



# Treatment of adult tibial diaphysis fractures with reamed and locked intramedullary nailing

## *Tibia diyafiz kırıklarının oymalı kilitli intramedüller çivi ile tedavisi*

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**Amaç:** Tibia diyafiz kırıklarının oymalı kilitli intramedüller çivi ile tedavi sonuçları değerlendirildi.

**Çalışma planı:** Çalışmaya, tibia cisim kırığı nedeniyle oymalı kilitli intramedüller çivi ile tedavi edilen 73 erişkin hasta (68 erkek, 5 kadın; ort. yaş 31; dağılım 17-68) alındı. AO/ASIF sınıflamasına göre, 28 kırık tip A, 29 kırık tip B, 16 kırık tip C olarak değerlendirildi. Kırıklar, 12 hastada 1/3 proksimal, 50 hastada 1/3 orta, 11 hastada 1/3 distal diyafiz seviyesinde idi. Yirmi sekiz hastada (%38.4) kapalı kırık vardı. Gustilo-Anderson sınıflamasına göre, 30 hastada (%41.1) derece I, 10 hastada (%13.7) derece II, beş hastada (%6.9) derece IIIA açık kırık vardı. On yedi hastada (%23.3) açık, 56 hastada (%76.7) kapalı redüksiyonu takiben çivileme yapıldı. Kırık oluşumu ile ameliyat arasında geçen süre ortalama 3.4 gün (dağılım 2-11 gün); ortalama takip süresi 48 ay (dağılım 24-60 ay) idi. Hastalar hareket açıklığı, kaynama süresi ve komplikasyonlar açısından değerlendirildi. Fonksiyonel değerlendirmede Johner-Wrush ölçütleri kullanıldı.

**Sonuçlar:** Tüm hastalarda ortalama 18.2 haftada (dağılım 8-52 hafta) kaynama elde edildi. Dört olguya kaynama gecikmesi nedeniyle dinamizasyon uygulandı. Bir hastaya grefonaj uygulandı. Dinamizasyon uygulanan bir hastada geçici duyu kaybı gelişti. Bir olguda radyografik kontrollerde distal kilit vidalarının çivi dışında görülmesi üzerine revizyon uygulandı. Diz ön ağrısı gelişen iki hastada (%2.7) sadece fleksiyon kısıtlılığı görülürken, diğer hastalarda hareket kısıtlılığına rastlanmadı. Johner-Wrush ölçütlerine göre, 45 olguda (%61.6) çok iyi, 28 olguda (%38.4) iyi sonuç elde edildi.

**Çıkarımlar:** Tibia diyafiz kırıklarında oymalı kilitli intramedüller çivi tedavisi, komplikasyon oranı düşük, uygun bir tedavi seçeneğidir. Kontaminasyonu fazla olmayan açık kırıklarda güvenle uygulanabilir.

**Anahtar sözcükler:** Kemik çivisi; kemik vidası; kırık tespiti, intramedüller; kırık, açık/cerrahi; tibia kırığı/cerrahi.

**Objectives:** We evaluated the results of reamed and locked intramedullary nailing for tibial diaphysis fractures.

**Methods:** The study included 73 patients (68 males, 5 females; mean age 31 years; range 17 to 68 years) who were treated with reamed and locked intramedullary nailing for tibial diaphysis fractures. There were 28 AO/ASIF type A, 29 type B, and 16 type C fractures. The fractures involved the proximal 1/3 (n=12), middle 1/3 (n=50), and distal 1/3 (n=11) of the tibial diaphysis. Twenty-eight fractures (38.4%) were closed. According to the Gustilo-Anderson classification, 30 patients (%41.1) had grade I, 10 patients (%13.7) had grade II, and five patients (%6.9) had grade IIIA open fractures. Intramedullary nailing was performed following open reduction in 17 patients (23.3%), and closed reduction in 56 patients (76.7%). The mean time to surgery was 3.4 days (range 2 to 11 days) and the mean follow-up was 48 months (range 24 to 60 months). The patients were evaluated with respect to range of motion, time to union, and complications. Functional results were assessed using the Johner-Wrush criteria.

**Results:** Union was achieved in all the patients within a mean of 18.2 weeks (range 8 to 52 weeks). Four patients required dynamization because of delayed union and grafting was performed in one patient. Transient sensorial deficit occurred in one patient after dynamization. One patient underwent revision surgery because of migration of the distal locking screws. The only limitation of range of motion was seen in flexion of two patients (2.7%) who developed anterior knee pain. According to the Johner-Wrush criteria, functional results were very good in 45 patients (61.6%), and good in 28 patients (38.4%).

**Conclusion:** Treatment of tibial diaphysis fractures with reamed and locked intramedullary nailing is an appropriate choice with a low complication rate. It can be safely used in moderately contaminated open fractures.

**Key words:** Bone nails; bone screws; fracture fixation, intramedullary; fractures, open/surgery tibial fractures/surgery.

Tibia shaft fractures are seen frequently in Orthopaedics and Traumatology. The complications are common and the treatment is troubled. Tibia fractures create 15% on average of all fractures, %15 of these fractures are open and are seen %15 pseudoarthrosis. So these fractures are called '15-15-15' fractures.<sup>[1]</sup> Tibia bone is most traumatized region of body because of its localisation. On the one hand, the increase in motor vehicle accident the other hand, the increasingly widespread use of mass sports increased incidence in this region fractures.<sup>[1]</sup> Tibia shaft fractures are the most common long bone fractures but authors had never consensus on the principles of treatment. In the treatment of these fractures ; there many techniques such as casts, functional bracing, internal fixation with plating and intramedullary nailing and external fixation 2. Intramedullary nails are used in an increasing intensity since 1980 because of low complication rates, success on stabilisation, low wasting time of surgery and postoperative early weight bearing advantages.<sup>[1,2,3]</sup> Intramedullary nails are role as internal support on fractured bone. Especially acts strong support against bending moments on bone. Because of not strong enough against axial forces ,researchers found locking screws. So it is provided strength by axial and rotational forces.<sup>[2,3,4]</sup> Locked intramedullary nailing is one of the major developments in the treatment of fractures in this century. Recognising and obtaining results of locked intramedullary nailing techniques in fracture treatment, other treatment method's use is limited. In the day of going on researches, surgical treatment of tibia shaft fractures with locked intramedullary nailing gains weight <sup>[1,3,4]</sup> The results of treatment, time to union and complications with reamed locked intramedullary nailing were evaluated for tibial diaphysis fractures. The aim of this study, evaluating the results of the cases treated in our clinic with reamed, statically locked intramedullary nailing the tibia shaft fractures between 1992-2007..

## Patients and method

Seventyeight patients with tibia shaft fractures who came and treated with reamed intramedullary nailing in Dr. Lütfi Kırdar Kartal Education and Research Hospital, 1. Orthopedics and Traumatology Clinic between 1992 to 2007 were evaluated. Sixtyeight (%93.2) of the patients' were male and 5 (%6.8) were female. Mean age of the patients were 31.1 (ranged 17-68). Mean follow time was 48 months (ranged 24-60 months). The fractures were on the right side in

32 patients ( %43.8) and on the left side in 41 patients (%56.2). Trauma mechanism of the fractures were traffic accident in 47, fall from height in 11 and direct trauma in 15 patients. Patients were graded with AO/ASIF Classification. According to this classification 28 cases were Type A, 29 cases were Type B and 16 cases were Type C (Table I). Cases were evaluated according to anatomic localisation of the fractures, 12 were proximal diaphysis, 50 were middiaphysis and 11 were distal diaphysis (Table II) . Soft tissue injuries of the cases were evaluated with Gustilo Anderson Classification. While twenty eight (%38.5) were closed fracture , 30 (%41.1) were Gustilo Anderson Grade I, 10 (%13.7) patients were Grade II and 5 (%6.7) patients were Grade IIIA (Table III).

In addition of the tibia fracture, there were head trauma in 4 cases, mandibula fracture in 1 case, pelvis fractures in 3 cases, vertebral transverse process fracture in 1 case, femur fractures in 6 cases, contralateral tibia fractures in 4 cases, metatarsal fractures in 3 cases and acromioclavicular separation in 1 case are detected.

Recourse to emergency patients to be seen in ankle and knee joints were taken leg anteroposterior and lateral graphics. At patients with open fractures, followed debridement and irrigation, antibiotherapy is commenced. To the all of the patients with open fractures are applied Sefazolin Sodium 1 gr 3 times per day, Gentamycin 160 mg per day and Ornidasol infusion 2 times per day. Sefazolin was applied for postop 2 days, Gentamycin was applied for postop 5 days and Ornidasol was applied for postop 3 days. Also low molecular weighted heparin all patients for proflacty. All of the patients were operated in electi-

**Table 1.** Kistribution of our cases according to AO/ASIF classification.

Type	Subgroup			Total
	1	2	3	
A1	–	–	–	–
A2	–	5	8	13
A3	2	8	5	15
B1	–	–	–	–
B2	2	7	5	14
B3	2	9	4	15
C1	–	2	–	2
C2	1	6	–	7
C3	2	3	2	7

ve conditions. C75 type stainless steel intramedullary nails were used to all the patients. Mean operation time of the patients were 3.4 days (ranged 2-11 days).

In our study reamed, statically locked intramedullary nailing were applied to 45 open tibia fractures. In these open fractures repair of the cut applied following irrigation and debridement in emergency room and started to the antibiotic medication. Twentyeight of 30 patients had Grade I open fractures were operated by closed technique, and 2 patients were operated by open technique. Five patients had Grade II open fractures and repaired the cuts before and had not evidence of infection were operated by closed technique. Other 5 patients had Grade II open fractures were operated by open technique. Five patients had Grade III open fractures were operated by open technique. Any of the patients which were open, complication did not seen about union time and infection evidence.

To the all of the patients intramedullary nailing were tried by closed technique under fluoroscopic control. But on 17 (%24.5) patients we had to operate by open technique because of could not provide the closed reduction. Fiftysix (%75.5) of the patients were operated by closed technique. Any of the patients which operated by open technique were not detected complication about infection and union.

Operations were made in supine position on radiolusent table. Traction table was not used. Tourniquet was not used any of the patient. A longitudinal incision made medial to the patellar tendon, between patellar distal pole and tuberositas tibia. Skin and under skin tissue were incised, then patellar tendon was pulled laterally and was reached to the intercondylar area. At the intercondylar region, medullar canal was opened by awl in front of the joint surface and medially to the midline. After fracture closed reduction under fluoroscopic control guide pin was inserted to the distal fragment and appropriate length of the nail was detected. The knee of the patient was flexed and patient's leg was hanged down. Rigid reamer was applied all of the patients. By beginning slimmest reamer, medullar canal was reamed to the preoperative detected size and nail was adapted. After nailing locking screws were adapted. Proximal locking screws adapted by using guide and distal locking screws were adapted by free hand technique. All of the nails were locked statically by using 2 screws to

the proximal holes and 2 screws to the distal holes.

Elastic bandage were adapted postoperatively. The second day after surgery without additional phenomenon of pathology, knee and ankle joints for movement and isometric muscle strengthening exercises without weightbearing mobilisation with a couple of crutches were performed. At the end of two weeks patients who were removed stitches took under control. Weightbearing was allowed when periost reaction and callus development were observed radiologically. Mean callus organisation time was 8 weeks (ranged 6-10 weeks).

Cases were called to control monthly. In this control, operation fields of cases, walking, leg circulation, and neurological examination findings were assessed. Atrophy in the leg and thigh, shortness of the tibia, whether the knee pain prevention, knee and ankle joint ranges of motion were assessed. Radiographs were taken and evaluated about union rate, angulation, nail condition and whether locking screws had broken. There was no follow up lost patients. Union times and postoperative seen complications were taken into, patients were evaluated with Johner-Wrush

## Results

Criteria for fracture union was accepted radiologically as callus appearance at 4 cortex and absence of fracture line on anteroposterior and lateral radiography, as well as clinically absence of pain and pathological movements. According to this evaluation, complete union of the fracture zone was obtained at an average of 18.2 weeks (8-52 weeks) in all our patients. In four of our cases dynamization was performed at an average of 18 weeks (16-24 weeks) due to delayed union. Cases who had undergone dynamization also had fibula fractures but fibula osteotomy was not necessary. Dynamization was performed by removing proximal lock screws in 2 and distal lock screws in other 2 of the patients. Bone grafting using autograft taken from ilium was performed to one of our patients who had undergone dynamization to accelerate bone healing. 1cm shortening of the extremity was detected in one and 2 cm shortening of the extremity was detected in another one of our patients.

Reduced sensation after dynamization occurred in one of our patients, but recovery of this complication was observed during the patient's follow-up. Neurological complications were not observed in other

**Table 2.** Johner-Wrush evaluation criteria<sup>[5]</sup>

	Excellent	Good	Fair	Poor
Ununion-Amputation	None	None	None	None
Neurovascular disorder	None	Minimal	Moderate	Severe
Deformity				
Varus-Valgus (°)	None	2-5	6-10	>10
Anteversio-Recurvation (°)	0-5	6-10	11-20	>20
Rotation(internal-external) (°)	0-5	6-10	11-20	>20
Shortening (mm)	0-5	6-10	11-20	>20
Mobility				
Knee (%)	Normal	>80	>75	<75
Ankle (%)	Normal	>75	>50	<50
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Insignificant limp Severely	Significant limp
Strenuous activity	Possible	Limited	Severely Limited	None

patients. Revision was performed to one patient after radiologic detection of distal locking screws being localized outside the nail during postoperative controls. None of the cases developed complications including fat embolism, compartment syndrome, deep and superficial infections, deep venous thrombosis and other vascular complications.

Fracture of proximal locking screw was observed in one case who exhibited a delayed union. There wasn't any complications observed about nails or locking screws in other cases. In two of our cases (2.8%) anterior knee pain was observed during postoperative period. Both patients who had anterior knee pain exhibited delayed union and irritation of patellofemoral region by the nail. Dynamization was performed to one of these cases and fixation material was removed after the fracture union to relieve the knee pain that causes restriction in daily activities. The rate of anterior knee pain was lower than the literature, and this was thought to be due to the fact that all fractures were statically locked and dynamization was not required except 4 patients. Proximal region irritation was observed in one of our patients with anterior knee pain due to the breakage of proximal locking screw; the other patient was dynamized by removing proximal locking screw. Impaction of the fracture zone caused knee anterior region irritation by the nail. Another cause of anterior knee pain is patellar tendon split during surgical approach. Because we choose medial parapatellar approach in all our patients, anterior knee pain was significantly lower with

respect to the literature. Extremity shortening of 1cm in one case and 2cm in another case was detected by measurements performed during recent follow-up of the patients. Thigh muscle atrophy measurements revealed 5.5 cm atrophy in one case with ipsilateral femur fracture and poliomyelitis sequel; 7 cm in one case who had undergone below-knee amputation due to contralateral tibia type 3C open fracture; 4 cm in one case who was performed fixation material removal due to anterior knee pain; 2 cm in two cases; and 1 cm in 5 cases. When we analyzed the cases according to leg atrophy, 2.5cm atrophy was detected in one case and 1cm atrophy detected in six cases.

In their recent follow-up cases were analyzed for malalignment. 2° varus deformity was detected in one case and 6° varus deformity was detected in another case; 10° valgus deformity was detected in one case and 2° valgus deformity was detected in another case; anterior angulation deformities were seen as 3° in three cases, 2° in one case and 4° in another case. None of the cases had posterior angulation or rotation deformity. When knee movements were analyzed, extension deformity wasn't detected in any of the cases. Knee flexion angles of two patients with anterior knee pain were analyzed as 94° and 114° respectively. Knee flexion angles of all remaining cases were higher than 130°. Ankle joint functions were analyzed and 5° loss of dorsiflexion and 10° loss of subtalar joint motion range were detected. In all cases plantar flexion movements were detected as normal.

Cases eventually were evaluated according to objective Johner-Wrushi criteria (Table 4). Perfect (45 cases; 61.6%) and good (28 cases ; 38.4%) results were obtained.

## Discussion

The aim of the treatment of tibia corpus fractures is, like all other fractures to obtain recovery without sequelae together with providing enough mobilization. In addition another aim is to provide the motion of the adjacent joints in a short time. Careful selection of the treatment modality, restoration of the structural stability and maintaining the mechanical axis of tibial shaft within an acceptable range are criteria for successful treatment. Acceptable reduction with minimal morbidity can be provided for each patient with different treatment options. Acceptable reduction criteria are related with alignment, rotation, length and position of the fracture and pretrauma activity level of the patient. Maximum functional restoration depends on the level of concomitant soft tissue injury. Treatment modality must be determined considering the risk of over injury with the recommended treatment. Today the most effective treatment modality for early mobilization, preventing joint stiffness and providing early activity in tibial corpus fractures is locking intramedullary nailing and it is one of the important stages in fracture treatment.

Acceptable reduction is minimal angulation, rotation and length change situation of fracture fragments with respect to normal anatomy. Nicoll considered that angulation greater than 10° was unacceptable in all planes. Sarmiento declared that there is adequate function in angulations smaller than 10°. None of these authors suggested reoperation for symptomatic malunions with angulation deformities smaller than 10°. Today 5° varus or valgus angulation, 10° anterior or posterior angulation, 10° rotation and 1cm shortening deformities in comparison with opposite extremity is considered acceptable in tibial shaft fractures. Our cases were evaluated for malalignment in their recent follow-up. 2° varus in one case, 6° varus in another case; 10° valgus in one case, 2° valgus in another case; and 3° anterior angulation in three cases, 2° anterior angulation in one case and 4° anterior angulation in one case were detected. Posterior angulation and rotation deformity were not detected in any of the cases. Reduction loss with locking intramedul-

lary nails does not occur if appropriate reduction of the fracture is achieved and the nail is locked.

An important point in addition to selection of right treatment modality is classification of the fractures and soft tissue injuries. A convenient classification of fractures must facilitate the selection of treatment modality, estimating the prognosis and evaluating the results by considering the severity of the injury. In our study we used AO/ASIF classification recommended by AO group which we accepted as the most suitable method for the aim of our study. AO group tries to estimate the severity of the trauma, difficulty of treatment and prognosis by evaluating the characteristics of the fracture line and existence of fibula fracture. This classification is increasingly preferred although it seems complicated. In this way it helps the formation of a definite standardization in fracture classification. However the level of the fracture line is not considered in AO/ASIF classification. Whereas in many studies it is reported that there is variety in the prognosis of tibial shaft fractures according to the 1/3 proximal, medial or distal localization of the fracture line.

Classification of open fractures recommended by Gustilo and Anderson is simple and useful which is shown as reference in many studies. In our study Gustilo-Anderson classification was used for classification of open fractures.

Closed reduction and plaster cast immobilization is the most cheap and easy method for the treatment of tibial shaft fractures. Also this method does not carry the risk of operation complications. In the studies performed by authors such as Littenberg, Hooper and Bone, intramedullary nailing and closed reduction-plaster cast immobilization treatment modalities were compared for tibial shaft fractures. The common consequence all the authors achieved is that intramedullary nailing is a better treatment modality than plaster cast immobilization in terms of union time and success for extremity functionality. Sarmiento et al reported the average duration of union with treatment of tibial shaft fractures using functional braces as 17.4 weeks in closed fractures and 21.7 weeks in open fractures. Bone et al reported the average duration of union in their study that compared plaster cast immobilization and intramedullary nailing as 26 weeks with plaster cast immobilization and 18 weeks with nailing method.

It is indisputable that achieving early union is a great advantage for the patient. However if this union is together with deformity, arising inconvenience makes this advantage worthless. Complete union of tibial shaft fractures restoring anatomic position is an ideal consequence, but complications of the treatment modalities that provide this must also be considered. Alho et al reported limited mobility of knee and elbow joints in 10% cases who had displaced tibial shaft fractures that were treated with locking intramedullary nails. Knee joint mobility of our patients were examined and extension deficiency wasn't detected in any of them. 94° and 114° knee joint flexion angles were detected in two of our cases who had suffered with anterior knee pain. In all other cases knee flexion was above 130°. Ankle joint functions were evaluated and averagely 5° dorsiflexion loss and 10° subtalar joint mobility loss was detected in all the cases. Plantar flexion movement was evaluated and determined as complete in all of the cases.

Patellar tendon irritation and anterior knee pain is a common situation encountered after intramedullary nailing. Causes of anterior knee pain were investigated in the performed studies. Anterior knee pain occurring rate in cases who had undergone patellar tendon split surgery were found higher than the rate in cases who were performed parapatellar approach. Another blamed factor is patellofemoral joint irritation due to leaving the proximal portion of the nail longer than the normal size. In our study anterior knee pain was seen in two cases (2.8%) during the postoperative period. Delayed union and patellofemoral region irritation by the nail occurred in both cases who had anterior knee pain. Dynamization was applied to one of these cases and after fracture union was complete fixation material removal was performed to terminate the knee pain that impairs the patient's daily activities. Our anterior knee pain ratios are lower than the literature. We think this was due to the fact that we left the proximal part of the nail outside and do not split the patellar tendon.

In 1991 Koval et al encountered neurological problems with a rate of 30% in their series including 60 patients. They concluded that the reason of this situation was the traction which significantly increases the compartment pressure. In our study neurological complication did not occur in our patients after intramedullary nailing, except a temporary sensorial

deficiency in one case.

Finally, locking intramedullary nailing is an effective modality for the treatment of tibial shaft fractures. It can be performed safely in type 1,2 and 3A open fractures. Closed reduction of the fracture helps to protect fracture hematoma, periosteum and adjacent soft tissues and also decreases the risk of postoperative infections; these are important factors for fracture union. Reaming process does not have a negative effect on fracture union and does not increase the risk of infection, but contrarily it also accelerates the fracture healing. The rate of infections, delayed union or nonunion with intramedullary nailing is not higher than other treatment modalities.

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