Comparison of intramedullary nailing and minimal invasive plate osteosynthesis in the treatment of simple intra-articular fractures of the distal tibia (AO-OTA type 43 C1-C2)

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Abstract

Objective: The aim of this study was to compare midterm functional and radiographic results of minimal invasive plate osteosynthesis (MIPO) with intramedullary nailing (IMN) of simple intra-articular distal tibial fractures (AO-OTA type 43 C1-C2).

Methods: Seventy-three simple intra-articular distal tibial fracture patients were evaluated retrospectively. All were treated between 2009 and 2014. The average age of the patients was 40.3 years. Thirty-seven patients were treated with IMN and 36 patients were treated with MIPO. Fibular plate osteosynthesis was applied in 5 cases (13.5%) in the IMN group and in 23 patients (63.9%) in the MIPO group.

Results: Functional results and complications of IMN and MIPO methods were assessed in 73 patients. The average union time was 16.4 ± 2.7 weeks in the IMN group and 15.2 ± 1.8 weeks in the MIPO group (p = 0.079). The average Olerud-Molander Ankle Score was 87.8 ± 8.1 in the IMN group and 81.5 ± 11.8 in the MIPO group (p = 0.013). Four patients in the IMN group experienced valgus malunion, while it was not observed in any patients in the MIPO group (p = 0.042). Recurvatum malunion was detected in 10 patients in the MIPO group and not seen in the IMN group (p = 0.001). Ankle dorsiflexion angle was 25.8 ± 4.5° in the IMN group and 33.3 ± 8.9° in the MIPO group (p = 0.000).

Conclusion: Simple intra-articular distal tibial fractures are successfully treated with IMN and MIPO. Prevalence of valgus malunion was higher in the IMN group and recurvatum was more prevalent in the MIPO group. MIPO is the first preference according to the literature; however, successful results have been obtained with IMN in this fracture pattern.

Level of Evidence: Level III, Therapeutic Study.
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Introduction

Treatment options for distal tibial fractures remain quite controversial. Intramedullary nailing, osteosynthesis with plates, and external fixation methods are used. Each method has its own advantages and disadvantages.

When distal tibial fractures extend to the joint line, the situation is further complicated. Currently, the most commonly used method is minimally invasive plate osteosynthesis (MIPO). External fixators and intramedullary nails are less preferred in practice. MIPO is the most often recommended technique, but studies about intramedullary nailing (IMN) are available for simple intra-articular distal tibial fractures that extend to the joint line. However, to our knowledge, so far there is no study comparing IMN with MIPO for AO-OTA type 43 C1-C2 simple intra-articular distal tibial fractures.
The aim of this retrospective study was to compare midterm functional and radiographic results of MIPO with intramedullary nailing of simple intra-articular distal tibial fractures (AO-OTA type 43 C1–C2). Our hypothesis was that IMN application is as successful and perhaps more successful than MIPO for simple intra-articular distal tibial fractures. IMN application is not a contraindication for simple intra-articular extension.

**Patients and methods**

This study was approved by the local ethical committee of our institution (2015/422). All tibial fractures were operated on in our hospital between January 2009 and June 2014. Fractures were determined to be AO-OTA type 43C–1 and C–2.

Thirty-seven patients treated with IMN and 36 patients treated with MIPO with at least 1 year of follow-up were included in the study. Extension to the ankle joint was evaluated with computed tomography. Early irrigation and debridement, antibiotic therapy, and skeletal traction were applied for open fracture patients. After observing that wound was clean and uncomplicated, permanent surgery was performed. The choice of treatment type was based on surgeon’s preference and experience.

**Group IMN**

Ankle joints were evaluated in supine position. Ankle mortise was evaluated in the presence of fibula fractures with mortise view under fluoroscopy. Unstable fibula fractures, major displaced fractures or syndesmosis injuries were fixed with fibular plates. Temporary percutaneous K-wires or screws were then applied to distal tibia above the ankle joint line under fluoroscopy. If IMN screws were sufficient to fix intra-articular fragment, only temporary K-wire application was made. Otherwise, intra-articular fracture was fixed with proper percutaneous screws before IMN. Afterward, all patients were treated with tibial IMN (Trigen Meta-nail™; Smith & Nephew, Inc., Memphis, TN, USA) through medial parapatellar approach at 90 degrees of knee flexion.

**Group MIPO**

Ankle joints were evaluated in supine position. Ankle mortise was evaluated in the presence of fibula fractures with mortise view under fluoroscopy. Unstable fibula fractures, major displaced fractures or syndesmosis injuries were fixed with fibular plates. Temporary percutaneous K-wires or screws were applied to distal tibia above the ankle joint line under fluoroscopy. If plate screws were sufficient to fix the intra-articular fragment, only temporary K-wire application was made. Otherwise, intra-articular fracture was fixed with proper percutaneous screws before MIPO. Medial longitudinal incision was made at the level of the medial malleolus, and 3.5 mm LCP™ medial distal tibial plate (DePuy Synthes, Warsaw, IN, USA) was inserted using minimally invasive technique. After reduction was achieved with traction and indirect fracture reduction, proximal screws and distal screws were secured to the plate with percutaneous stab incisions.

Weight-bearing was not permitted in either group for 6–8 weeks postoperatively. Partial weight-bearing was then permitted. At least 3 bridging cortex calluses on biplanar radiographs and absence of clinical pain with full load-bearing was considered full union. Full load was allowed once radiological union was achieved (Figs. 1 and 2). Biplanar ankle radiographs and biplanar tibia radiographs were taken during follow-up of patients. All patients were assessed 2–4 weeks before union and 6 months after union was achieved.

Patient age, gender, side, fracture type (AO-OTA classification), open fracture classification, mechanism of injury, presence of polytrauma, smoking habit, diabetes, fibular fracture, fibular fixation, and number of non-implanted screws were recorded and evaluated for both groups. In the postoperative assessment, average follow-up period, mean time to union, union status, infection status, and malunion were assessed.

To determine malunion, distal tibial varus-valgus and procurvatum-recurvatum deformities were evaluated radiologically. Rotational deformity was assessed clinically. Comparison was made with the other limb and deformity was determined based on tibial tubercle, tibial crest, and ankle midpoint.

Clinically and radiologically, anything above 5 degrees of deformity in any plane was considered malunion. The number of screws removed from implant was reviewed. Clinical assessment of patients was conducted using the Olerud–Molander Ankle Score (OMAS) and by measuring ankle joint range of motion with goniometer.

**Statistical analysis**

SPSS software (version 22.0; SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Average, standard deviation, median minimum, median maximum, frequency, and ratio values were used for data descriptive statistics. Distribution of variables was analyzed using the Kolmogorov–Smirnov test. For quantitative data analysis, Mann–Whitney U test, a Kruskal–Wallis test, and an independent sample t-test were conducted, and chi-square test was used for qualitative data analysis. Fischer’s exact test was performed when chi-square test conditions were insufficient. Spearman correlation analysis was conducted. P value of <0.05 was considered statistically significant.

**Results**

Seventy-three patients were divided into 2 groups. Group IMN had 37 patients and group MIPO had 36 patients. Mean age was 40.3 years (range: 18–82 years). Fifty-two of the patients (71.2%) were male and 21 of the patients (28.8%) were female. There were 27 patients (36.9%) with right side fracture and 46 patients (63.1%) with left side fracture; 39 were AO-OTA 43 C1 and 34 were AO-OTA 43 C2. The mechanism of injury was a fall for 52 patients (71.2%), attack in 1 case (1.4%), traffic accident for 17 patients (23.3%), and sports injury for 3 patients (4.1%). A total of 29 patients (21.9%) were polytraumatic.

Open fracture was present in 14 patients; 8 patients (11%) had Gustilo Anderson type I, and 6 patients (8.2%) had Gustilo Anderson type II open fracture. Fibula fracture was present in 64 patients (87.6%). Fibula fractures were resolved with fibular plates in 28 patients (38.4%); 5 patients in the IMN group and 23 patients in the MIPO group. Non-implant screws were used in 29 patients in the IMN group and in 13 patients in the MIPO group. Nine patients were diabetic (12.3%), and 26 patients (35.6%) were smokers. The characteristics of the patients in each group are provided in detail in Table 1.

Mean follow-up time was 29.4 months (range: 13–50 months). The average union time was 16.4 ± 2.7 weeks in the IMN group and 15.2 ± 1.8 weeks in the MIPO group. There was no statistically significant difference between the 2 groups (p = 0.079). Union was achieved in all patients in the IMN group; nonunion was encountered in 1 patient in the MIPO group (Table 2). The average OMAS was 87.2 ± 8.1 in the IMN group and 81.5 ± 11.8 in the MIPO group. There was a significant statistical difference between the 2 groups (p = 0.013). Ankle dorsiflexion angle was 25.8 ± 4.5° in the IMN group and 33.3 ± 8.9° in the MIPO group.
Ankle dorsiflexion was signiﬁcantly higher in the MIPO group \((p = 0.000)\). Ankle plantar flexion was \(39.3 \pm 5.8^\circ\) in the IMN group and \(37.6 \pm 6.9^\circ\) in the MIPO group. There was no statistically significant difference between the 2 groups \((p = 0.205)\) (Table 2).

In terms of complications, nonunion was seen in 1 patient in the MIPO group. In addition, superficial infection was observed in 3 patients \((8.1\%)\) in the IMN group and in 7 patients \((19.4\%)\) in the MIPO group \((p = 0.159)\). Deep infection was not observed in the IMN group, but was seen in 1 patient \((2.8\%)\) in the MIPO group \((p = 0.493)\). Anterior knee pain was observed in 8 patients \((21.6\%)\) in the IMN group (Table 3).

Varus malunion was observed in 1 patient \((2.7\%)\) in the IMN group but was not observed in the MIPO group \((p = 0.321)\). Valgus malunion was observed in 4 patients \((10.8\%)\) in the IMN group but was not seen in any patients in the MIPO group \((p = 0.042)\). Of those, valgus malunion was determined in 1 patient in fibula-ﬁxed IMN group \((n = 5)\) and in 3 patients in fibula-ﬁxed MIPO group \((n = 32; p = 0.531)\). Recurvatum malunion was not observed in the IMN group, while it was observed in 10 patients \((27.8\%)\) in the MIPO group \((p = 0.001)\). Procurvatum malunion was not observed in any patients in the IMN group, but it was observed in 1 patient \((2.8\%)\) in the MIPO group \((p = 0.493)\). Rotation was observed in 2 patients \((5.4\%)\) in the IMN group, but it was not found in any patients in the MIPO group \((p = 0.493)\) (Table 3).

Average varus, procurvatum, and rotation angle showed no signiﬁcant statistical differences. Average valgus angle in the IMN group was \(2.1 \pm 1.8^\circ\), while it was \(0.0 \pm 0.2^\circ\) in the MIPO group \((p = 0.000)\). Average valgus angle of ﬁbula-ﬁxed IMN group \((n = 5)\) was \(2.60 \pm 2.41^\circ\), and average valgus angle of ﬁbula non-ﬁxed IMN group \((n = 32)\) was \(1.97 \pm 1.67^\circ\) \((p = 0.456)\).

Average recurvatum angle in the IMN group was \(0.3 \pm 0.8^\circ\), while it was \(3.1 \pm 2.3^\circ\) in the MIPO group \((p = 0.000)\) (Table 2). Malunion created no functional complaints; therefore, no intervention was applied.

**Discussion**

There is still no clear consensus on treatment of intra-articular distal tibial fractures.\(^1\)\(^–\)\(^3\) IMN, plate osteosynthesis, and external
procedure than MIPO. We determined that angle of dorsiflexion was significantly higher in MIPO group \( (p = 0.000) \). Although ankle dorsiflexion is a very important parameter for functional outcome, it is included in OMAS, and therefore we believe OMAS is more important in this comparison of techniques.

Anterior knee pain is a common complication after IMN treatment; frequency rate of 10%–70% has been reported in the literature.19 The etiology is still unclear. Anterior knee pain was observed in 8 patients (21.6%) who were treated with IMN in present study. The authors think that this is due to medial parapatellar approach. In the MIPO group, this complication did not occur because the surgical procedure does not interfere with the knee.

Generally, more alignment and mechanical instability problems are seen in IMN application.4–6 New generation intramedullary nail types increased biomechanical strength by allowing more distal screws. In most meta-analysis studies that compare intramedullary nailing and plate osteosynthesis, malunion is much more often seen in the IMN group.7 It is believed that because plate osteosynthesis is achieved using open reduction internal fixation (ORIF) method, fewer instances of malunion occur.10 Recent studies have reported similar malunion rate for IMN and MIPO methods, which both use indirect reduction techniques, in contrast to ORIF.10

Kuhn et al compared IMN and MIPO biomechanically in simple intra-articular fractures in an experimental study. They found IMN to be significantly more durable with regard to axial loadings, while no significant difference was found with respect to torsional loading.9

Plane of malunion was not stated clearly in the studies. Present study provides important information in terms of which malunion types to examine in further detail. We found more valgus malunion in the IMN group and more recurvatum in the MIPO group. All IMN applications were done with 90-degree knee flexion. We think that sagittal plane deformities are lessened with the effect of gravity in IMN application. Rate of coronal plane malunion (especially varus) in IMN application was thought to occur for 2 reasons. The first has to do with reduction problems due to not being at the center of the ankle joint in the coronal plane. The second reason is different fibula fracture fixation rates: 13% in IMN Group (5 patients) and 63.9% (23 patients) in MIPO Group. Therefore, more valgus deformity in the IMN group can be explained by fewer patients with fibular fixation. No statistically significant difference in malunion was found between fibula-fixed and non-fixed IMN groups, which is thought to be because of the small number of cases. Egel et al found that 4% of patients had malunion in a fibular fixation group and 13% in a non-fibular fixation group in their study on the effect of fibular fixation on malunion.20

Less occurrence of valgus deformity in the MIPO group also occurred for 2 reasons. The anatomical shape of plates reduces

### Table 2
Results.

| Follow up (months) | Group IMN | Group MIPO | P    |
|--------------------|-----------|------------|------|
|                    | Average ± s.d | Med (Min–Max) | Average ± s.d | Med (Min–Max) |
| 32.1 ± 9.6 | 32.0 | 13.0–50.0 | 26.6 ± 7.8 | 28.5 | 13.0–38.0 | 0.011 |

### Table 3
Complications.

| Group IMN | Group MIPO | P    |
|-----------|------------|------|
| Varus malunion | 1 | 2.7% | 0 | 0.0% | 0.321 |
| Valgus malunion | 4 | 10.8% | 0 | 0.0% | 0.042 |
| Recurvatum malalignment | 0 | 0.0% | 10 | 27.8% | 0.001 |
| Procurvatum malalignment | 0 | 0.0% | 1 | 2.8% | 0.493 |
| Rotation malunion | 2 | 5.4% | 0 | 0.0% | 0.493 |
| Superficial infection | No | 34 | 91.9% | 29 | 80.6% | 0.159 |
| Deep infection | No | 37 | 100.0% | 35 | 97.2% | 0.493 |
| Knee pain | No | 29 | 78.4% | 36 | 100.0% | 0.003 |

The italics represents in the table for which p value is <0.05.
coronal plane deformity, and as previously mentioned, fibula fracture fixation rate was higher in the MIPO group (63.9%). We believe that fibular fixation will reduce valgus rates in IMN practice. However, some studies have also reported that fibula fracture fixation increases surgical complication rates. Vallier et al found nonunion rates were significantly higher when fibular fracture was fixed. The same study reported that the most common malunion was valgus malunion and that fibular fixation did not decrease malunion.14

We found that sagittal plane deformities, especially recurvatum, were significantly higher in the MIPO group. MIPO application is made in a supine position. Pressing calcaneus to the operating table during surgery can cause recurvatum. This situation often escapes the attention of the surgeon. Therefore, reduction should be obtained with very good lateral fluoroscopic images during surgery. Manual traction should be applied and posterior of the fracture should be supported, leaving the calcaneus free. The present study has some weaknesses. There was small number of cases, it was a retrospective study, and there was different fibula fracture fixation rate in the 2 groups (Group IMN: 13%, Group MIPO: 63%). In addition, as it was a retrospective study, functional assessment was done at different time for each patient. In conclusion, IMN and MIPO had successful functional results in treatment of simple intra-articular distal tibial fractures. However, valgus malunion was more common in the IMN group, and recurvatum was more prevalent in the MIPO group. We think that this complication rate can be reduced to a lower level through careful radiological assessment during surgery. MIPO is the first preference according to the literature; however, successful results have been obtained with IMN in this fracture pattern.

Conflict of interest

The authors declare that they have no conflict of interest.

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