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Comparison of minimally invasive plate osteosynthesis and intramedullary nailing in the treatment of distal extraarticular tibial fractures

Eklem dışı distal tibia kırıklarının tedavisinde minimal invazif plaklı osteosentez ile intramedüller çivilemenin karşılaştırılması

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ABSTRACT

Aim: Our study's aim was to investigate the effectiveness of minimal invasive plate osteosynthesis (MIPO) and intramedullary nailing (IMN) in extraarticular distal tibia fractures and to compare the outcomes of these two treatment methods.

Materials and Methods: Between January 2008 and January 2015, 59 patients had extraarticular distal tibia fracture and treated with MIPO or IMN were evaluated retrospectively. Postoperative x-rays were evaluated for fracture consolidation and angular deformities. For the functional evaluations of the patients Olerud-Molender Ankle Scoring (OMAS) method was used and ankle joint range of motion was measured by goniometer.

Results: At the last visit, all the fractures consolidated. Average union time was 16.1weeks (range, 12-24 weeks) in MIPO group and 15.5 weeks (range 10-24 weeks) in IMN group, respectively (p = 0.254). The mean OMAS scores were 67.5 (range 40–90) and 63 (range 30-90) in the IMN and MIPO groups, respectively (p= 0.12). The mean operation time was 95(range 45-115) minutes in IMN group and 75(range 40-100) minutes in MIPO group (p= 0.04). The mean operative radiation exposure times were 30(range 8-143) and 17 (range 5-65) seconds in IMN and MIPO groups, respectively (p= 0.03). Angular deformities were found in IMN group at 7 (23%) patients and in MIPO group at 5 (17%) patients, respectively. Soft tissue problems were seen in more patients in MIPO group.

Conclusion: In conclusion, IMN and MIPO can be used safely in the treatment of distal tibial metaphyseal fractures. While IMN caused more angular deformity and more union delay, patients treated with MIPO had poorer functional results and more soft tissue problems.

Keywords: Distal tibia fracture, intramedullary nailing, minimally invasive plate osteosynthesis, angular stable locking plate.

ÖZ

Amaç: *Çalışmamızın amacı, eklem dışı distal tibia kırıklarının tedavisinde kullanılan intramedüller çivileme (İMÇ) ve minimal invazif plaklı osteosentezin (MİPO) fonksiyonel ve radyolojik sonuçlarının karşılaştırılmasıdır.*

Gereç ve Yöntem: *Ocak 2008 ve Ocak 2015 tarihleri arasında hastanemizde eklem dışı distal tibia kırığı tanısıyla MİPO ya da İMÇ ile tedavi edilen 59 hasta geriye dönük olarak değerlendirildi. Kırık kaynamasının ve açısal deformitelerin değerlendirilmesi için postoperatif radyografiler kullanıldı. Hastaların fonksiyonel sonuçlarının değerlendirilmesinde ise Olerud-Molender Ankle Scoring (OMAS) yöntemi kullanıldı ve hastaların ayak bileği hareket genişlikleri goniometre ile ölçüldü.*

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Bulgular: *Yapılan son değerlendirmede tüm kırıkların kaynadığı görüldü. Kırıkların ortalama kaynama süresi MİPO grubunda 16,1 hafta (12-24 hafta) ve İMÇ grubunda ise 15,5 hafta (10-24 hafta) idi (p= 0.254). Ortalama OMAS skoru İMÇ grubunda 67,5 (40–90) MİPO grubunda ise 63 (30-90) idi (p= 0,12). Ortalama operasyon süresi İMÇ grubunda 95(45-115) dakika ve MİPO grubunda 75 (40-100) dakikaydı (p= 0,04). Ortalama radyasyon maruziyet süresi İMÇ grubunda 30 (8-143) saniye ve MİPO grubunda 17 (5-65) saniyeydi (p= 0,03). Açısal deformiteler İMÇ grubunda 7 (%23) hastada MİPO grubunda 5 (%17) hastada görüldü. Yumuşak doku problemleri ise MİPO grubunda daha fazla hastada görüldü.*

Sonuç: *Sonuç olarak İMÇ ve MİPO distal tibia metafizer bölge kırıklarının tedavisinde güvenle kullanılabilmektedir. İntramedüller çivileme daha fazla hastada açısal deformiteye ve gecikmiş kaynamaya neden olurken MİPO daha sık yumuşak doku sorunlarına ve daha kötü fonksiyonel sonuçlara sebep olabilmektedir.*

Anahtar Sözcükler: *Distal tibia kırığı, intramedüller çivileme, minimal invazif plaklı osteosentez, açısal stabil kilitli plak.*

INTRODUCTION

Distal tibia fractures (DTF) are common fractures that affect all age groups. These fractures can be seen as spiral oblique fractures as a result of low-energy injuries, as well as communited fractures as a result of high-energy traumas (1, 2). In the treatment of distal tibia fractures, open reduction and rigid fixation with conventional plates have been used for a long time (2). Although anatomical reduction can be achieved with this treatment method, non-union can be observed as a result of high degree of periost stripping. Catastrophic wound problems can be observed due to the weak soft tissue cover in this area and damage to these tissues during both injury and operation (3). As the importance of soft tissue in fracture healing is understood, less invasive methods started to be used over time. Intramedullary nailing (IMN) provides both stable fracture fixation and less damage to soft tissue. This treatment method allows early load bearing, resulting in earlier return to her/his daily life (4-6). In minimal invasive plate osteosynthesis tecnique (MIPO), it is possible to provide osteosynthesis with small incisions without damaging the periost and destroying the viability of the fracture ends. MIPO has gained popularity with the development of precontoured angular-stable locking plates (7-9). Although positive results have been reported in the treatment of distal tibia fractures with MIPO and pre-contoured plates, angular deformities may also appear as a complication of this treatment method (10).

Our study's aim was to investigate the effectiveness of minimal invasive plate osteosynthesis and intramedullary nailing in extraarticular distal tibia fractures and to compare the outcomes of these two treatment methods. Our hypothesis is that MIPO can be used safely in the treatment of distal tibia fractures and causes less angular deformities compared to intramedullary nailing with better functional results.

MATERIALS and METHODS

The study was initiated after the approval of the local ethics comittee (Date: 03.07.2014, IRB#:141). Between 2008 and 2015, patients with distal tibia fracture were operated in our hospital were evaluated retrospectively. Inclusion criteria were; **1)** patients older than 18 and who completed bone development, **2)** fractures, presence of a distal fragment of at least 4 cm in length with no articular incongruity, according to AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopaedic Trauma Association) classification 43-A fractures, **3)** closed fractures and according to the Gustillo-Anderson classification type 1 and 2 open fractures and 4) patients followed for at least 1 year. Intra-articular fractures, according to the Gustillo-Anderson classification type 3 open fractures, pathological fractures, patients had dysfunction in the lower extremity before injury, and patients with more than one fracture in the same limb were excluded from the study. When the patient records were examined in the light of these criteria, there were 69 patients who met the criteria. Six patients could not be reached due to address and phone change and 4 patients refused to participate in the study. Totaly 59 patients were included to study. Patients were divided into two main groups according to the treatment method; IMN group (treated with

intramedullary nailing, n=30) and MIPO group (treated with angular-stable plates and minimal invasive plate osteosynthesis tecnique, n=29). Preoperative anteroposterior (AP) and lateral views were obtained to analyze the fracture. In the light of the preoperative x-rays and CT scans fractures were classified according to AO/OTA classification system. The distrubution of the fractures according to AO classification system were given in the (Table-1).

In IMN group, intramedullary nailing (VersaNail TM, DePuy Orthopaedics, Johnson & Johnson, Warsaw, IN, USA) was performed after reaming and a minimum of two distal and two proximal locking screws were used (Figure-1).

In MIPO group, pre-contoured locking plate (VariLoc, Distal medial tibia locking compression plate, Changzhou Kanghui Med. Inn., Changzhou, Jiangsu, P.R.C) is inserted at the distal end of the tibia through 5 cm incision and passed under the skin onto the surface of the bone. During the fixation, bridging technique was used and fixation was achieved by using the appropriate number of screws and providing the appropriate fracture working distance (Figure-2).

In both treatment methods, fractures were tried to be reduced by using closed reduction techniques. When the fracture could not be reduced by closed manner, reduction was achieved with small incisions made on the fracture line or through open fractures wounds with minimum soft tissue dissection. Combined fibular fractures were fixed if they were associated with syndesmotic instability, which was tested after tibial fixation.

The operations in both groups were performed by same senior surgeons or under their supervisions. Postoperative care was performed in the same way in both groups. Antibiotic prophylaxis was performed in the postoperative 24 hours (Cephalosphorin every 6 hours, 1 gr). Removable splints were not used and foot and knee movements were started when the patient's postoperative pain disappared. Toe-touch gait with crutchs was allowed immediately after surgery, with subsequent progression to full weight-bearing following radiographic evidence of healing. Patients were followed-up at 15th day, 6th week, 3th, 6th and 12th months with regular clinical and radiographic review.

Table-1. Demographic data of the patients.

Characteristics	**IMN group (n:30)**	**MIPO group (n:29)**
Age (years), Mean±SD	47 (range 25-80)	52 (range 20-82)
Sex, n (%)		
Male	19 (63%)	16 (55%)
Female	11 (37%)	13 (45%)
Cause of injury, n (%)		
Simple fall	14 (47%)	15 (52%)
Fall from height	2 (6%)	4 (14%)
Traffic accident	14 (47%)	10 (36%)
Fracture Type (AO/OTA), n (%)		
A1	15 (50%)	13 (45%)
A2	10 (33%)	12 (41%)
A3	5 (17%)	4 (14%)
Fibula fracture, n (%)	28 (93%)	27 (93%)
Fibula fixation, n (%)	3 (10%)	6 (22%)
Mean follow-up (months)	28 (range 13-98)	35 (range 15-84)
Gustillo-Anderson classification		
Grade 1	5 (17%)	3 (10%)
Grade 2	3 (10%)	2 (7%)

(IMN: Intramedullary nailing)

(MIPO: Minimally invasive plate osteosynthesis)

(AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association)

Postoperative AP and lateral radiographs were evaluated to determine rate of union, possible changes in hardware position and angulations at both view. Radiologic bone union was defined as the presence of callus in at least 3 cortices in AP and lateral views. Malunion was considered as angular deformations of >5° in both planes and rotational malalignment of greater than or equal to 10°. Functional evaluations of the patients were performed by using Olerud-Molender Ankle Scoring (OMAS) method and by measurement of ankle motion.

The datas were evaluated with SPSS-MacOSX 22.0 statistical program (SPSS Inc. Chicago, IL, USA). The unpaired independent t-test was used to compare outcome measures with parametric means. $p \leq 0.05$ was considered statistically significant.

Table-2. Functional results of patients.

	IMN group	**MIPO group**	**p**
Mean union time(week)	**15.5 (range 10-24)**	**16.1 (range, 12-24)**	**0.483**
Angulation in sagittal plane (degree)	2.7	1.8	0.18
Angulation in coronal plane (degree)	2.4	1.5	0.34
OMAS	67.5 (range 40-90)	63 (range30-90)	0.12
Excellent n (%)	1 (3%)	1(3%)	
Good n (%)	24 (80%)	18(62%)	
Moderate n (%)	5 (17%)	9(31%)	
Bad n (%)	0(0%)	1(3%)	
Ankle dorsiflexion (degree)	18.5 $\pm$ 3.5	16.9 $\pm$ 2.4	0.17
Ankle plantarflexion (degree)	35.5 $\pm$ 4.8	32 $\pm$ 4.5	0.24
Operation time (minute)	95(range 45-115)	75(range 40-100)	0.04
Radiation exposure time (second)	30(range 8-143)	17(range 5-65)	0.03

(IMN: Intramedullary nailing)

(MIPO: Minimally invasive plate osteosynthesis)

(OMAS: Olerud-Molender Ankle Scoring)

Table-3. Complications.

Complication type	**IMN group (n:30)**	**MIPO group (n:29)**	**p**
Superficial infection, n (%)	1 (3%)	3 (10%)	0.12
Deep infection, n (%)	0 (0%)	1(3%)	0.342
Nonunion, n (%)	0 (%)	0 (%)	
Delayed union, n (%)	5 (17%)	0 (%)	0.03
Valgus malunion, n (%)	2 (7%)	0 (%)	0.242
Varus malunion, n (%)	1 (3%)	2 (7%)	0.393
Recurvation malunion, n (%)	2 (7%)	3 (10%)	0.492
Procurvatum malunion, n (%)	2 (7%)	0 (%)	0.242

(IMN: Intramedullary nailing)

(MIPO: Minimally invasive plate osteosynthesis)

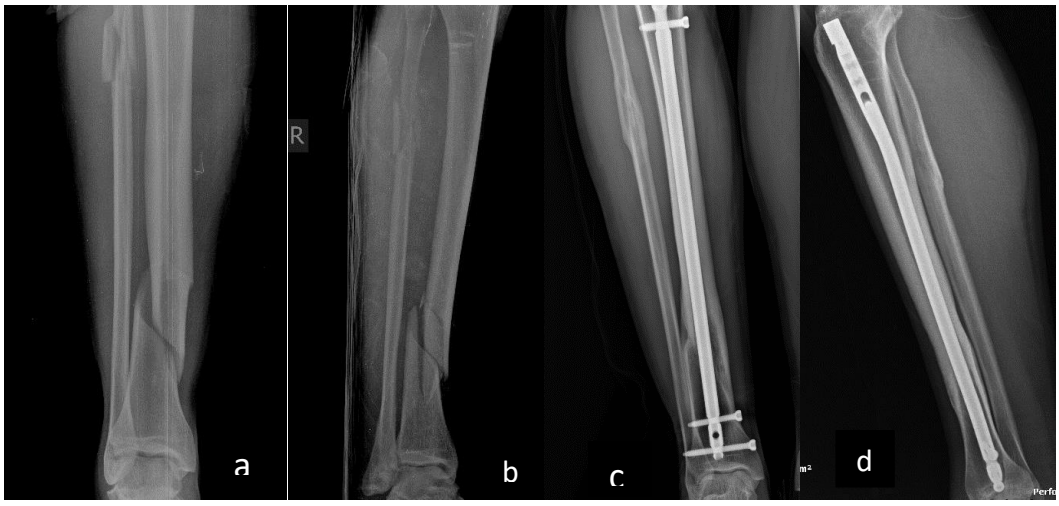

Figure-1. A 43 years old patient treated with intramedullary nailing. **(a, b)** Preoperative anteroposterior and lateral views, **(c, d)** postoperative one year anteroposterior and lateral views.

Figure-2. A 54 years old patient treated with minimally invasive plate osteosynthesis. **(a, b)** Preoperative anteroposterior and lateral views, **(c, d)** postoperative 6th month anteroposterior and lateral views.

RESULTS

In IMN group, there were 30 patients and 19 (63%) patients were male. The average age of patients at the time of admission was 47 years (range 25-80). Patients' demographic properties and fracture characteristics were similar between the two groups and given in Table-1. Consolidation was observed in the fractures of all patients participating in the study. The mean union times were 16.1 weeks (range, 12-24weeks) and 15.5 weeks (range 10-24 weeks) in the MIPO and IMN groups, respectively (p= 0.254). Fibula fracture was seen in 55 (93%) patients. Open reduction and plate osteosynthesis was applied to fibula fractures of 6 patients in the MIPO group and 3 patients in the IMN group. The mean operation time was 95 (range 45-115) minutes in IMN group and 75 (range 40-100) minutes in MIPO group (p=0.04). The mean operative radiation exposure times were 30(range 8-143) and 17 (range 5-65) seconds in IMN and MIPO groups, respectively (p=0.03) (Table-2).

The mean OMAS scores were 67.5 (range 40–90) and 63 (range 30-90) in the IMN and MIPO groups, respectively (p = 0.12). When the patients were evaluated according to OMAS, in the IMN group, 1 excellent, 24 good and 5 moderate results and in MIPO group 1 excellent, 18 good, 9 moderate and 1 bad results were

found. The ankle range of motion was similar in both treatment groups (Table-2).

In IMN group, 3(10%) patients had varus / valgus deformity and 4 (13%) patients had procurvatum /recurvatum deformity. In MIPO group, varus / valgus deformity was observed in 2 (7%) patients and procurvatum / recurvatum deformity in 3 (10%) patients (Table-3). There was not statistically difference between 2 groups according to angular deformities (p=0.316, p=0.531 respectively). The mean coronal plane angle was 2.4 and 1.5 in IMN and MIPO groups, respectively (p=0.12). The mean sagittal angular angle was 2.7° and 1.8° in IMN and MIPO groups, respectively (p=0.18). There was no correlation between malunion and fracture type or presence of fibula fracture or fibula fixation (p=0.235, p=0.324, p=0.12, respectively). Since malunion did not cause functional problems in patients, surgical correction was not applied to any patient. While there was no delay in consolidation in any of the patients in the MIPO group, there were five patients in the IMN group. In these five patients dynamization was applied to the nail due to the delay in union. At the end of the treatment, consolidation was observed in all patients.

In MIPO group 3 (10%) patients and in IMN group 1(3%) patient had early postoperative superficial wound infection managed nonoperatively with oral antibiotics and wound care. One year after the operation, in one patient who was treated with plate osteosynthesis, wound dehiscence was seen on the distal part of the plate. The plate was removed and skin defect repaired with full thickness skin graft. At the end of the treatment wound healed uneventfully.

DISCUSSION

The optimal treatment of distal tibia fractures is still controversial. Despite the developing implant technologies, problems are still encountered in the surgical treatment of this region (11,12). The weak soft tissue cover around the distal tibia can cause non-union and soft tissue problems during treatment. Over time, minimally invasive methods have been developed as a result of understanding the effects of soft tissue on fracture healing. To prevent further deterioration of the viability around the fracture that damaged during trauma, both plates and nails were placed using minimally invasive reduction methods (13-15).

In the literature, there are studies comparing the results of the treatment of distal tibia fractures with plate osteosynthesis and intramedullary nailing (4-20). In many studies, MIPO and IMN have not been found to be superior to each other in terms of functional results obtained as a result of treatment (17-21). Barcak et al. evaluated the functional results of patients with distal tibia fractures treated with IMN and MIPO both according to the AOFAS scoring system and Short Form 36 (SF 36). While functional results between the two groups were close to each other compared to AOFAS, SF 36 scores were quantitatively higher in the IMN group (13). Mioc et al. used OMAS to evaluate functional results and could not find any difference between the two groups (18). We also used OMAS in our study and although the OMAS scores were higher in the IMN group (p=0.12). Nevertheless, when OMAS scores were categorically evaluated between 2 groups, more 'excellent and good' results were found in IMN group compared to MIPO group. An important limitation of the OMAS system is that it is affected by age-related activities. Activities such as running, crouching can be affected not only by ankle problem, but by knee or hip problems or the general condition of the patient. The wide range of ages of our patients indicates that our functional evaluation was not performed in standard groups. To minimize this error, case groups of similar age and performance could be selected. VAS (Visual Analog Scala) was used as an auxiliary method in functional evaluation in our study. The patients were asked to look at the scale and mark the severity of pain in the lower extremity where there was a fracture. Although the difference between the two groups in terms of VAS scores was not statistically significant, the satisfaction in the IMN group was higher when only pain was taken as a parameter (p=0.616).

However post-operative weight-bearing varies depending on the type of fracture, bone quality, and condition of the soft tissue, many authors allow early weight-bearing after intra-medullary nailing compared with MIPO. A recent biomechanical study showed that, intramedullary nailing exhibits better biomechanical behavior than plate osteosynthesis under axial and torsional loads (11). Although functional results are better in the early period after intramedullary nailing, there is no significant difference between the two methods in terms of time to return to normal life and work. Costa et al. claimed that, neither nail fixation nor locking plate fixation resulted in superior disability status at sixth month (14).

Alignment problems can be encountered more frequently when intramedullary nailing is used as

a treatment method in the metaphyseal fractures of the tibia (19). In metaanalysis, comparing plate osteosynthesis and intramedullary nailing, malunion was detected in more patients in IMN group (4). The reason is that most of the plate osteosynthesis in these studies are performed with open reduction (5). In recent studies, it was reported that there was no significant difference in malunion between IMN and MIPO groups which both minimally invasive methods were used (7, 16). In our study, two groups were similar in terms of malunion. In the IMN group, angular deformity above 5 degrees in the coronal or sagittal plane was seen in 7 (23%) patients, while 5 (17%) patients in the MIPO group. When we evaluated all postoperative x-rays of the patients, it was seen that these deformities did not develop overtime and fractures were fixed in this position during the operation.

Non-union and union delay rates have been reported as 5-17% in many studies (4, 5). In our study, we did not observe non-union in any fracture. There was no difference between the two groups in terms of union times. Even though osteosynthesis can be achieved without disruption of the fracture biology with MIPO, union delay can be observed especially in simple fractures (8). Kim et al. suggested that the delay in union can be prevented by reducing the fracture gap during osteosynthesis, they observed more union delay in more patients in the MIPO group (16). El-Attal et al. found a 10.6% of delated union and 5.4% rate of 5° or more axial malalingnment in their patients treated with IMN (6). Although it has been suggested that open fracture has a negative effect on union, this could not be demonstrated in our study. Open fracture was present in two of five patients with delayed union. One of the factors affecting the union delay of distal tibia fractures is thought to be fibula fracture. Vallier stated that fixation of fibula does not prevent valgus deformity and may cause delayed union (19). In our study group, since most of the fibula fractures did not affect the ankle stability, they were left without fixation and there was no relationship between fixation of the fibula and non-union or delay in union.

Soft tissue problems can often be encountered in the treatment of distal tibial fractures. Early and late infections, wound lips necrosis and wound dehiscence can be seen up to 15%, even if minimally invasive methods are used (12). In recent study, soft tissue problems were seen more in MIPO group. In a patient who underwent plate osteosynthesis, more than 1 year after the injury, wound dehiscence on the plate was observed and the patient did not have diabetes mellitus and heavy smoking. Therefore, in open fractures, it seems more rational to use intramedullary nails for fixation of these fractures to prevent implant exposure during soft tissue debridements.

Implant irritation and, accordingly, implant removal can often be seen in the use of both MIPO and IMN in the treatment of distal tibia fractures. Distal locking screws of intra-medullary nails can cause skin irritation especially in patients with weak subcutaneous tissues (19). Plates can cause implant prominence both distally and proximally of the leg and irritate the skin, especially during the using of boots. Barcak et. reported that, three distal locking screws were used to ensure stability in IMN, especially the AP locking screw caused irritation on the skin. They also stated that, implant removal was required in more patients in the IMN group (26%) compared to MIPO group (8%) (13). Maufrey et al. reported that they performed implant removal in 4 (33%) patients in the MIPO group and in 1 (8%) patient in the IMN group (9). In our study, due to skin irritation, distal locking screws were removed in 2 (7%) patients in the IMN group, and plate was removed in 2 (7%) patients in the MIPO group.

Our study has some weaknesses. Firstly, this was a retrospective study, therefore, fracture union assessment and functional evaluations of patients were performed at different times for each patient. A second limitation is we have small number of patient and it makes difficult to draw conclusions. The results should be verified in a larger patient group.

CONCLUSION

In conclusion, we determined that in the treatment of distal tibial extraarticular fractures, IMN and MIPO can be used safely. At the end of our study we have partially proved our hypothesis. MIPO causes less union delay and less angular deformities compared to IMN. However, MIPO causes worse functional results and more soft tissue problems than IMN.

Conflict of interest: Mert Kumbaraci and Ahmet Savran declare that there is no conflict of interest.

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