
20	17	7(14)	10(20)	
30	2	0	2(4)	

MIPLPO-study group, MIPPO-control group, ***p<0.0001

Discussion

Distal tibia fractures, especially those that extend into and around the ankle joint, and are not suitable for intramedullary fixation, have been treated in recent years with so-called minimally invasive techniques. The emphasis in these techniques is given to biological priorities rather than the mechanical stability of the fragments and their rigid fixation. This relatively new way of using the plates is based on the idea of using the implant as "internal fixator", with bridging type of osteosynthesis. With this type of osteosynthesis, the natural healing process is maximally stimulated, which implies minimal or no evacuation of the fracture hematoma, which, as we know, is the main carrier of the healing process[8,9]. Every healing process in fractures begins with the formation of a hematoma, as part of the inflammatory phase. The formation of the hematoma represents an initial moment of the healing process and one of the main decisive factors for the success of the healing process[10].

Using a plate in the bridging mode, on the other hand, allows less pressure of the implant on the periosteum, and thus preservation of the periosteal vascularization. This type of plate (pre-shaped titanium locking plates) in itself has no advantage over the previously used compression plates; its advantage is reflected in the fact that this type of implant provides stability due to the angular stability of the entire structure, unlike the previously used compression plates, which in order to provide stability need to be strongly compressed to the cortex[11].

This type of osteosynthesis also has the advantage of reduced bone resorption (bone loss) under the implant. This phenomenon occurs more often when using the plates in the classic way, with interfragmentary compression. With Wolff's law[12] as well as with its more recent interpretations[13], it has been proven that this phenomenon mainly depends and is directly proportional to the contact surface between the plate and the bone, and as a result, the damage to the periosteal circulation[14]. This has been proven when using plates with limited contact, where the bone loss zone is minimal and, on the contrary, when using plates with a large contact surface, where the bone loss zone is larger[15]. All previously mentioned is confirmed by the discovery of the so-called Strain theory[16].

The Strain theory also explains an apparent illogicality, stating that the instability of fragments in rigid osteosynthesis has a disastrous effect, while the same instability in biological osteosynthesis has a positive effect. As a generalized problem in the treatment of this type of injuries, there is a high percentage of the need for revisions. This percentage ranges from 0-20% in some series[17-21]. This number may seem large, but when compared to the number regarding the percentage of the need for secondary operations in intramedullary fixation, which is about 42% in this type of osteosynthesis, it can be concluded that the placement of plates in

this type of injuries is more effective in achieving timely healing without the need for additional (secondary) interventions[22-27].

Conclusion

Having in mind the obtained results, it can be concluded that the duration of the operative procedure was significantly shorter with the MIPLPO technique compared to the MIPPO technique. This can be attributed to the fact that the pre-shaped plates do not need additional modeling, as well as the lack of need for the ideal fit of the implants. A statistically significant difference was also determined in the presence of deformity on control X-rays more often in patients operated with the MIPPO technique than in those operated with the MIPLPO technique. Also, plantar extension limitation occurred more often after 5 weeks postoperatively in patients treated with the MIPPO technique than in those with the MIPLPO technique. The analysis of the amount of strain also showed that the group of patients treated with the MIPLPO technique had significantly more strain compared to those treated with the MIPPO technique. We also found that callus appeared more often on control X-rays in the group treated with the MIPPO technique than in the group treated with MIPLPO.

In conclusion, patients treated with the MIPLPO technique showed statistically better results compared to those treated with the MIPPO technique in almost all parameters. But, especially satisfying was the fact that they were better in the parameters that showed the functionality of patients after surgery, such as the amount of the load as well as the range of movements in the area of the ankle joint.

Conflict of interest statement. None declared.

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