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THE EFFECT OF INTACT FIBULA ON UNION AND FUNCTIONAL OUTCOMES FOR TREATING TIBIAL DIAPHYSEAL FRACTURES WITH INTRAMEDULLARY NAILING: EVALUATION WITH RADIOGRAPHIC UNION SCALE IN TIBIAL (RUST) FRACTURES

TİBİA DİYAFİZER KIRIKLARININ İNTRAMEDÜLLER ÇİVİ İLE TEDAVİSİNDE SAĞLAM FİBULANIN KAYNAMAYA VE FONKSİYONEL SONUÇLARA ETKİSİ: RADYOLOJİK KAYNAMA SKORU İLE DEĞERLENDİRME

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Abstract

Objective: To compare radiological union scoring system (RUST) scores, union status, and functional outcomes of isolated tibial and both tibia and fibula fracture treated with intramedullary nailing.

Materials and Methods: The records of 205 patients diagnosed with tibial diaphyseal fractures and treated with intramedullary nailing between January 2015 and December 2020 were reviewed, and 74 patients were included in the study. Patients were divided into two groups: isolated tibial fracture (Group 1) and both tibia and fibula fracture (Group 2). The smoking status and presence of open fractures were noted. The Radiological Union Scoring System (RUST) was retrospectively evaluated using radiographs at 3rd, 6th, 9th, and 12th months. The SF-36 physical function score and VAS were evaluated at the last follow-up visit.

Results: The mean age of the patients was 41.9 years (18-77). 25 patients (12 stage 1, 8 stage 2 and 5 stage 3) had open fractures. When the RUST scores were evaluated, a statistically higher rate of union was observed in group 2 than in group 1 at the 3rd, 6th, 9th and 12th months. While union was seen in the 6th month radiographs in group 2, it was seen in the 12th month in group 1. Smoking and open fractures significantly decreased RUST scores at 6th month. However, there was no difference in RUST scores at the 12th month. In addition, there was no significant difference in the SF-36 physical function score or VAS between the two groups at the last follow-up.

Öz

Amaç: İntramedüller çivi ile tedavi edilen izole tibia ve krus çift kırıklarının radyolojik kaynama skorlama sistemi (RUST) skorları, kaynama durumu ve fonksiyonel sonuçlarının karşılaştırılması.

Gereç ve Yöntem: Ocak 2015 ile Aralık 2020 tarihleri arasında tibia diyafiz kırığı tanısı alan ve intramedüller çivileme ile tedavi edilen 205 hastanın kayıtları incelendi ve 74 hasta çalışmaya dahil edildi. İzole tibia kırığı (Grup 1) ve krus çift kırık (Grup 2) olmak üzere hastalar 2 gruba ayrıldı. Sigara içme durumu ve açık kırık olup olmadığı bilgileri not edildi. Radyolojik Kaynama Skorlama Sistemi (RUST) 3., 6., 9. ve 12. aylardaki grafilerle retrospektif olarak değerlendirildi. Son kontrollerinde SF-36 fiziksel fonksiyon skoru ve VAS değerlendirildi.

Bulgular: Hastaların ortalama yaşı 41,9 (18-77) idi. 25 hastada (12 evre 1, 8 evre 2 ve 5 evre 3) açık kırık mevcuttu. RUST puanları değerlendirildiğinde Grup 2'de Grup 1'e göre 3., 6., 9. ve 12. aylarda istatistik olarak daha yüksek oranda kaynama görüldü. Kaynama Grup 2'de ortalama 6. ay grafilerinde görülürken Grup 1'de 12. ayda görülmüştür. Sigara içmek ve açık kırık olması 6. ay RUST skorlarını anlamlı olarak düşürmüştür. Ancak 12. ay RUST skorlarında fark izlenmemiştir. Ayrıca son kontrollerinde her iki grup arasında SF-36 fiziksel fonksiyon skoru ve VAS arasında anlamlı fark belirlenmemiştir.

Sonuç: İzole tibia kırıklarında krus çift kırıklarına göre radyolojik olarak kaynama daha yavaş olmakla birlikte 12. ayda her iki grupta da kaynama

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Conclusion: Although radiological union is slower in isolated tibial fractures than in both tibia and fibula fractures, union can be achieved in both groups at the 12th month. A similar phenomenon was observed in smokers and open fractures. Especially in isolated tibial fractures, smokers and patients with open fractures; it is advisable to wait for this period before performing additional procedures.

Keywords Both tibia and fibula fracture · intramedullary nailing · union, nonunion · Radiographic Union Scale in Tibial (RUST) Fractures · isolated tibia fracture

sağlanabilmektedir. Sigara kullananlarda ve açık kırıklarda da benzer bir durum gözlenmektedir. Özellikle izole tibia kırıklarında, sigara içen hastalarda ve açık kırıklarda ek işlem için bu süreyi beklemek faydalı olacaktır.

Anahtar Kelimeler Hem tibia hem de fibula kırığı · intramedullar çivileme · kaynama · kaynamama · radyolojik kaynama skorlama sistemi · izole tibia kırığı

INTRODUCTION

Tibial shaft fractures are the most frequently treated long bone fractures through surgical intervention, with intramedullary nailing being the preferred treatment method treatment. (1). In 22% of tibial shaft fractures, the fibula on the fracture side remains intact (2). Tibial union in osteosynthesis with intramedullary nailing depends on cortical contact. (3-5) Thus, it has been theorized that an intact or surgically stabilized fibula reduces axial loading, that is, compression forces, on the tibial fractures, which may be detrimental to the healing of tibial fracture (6). Therefore, it is theoretically thought to cause nonunion (7, 8). Surgical fibular stabilization for treating both tibia and fibula fractures is still controversial and indications change based on the tibia and fibula fracture pattern and soft tissue condition (7-12). Some authors have argued that fibular fixation provides length and prevents malalignment, especially in distal 1/3 tibial fractures (4). Some authors have supported the view that it increases nonunion by decreasing compression forces (13). This study aimed to perform a comparative analysis of the union times and functional scoring of both tibia and fibula fractures and isolated tibial fractures treated with intramedullary nailing.

MATERIALS AND METHODS

Patients aged 18 years and above diagnosed with tibial diaphyseal fractures or both tibia and fibula fractures treated with intramedullary nailing at a single Level 1 trauma center between January 2015 and December 2020 were included. Both open and closed fractures were considered, provided that no open reduction was performed. A total of 205 patients were included in the study. Patients with incomplete or missing medical records or imaging data were excluded. The initial reduction quality was assessed, and patients with more than 10°of angulation, more than 5 mm displacement between the major fracture fragments, or more than 5 mm gap between the major fracture fragments in anteroposterior or lateral direct radiographic views were excluded to ensure uniform conditions for fracture healing. Patients with pathological fractures due to malignancy were excluded. Polytrauma patients with multiple long bone injuries requiring prolonged ICU admission, individuals with severe pre-existing bone diseases (osteogenesis imperfecta, rickets, etc.), or those who underwent external fixation before intramedullary nailing were also excluded. Patients without adequate soft tissue coverage or severe pre-existing deformities were also excluded. Patients with non-traumatic tibial fractures (e.g., stress fractures), neurological disorders affecting limb function, or prior fractures or surgeries on the same tibia were excluded. Patients with a history of systemic infections, inflammatory diseases, or experimental treatments were also excluded. Finally, patients who withdrew their consent or declined to participate in the retrospective analysis were excluded. After a thorough selection process based on our exclusion criteria, 74 patients were included in this study.

A unified surgical team, including at least one attending orthopedic surgeon for each procedure, performed all surgical interventions. The surgical procedure included reaming and the use of an intramedullary nail size that would fill the intramedullary cavity in a press-fit manner. All surgeries were performed using closed reduction, and open reduction was not preferred.

Patients were divided into two groups: isolated tibia fracture (Group 1) and both tibia and fibula fracture (Group 2). Information on smoking and open fractures was also noted. The radiographic union score for tibial (RUST) fractures was evaluated retrospectively at the 3rd, 6th, 9th, and 12th months. RUST is a validated scoring system that assesses the healing of fractures on anterior-posterior and lateral radiographs by assigning scores to each of the four cortices (anterior, posterior, medial and lateral) from 1 to 3 based on the presence of callus and the visibility of the fracture line, resulting in a total score that ranges from 4 (indicating no healing) to 12 (indicating complete healing) (14). SF-36 and VAS scores were evaluated at the last follow-up visit.

Radiological assessments were performed by a single orthopedic surgeon. *SF-36, VAS* and *Lysholm scores* were also evaluated by the same orthopedic surgeon at the last follow-up visit. No blinding procedure was performed.

Statistical analyses were performed using the SPSS version 22.0 software. The conformity of the variables to a normal

distribution was tested using the Kolmogorov-Smirnov method. Student's t-test was used to compare the RUST scores between the groups. Pearson's correlation analysis was used to evaluate the relationship between age and RUST scores. Linear regression analysis was used to examine the effectiveness of the variables on the RUST score at the 6th month.

Institutional Review Board and the İstanbul Faculty of Medicine Clinical Research Ethics Committee approval was obtained for this retrospective study (Date: 27.12.2024, No: 25). This study was conducted in accordance with the latest version of the Declaration of Helsinki of the World Medical Association and the recently published Good Clinical Practice Guidelines of the Republic of Türkiye Ministry of Health. All participants were adequately informed about the study, and informed consent was obtained from them.

RESULTS

The mean age of the patients was 41.9 (18-77). Group 1 consisted of 2 crush injuries, 28 motor vehicle accidents (MVAs), 16 falls, 5 gunshot injuries, and 2 sports injuries. Group 2 comprised 13 MVAs, 5 falls, and 3 gunshot injuries. Our analysis showed that the proportions of injury types (e.g., gunshot injuries, falls, and MVAs) were similarly distributed in Groups 1 and 2. There were open fractures in 25 patients (12 grade 1, 8 grade 2, and 5 grade 3). When the RUST scores were evaluated, a statistically higher rate of union was observed in Group 2 than in Group 1 at the 3rd, 6th, 9th and 12th months. While union was seen on average at 6th month radiographs in Group 2, it was seen at 12th month in Group 1. Smoking and open fractures significantly decreased RUST scores at 6th month. However, no difference was observed in the 12th month RUST scores. In addition, there was no significant difference between the SF-36 physical function scores and VAS scores between the two groups at the final follow-up (Table 1).

In the 3rd month RUST comparison of Groups 1 and 2, it was observed that RUST was higher in Group 2 (8.3±1.1) than in Group 1 (6.2±1.2) (p<0.001). RUST 3rd month scores were higher in Group 2 (9.7±1.2) than in Group 1 (7.6±0.8) (p<0.001). RUST 9th month scores were higher in Group 2 (11.1±1.7) than in Group 1 (8.4±0.9) (p<0.001). RUST 12th month scores were higher in Group 2 (11.5±0.9) than in Group 1 (10.2±0.9) (p<0.001).

When statistically compared according to the Lysholm and VAS scores, no significant differences were observed between the groups (p=0.9, p=0.5).

When we compared the RUST scores between the smoking and non-smoking groups, no significant difference was found at 3rd, 9th and 12th months (p=0.2, p=0.5, p=0.07, respectively). However, at the 6th month, the RUST scores were higher in the non-smoking group (9.5±1.5) than in the smoking group (8.6±1.4).

Table 1. Demographic and quality-of-life results of the patients in Groups 1 and 2

	Group 1		Group 2	
	Mean±SD	**Range**	**Mean±SD**	**Range**
Age (year)	42.4±12.8	11-72	38.5±16.2	20-77
Gender (Female/Male)	16/37		8/13	
Smoking (Yes/no)	24/29		8/13	
Open fracture (Yes/no)	18/35		7/14	
Side (Right/left)	29/24		9/12	
RUST at 3rd month	8.3±1.1	5-11	6.2±1.2	5-9
RUST at 6th month	9.7±1.2	6-12	7.6±0.8	6-11
RUST at 9th month	11.1±1.7	8-12	8.4±0.9	10-12
RUST at 12th month	11.5±0.9	8-12	10.2±0.9	12-12
SF-36 (PCS)	49.5±3.17	40-56.2	49.3±2.6	43.7-53.7
SF-36 (MCS)	55.2±4.98	45-67	54.7±3.6	48-61
Lysholm score	75.41±13.02	41-100	75.71±12.53	50-99
VAS Score	2.52±1.35	0-7	2.28±1.38	1-7

SD: Standard deviation, RUST: The radiographic union scale in tibial fractures, SF-36: Short form-36, VAS: Visual Analogue Scale, PCS: Physical Component Summary, MCS: Mental Component Summary

When RUST scores were compared between open and closed fractures, no significant difference was observed at RUST 3rd, 9th and 12th months (p=0.6, p=0.6, p=0.2, respectively). However, there was a statistically significant difference between the RUST 6th month scores between the open and closed groups (p=0.02), and the RUST 6th month scores of the closed group (9.4±1.4) were higher than those of the open group (8.6±1.6).

In the comparison analysis of RUST scores according to gender, no significant difference was found at 3rd, 6th, 9th and 12th months (p=0.9, p=0.5, p=0.3, p=0.6, respectively).

Pearson correlation analysis for the relationship between age and RUST scores showed no significant difference at 3rd, 6th, 9th and 12th months (p=0.4, p=0.7, p=0.5, p=0.7, p=0.5, and p=0.7, respectively).

When we looked at the factors associated with the RUST 6th month score, it was seen that being isolated tibia versus tibia-fibula fracture, being open versus closed fracture and smoking status were related. Regression analysis was then performed to evaluate the effects of these variables on the RUST 6th

month scores. According to the results of the linear regression analysis, all these variables had an effect on the RUST 6th month score, but the most significant effect was the single versus double fracture (β= 0.680, p<0.001) (Table 2).

Table 2. Comparison of the RUST scores of the specific subgroups

		RUST			
Period		**3rd month**	**6th month**	**9th month**	**12th month**
Total	Group 1	8.24±1.23	9.87±1.21	10.9±1.3	11.34±1.1
	Group 2	7.5±1.5	9.2±1.2	8.4±0.9	10.2±0.9
	p value	<0.001	<0.001	<0.001	<0.001
Smoking	Yes	7.46±1.5	8.6±1.4	10.1±2.2	10.8±1.3
	No	7.9±1.3	9.5±1.5	10.4±1.6	11.33±0.7
	p value	0.2	0.01	0.5	0.07
Open fracture	Yes	7.2±1.5	8.6±1.6	9.7±1.7	10.8±1.3
	No	7.9±1.3	9.4±1.4	10.5±1.9	11.2±0.9
	p value	0.6	0.02	0.6	0.2
Gender	Female	7.7±1.3	9.2±1.4	10±1.5	11.2±0.9
	Male	7.7±1.5	9±1.5	10.4±2	11±1.1
	p value	0.9	0.5	0.3	0.6

SD: Standart deviation, RUST: The radiographic union scale in tibial (RUST) fractures, SF-36: Short form-36, VAS: Visual Analogue Scale, PCS: Physical Component Summary, MCS: Mental Component Summary

DISCUSSION

This study showed that isolated tibial fractures show the occurrence of union later than both tibia and fibula fractures. However, there was no statistical difference in union at the 12th month in either group. High-energy injuries were observed in 80% of the patients.

Balaji et al. compared fibula intact fibula fractures regarding the open or closed nature of the fractures and found no difference in union between the two groups (7). In our study, we also evaluated the fractures regarding the open and closed nature of the fractures, and there was no difference between the open and closed groups. In a study by Githens et al., the effect of fibular fixation on tibial union in both tibia and fibula fractures was evaluated and it was shown that fibular fixation was not associated with nonunion (8). In our study, fixation was established using IM K-wires of adequate size to provide fibular length in four patients. There was no difference in terms of union at 12th month, but we observed that union was delayed compared to the both tibia and fibula fractures without the fixation in terms of the timing of union. However, we need a larger series because the number of patients is insufficient.

O'Hallaran et al. has analyzed certain variables thought to predict nonunion during tibial IM nailing in their recent retrospective study (4). By performing a multivariate logistic regression model, they found that certain variables were significantly associated with tibial nonunion. One of those variables, fibular fixation, was found to be significantly associated with nonunion (p=0.02), but since there were only 13 out of 382 patients treated with fibular fixation in their cohort, this was not included in their model. Their results coincide with those of our study; however, we must reiterate that a larger series is needed.

Meister et al. investigated the impact of bone grafting on the surgical treatment of delayed unions and nonunions of the tibia and found that the average time from injury to surgery was 10.9 months (15). In our study, while union was seen on average at the 6th month radiographs in isolated tibia fractures, it was seen in both tibia and fibula fractures at the 12th month. When we consider that the union time was significantly longer in the both tibia and fibula fracture group, we may need to consider the reoperation time for delayed unions and nonunions, especially in both tibia and fibula fractures.

Leow et al. showed that the RUST score is reliable and reproducible for evaluation (14). We also used the RUST score. In a study by Carter et al. in a series of 45 patients with intact fibula tibia fractures, 12 varus malunion and 1 delayed union were reported (6). When we compared this with our study, no patient with nonunion was found.

There are some limitations to this study. The retrospective nature of the analysis may have led to selection bias. The relatively limited number of patients, especially in subgroup assessments, may have affected the statistical power. Radiological assessments were conducted by a single evaluator, which may limit the generalizability of the findings. Additionally, functional outcomes were measured only at the final follow-up, without baseline or longitudinal comparisons..

CONCLUSION

Although union is radiologically slower to occur in isolated tibial fractures than in both tibia and fibula fractures, union can be achieved in both groups at the 12th month. A similar phenomenon was observed in smokers and patients with open fractures. Therefore, this study suggests that, especially in isolated tibia fractures, it might be beneficial to wait for this extended time before an additional procedure particularly in patients who smoke and have open fractures. Further prospective randomized controlled studies are needed to better investigate this phenomenon, which may contribute to our clinical practice by enabling us to provide better treatment for these fractures.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of İstanbul Faculty of Medicine Clinical Research Ethics Committee (Date: 27.12.2024, No: 25).

Informed Consent: Consent was obtained from all participants who participated in the study.

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