How should open tibia fractures be treated? A retrospective comparative study between intramedullary nailing and biologic plating

Açık tibia kırıkları nasıl tedavi edilmelidir? İntramedüller çivileme ve biyolojik plaklama arasında kıyaslamalı geriye dönük çalışma

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BACKGROUND
In this retrospective study, our purpose was to compare two treatment alternatives clinically.

METHODS
Forty-five patients who had grade I or II open tibia fractures were included. Twenty-five of them, treated via minimally invasive plate osteosynthesis (MIPO), comprised group I. The latter 20 cases, treated via partial reamed intramedullary nailing (PR-IMN), comprised group II. Clinical evaluation was made on the basis of modified Ketenjian's criteria.

RESULTS
Full weight-bearing periods in groups I and II were 21 and 22.4 weeks, respectively. Non-union in one case of group I was revised with circular fixator. In another case, implant removal was needed due to chronic osteomyelitis. Mal-union was detected in another. In group II, two cases needed implant revision with intramedullary nail in one and circular fixator in another for non-union. Mal-union in one case and chronic osteomyelitis in another were the late complications in group II. At the last follow-up, satisfaction rates were: 21/25 in group I and 18/20 in group II. There was no significant difference between groups (p>0.05).

CONCLUSION
The clinical results of both groups were similar. Although intramedullary nailing is the first choice, MIPO is an alternative method for open tibia fractures.

Key Words: Biological fixation; intramedullary nailing; open fracture; tibia; partial reaming.

AMAÇ
Açık tibia kırıklarında iki farklı tedavi yönteminin geriye dönük incelemeyle karşılaştırılması amaçlandı.

GEREÇ VE YÖNTEM
Tip I ve II açık tibia kırıklı 45 olgu çalışmaya alındı. Olguların 25'i (Grup I) minimal invasif plak osteosentezi (MİPO) ile, geriye kalan 20 olgu (Grup II) kısmi oymalı intramedüller çivi ile tedavi edildi. Son kontrolde klinik değerlendirme modifiye Ketenjiyan ölçütler kullanılarak yapıldı.

BULGULAR
Olguların tam yüklenme süreleri Grup I'de 21, Grup II'de 22,4 hafta idi. Grup I'de kaynamama saptanan bir olguya halkasal fiksatörle yeniden tespit sağlandı. Bir olguda kronik ostemiyelit gelişmesi nedeniyle tespit cihazı çıkarıldı. Bir diğer olguda da kötü kaynama saptandı. Grup II'de kaynamama gelişen iki olguya; biri intramedüller çivi ile diğeri halkasal fiksatörle yeniden tespit uygulandı. Ek olarak bir olguda kötü kaynama, bir değerinde ise kronik osteomiyelit gelişen geç komplikasyonlardı. Son kontrolde klinik yeterlilik oranları; Grup I'de 21/25, Grup II'de 18/20 idi. Bu sonuçlar arasında anlamlı fark saptanmadı (p>0,05).

SONUÇ
Her iki grupta sağlanan klinik sonuçlar benzerdir. İntramedüller çiviler açık tibia kırıklarında ilk tercih olmasına rağmen MİPO alternatif bir tedavi seçeneğidir.

Anahtar Sözcükler: Biyolojik tespit; intramedüller çivileme; açık kırıklar; tibia; kısmi oyma.

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There is no absolute consensus regarding the treatment of open tibia fractures because of highly frequent complications such as infection, non-union, and delayed union.[1,2] Many treatment methods, such as cast immobilization, external fixation, open reduction and plate fixation, and intramedullary nailing, have been reported.[3-6] Cast immobilization generally results in high infection and delayed union rates as major complications.[6] Furthermore, pin tract infection, cosmetic complaints due to bulky frame and union problems have contributed to some limitations in the use of external fixators for open tibia fractures.[7]

Previous researches about open reduction and plate fixation reported unsatisfactory results for open tibia fractures.[3] However, it was concluded that minimally invasive plate osteosynthesis (MIPO) decreases the complication rate.[2] Intramedullary nailing, either reamed or unreamed, is the most popular and current treatment alternative for these fractures.[8,9] Choice of reamed or unreamed nailing is another issue of debate because both present some advantages and disadvantages. Thus, a new concept referred to as "minimal reaming" that includes the advantages of both systems has been advocated.[10]

The aim of this study was to report our experience, retrospectively comparing the effectiveness of minimally reamed intramedullary nailing and biological plating of open tibia fractures.

MATERIALS AND METHODS

Forty-five cases with open tibia fractures, treated between 1999 and 2002, were analyzed. Group I included 25 patients (19 M, 6 F) who underwent MIPO and were admitted to our clinic between 1999-2000. The mean age of group I was 40±12.5 years (range: 18-67). According to AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen and Orthopedic Trauma Association) classification, the fracture types were as follows: 3 A1, 1 A2, 6 A3, 2 B2, 3 B3, 1 C1, 1 C2, and 8 C3.[11]

Group II consisted of 20 cases (19 M, 1 F) treated via partial reamed intramedullary nailing (PR-IMN) between 2001-2002. The mean age of group II was 42±11.8 years (range: 17-65). Distribution of fracture types in group II was as follows: 1 A1, 3 A2, 6 A3, 2 B1, 4 B2, 1 B3, 1 C1, and 2 C3 fractures.

Aggressive debridement was performed in each case after irrigation of the wound in the operating room. All avascular and necrotic tissues including bone were then removed, and definitive fixation was carried out. Antibiotic prophylaxis was used for 2 to 3 days with cefazolin and gentamicin. If necessary, a second look and further debridement was performed before discharge from the hospital. In the MIPO group, fixation was achieved by using anatomical plates in 18 cases and limited contact dynamic compression plate (LC-DCP) in 7 cases. In the PR-IMN group, static locked intramedullary nails were used in all cases.

MIPO was performed through limited proximal and distal incisions under pneumatic tourniquet (Figs. 1a, b). Rotational and axial alignments were controlled after manual traction and indirect reduction under the control of C-armed fluoroscopy. At least 3 screws were used for each side of the fracture to gain relative stability (Figs. 1c-g).

PR-IMN was performed via anteromedial incision. After partial reaming to determine the true diameter of the medullary canal, the fracture was reduced and fixed under fluoroscopic control. Static locking was performed in all cases (Figs. 2a-d).

Fractures not suitable for intramedullary nailing and interlocking, within the distal one-fifth and the proximal one-fourth of the tibia, were excluded from the study. Healing was accepted as three cortex callus bridges seen radiologically and with no pain during weight-bearing clinically. Open fractures were classified according to Gustilo and Anderson criteria.[12] Patients were evaluated functionally based on the modified Ketenjian's criteria.[13]

Statistical analyses were performed by using SPSS for Windows. Statistical analysis was done using unpaired t test and Fisher's chi-square exact test with $p<0.05$ considered as significant.

RESULTS

There were no significant differences between groups regarding demographic data (age, gender) and fracture type ($p>0.05$). In addition, there was no significant difference in operation time [47±11.1 minutes (range: 38-67) for group I and 42±9.2 minutes (range: 35-62) for group II].

Group I: Mean follow-up period was 35 months (range: 12-61). Four of the 29 patients were lost; therefore, 25 cases could be evaluated. There were 11 grade I and 14 grade II open tibia fractures according to Gustilo and Anderson criteria. The additional injuries of group I were as follows: 5

Fig. 1. **(a)** NE, Female, 46 years, screw placement through mini-incision. **(b)** The intraoperative view after bony stabilization and before skin closure. **(c)** The preoperative anteroposterior (AP) X-ray of the same case. **(d)** The preoperative lateral X-ray of the same case. **(e)** Early postoperative X-rays. **(f)** 61 months later, AP X-ray demonstrates excellent results. **(g)** 61 months later, lateral X-ray.

femur fractures, 2 pelvic injuries, and 1 humerus and 1 calcaneus fracture. The mean hospitalization period was 7±0.9 days (range: 5-8). Patients were encouraged regarding full-weight bearing without crutches at 21±5.6 weeks (range: 16-40) postoperatively. In the early period, there were 2 superficial infections (8%). These cases were treated with oral antibiotics and meticulous wound care. Non-union was detected in 1 case (4%) who had type II open fracture, and it was treated by bone grafting - fixation revision with circular external fixator. Healing was achieved in the 40th week postoperatively. Chronic osteomyelitis was determined in 1 case and implant was removed after bony consolidation (4%). There was also a case with 19º anterior angulation that was accepted as mal-union (4%).

Fig. 2. **(a)** FE, Male, 58 years, preoperative X-rays. **(b)** Early postoperative AP X-ray; static stabilization was achieved. **(c)** Early postoperative lateral X-ray. **(d)** 39 months later, follow-up X-rays demonstrate excellent results.

Group II: Mean follow-up period was 29 months (range: 12-59). Two patients were lost to follow-up so clinical evaluation was possible in 20 patients. According to Gustilo and Anderson criteria, there were 13 grade I and 7 grade II open tibia fractures. The additional injuries detected included femur fractures in 2 cases and patella fracture in 1 case. The mean time to hospitalization was 6±1 days (range: 4-8). The average full weight-bearing time without crutches was 22.4±5.7 weeks (range: 12-36). Superficial infections were defined in 4 cases (20%). These infections were ameliorated with antibiotics and wound care intervention. Two cases needed grafting and implant revision as re-fixation with intramedullary nailing in the first and circular external fixator in another for non-union (10%). One of 2 had type I and the other had type II open fractures. Healing was achieved in these cases at the 46th and 51st weeks. However, chronic osteomyelitis developed in 1 case requiring implant removal after bony consolidation. Anterior knee pain in 4 cases and mal-union as varus angulation in 1 case were the other late complications. Implants were removed from those cases suffering from pain while kneeling. No further surgery was performed for varus angulation due to the patient's satisfaction.

Based on the modified Ketenjian's criteria, there were 21 satisfactory (17 excellent, 4 good) and 4 unsatisfactory (3 fair, 1 poor) results in the MIPO group. Similarly, 18 satisfactory (15 excellent, 3 good) and 2 unsatisfactory (1 fair, 1 poor) results were defined in the PR-IMN group. The satisfaction rates in groups I and II were 84% and 90%, respectively. No statistical difference was found between the two groups ($p>0.05$).

DISCUSSION

Interventions in open tibia fractures result in high incidence of complications in the

form of infection, non-union, and mal-union. Current techniques including radical wound debridement, antibiotic therapy, and tissue coverage have led to a decrease in these complications.[1] External fixation is one of the most popular techniques, but complications such as pin tract infection, loosening, and union problems have resulted in surgeons trying alternative methods.[3,7] Therefore, many authors have recommended intramedullary nailing as the first choice of treatment for open tibia fractures.[10,14,15] However, for open fractures, reaming versus unreaming has been another matter of debate. Kessler et al. claimed that reaming caused spread of the contamination from the open wound along the medullary canal and stripping of small bone fragments from soft tissue attachment.[16] Chapman stated that reaming was contraindicated due to high incidence of sepsis.[17] On the other hand, despite low infection rates and reduced blood supply disturbances, some disadvantages for unreamed nailing, such as increased re-operation rate due to hardware failure, were mentioned.[18,19] In a prospective randomized study including 51 open tibial fractures, Ziran et al. compared the clinical outcomes of unreamed nailing with partially reamed nailing.[10] They found no statistical difference for rates of union and infection. However, the unreamed group required a greater number of secondary procedures to achieve union that resulted in higher costs when compared with the partially reamed group.

There is not much knowledge about the effect of plating in the intervention of open tibia fractures. In a prospective randomized study, Bach and Hansen compared external fixation with open reduction and plate fixation for types II and III open tibial fractures.[3] They reported the prevalence of infection and osteomyelitis in plate fixation and external fixation groups as 35%, 19% and 13%, 3%, respectively. In conventional plating, the procedure requires extensive soft tissue dissection leading to more frequent complications. Ruedi et al. reported a 12% infection rate after plate fixation of open tibial fractures.[20] However, bridge plating, known as biological fixation, has been used for comminuted fractures in diaphyseal-metaphyseal junction. The advantages of biologic plating were reported as low rates of infection, non-union, and mal-union by preserving blood supply of bony fragments. It was believed that it is important to gain a more viable environment and relative stability rather than precise reduction and absolute stability.[2,21,22]

Stability is an important factor for fracture healing, which was defined by Perren as the degree of load-dependent displacement of the fracture surfaces.[2] Relative stability that permits the critical movement of fracture ends is the main principle of biologic plating. MIPO technique offers that required relative stability. Unlike with conventional plating, the greater the protection of blood supply of bony fragments, the greater and the faster the union rates that can be achieved.[2,21,23]

MIPO technique was recommended especially for metaphyseal fractures.[21,22] However, many reports have been published that indicate its suitability also for diaphyseal fractures.[23,24] Therefore, in multi-traumatized cases, it may be an alternative fixation method to avoid pulmonary complications. On the other hand, MIPO has a longer training curve, particularly in reconstruction of axial and rotational alignment of the lower limb.

In many trauma centers, the first choice for the treatment of open tibia fractures is intramedullary nailing.[7-9,13] Most orthopedic surgeons are more familiar with it rather than biological plating. In addition, it offers more stable fixation. However, among its complications are anterior knee pain, neurovascular problems, hardware breakage, thermal necrosis and bone damage.[1,16,17,25] Pulmonary complications due to marrow embolism may also occur.[25,26] Difficulty in distal interlocking is another disadvantage of this method. On the other hand, when intramedullary nailing equipment is not available in emergency conditions, the orthopedic surgeon can fix the open tibial fracture using MIPO technique as definitive treatment instead of external fixation.

In the current study, mean full weight-bearing periods in both groups were similar to those in the literature.[8-10,14] There was also no significant difference in functional outcome between groups I and II according to modified Ketenjian's criteria.

The complications in the early and late periods summarized above are consistent with those reported in other studies.[8,17,18] Union was achieved in all cases, but three cases required secondary surgeries as grafting and re-fixation. Two of these cases with non-union had type II and one had type I open fractures. Chronic osteomyelitis developed in two cases. Implant removal was carried out after bony healing.

In conclusion, intramedullary nailing should be

the first method of treatment for the internal fixation of open tibia fractures. Plate fixation done by MIPO technique can be an alternative method to intramedullary nailing for the treatment of those cases in whom intramedullary nailing can not be done or is not available.

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