ORIGINAL ARTICLE

Radiographic and clinical outcomes of distal tibia fractures (3–12 cm proximal to the plafond): Comparison of two intramedullary nailing

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ABSTRACT

BACKGROUND: There are various distal locking options for the repair of tibia distal diametaphyseal fractures with intramedullary nails. There is no consensus about the superiority of any of these distal locking options. In our study, comparing nails with distal bolt locking screw (DSBLS) and conventional nails; we aimed to compare the clinical and radiological results of intramedullary nail models in fixing tibial distal diametaphyseal fractures.

METHODS: In our orthopedics and traumatology department, 117 tibial distal diametaphyseal fractures of 116 patients treated with intramedullary nails between August 2007 and May 2015 were retrospectively evaluated. Forty-six tibial distal diametaphyseal fractures of 45 patients who came to regular visits to outpatient clinic controls and who had a minimum follow-up of 18 months and whose fracture distance was between 3 and 12 cm were included in the study. The average follow-up period of the study group consisting of 28 males and 17 females with an average age of 44 (16–76 years) which was 48 months (18–100 months). The group using the DSBLS locking intramedullary nail was considered the first group and the group using the conventional distal locking intramedullary nail was considered the second group. Radiological union times, coronal, sagittal, and axial plan angulations and malunion presence were compared between the two groups. In addition, the two groups were compared clinically with length of time spent on weight-bearing and return to work, Olerud-Molander ankle score, and American Orthopedic Foot and Ankle Society Score scores.

RESULTS: We found that the first group was superior in terms of length of time spent on partial and full weight-bearing between the two groups (p=0.00031 and p=0.00007). In addition, the union time of the first group was shorter (p=0.0149). Other radiological or clinical results did not differ significantly between the two groups. In addition, no significant correlation was found between the distance of the fracture from the tibial plate and its angulation. In cases with malunion alone, the fracture line was more distal than those without malunion (p=0.0411).

CONCLUSION: Newly developed DSBLS intramedullary nails give as good results as conventional nails in tibia distal diametaphyseal fractures. Due to its ability to loading bone early and have a shorter union time, DSBLS can be safely preferred in distal diametaphyseal fractures and reduce complications from immobilization.

Keywords: Diametaphysis; distal; distal locking; intramedullary nail; tibia fractures.

INTRODUCTION

The management of distal tibia fractures is challenging for most orthopedic surgeons. Special anatomical characteristics, high degree of fragmentation, and soft-tissue trauma contribute to high complication rates after open surgical intervention. While many methods have been advocated, optimal treatment is still unclear and controversial.

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In surgical treatment, there are options such as plate screw, intramedullary nailing, and external fixator. With plate fixation, stable fixation and good reduction are achieved, but there are disadvantages such as extensive soft-tissue dissection, disruption of periosteal blood flow, non-union, infection, and implant irritation. In recent years, closed reduction and minimally invasive plating have gained popularity.[1–3] External fixation can be applied temporarily or as a permanent treatment for widespread soft-tissue injury, but problems such as malunion, delayed union, pin-tract infections, and reduced ankle range of motion may occur.[4,5]

For these reasons, intramedullary nails have become one of the preferred treatment techniques for extra-articular distal tibia fractures. The biggest problem in closed intramedullary nailing is the difficulty in locking distal holes. Failure to lock can prevent fracture stability and cause non-union and pseudoarthrosis. Different locking options have been developed to overcome difficulties in distal locking. Recently, the most commonly used are static locking screws and angular stable locking screws.[6,7] Due to the lack of adequate distal locking in distal tibial fractures, Gorczyca et al.[8] tried to find a solution by cutting the distal of the tibial nails with a method they found, but, they did not get the desired result. In their biomechanical studies, Agathangelidis et al.[9] investigated the ideal locking option by increasing the number of distal screws or with different screw configurations. However, they did not find a significant difference between different locking options. Kaspar et al.[10] aimed to bring a different solution to distal locking problems with the studies of angular stable locking screws applied in sheep tibia. Kucukdurmaz et al.[11] aimed to find solutions to distal locking problems even in the most distal fractures with the distal locking bolt screw (DSBLS).

However, we did not find a study comparing conventionally designed nails with conventional nails in the literature. In our study, comparing the nails with the special locking system (DSBLS) and the conventional nails; we aimed to compare the clinical and radiological results of intramedullary nail models in the detection of tibial distal diametaphyseal fractures. In the hypothesis of our retrospective cohort study, we argued that we can achieve similar radiological and clinical results with DSBLS as in conventional distal locking nails.

MATERIALS AND METHODS

Patients

In our orthopedics and traumatology department, 117 tibial distal diametaphyseal fractures of 116 patients treated with intramedullary nails between August 2007 and May 2015 were retrospectively evaluated. Forty-five patients with 46 tibial distal diaphyseal metaphyseal fractures and treated with intramedullary nail were included in the study. The study was approved by the local ethics committee and informed consent was taken from the patients before surgery. The inclusion criteria were as follows: (1) An extra-articular distal tibial shaft fracture located between 3 and 12 cm from the tibial plafond and (2) Gustilo-Anderson (GA) type I or II open fractures and follow-up time of more than 18 months.[12] Patients with any of the following were excluded: (1) Ipsilateral or contralateral lower limb fractures, dislocations, or both, (2) pathological fractures, (3) Gustilo type III open fractures, (4) nerve or vascular-related fractures requiring repair, and (5) metabolic bone disease, previous ipsilateral lower extremity surgery, or mental illness.

The average age of the study group consisting of 28 men and 17 women was 44 (16–76 years). The average follow-up was 48 months (18–100 months). Twenty-three patients had left, 21 patients had right, and one patient had bilateral tibial distal diametaphyseal fractures.

Fractures were classified according to the AO/OTA system.[13] Accordingly, 27 of the fractures were 42A, nine were 42B, and 10 were 42C. Six fractures were type 1 and four fractures were type 2 open fractures. The distance of the broken lines with the tibial plafond was an average of 80.7 mm with a minimum of 3 and a maximum of 12 cm.

The patients were operated on average 6th day.[1–16] Patients with excessive swelling or bruising of the soft tissues underwent delayed surgery.

All patients with tibial distal diametaphyseal fracture; 24 of them were operated with distal locking bolt intramedullary nail (DSBLS) (TIN, TST, Istanbul, Turkey) while 22 of them were operated with conventional distal locking intramedullary nails (12 with VersaNail, DePuy, Warsaw, Indiana, USA; 10 with Trigen Meta-Nail, Smith and Nephew, Memphis, Tennessee, USA). DSBLS intramedullary nail group was considered as the first group and conventional distal locking intramedullary nail group was considered as the second group.

Surgical Technique

All patients received prophylaxis with 1 g of Cefazole 30 min before surgery. The patients were placed in the supine position on the radiolucent table. Tourniquet was not used in any patient. Transpatellar approach was preferred. The medullary canal was widened with the help of the pathway, by determining the entry site. At this point, the surgical technique of the nails in the two groups differs.

In the first group of nails, the fracture was reduced and the nails were sent intramedullary without reaming. The K wire, which was sent parallel to the joint in the lateral plane, was sent to the tip of the nail until it was sent approximately 2 cm distally under the scope. First, a 5 mm drill was drilled to the lateral cortex over the K wire, then only the medial cortex was drilled with a 8.5 mm drill. Then, the wide mouth of the measured length DSBLS was placed proximally. The nail

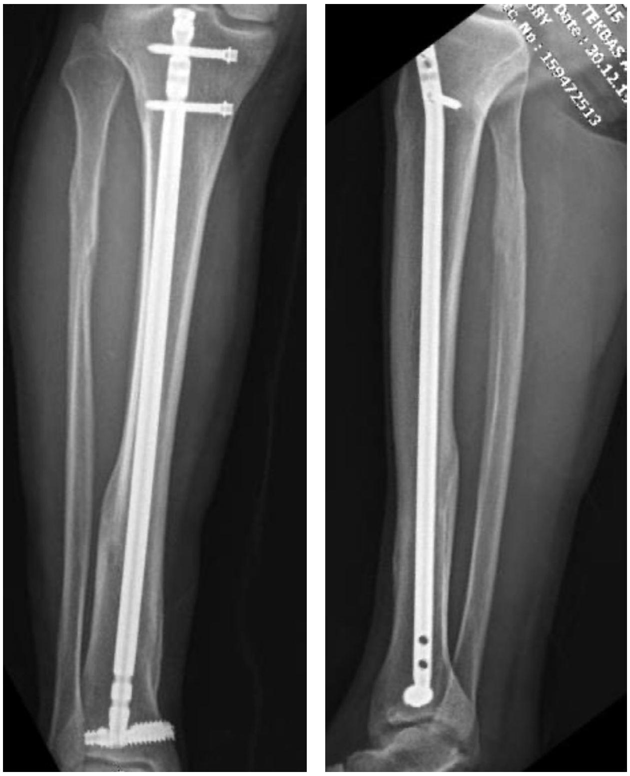

Figure 1. A 38-year-old male, AO type 43-C1.3 fracture treated with DBSL, at 42 weeks follow-ups AP and LAT radiographic images. The union was achieved at 12 weeks.

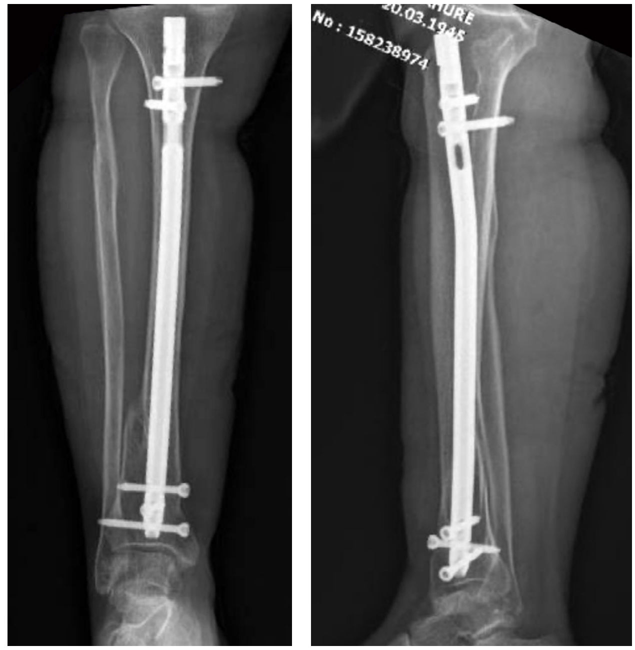

Figure 2. A 71-year-old female, AO type 42-A1.2 fracture treated with Trigen nail, at 50 weeks follow-ups AP and LAT radiographic images. The union was achieved at 15 weeks.

was pushed forward and it was felt that the nail was placed in the mouth of the screw. It was checked whether the nail was placed in the mouth of the screw with DSBLS's back and forth movements or set screw. If the surgeon was not sure, the position was also checked with scope. Distal locking was completed with the set screw, which was 18 mm shorter than DSBLS (Fig. 1).

In the second group of nails, after closed reduction, carved intramedullary nail was sent over the guide wire. By controlling with scope, distal locking screws are locked with free-hand technique or with the help of magnetic probe (Smith and Nephew Trigen Sureshot). Proximal locking was performed on the guide, which was placed on the holder in the same way in all nails. After making static locking with at least two screws over the guide, the crown screw was placed (Fig. 2).

Post-operative Care

Post-operative care was similar for both groups. Ankle and knee joint exercises were started the day after surgery. The second group of patients was allowed to carry partial weights after seeing radiological evidence of union 6 weeks after surgery. In the first group, full weight-bearing was allowed on the 1st post-operative day.

For radiographic evaluation, anteroposterior (AP) and lateral tibial views obtained before and after surgery until the fracture union was achieved in 6-week periods. AP and lateral image radiographs of knee were used to determine the long axis of the tibia. All radiographic alignment measurements were done by an independent radiologist who was blinded to treatment. The independent observer evaluated all radiographs twice a day. All measured values are calculated up to two decimal places. A single radiographic examination was used to eliminate interobserver variability. Fracture union was defined as the absence of pain in three of the four cortices seen on the AP and lateral radiographs of the tibia and the presence of a bridging callus. While the healing time lesser than 6 months was considered normal, the healing time from 6 months to 9 months was considered as a delayed union. Fractures that did not heal within 9 months were classified as non-union.

The length of the tibia was defined as the distance between the tuberositas tibia area and the inferior edge of medial malleolus.[6,14] Shortening was defined as a left/right difference in length of the tibia of greater than 1 cm. Malalignment was defined as greater than 5° ante-/recurvation, greater than 5° varus/valgus deformity, or greater than 15° rotation difference. Complications, the length time of recovery, return to work, and secondary operations were recorded. "American Orthopedic Foot and Ankle Society Score" (AOFAS) and "Olerud-Molander Ankle Score" (OMAS) systems were used for evaluations.[15,16] At the last follow-up examination, the AOFAS scoring system was used to evaluate ankle function. In AOFAS, the maximum score was 100 points. OMAS is an ordinal rating scale from 0 points (totally impaired function) to 100 points (completely unimpaired function) which is related to nine different items given different points: Pain, stiffness, swelling, stair climbing, running, jumping, squatting, supports, and work/activity level and commonly used to assess patients with ankle fractures. Clinical outcomes were assessed by an independent assessor at final follow-up assessments. The assessor was blinded to the treatment technique and performed all assessments twice in 1 day. The mean value of each score was used for the statistical analysis.

Statistical Analysis

All clinical measurements were taken twice at 1 day apart by one independent reviewer for all patients, and the average of these two measurements was used as the data.

R Core Team (2016) which is a language and environment for statistical computing program was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, and frequency) were used while evaluating our data. T-test was used to compare the population parameters of homogenous and normally distributed samples. Mann–Whitney U-test was used to compare the parameters of the groups that did not show normal distribution. In addition, Pearson correlation test was used to show the linear relationship between two variables. When comparing qualitative data, Fisher's exact test was used. P<0.05 was evaluated statistically significant.

RESULTS

Of the 46 tibia distal diametaphyseal fractures evaluated, 52.2% (n=24) were in the first group and 47.8% (n=22) in the second group. A complication was observed in one patient in the first group whose DSBLS was broken after the fracture union was completed. There was no additional operation. All patients except one patient had fibula fractures. Osteosynthesis was performed in 6.6% (n=3) of patients with fibula fractures. One was fixed with a plate screw and two were fixed with an intramedullary K-wire, which was sent through the fibula. Block screw was not used in any fracture.

When the angles in the coronal, sagittal, and axial plane are compared between the first and second groups, the average varus-valgus angulation in the coronal plane was 2.22 degrees (0–9.6 degrees) in the first group and 2.44 degrees (0–9.9) in the second group. When the angulations in the coronal plane were evaluated statistically, no significant difference was observed (p>0.05) (Table 1).

The average of angulation in the sagittal plane was 1.18 degrees (0–9.5) in the first group; 1.23° (0–9.1) in the second group. When the antecurvatum-recurvatum measurements were evaluated between the two groups, there was no statistically significant difference (p>0.05) (Table 1). The average of values measured between 0 and 10 degrees in rotation is 1.83 degrees. The average rotation angle was 1.88 degrees (0–10) in the first group and 1.77 degrees (0–9) in the second group. There is no statistically significant difference between the angulations of these two groups in the axial plan (p>0.05) (Table 1).

Table 1. Evaluation of coronal, sagittal and axial plane angles and clinical scoring between the two groups

	1. Group	2. Group	p*
	Average±SD Median	**Average±SD Median**	
Varus-valgus angulation	2.22±2.99 (0)	2.44±3.27 (0)	0.52077
Antecurvatum-recurvatum Angulation	1.18±2.56 (0)	1.23±2.50 (0)	0.92716
Rotation angulation	1.88±3.46 (0)	1.77±3.19 (0)	1
OMAS Score	93.96±6.91 (95)	91.36±7.90 (92.5)	0.24914
AOFAS Score	93.46±8.09 (98.5)	92.64±6.33 (92.5)	0.4002

*Mann-Whitney U Test. OMAS: Olerud-Molander Ankle Score; AOFAS: American Orthopedic Foot and Ankle Society Score; SD: Standard deviation.

Clinical scoring between the two groups was compared using OMAS and AOFAS scoring system. According to the OMAS system; the first groups mean score was 93.96 (70–100) while the second groups mean score was 91.36 (75–100) which showed no significant difference (p>0.05) (Table 1). According to the AOFAS scoring system; the first groups mean score was 93.46 (76–100), the second groups mean score is 92.64 (80–100). This scoring system does not show a statistically significant difference (p>0.05) (Table 1).

The average union time of the first group was 14.04 weeks (8–30), and the average union time of the second group was 16.07 weeks (11–30). When the two groups were compared statistically, there was a significant difference (p<0.05) (Table 2).

The measured values were also compared between the two groups in terms of malunion and Fisher's exact test was used. Five cases were accepted as malunion in both groups and no statistically significant difference was observed between the two groups (p>0.05) (Table 2).

Although the fracture joint distance varies between 48 and 90 mm in malunion fractures, the average was 66.80. In non-malunion fractures, this distance is between 30 and 120 mm and the average was 84.53 (Table 3).

The return to work in the first group is 4–50 weeks with an average of 21.63 weeks while it is 8–76 weeks with an average

Table 2. Evaluation of union week, presence of malunion and return to work week between the two groups

		1. Group	2. Group	p*
		Average±SD Median	Average±SD Median	
Union week		14.04±2.67 (14)	16.07±2.75 (16)	0.0149*
Malunion	(+)	5 (10.87)	5 (10.87)	0.6961**
	(-)	19 (41.30)	17 (36.96)	
Return to work week		21.63±13.30 (19)	25.05±13.37 (20)	0.33798***

*T-Test. **Fisher Exact Test. ***Mann-Whitney U Test. SD: Standard deviation.

Table 3. Evaluation of the presence of malunion and fracture-joint distance

	Malunion		p*
	(+)	(-)	
	Average±SD Median	Average±SD Median	
Fracture-joint distance	66.80±15.16 (67.5)	84.53±22.56 (87)	0.0243*
OMAS Score	91.00±6.99 (92.5)	93.19±7.57 (95)	0.30651**
AOFAS Score	93.80±5.07 (96)	92.64±7.62 (96)	0.55384**

*T-Test. **Mann-Whitney U Test. OMAS: Olerud-Molander Ankle Score; AOFAS: American Orthopedic Foot and Ankle Society Score; SD: Standard deviation.

of 25.05 weeks in the second group. When evaluated statistically, no significant difference was observed in terms of return to work (p>0.05) (Table 2).

None of the patients in each group had wound dehiscence, other wound healing problem or deep or superficial infection.

DISCUSSION

There are different opinions among acceptable angular deformities in distal tibial fractures.[6,14,17,18] A fixation made in the internal rotation above 10 degrees in the axial plan causes walking disturbance, while the external rotation can be easily tolerated up to 20 degrees. Likewise, valgus deformity is better tolerated than varus deformity.[19] Nork et al.[17] measured the sagittal plan deformity by an average of 0.9 (0–5) degrees and the coronal plan deformity by an average of 0.3 (0–5) degrees in the measurements made after the detection of the tibial distal metaphysis fractures with intramedullary nail. Vallier et al.[20] reported angular malalignment of ≥5 degrees occurred in 29% of patients treated with intramedullary nailing for distal tibia fractures. In another prospective, randomized study designed by Vallier et al.,[21] they reported 23% malalignment after nailing. In our study, the average angulation in the coronal plan was 2.22 (0–9.6) degrees in the first group and 2.44 (0–9.9) degrees in the second group. The mean angulation in the sagittal plan was 1.18 (0–9.5) degrees in the first group and 1.23 (0–9.1) degrees in the second group. Average rotational angulation was 1.88 (1–10) degrees in the first group and 1.77 (1–9) degrees in the second group. The angulations in these three plans did not show a statistically significant difference in either group. Malalignment was detected in 10 cases (22.2%), five in each group. When the cases with malalignment in both groups were examined, the level of fracture was closer to the joint (mean 66.80 mm). We think that this situation is due to the fact that the diameter of the canal expands in the metaphyseal region as the anatomy of the distal tibia approaches, and anatomical reduction is difficult with closed methods in this region fractures. In addition, none of our cases showed angulation above 10 degrees or shortening above 1 cm.

Total union rates have been reported in distal tibial fractures in many studies. In all of our cases, full union with intramedullary nail was obtained. When the literature is researched, the average union time in tibial distal fractures is 17 weeks (12–28) in the study of Fan et al.;[23] 16 weeks (12–18) in the study of Megas et al.;[22] and 16 weeks (10–50) in the study of Robinson et al.[18] Deleanu et al.[24] compared reaming versus non-reaming nails in tibial fractures and there were no significant differences between the two groups regarding the average time to healing for both clinical. Lin et al.[25] studied the effects of reamed versus non-reamed nails an international randomized control trial. There were no differences in functional outcomes between reamed and unreamed patients. Larsen et al.[26] examined if any differences exist in healing between reamed and unreamed nails. The average time to fracture healing was 16.7 weeks in the reamed group and 25.7 weeks in the unreamed group. Li et al.[27] evaluated the clinical efficacy of reamed and non-reamed intramedullary nailing in the treatment of closed tibial fractures at their systematic meta-analysis. They reported that reamed intramedullary nailing was better than non-reamed intramedullary nailing in non-union rate and implant failure rate. In our study, the union time in the second group was found to be 16.07 weeks (11–30) in accordance with the literature. In the first group, the union time was 14.04 weeks (8–30) and showed a statistically significant difference. In our opinion, the shorter union time of the first group is due to the shortness of giving partial and full weight pressure to the lower extremities of these patients. The union of the fracture is stimulated by micro movements, which shortens the union time in the group given early mobility.

When evaluating the clinical and functional results of the ankle in distal tibia fractures, OMAS and AOFAS scales are generally preferred. Robinson et al.[18] reported the mean OMAS as 89. Guo et al.[28] found an average of 86.1 (83.7–88.6) AOFAS score in 44 distal tibial fractures. In the present study of Fang et al.,[29] the AOFAS score was 92.5 (68–100) on average. In our study, while the mean OMAS score in the first group was 93.9; AOFAS score was 93.4. In the second group, OMAS mean score was 91.3; AOFAS score was 92.6. Our clinical scores showed similar values with the literature, and the greater distance between the fracture and tibial plafond in our cases shows our scores better.

While the average time to return to work or to do all of their work independently in the first group was 21.63 (4–50) weeks; 25.05 (8–76) weeks in the second group. Although the first group returned to work earlier, the difference between them was not statically significant. In their study, Gaston et al.[30] stated the duration of their patients to return to work as 13 weeks on average, while they determined the duration of doing sports activities as 45 weeks. In this respect; we think that psychosocial improvement along with physical recovery is a positive factor in terms of shortening the time to return to work.

DSBLS introduced a new method with "nails in the screw" instead of "screws in the nails." DSBLS intramedullary nail can provide stability in multiple planes with a single screw. With this stability, proper sequencing can be maintained, such as conventional intramedullary nails. When we evaluated the angulations in the coronal, sagittal, and axial plan in our study, we did not see any difference between DSBLS intramedullary nails and conventional intramedullary nails. One of the important advantages of DSBLS intramedullary nails is its high resistance to axial loading.[31] In this way, we were able to give our patients the ability to bear weight earlier. We found that DSBLS intramedullary nails had shorter union times as well as early loading. However, return to work time do not differ in both nail applications.

The most obvious limitation of our study is its retrospective structure, non-randomized design, low number of patients, the fact that multiple surgeons participated in the treatment. İn addition, we have lost to follow-up 72 patients.

Conclusion

DSBLS intramedullary nails can be safely preferred in tibial distal diametaphyseal fractures due to its ability to give early weight-bearing and shorter union time compared to conventional intramedullary nails.

Ethics Committee Approval: This study was approved by the Umraniye Training and Research Hospital Ethics Committee (Date: 19.01.2017, Decision No: B.10.1.TKH.4.34.H.GP.0.01/4)..

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ORİJİNAL ÇALIŞMA - *ÖZ*

Distal tibia kırıklarının (plafondun proksimalinde 3 ila 12 cm) radyografik ve klinik sonuçları: İki intramedüller çivilemenin karşılaştırılması

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AMAÇ: Tibia distal dia-metafizyel kırıkların intramedüller çivi ile tespitinde çeşitli distal kilitleme seçenekleri mevcuttur. Bu distal kilitleme seçenekleri arasında herhangi birinin üstünlüğü konusunda görüş birliği yoktur. Distal kilitleme bolt vidasına (DSBLS) sahip çivi ile konvansiyonel çivilerin kıyaslandığı çalışmamızda; tibia distal diametafizyel kırıkların tespitinde intramedüller çivi modellerinin klinik ve radyolojik sonuçlarını kıyaslamayı amaçladık.
GEREÇ VE YÖNTEM: Ortopedi ve Travmatoloji Kliniği'mizde Ağustos 2007 ile Mayıs 2015 tarihleri arasında intramedüller çivi ile tedavi edilmiş 116 hastanın 117 tibia distal dia-metafizyel kırığı etik kurul onayı ile geriye dönük olarak değerlendirildi. Poliklinik kontrollerine düzenli gelmiş, minimum 18 aylık takibi olan ve tibial plafond ile kırık mesafesi 3 ile 12 cm arasında olan 45 hastanın 46 tibia distal dia-metafizyel kırığı çalışmaya dahil edildi. Yaş ortalaması 44 (dağılım, 16–76 yaş) olan 28 erkek ve 17 kadından oluşan çalışma grubunun ortalama takip süresi 48 ay (dağılım, 18–100 ay) idi. DSBLS kilitlemeli intramedüller çivi kullanılan grup 1. grup, konvansiyonel distal kilitlemeli intramedüller çivi kullanılan grup 2. grup olarak kabul edildi. İki grup arasında radyolojik olarak kaynama süreleri, koronal, sagittal ve aksiyel plandaki açılanmaları ve malunion varlığı kıyaslandı. Ayrıca iki grup klinik olarak yük verme zamanları, işe dönüş zamanları, OMAS ve AOFAS skorları ile karşılaştırıldı.
BULGULAR: İki grup arasında parsiyel ve tam yük verme süreleri bakımından 1. grubun üstün olduğunu bulduk (p=0,00031, p=0.00007). Ayrıca 1. grubun kaynama süreleri daha kısadır (p=0.0149). İki grup arasındaki diğer radyolojik veya klinik sonuçlar anlamlı farklılık göstermemektedir. Ayrıca kırığın tibial plafonda olan mesafesi ile açılanmalar arasında anlamlı bir ilişki saptanmamıştır. Yalnız malunion görülen olgularda malunion görülmeyen olgulara göre kırık hattı daha distaldedir (p=0.0411).
TARTIŞMA: Tibia distal dia-metafizyel kırıklarda yeni geliştirilmiş DSBLS kilitlemeli intramedüller çiviler de konvansiyonel çiviler kadar iyi sonuçlar vermektedir. Erken yük verebilme ve daha kısa sürede kaynaması nedeniyle tibia distal dia-metafizyel kırıklarda güvenle tercih edilebilir ve immobilizayona bağlı görülebilen komplikasyonları azaltabilir.
Anahtar sözcükler: Dia-metafiz; distal; distal kilitleme; intramedüller çivi; tibia kırığı.

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