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Distal Ekstra-Artiküler Tibia Kırığının Tedavisinde Minimal İnvaziv Plak veya İntramedüller Çivi, Hangisi Daha İyi?

Minimally-Invasive Plate or Intramedullar Nail in the Management of Distal Extra-Articular Tibial Fracture, What Is Better?

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ÖZ

Amaç: Bu çalışmanın amacı, intramedüller çivileme (IMN) veya minimal invaziv plak osteosentezi (MIPO) ile tedavi edilen distal tibia ekstraartiküler kırıklı hastaların klinik ve fonksiyonel sonuçlarını karşılaştırmaktır.

Materyal ve Metot: Bu retrospektif çalışma, IMN ile tedavi edilen 47 hastayı ve MIPO ile tedavi edilen 41 hastayı içermektedir. Klinik ve radyografik sonuçlar son takipte değerlendirildi. Klinik ölçüm olarak ön diz ağrısı, Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) Ayak Bileği-Arka Ayak Ölçeği puanı ve Lysholm diz puanlama ölçeği kullanıldı.

Bulgular: İki gruptaki hiçbir hastada kaynamama geliştirmedi. IMN grubunda kaynama süresi ve operasyon süresi MIPO grubuna göre anlamlı olarak daha yüksek olmasına rağmen (p<0,001), MIPO grubunda tam yük taşıma süresi ve hastanede kalma süresi daha yüksekti (p<0,001). Gruplar arasında yara sorunu, yanlış pozisyon, enfeksiyon ve greftleme oranları açısından istatistiksel olarak fark yoktu (p>0,05). AOFAS skoru IMN grubunda istatistiksel olarak daha yüksek olmasına rağmen (p=0,031), Lysholm diz skoru MIPO grubunda daha yüksekti (p<0,001).

Sonuç: MIPO, erken kaynama, kısa operasyon süresi ve diz eklemine zarar vermemesi ile avantajlıyken, IMN daha erken tam yük taşımaya, daha kısa hastanede yatmaya ve daha iyi ayak bileği fonksiyonel sonuçları elde etmeyi sağlamaktadır.

Anahtar Kelimeler: Distal tibia kırıkları, intramedüller çivi, minimal invaziv plak osteosentezi

ABSTRACT

Objective: The aim of this study was to compare the clinical and functional outcomes of patients with distal tibia extraarticular fractures treated with Intramedullary nailing (IMN) or Minimally invasive plate osteosynthesis (MIPO).

Materials and Methods: This retrospective study included 47 patients treated with IMN and 41 patients with MIPO. Clinical and radiographic results were evaluated at last follow-up. Anterior knee pain, American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale score and Lysholm knee scoring scale were used as clinical measurement.

Results: Although the union time and operation time were significantly higher in the IMN group compared to the MIPO group (p<0.001), the full weight bearing time and the hospital time were higher in the MIPO group (p<0.001). There were no statistical differences between wound problem, malposition, infection and grafting rates in both groups (p>0.05). Although the AOFAS score was statistically higher in the IMN group (p=0.031), the Lysholm knee score was higher in the MIPO group (p<0.001).

Conclusion: While MIPO is advantageous with low union time, low operating time and no damage to the knee joint, IMN allows earlier full weight bearing, lower hospitalization and has better ankle functional results.

Keywords: Distal tibial fractures, intramedullary nail, minimally invasive plate osteosynthesis

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INTRODUCTION

Distal tibial fractures with or without simple articular involvement can be difficult to treat. Realignment or fixation and stabilization of the thin, flute-shaped metaphyseal bone with a short distal fracture segment may be difficult.[1]

The anatomy of the distal tibia also has a limited soft tissue envelope that, when injured and operated on, can result in potentially catastrophic wound complications. Multiple modes of fixation for this type of fracture have been discussed in the literature.[1,2] Traditional open reduction with internal fixation using plates and screws has been linked to soft tissue complications and nonunion.[2] Hence, treatments aimed at minimizing soft tissue disruption have been considered; these include biology-sparing fixation techniques using plates or intramedullary nails.[2]

Intramedullary nailing (IMN) is widely used for the fixation of tibial shaft fractures because of its successful outcomes. IMN of distal tibial fractures avoids disturbing the soft tissue coverage and protects the vascular supply, resulting in high union rates. IMN has been reported to be effective in stabilizing the distal tibia. However, the fixation of distal tibial metaphysis fractures by IMN is associated with technical challenges due to the large cavity. Thus, IMN in patients with distal tibial fractures may lead to high rates of malunion, knee pain, and secondary procedures.[3]

Tibial plating provides anatomic reduction with reliable fixation, maintaining the limb alignment and allowing early rehabilitation. However, this technique is associated with a high incidence of wound complications, infections, and reoperations. With the development of minimally invasive techniques, biological plate fixation has become an attractive option for fracture treatment. Minimally invasive plate osteosynthesis (MIPO) is a valid option that results in indirect reduction, percutaneous fixation, and fewer wound complications.[4]

It is obvious that IMN and MIPO have their own advantages and disadvantages in treating distal tibial fractures; however, neither method is considered the gold standard. The present study aimed to compare these methods for treating extra-articular distal tibial fractures.

MATERIALS AND METHODS

Our study was approved by the Sakarya University Ethics Committee (Date: 24.02.2021, decision no: 202). The present study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Our institutional review board approved the study protocol, and all the patients provided written informed consent prior to their inclusion in the study.

This study was conducted from 2014 to 2017 at a tertiary care orthopedic trauma hospital. All patients aged 19–85 years who had closed extra-articular distal tibial fractures were included in the study. Patients with polytrauma, pathological fractures, compound fractures, ipsilateral or contralateral upper limb fractures, pediatric fractures, and fractures with intra-articular extension were excluded from the study. Patients who were either lost to follow-up or did not provide their consent for participating in the study were also excluded.

The patients were divided into two groups (47 patients in the IMN group and 41 patients in the MIPO group) by means of permuted randomization. In the IMN group, the patients were managed by interlocking IMN. In the MIPO group, the patients were managed using the MIPO technique. Additional fibular fixation was performed in both the groups depending on the level of simultaneous fibular fractures. All surgeries were performed by a senior surgeon in order to avoid bias. The surgeries were performed under spinal anesthesia.

A standard postoperative follow-up protocol was developed. The patients were followed up once every 3 weeks until fracture union, followed by once every 3 months for a year and twice in the subsequent year. Weight bearing was allowed when callus was seen in two cortices on an anteroposterior (AP) view or a lateral view. Although IMN is the system that allows load bearing, we did not have early weight bearing due to the fact that the fractures are very distal (distal metaphyseal area). Because we thought that there might be reduction loss with early weight bearing. At the final follow-up, clinical and radiological examinations were performed and the patients were assessed on the basis of the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale score. Coronal and sagittal alignment was assessed using AP and lateral plain radiographs. Rotation was clinically assessed on the basis of the foot–thigh angle; the difference was measured using a goniometer. Union was defined as the consolidation of three or more cortices on plain radiographs and the absence of pain during unassisted weight bearing. Malunion was defined as varus or valgus greater than 5° in the coronal plane and procurvatum or recurvatum greater than 10° in the sagittal plane (lateral x-ray) or as external or internal rotation greater than 10° (foot–thigh angle).[5] Any complication during the surgery and follow-up period was recorded.

In the MIPO group we used Cytronics plates (Cytronics, Bursa, Turkey) with antero-medial access. In the IMN group we used Tasarimmed nails (Tasarimmed, Istanbul, Turkey) with parapatellar

medial access.

The postoperative protocol in each group included elevation and pain management. If the patient's overall condition allowed, the postoperative protocol also included early gentle mobility with physical therapy for gait training without weight bearing on the injured leg. After the early postoperative follow-up for wound checks, suture removal, and education, the patients were followed up at 5–6-week intervals with clinical and plain radiographic examinations, which included four radiographic views of the high ankle, in which the x-ray beam was pointed in the AP, lateral, and oblique directions 5–6 cm cephalad to the ankle joint.

Evaluation: Patient and injury characteristics were obtained to evaluate their association with the clinical and functional outcomes.

In this study, the fractures were classified according to the Orthopaedic Trauma Association (OTA) scheme,[6] the union of the fracture was accepted when callus was seen in 3 cortices radiographically.[7] AOFAS,[6] Lysholm Knee Scoring Scale were used in the functional evaluation.[8]

Statistical Analysis: The SPSS 15.0 for Windows program was used for statistical analysis. Descriptive statistics are presented as the number and percentage for categorical variables and as the mean, standard deviation, minimum, and maximum for numerical variables. For numerical variables with a normal distribution, the comparisons between two independent groups were made using Student's t test. For numerical variables without a normal distribution, the Mann–Whitney U test was used. Spearman correlation was used to assess the relationships between the numerical variables as the parametric test conditions were not met. The determining factors were examined by linear regression analysis. A p value < 0.05 was considered statistically significant.

RESULTS

In the present study, 88 patients who had distal tibia extraarticular fractures were included in the IMN (47 patients) (Figure 1) and MIPO (41 patients) (Figure 2) groups. In total, 59% (28/47) of the patients in the IMN group got an associated fibula fracture repaired. Moreover, fibula fractures were repaired in 44% (18/41) of the patients in the MIPO group ($p>0.05$).

Figure 1: Radiographs **(a,b)** before and **(c,d)** 10 months after intramedullar nail osteosynthesis for distal tibial fracture.

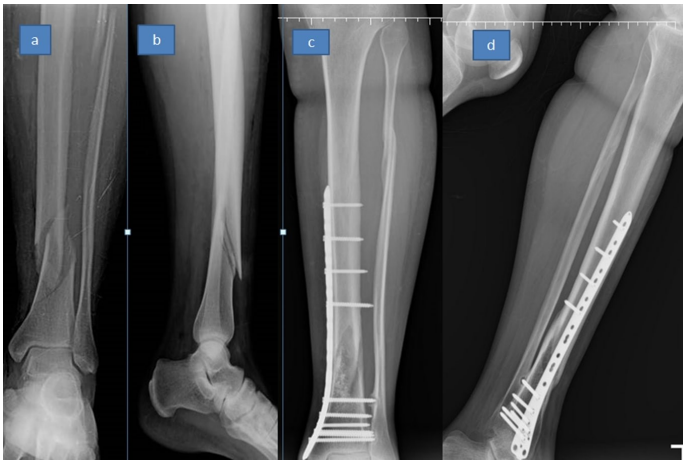

Figure 2: Radiographs **(a,b)** before and **(c,d)** 8 months after minimally invasive plate osteosynthesis for distal tibial fracture.

In the IMN group, the patients were evaluated at an average of 26 months after the injury (range, 19–37 months). Similarly, in the MIPO group, the patients were evaluated at an average of 26 months after the injury (range, 18–36 months). Patient demographics and injury data are provided in Table 1.

Clinical results are provided in Table 2. The mean duration between the injury and the surgery was 2.8 days (range, 1–6 days) in the IMN group and 2.4 days (range, 1–13 days) in the MIPO group; this difference was statistically significant ($p<0.05$). The mean surgery duration was 91 min (range, 75–113 min) in the IMN group and 71 min (range, 55–89 min) in the MIPO group; this difference was statistically significant as well ($p<0.05$). Moreover, the mean duration of postoperative hospitalization was 3.7 days (range, 2–6 days) in the IMN group and 4.5 days (range, 3–7 days) in the MIPO group, with the difference being statistically significant ($p<0.05$) (Table 2).

All the evaluated patients ultimately healed, with the average time to union being 21.9 weeks (range, 16–32 weeks) in the IMN group and 19.9 weeks (range, 16–33 weeks) in the MIPO group. The time to union was significantly longer in the IMN group ($p<0.001$). The complications included three (6.4%) delayed unions in the IMN group and one (2.4%) delayed union in the MIPO group ($p>0.05$). All these patients underwent successful surgeries, including bone grafting, to achieve union. The full weight-bearing time was significantly longer in the MIPO group than in the IMN group (16.1±1.5 weeks and 11.6±1.7 weeks, respectively; $p<0.05$). In the IMN group, six (12.8%) patients had a malunion [four varus deformities (one patient 7 degree, one patient 9 degree, one patient 10 degree, one patient 12 degree), one valgus deformity (11 degree), and one sagittal plane deformity (13 degree)]. In the MIPO group, two (4.9%) patients had a malunion [(one varus deformity (10 degree) and one valgus deformity (12 degree)]. The difference was not statistically significant ($p>0.05$). Two (4.3%) and three (7.3%) superficial infections were noted in the IMN and MIPO groups, respectively. Although the infection rate was higher in the MIPO group, the difference was not statistically significant ($p>0.05$). In the IMN group, seven patients experienced anterior knee pain (14.8%). The average AOFAS score was higher in the IMN group (87.6±7.0) than in the MIPO group (85.7±5.2) ($p<0.05$). However, the Lysholm Knee score was higher in the MIPO group (93.4±3.0) than in the IMN group (82.4±8.0) ($p<0.05$) (Table 2).

Table 1. Demographical characteristics of the patients.

		Group1		Group 2		
		n	**%**	**n**	**%**	**p**
Gender	Female	23	48.9	18	43.9	0.637
	Male	24	51.1	23	56.1	
Mean age		41.7±13.8 (19-83)		43.9±18.0 (20-85)		0.514
Side	Right	22	46.8	21	51.2	0.680
	Left	25	53.2	20	48.8	
Trauma mechanism	Falling	15	31.9	10	24.4	0.720
	Sport	3	6.4	2	4.9	
	Traffic accident	29	61.7	29	70.7	
Type of fracture	Open	9	19.1	6	14.6	0.574
	Closed	38	80.9	35	85.4	
Lateral malleolus fracture		28	59.6	18	43.9	0.142
Follow up (months)		26.6±4.8 (19-37)		26.1±5.9 (18-36)		0.549
Distance to joint (mm)		81.3±8.6 (70-115)		70.3±19.3 (34-115)		**0.001**

Table 2. Comparison of results in the intramedullar nail and minimally invasive plate groups.

	Group1		**Group 2**		
	Mean±SD (Min-Max)		Mean±SD (Min-Max)		p
Union time (week)	21.9±3.2 (16-32)		19.9±3.5 (16-33)		**<0.001**
Weight bearing (week)	11.6±1.7 (9-17)		16.1±1.5 (13-19)		**<0.001**
Preoperative hospitalization (day)	2.8±1.3 (1-6)		2.4±2.3 (1-13)		**0.011**
Operation time (minute)	91.0±10.2 (75-113)		70.9±10.3 (55-89)		**<0.001**
Hospital time (day)	3.7±1.0 (2-6)		4.5±1.0 (3-7)		**<0.001**
AOFAS Score	87.6±7.0 (74-98)		85.7±5.2 (75-97)		**0.031**
Lysholm Knee Score	82.4±8 (7294)		93.4±3 (74-98)		**<0.001**
	n	**%**	**n**	**%**	**p**
Wound problem	3	6.4	4	9.8	0.700
Malpozition	6	12.8	2	4.9	0.276
Infection	2	4.3	3	7.3	0.661
Grafting	3	6.4	1	2.4	0. 620

AOFAS Score: AOFAS Score: American Orthopaedic Foot and Ankle Society Score; SD: Standard deviation.

DISCUSSION AND CONCLUSION

Several studies have compared MIPO and IMN for treating extra-articular distal tibia fractures. However, there is no definite conclusion about the superiority of one fixation method over the other.[9,10]

Biological plate fixation has generally been associated with low infection rates.[11] However, high infection rates have been reported by Lau et al. (15%)[12] and Collinge et al. (19%).[13] In 2016, Shen et al. reported wound complications to be more common in the IMN group than in the MIPO group (8.2% and 3.1%, respectively).[14] In their meta-analysis, Kwork et al. did not find any significant difference in the incidence of infection between the plating and IMN groups.[15] A recent meta-analysis on this topic concluded that the MIPO technique is associated with a longer time to union and an increased rate of wound complications.[16] Although wound complication and infection were found to be higher in the MIPO group than in the IMN group in the present study, the difference was not statistically significant.

In the study of Shen et al., the surgery duration was 56 min in the MIPO group and 85 min in the IMN group.[14] Li et al. reported a shorter surgery duration in the IMN group than in the MIPO group (87.5 min versus 114.4 min; $p < 0.05$).[10] In the present study, the surgery duration in the MIPO group was much shorter than that in the IMN group (71 min vs. 91 min; $p<0.001$; Table 1).

Malalignment has been found to be a problem in distal tibial fractures because the small distal fragment is difficult to control. An ideal treatment should provide anatomical or at least acceptable fracture alignment to avoid posttraumatic arthritis in the ankle joint.[17]

Numerous studies have shown high malalignment rates when IMN or MIPO has been used to treat distal tibial fractures (8%–58% with IMN and 5%–35% with MIPO). However, the incidence certainly depends on several factors, including how malalignment has been defined.[18,19] Costa et al. reported no significant difference in lateral deformities ($p=1.000$) and AP deformities ($p=0.081$) between the IMN and plating groups. Nevertheless, they found shortening deformities (>10 mm) to be associated with the IMN group ($p = 0.028$).[15,20] Moreover, Wani et al. reported that patients treated with the IMN technique had significantly higher rotational malalignment than those treated with the plating technique. However, they did not find any significant difference in varus or valgus deformities and in the anterior/posterior angulation.[21] Guo et al. and Li et al. reported equal malalignment in both the groups in their studies.[9,10] While the incidence of union-related complications, including delayed union, nonunion, and malunion, was found to be similar between the IMN and MIPO groups in two meta-analyses,[15,22] the incidence of malunion was found to be higher in the IMN group in another meta-analysis.[23] In the present study, the malunion rate was higher in the IMN group than in the MIPO group; however, the difference was not statistically significant.

Li et al. reported two cases of nonunion (one in the IMN group and one in the MIPO group).[10] In the present study, we had no case of nonunion, similar to the findings of a previous study.[24] Although the time to union was longer in the IMN group, the full weight-bearing time was significantly shorter in the IMN group than in the MIPO group in the present study.

Guo et al. compared MIPO with IMN in a series of 85 patients and found statistically similar AOFAS scores in both the groups.[9] In the present study, the AOFAS score was 87.6 in the IMN group and 85.7 in the MIPO group. We noted better functional outcomes in the IMN group.

It is known that IMN causes more anterior knee pain than MIPO. This is because no incision is made around the knee in MIPO.[25] Yang et al. compared the results of IMN with those of open reduction and plating of distal tibial fractures and reported anterior knee pain in half of the patients treated with IMN.[26] Moreover, in their retrospective series, Jansen et al. reported a significantly higher frequency of anterior knee pain during kneeling and squatting in the IMN group.[27] In the present study, 14.8% of the patients in the IMN group reported anterior knee pain. Moreover, the Lysholm Knee score was significantly lower in the IMN group.

The infrapatellar approach for the nail insertion has long been considered the standard procedure, however high incidence of anterior knee pain , ranging from 10 to 80%, has been reported.[28] For treatment of distal fractures suprapatellar tibial nailing is an alternative surgery. Suprapatellar tibial IMN may be applicable to distal tibial fractures. Providing easy anatomic reduction in the semiextended position, convenient fluoroscopic imaging, safety for the PF joint, acceptable anterior knee pain, and satisfactory functional outcomes render the SP technique more feasible.[29] Lu et al. found less malalignment with the suprapatellar method in distal tibia fractures.[30] Therefore, we preferred the suprapatellar method.

In conclusion, there are several limitations in this study. Small number of patients and relatively short follow-up periods in this study limited findings. Another limitation this study that it is a retrospective study. While MIPO is advantageous with low union time, low operating time and no damage to the knee joint, IMN allows earlier full load bearing, lower hospitalization and has better functional results.

Ethics Committee Approval: Our study was approved by the Sakarya University Ethics Committee (Date: 24.02.2021, decision no: 202). The present study was conducted in accordance withthe ethical standarts laid down in the 1964 Declaration of Helsinki and its later amendments. Our instutional review board approved the study protocol, and all the patients provided written informed consent prior to their inclusion in the study.

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept – AK; Supervision – ES, AK, MEI; Materials – AK, OB; Data Collection and/or Processing – EO, ES; Analysis and/ or Interpretation – ID, TM, ZF; Writing – AK, ES.

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