

ID Design 2012/DOOEL Skopje, Republic of Macedonia
 Open Access Macedonian Journal of Medical Sciences. 2017 Aug 15; 5(5):630-634.
<https://doi.org/10.3889/oamjms.2017.099>
 eISSN: 1857-9655
Clinical Science



Two Stage Minimally Invasive Method with Locking Plate Application on Distal Tibia Fractures - Our Experience

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Abstract

Citation: Hasani I, Kaftandziev I, Stojmenski S, Trpeski S, Kostov H, Nikolov L, Arsovski O, Emimi S. Two Stage Minimally Invasive Method with Locking Plate Application on Distal Tibia Fractures - Our Experience. Open Access Maced J Med Sci. 2017 Aug 15; 5(5):630-634. <https://doi.org/10.3889/oamjms.2017.099>

Keywords: distal tibia; minimally invasive approach; locking plate; functional results; anatomic pre-shaped locking plate.

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Received: 17-Apr-2017; Revised: 21-May-2017; Accepted: 22-May-2017; Online first: 26-Jul-2017

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Funding: This research did not receive any financial support.

Competing Interests: The authors have declared that no competing interests exist.

INTRODUCTION: In the past distal tibia fractures, including intraarticular fractures, frequently led to poor functional outcomes. The Ruedi-Allgower four steps open method, and later the Patterson and Sirkin recommendations for delayed operative treatment has made a drastic advancement in the treatment of these fractures. The two-stage minimally-invasive protocol using locking plate fixation proved a historical turning point, improving functional results to the highest levels compared to all other methods.

AIM: To present the superior results of the two-stage minimally-invasive method using locking plate fixation, making this a historic step forward in treating distal tibia fractures.

MATERIAL AND METHODS: A prospective longitudinal study, collecting data from Traumatology-Clinic in the 2014-2016 periods, available for nine-month follow-up. Twenty-three patients were finally included in the study.

RESULTS: In analysing the data collected, we focused our attention on the final functional outcomes as indicated by dorsiflexion nine months after injury and also according to the AOFAS Ankle-Hindfoot Scale. Results were excellent with no or minimal consequences. Where complications were present, these were benign and did not require further surgery.

CONCLUSION: We believe this modern method for the treatment of distal tibia fractures should be applied routinely and considered as the gold standard in this domain.

Introduction

In recent years, the minimally invasive approach is a trend in traumatology, and it is continually proved to be superior over the traditional open surgery in traumatology [1, 2]. This minimally invasive concept is applied as a percutaneous technique, minimally open approach or endoscopic approach using advanced medical instruments such as endoscopes. The application of modern navigation systems in the modern bone and joint surgery is evergrowing.

The minimally invasive approach in fracture treatment is preferred to others due to the reduction of the surgical approach, leading to less postoperative pain and also early rehabilitation, which is the precondition for obtaining good functional results [4-7].

Furthermore, in locking plate application, the osteosynthetic material is not placed directly on the bone, but, to prevent damaging the periosteal biological power, it is placed in the epi periosteal space, preserving the bone vascularization that is enabled via the periosteum [1]. Periosteal circulation preservation is of great importance in facilitating of the bone healing [2]. Furthermore, locking plate application implements the principles of internal fixation, which enables avoiding rigid fixation of the fractured fragments [3]. On the contrary, this allows micro movements in the fracture line, which is proved to stimulate osteogenesis and accelerate bone healing [2].

Pilon fractures are intra-articular fractures of the distal tibia, involving its articular surface. They presented great difficulties for both the patients and the surgeons, causing disappointment with the results

and complications that were associated with major disability. For this reason, pilon fractures were considered inoperable in the 1960s (Bonnier & Gay). However, by studying the anatomy and pathophysiology of the distal tibia region, the scientists have come to understand that better functional results require operative approach. In the 1970s, Ruedi&Algower introduce the open surgical approach, achieving very good results [4, 5]. They describe four phases of the surgical treatment of pilon fractures: reconstruction of the distal fibula length, reconstruction of the articular surface of the tibia, bone grafting of metaphyseal defects, and stabilisation of the distal tibia with medial plating.



Figure 1: Goniometric measurement of dorsiflexion plantarflexion and dorsiflexion of the ankle are measured with the use of a goniometer. The goniometer's stationary arm is placed over the imaginary line that connects the lateral malleolus with the fibula head, while the moveable arm is placed in a position that is parallel to the fifth metatarsal bone. While measuring the dorsiflexion angle, it is important that the patient's foot is in neither inversion nor eversion, as this may produce false results

Postponing the definitive intervention from Patterson and Sirkin greatly reduces the complications that are associated with the open surgical treatment of distal tibia fractures [6, 7]. This leads to reducing swelling, local microcirculation enhancement, better healing of the surgical wound, as well as a decrease in complications, early rehabilitation and better functional results [8].

The application of the minimally invasive approach in cases of postponed definitive intervention and pre-shaped anatomical locking plate application with internal fixation, theoretically and practically leads to drastic improvement of the quality of life and reduction of the disability of patients with intra-articular distal tibia fracture [1, 3, 9-11].

The purpose of this study is to present the functional results following distal tibia fracture stabilisation with intra-articular propagation using the minimally invasive approach and osteosynthesis with locking plate, as well as to present the complications.

Material and Methods

This clinical study is a prospective longitudinal clinical study; the data extracted from the case report forms refer to patients that are included in this study. These are patients with pilon fractures that have been operated in the Clinic of Traumatology in 2014 and 2015 and are available for 9 month follow-up. The inclusion criteria include patients at the age of 16 or above with closed or open type I, II, IIIa and IIIb intra-articular fracture of the distal tibia, or type 43: A, B and C according to AO/ASIF classification. The study excludes patients with distal tibia fracture that are younger than 16, patients with ASA (American Society of Anesthesiologists) score 5, patients with open fractures accompanied by neurovascular injuries (type IIIC according to the Gustilo-Anderson open fractures classification).

The functional results are presented through dorsiflexion measurements and quantification according to the American Foot and Ankle Society Ankle-Hindfoot Score.

The complications observed are an infection, non-union, loosening of the osteosynthetic material, mal-union, as well as necessity of further intervention and other complications.

The subject of analysis in this study is the Minimally Invasive Approach by placing an anatomical pre-shaped locking plate for the distal tibia, applied when treating pilon fractures in the distal tibia. The treatment has two stages, except in cases of low energy trauma with minimal soft-tissue swelling, and in cases when the surgical intervention follows immediately after the injury. High-energy fractures with poor findings of the soft tissue are treated with temporary bypass external fixator, with or without fixation of the fibula. Sometimes the alternative may be calcaneal skeletal traction as a temporary solution for provisional stabilisation of the fracture while waiting for the soft tissue stabilisation. Several days after the injury, the soft-tissue swelling is reduced, and the definitive treatment of the fracture takes place. The "wrinkle sign" [7], which is often used in the science literature, indicates it is safe to start the definitive treatment.

In non-displaced intra-articular fractures, the non-displaced intra-articular component is protected by percutaneously placed osteosynthetic material or instruments, followed by percutaneous placement of the locking plate, with small incisions from the medial side of the distal shinbone, namely two incisions: distal and proximal in length of 3-5 cm, as well as smaller incisions in order to place the screws. In displaced intra-articular fractures, an open approach to the intra-articular component is applied, and it is limited only to reposition and reconstruction of the distal tibia articular surface, while the stabilisation is applied similarly to non-displaced intra-articular

fractures.

The placement of the plate applying the minimally invasive approach starts with a distal incision of 3-5 cm above the medial malleolus, tunnelling a percutaneous epi-periosteal space using a raspator. The upper incision is planned by placing and pressing the plate implant to the skin. The skin shows temporary markings that can be used to plan the upper incision, and also the smaller incisions along the plate, which are needed for the placement of the other screws.

Ankle-hindfoot scale

Parameter	Points
Pain (40 points)	
None	40
Mild	30
Moderate	20
Severe	0
Function (50 points)	
Activity limitations	
None	10
Limitations on recreational activities	7
Some limitations on daily and recreational activities	4
Severe limitations on daily and recreational activities	0
Maximum continuous walking distance	
600m or more	5
400 m to less than 600m	4
100 m to less than 400m	2
Less than 100m	0
Walking surfaces	
No difficulty on any surface	5
Some difficulty on uneven terrain, stairs, inclines	3
Severe difficulty or inability to walk on uneven terrain, stairs, inclines	0
Gait abnormality	
None or slight	8
Obvious (walking possible but gait abnormality obvious)	4
Marked (walking difficult and gait abnormality obvious)	0
Sagittal motion (flexion plus extension)	
Normal or mild restriction (30° or more)	8
Moderate restriction (15°–29°)	4
Severe restriction (less than 15°)	0
Hindfoot motion (inversion plus eversion)	
Normal or mild restriction (75%–100% normal)	6
Moderate restriction (25%–74% normal)	3
Severe restriction (less than 25% normal)	0
Ankle-hindfoot stability (anterior drawer, varus-valgus stress)	
Stable	8
Unstable	0
Alignment (10 points)	
Good, plantigrade foot, well aligned	10
Fair, plantigrade foot, mild to moderate degree of malalignment	5
Poor, nonplantigrade foot, severe malalignment	0

Figure 2: AOFAS (American Orthopedic Foot and Ankle Society) Ankle hindfoot scale

The anatomical pre-shaped plate for distal

tibia is a low profile plate with combi holes that serve as points where the screws are inserted or can be used for locking and for ordinary cortical screws, respectively. This plate is inserted into the previously prepared tunnel, fixed to the bone using cortical screws, and then locked with locking screws.

Immobilisation is not applied postoperatively to enable the immediate early rehabilitation process.

Results

The total number of patients is 23: 13 men and 10 women. The median age of the patients is 56 years. Six of the patients were treated with primary definitive operative intervention, while the rest 17 patients were treated applying a two-stage strategy approach.

Nine months after the surgical intervention, the dorsiflexion is 17.13° ($6-21^{\circ}$). The functional results according to the ANKLE-HINDFOOT SCALE of the American Orthopedic Foot and Ankle Society are as follows: pain points 35,7 (0-40), function points 47.4(0-50), alignment points 9.78 (0-10), total points 92.87(0-100).

Delayed healing of the surgical wound occurred in three patients, without the need of extracting the osteosynthetic material. In one patient a rotational deformity occurred due to a fixation in external rotation with a bone defect and delayed healing and prolonged rehabilitation period. Four of the patients had reflex sympathetic dystrophy, which required a medicament treatment. In 7 of the patients with the poor general physical constitution, a prominence of the osteosynthetic material with skin impingement was observed, but removal was not necessary. Non-union did not occur in these patients.

Table 1: Pilon tibial fracture in literature

	No. Cases	Treatment			Func. Good Result %
		Follow-up	Closed	Open	
Bonier 1960	30	30	20	10	43
Decoulx 1961	49	49	25	23	45
Gay 1963	142	96	70	72	50
Fourquet 1959	29	29	8	21	55
Rüedi 1968	84	80	0	84*	74
Heim 1976	128	121	0	128*	90

* Open reduction following the four principles of the Swiss Study Group.

Discussion

Before we start discussing our method of distal tibia fracture treatment, we must emphasise that there is no perfect method for distal tibia fracture treatment that would lead to ideal results and no

complications. All methods applied in distal tibia fracture treatment should be adjusted according to the fracture features, including all the components of the fracture and the patient, but also the surgeon, surgical team, implants and circumstances. There are some well-known issues that are implementable in these fractures, for example, the complexity of the fracture is associated with poorer results, and that these require special conditions regarding implants and experienced surgical team.

Nevertheless, there are certain things that have to be followed when it comes to treating distal tibia fractures, which are historically difficult and associated with poor results. One of the basic aspects is respecting the soft-tissue envelope [7], i.e. good evaluation of the soft-tissue trauma, which we classify according to Tcherne. The general principal in medicine, *premium nil no cure* or 'first, do no harm', is seriously applicable here. If there is a severe soft-tissue trauma with no signs of open fracture, it is necessary to apply a two-stage treatment of distal tibia fracture, until the occurrence of the 'wrinkle sign', which allows us a safer operative approach to these fractures [6, 8, 10].

The second important moment in the distal tibia fracture treatment also refers to soft tissue protection. All techniques that spare the soft tissue above the fracture, such as external fixation, intramedullary fixation¹¹, minimally invasive approach, should be preferred to the open surgical approach for treating distal tibia fracture due to the specificities of the rigid soft-tissue envelope of distal tibia [3,12,13].

The principle of better reconstruction of the articular surface to get better functional results is also implementable to distal tibia fractures. However, in these fractures, the reconstruction needs to be performed with as minimal invasion to the soft tissue as possible [7].

The minimally invasive method with locking plate application in distal tibia fractures was developed to enable the advantages above in distal tibia fracture treatment. Furthermore, the locking pre-shaped anatomical plate for distal tibia provides absolute fixation of the anatomically repositioned articular fracture component, as well as the relative stability of the metaphyseal part of the fracture [3, 12, 14].

When we add the fact that the surgical intervention is performed in two stages when the soft tissue is at risk, we are not surprised by the superior results of the application of this technique in distal tibia fracture treatment [15].

After the historical step of Ruedi & Algower of applying the four principals open method leading to great advancement of the functional results, and after the drastic advancement with the recommendations of Patterson and Sirkin, the minimally invasive method with locking plate application is a historical turning

point in the treatment of distal tibia fractures, improving the functional results to the highest possible level compared to all other methods in any historical period [4,15,16].

We are happy to say that the small group of our patients that received this type of treatment has been rewarded with good functional results and a small number of slight complications that do not require additional surgical intervention. The general impression is that the patients that underwent surgery with this technique are pleased with the results and nine months after the intervention they have no complaints associated with any severe pain or swelling, their gait is normal, there are no serious difficulties, the dorsiflexion is minimally limited, and this general impression is confirmed with the objective results of this study as well [7, 16].

Aspects of concern in the application of the method, which is the subject of this paper, is the fact that it is very demanding regarding operator and surgical team skills, as well as the implant. The curve of learning the surgical techniques is long and requires long experience with open treatment of distal tibia fractures, good three-dimensional presentation of the distal tibia anatomy, as well as the pathological anatomy of the fracture, good assistance and instrumentation. Indirect reposition and temporary fracture stabilisation using percutaneous methods are also a challenging aspect of this technique application. The radiation exposure period is always longer compared to other techniques, which must be taken into consideration in the implementation of this method. Also, the price of the implant is high when compared to other implants used in distal tibia fracture treatments, which sometimes is a decisive factor when choosing the treatment method in hospitals lacking low-profile anatomical pre-shaped locking plate that is designed for distal tibia fracture treatment.

The prominence of the implant under the skin above the distal tibia with skin impingement occurs as a problem in almost every case of operated thin patient, a phenomenon that sometimes causes uncomfortable sensations in the operated area¹⁵. Although this phenomenon occurred in three of our patients, the condition did not require a removal of the osteosynthetic material.

In conclusion, performing precise anatomic reduction of the articular surface, with conservation of limb axis, with maximal preservation of the soft tissue is a precondition for successful treatment of all intraarticular fractures, and in particular in distal tibia fractures. This is due to the very specific soft tissue envelopment that has a tendency for compartment phenomena, and because the ankle joint pain or movement limitation is related to limp gait and serious disability that compromises the quality of life.

Also, pre-shaped anatomic locking plate for distal tibia combines the advances of articular rigid fixation with multiple screws in a different direction,

and also relative stability in the metaphyseal region of the distal tibia that enhances the bone formation. In combination with the ability of this plate to preserve periosteal and endosteal bone circulation, this plate represents the most biological one in the market.

The two-staged minimally invasive approach with anatomical locking plate application is a superior treatment method for distal tibia with or without intra-articular involvement, since has shown superiority in functional results and rate of complication, compared to other methods and should be declared a gold standard in the treatment of these fractures.

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