ORIGINAL ARTICLE

A novel reduction support frame for management of unstable tibial fractures with intramedullary nail: Preliminary report

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ABSTRACT

BACKGROUND: Management of unstable tibial fractures (UTF) can be challenging due to widening of the proximal and distal metaphyseal zone, soft tissue problems, and poor vascularity. We aimed to compare the effect of novel tibial orthopedic reduction support (TORS) frame constructed by re-used tubular external fixator systems and manual traction with regard to the quality of reduction, and fracture healing.

METHODS: A total of 65 patients who were admitted with UTF and underwent intramedullary nailing were assessed; 43 patients underwent manual traction technique, and 22 patients underwent TORS technique. The sagittal and coronal plane angulations were evaluated in initial postoperative radiographs, and radiologic union scores for tibial fractures (RUST) were compared at follow-up X-rays.

RESULTS: The mean age of patients was 43.49±19.09 years in the manual-traction group and 43.41±16.8 years in the TORS group. The mean coronal plane angulation was 1.84±3.16 in the manual traction group and 1.86±4.21 in the TORS group. The mean sagittal plane angulation was 1.19±1.93 in manual traction group and 0.32±0.65 in the TORS group. The number of coronal and sagittal plane angulations >5° was higher in manual traction group than TORS group. The mean RUST was significantly higher in the TORS group than in the manual traction group at 6th, 9th, and 12th-month controls. The union rates were also higher in the TORS group at 9th and 12th-month controls.

CONCLUSION: TORS frame is a simple and cheap technique and should be considered as reduction support in the management of UTF by intramedullary nailing.

Keywords: Intramedullary nailing; reduction device; reduction frame; tibial fractures.

INTRODUCTION

Management of unstable tibial shaft fractures (UTF) can be challenging due to widening of the proximal and distal metaphyseal zone,[1] soft-tissue problems, and poor vascularity.[2] Intramedullary nailing (IMN) is the gold-standard treatment for the management of UTF.[3] An accurate reduction is mandatory for particularly long bone fractures of the lower extremity before fracture fixation. Anatomical reduction of tibial fractures prevents eccentric reaming of one cortex, which cause loss of reduction during rimerization and insertion of the nail.[4] In addition, improvement in the reduction of tibia can prevent delayed and non-union by reducing the fracture gap, allow earlier weight-bearing and improve the cosmetic appearance of the extremity.[5–7]

Reduction techniques of manual traction, sustained traction using a fracture table, assisting devices as temporary distrac-

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tors, reduction clamps, and unilateral external fixators are reported to be effective for achieving an accurate reduction and maintaining reduction during the rimerization of medullary canal and insertion of proximal and distal locking screws of the intramedullary system.[4,8–12] However, all these techniques and devices have some drawbacks. Manual traction usually requires more assistants where temporary distractor, reduction clamps, fracture table, and unilateral external fixators are invasive techniques which usually prolong surgical time and impair obtaining intraoperative C-arm images.[4,8–13] Thus, an ideal reduction technique and device should aim to maximize the surgeons' control of the unstable fragments, interfere minimally with, and help to achieve reduction with the support of a minimum number of residents.

We hypothesized that reducing a tibial fracture and maintaining the reduction throughout the intramedullary nailing procedure with this pre-constructed frame enhances reduction quality of UTF, reduces required number of assistant and staff and augments fracture healing. It also needs to be cost-effective, easy to be modified for each patient and applied in a short time. For this purpose, we designed a frame constructed by pre-used clamps and carbon fiber rods of tubular external fixator system to help reduction and resist loss of reduction during rimerization, insertion of intramedullary nail, and insertion of locking screws. We named this frame "tibial orthopedic reduction support frame (TORS frame)."

In this study, we aimed to compare the effect of TORS frame constructed by re-used tubular external fixator systems and manual traction with regard to the quality of reduction, maintenance of reduction, and fracture healing.

MATERIALS AND METHODS

This retrospective study was approved by the Local Ethics Committee (29.04.2020, approval no: 2020.04.05). The study was conducted in accordance with the principles of the Declaration of Helsinki. Of the 272 patients who admitted to our clinic with UTF between March 2017 and March 2019, 65 patients with UTF treated by intramedullary nailing were included in this study. Manual traction technique was applied for 43 patients between March 2017 and March 2018 who formed the manual traction group. TORS frame was used for 22 patients since March 2018 to March 2019. The post hoc analysis of our study was performed with the difference between two independent means test. When the effect size was calculated as 1.67 (8.32±1.93; Group 1 and 11.1±1.34; and Group 2, RUST at the 12th month), manual traction group (n=43), TORS group (n=22) with an alpha margin of error of 0.05; the power of the study was found as 99.9%. Patients with open fractures, tibial plateau fractures with an intra-articular extension, pathological fractures, intra-articular pilon fractures, and inadequate or absent radiographic data were excluded from the study. Demographic data of patients such as age, sex, side of injury, and mechanism of injury were obtained from the ENLIL system (ENLIL hospital management system, version v2.19.46 20191118). Type of anesthesia and number of orthopedic expert surgeon and assistants who contributed to surgery were collected from patients' records of the anesthesia department. AO/OTA classification[14] and coronal (varus-valgus) and sagittal (anteroposterior) alignments were evaluated from pre and initial postoperative radiographs of the injured side in anteroposterior and lateral views. Angulation more than 5° in any plane was accepted as malalignment according to criteria described by Freedman and Johnson.[15] Union was evaluated by radiologic union score for tibial fractures (RUST) at 6 weeks and 3, 6, 9, and 12 months of follow-up radiographs.[16] Radiographic cortical bridging by callus and the lack of a fracture line was accepted as the most reliable signs of bone healing. All radiological measurements were determined by a single observer blinded to the type of technique used.

Surgical Techniques

In the manual traction group, the patient was positioned supine on an operating table with a radiolucent table extension. The entire affected extremity was then prepared and draped in a sterile fashion. The opposite leg was simply left lying on the table under the drapes, or, if contralateral injuries required operative intervention, it was prepared and draped simultaneously. The C-arm was placed on the opposite side of the tibial injury. Usually, a bolster of cover pack or gown

Figure 1. Standard table positioning for manual traction technique. The leg is free draped. The thigh is placed over a bolster of cover pack to facilitate knee flexion for intramedullary nailing.

pack was placed under the thigh to aid in the manual traction technique (Fig. 1).

The TORS frame consists of a tibial tray and base. Two 450 mm, five 300 mm, and one 200 mm long, 11 mm diameter radiolucent carbon fiber rods, and 14 rod-to-rod clamps of re-used external fixators were used for the installation of the device (Fig. 2a and b). The tibial tray contains clamps on each side in the middle for stability, and at the top for the setting of height. The clamps at the top loosen by turning the nuts, allowing the height of the tibial tray to be set according to patients' tibial height intraoperatively (Fig. 2b). The base prevents uncontrolled movement of the tibial tray. TORS have a removable anterior support (hammock mechanism) which is made from re-used operating table cover by hospital tailor to hold the tibia in a straight line in maintaining the reduction (Fig. 2c). This anterior support can be removed intraoperatively to allow more knee flexion if necessary. All part of TORS frame can be disassembled and reinstalled. In addition, it is proper for any kind of antisepsis and sterilization methods, either in constructor or disassembled form.

In the TORS group, patients were positioned supine on a radiolucent trauma table. The ipsilateral limb was prepared in the usual sterile fashion. The opposite leg was simply left lying on the trauma table under the drapes, or, if contralateral injuries required operative intervention, it was prepared and draped simultaneously. The frame which has been set up before the surgery was placed under the popliteal region. Typically, the tibial tray length was adjusted according to the patient's leg length. TORS frame allows full extension and 125° flexion of knee intraoperatively. The affected tibia simply lied straight on the anterior support of the TORS, and the reduction was achieved with the force of gravity and simple manipulations by an assistant (Fig. 3a). Additional traction was applied manually to achieve and maintain reduction and length when the force of gravity is inadequate. Moreover, rotational alignment and fine-tuning of varus/valgus alignment were adjusted by the assistant holding the fracture's distal part. Alignment and rotation of the tibia were generally planned according to the tibial crest and first webspace, and the reduction was confirmed with intraoperative fluoroscopy. The C-arm was placed on the opposite side of the tibial injury to easily obtain the orthogonal views (Fig. 3b and c). All staff moved safe distance from C-arm tube during fluoroscopic imaging of reduction while nail insertion and checking distance of distal end point of nail to the distal tibial joint. TORS frame offers a huge convenience for intraoperative imaging because it was made of a radiolucent material, and the frame was localized out of the fluoroscopic field. The images were obtained during guide-wire insertion, rimerization, and placing the nail after reduction without any need for movement of the leg. Tibial intramedullary nailing was performed in a standard manner as previously described.[17,18]

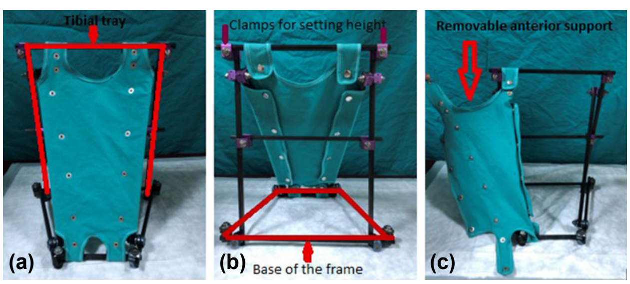

Figure 2. Tibial orthopedic reduction support frame. **(a)** Anterior view. **(b)** Posterior view. **(c)** Removable anterior support (Hammock mechanism).

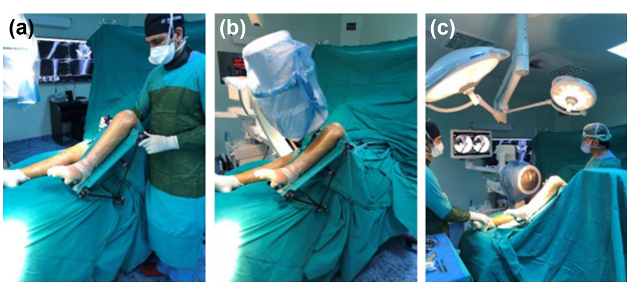

Figure 3. TORS frame positioning on operating table for intramedullary nailing of the tibia. The opposite leg is simply lying on the operating table. **(a)** The hip and knee flexed, force of gravity used for traction, and hammock mechanism for maintaining the reduction. **(b and c)** The C-arm positioning for the anteroposterior and lateral orthogonal views, respectively.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) for Windows 25.0 (IBM SPSS Inc., Chicago, IL). The variables were examined using visual (histogram and probability plots) and analytical methods (Shapiro-Wilk's test) to determine whether they were normally distributed. Descriptive analyses are presented as percentiles using median and minimum-maximum values (median [min-max]) for variables that are not normally distributed. The Mann–Whitney U-test was used for comparative analysis between the two groups for non-normally distributed variables. Fisher's exact test was used to compare the analysis of categorical variables between independent groups. The results were accepted as a 95% confidence interval. $P<0.05$ was considered to show a statistically significant difference.

RESULTS

A total of 65 patients who suffered from UTF, treated with IMN were assessed; 43 patients who underwent manual traction, and 22 patients who underwent the TORS technique. The mean age of the patients included in the study was 43.49±19.09 years in the manual traction group and 43.41±16.8 years in the TORS technique group. In total, 46 patients were classified as AO type 42A, 9 were AO type 42B, and 10 were AO type 42C. The majority of patients underwent spinal and epidural anesthesia. In the majority of patients in both groups, the mechanism of injury was motor vehicle accidents. Right-sided tibia fractures were more common than left-sided fractures. The manual traction technique was performed by one expert surgeon and two assistants, while TORS technique was performed by one expert surgeon and one assistant. The distribution of demographic characteristics of patients is summarized by groups in Table 1.

At the initial post-operative radiographs, the mean coronal angulation was 1.84±3.16 in manual traction group, 1.86±4.21 in TORS group. There was a patient with an 18° of valgus angulation in manual traction group and one patient with 20° of valgus angulation in the TORS group. There was no statistically significant difference between groups in coronal angulation (p=0.723). The number of patients with coronal (n=23; manual traction group, n=11; TORS group) and sagittal (n=21; manual traction group, n=5; TORS group) deformities was higher in manual traction group than TORS group. However, there was no significant difference between groups regarding number of coronal and sagittal plane deformities (p=0.1.000, p=0.628, respectively). There were eight patients who had coronal deformity >5°, six in manual traction group, and two in the TORS group without statistically significant distance (2 out of 22=9% vs. 6 out of 43=13.9%, p=0.706). There were four patients who had sagittal deformity >5° in manual traction group; where, sagittal deformity was not observed in any patient in the TORS group. However, there was no significant difference between groups with regard to number of patients who had sagittal deformity >5° (p=0.291). The mean angulation in sagittal plane was significantly higher in the manual traction group (1.19±1.93) than in the TORS group (0.32±0.65) (p=0.033). There was no shortening and rotational deformity on clinical measurements in both groups. The details of coronal and sagittal deformities are summarized in Table 2.

Table 1. Distribution of patient characteristics by surgical technique

	Manuel traction (n=43)	TORS technique (n=22)
Sex, n (%)		
Male	38 (76)	12 (24)
Female	5 (33.3)	10 (66.7)
Age,		
Mean±SD	43.49±19.09	43.41±16.8
Median (min–max)	37 (19–90)	42.5 (18–76)
Type of anesthesia, n (%)		
Combine spinal and epidural	27 (64.3)	15 (35.7)
General anesthesia	16 (72.7)	6 (27.3)
Sciatica block	0 (0)	1 (100)
Injury mechanism, n (%)		
Battered	3 (100)	0 (0)
Crush injury	2 (50)	2 (50)
Fall from high	7 (70)	3 (30)
Fall from standing height	3 (50)	3 (50)
Industrial injury	5 (71.4)	2 (28.6)
Motor vehicle accident (in vehicle)	6 (66.7)	3 (33.3)
Motor vehicle accident (out vehicle)	9 (64.3)	5 (35.7)
Motorcycle accident	7 (70)	3 (30)
Sports injury	1 (100)	0 (0)
Stress fracture	0 (0)	1 (100)
Side, n (%)		
Right	23 (69.7)	10 (30.3)
Left	20 (62.5)	12 (37.5)
AO classification, n (%)		
42A	27 (58.7)	19 (41.3)
42B	9 (100)	0 (0)
42C	7 (70.0)	3 (30)

TORS: Tibial orthopedic reduction support; SD: Standard deviation.

Table 2. Malalignment by surgical technique

	Manuel traction (n=43)	TORS technique (n=22)	p-value
Coronal (varus/valgus) angulation			
Mean±SD	1.84±3.16	1.86±4.21	0.906^{2}
Median (min–max)	1 (0–18)	0.5 (0–20)	
Sagittal (anteroposterior) angulation			
Mean±SD	1.19±1.93	0.32±0.65	0.033^{2}
Median (min–max)	0 (0–8)	0 (0–2)	
No. Coronal deformities, n (%)			
Valgus	20 (66.7)	10 (33.3)	1.000^{1}
Varus	3 (75)	1 (25)	
No. Sagittal deformities, n (%)			
Procurvatum	8 (88.9)	1 (11.1)	0.628^{1}
Recurvatum	13 (76.5)	4 (23.5)	
No. Coronal deformities >5°, n (%)			
Malalignment (>5°)	6 (75)	2 (25)	0.706^{1}
Acceptable aligned (<5°)	37 (64.9)	20 (35.1)	
No. Sagittal deformities >5°, n (%)			
Malalignment (>5°)	4 (100)	0 (0)	0.241^{1}
Acceptable aligned (<5°)	39 (63.9)	22 (36.1)	

^{1}Fisher's exact test, ^{2}Mann-Whitney U test. TORS: Tibial orthopedic reduction support; SD: Standard deviation.

The mean RUST was similar at the 6th week (4.65±1.27 in manual traction group, 4.77±1.38 in TORS group) and 3rd month (5.77±1.81 in manual traction group, 6.5±1.74 in TORS group) controls in both groups (p=0.736, p=0.093, respectively). However, it was significantly higher in TORS group than manual traction group at 6th, 9th, and 12th-month follow-up X-rays (p=0.043, p<0.001, p<0.001, respectively). The details of RUST are summarized in Table 3.

In the 9th-month follow-up, there were ten patients who had non-union, nine in the manual traction group, one in the TORS group (9 out of 43=20.9% vs. 1 out of 22 = 4.5%, p=0.145). All patients who had non-union at 12th-month follow-up underwent revision surgery with an exchange nailing and autograft implantation. The difference in the number of patients with non-union at 9th and 12th-month controls was not statistically significant (p=0.145).

DISCUSSION

Achieving an accurate intraoperative reduction and maintenance of reduction is essential for management of UTF with intramedullary nailing. Original manual traction technique for nail insertion was described by McKee et al.[13] The development of alternative reduction techniques such as pin-assisted traction table,[12] fixator-assisted traction,[19] temporary distractors,[11,20,21] and triangle device[22] was required by both practical and theoretical disadvantages of standard positioning and manual traction on operating table for the performance of intramedullary nailing of the UTF.[20] In the present study, we demonstrated that the frame constructed by re-used external fixator bars and clamps (TORS frame) has similar results compared to manual traction technique in terms of deformity correction. In addition, fracture healing was significantly better than manual traction as shown by higher RUST results.

In the intramedullary nailing of tibial fractures, placing the guidewire in ideal position and the optimal rimerization of the medullary canal before nail insertion are essential in achieving and maintaining the reduction until insertion of the locking screws. In addition, anatomical reduction or near anatomical reduction are mandatory in the tibial fracture union. Dunbar et al.[23] have described a provisional plating technique before nailing which needed additional manual traction for the reduction of the 301 tibial fractures. They reported five (16.7%) non-unions in the study group. In the current study, there were ten patients with non-union, nine (20.9%) in manual traction group, and one (4.5%) in TORS group. We think that this higher union rate of TORS group indicates the effectiveness of the anterior hammock mechanism of the frame. This hammock mechanism (anterior support) avoids the need for repetitive manipulations for reduction, lower additional soft tissue injury and provides maintenance of the reduction during the rimerization of the medullary canal and insertion of the nail. However, more data to guide clinical

Table 3. RUST at each follow-up period by surgical technique

	Manuel traction (n=43)	TORS technique (n=22)	p-value
RUST 6th week			
Mean±SD	4.65±1.27	4.77±1.38	0.736[2]
Median (min–max)	4 (4–9)	4 (4–8)	
Median (IQR)	4 (4–5)	4 (4–5)	
RUST 3rd month			
Mean±SD	5.77±1.81	6.5±1.74	0.093[2]
Median (min–max)	5 (4–10)	7 (4–9)	
Median (IQR)	5 (4–7)	7 (5–8)	
RUST 6th month			
Mean±SD	6.7±2.22	7.73±1.69	0.043[2]
Median (min–max)	7 (4–11)	8 (4–10)	
Median (IQR)	7 (5–8)	8 (7–9)	
RUST 9th month			
Mean±SD	7.19±2.35	9.36±1.65	<0.001[2]
Median (min–max)	7 (4–12)	10 (4–12)	
Median (IQR)	7 (6–9)	10 (8–10)	
RUST 12th month, n=55			
Mean±SD	8.32±1.93	11.1±1.34	<0.001[2]
Median (min–max)	8 (5–12)	12 (8–12)	
Median (IQR)	8 (7–10)	12 (10–12)	

[2]Mann-Whitney U test. TORS: Tibial orthopedic reduction support; RUST: Radiologic union score for tibial fractures; SD: Standard deviation.

practice would have been acquired about union rates, if the study would have been performed with a higher number of patients.

Seyhan et al.[24] described a technique using both gravity and manual traction for the reduction of tibial fracture in which the contralateral leg is held in the lithotomy position, and the ipsilateral leg is flexed at 90° hanging off the operating table. However, they reported exaggerated edema in 12 patients. This complication can be explained by failure of venous circulation. Usually, a venous flow back failure occurs in the fractured extremity due to the trauma. The hanging off the leg may cause an additional deficiency in the venous flow back by the positioning of the leg lower than the heart level. Furthermore, this failure of venous circulation may also cause collection (pool) of blood intra/inter compartmental space and increase hydrostatic pressure, and consequently increase the risk of compartment syndrome. In the TORS technique, we use the force of gravity via the frame for traction like as used by Seyhan et al. The leg is hanged off over the frame; which is still placed over the heart level on the operating table; hence it does not cause an additional venous flow back deficiency. This may explain why an exaggerated edema, or a compartment syndrome was not seen in any patient in our study. In addition, as a further complication, the risk of postoperative infection may increase as a result of hanging off the leg from the operating table, positioning the extremity at the borders of the sterile surgical field. In the TORS technique, the leg is placed in the sterile safe zone on the table to minimize contamination of the surgical field. Another drawback of their technique is limited access to the contralateral limb due to the lithotomy position, which makes the assessment of rotational deformity difficult. However, in our technique, the opposite leg was simply left lying on the trauma table under the drapes allowing comparison of the rotational deformity between two sides. Thus, the TORS group had significantly better postoperative reduction degrees especially in the sagittal plane and had fewer number of patients with malalignment. Although they stated that they do not have any difficulty in imaging of the tibia, it may be difficult to obtain qualified views, especially in determining the proximal insertion point of the nail and placing the proximal locking screws due to the difficulty of positioning of the C-arm and presence of hardware of table in the fluoroscopic field. In the TORS technique, fluoroscopic visualization is optimized because the frame is made of a radiolucent material and it is localized out of the radiographic field to provide high quality images.

The traction table method offers the surgeon to perform the surgery with one assistant and provides excellent consistency of traction through insertion of calcaneal pins.[25,26] However, some pin associated complications in the traction table method, such as frequent oblique insertion of the calcaneal pin what may lead to varus or valgus angulation may occur. The use of a calcaneal pin may cause subtalar encroachment, hemorrhage, and pain at the entry point due to neuroma formation.[25] In addition, using a traction table increases operative time due to the set-up of the table and it limits access to the remainder of the ipsilateral and contralateral lower extremity.[13] This is a significant disadvantage, especially in the poly-trauma patient, which may increase the operative time by requiring repetitive positioning and re-draping. This limited access to the contralateral limb also makes assessment of rotational deformity difficult. The TORS technique avoids invasive procedures. It is performed on a standard trauma table while the traction table method requires the purchase of additional table and accessories. Moreover, the TORS frame can be easily installed and sterilized before the surgery; therefore, it does not cause prolongation in operative time by the feasibility of pre-setting of the frame.

The distraction devices[11,20,21] were described for tibial fractures. The use of the distractors enables surgeons to correct angular deformities and maintain tibial length while eliminating the need for the fracture table.[1,4] However, these distractors also have increased setup time that is typically quoted at around 20 min.[4] They may also cause distraction at the fracture site from excessive traction, generation of high intercompartmental pressures, and have additional invasiveness.[4,11,27–29] In addition, the configuration of the distractor may increase residual angular deformity due to the relatively lower tension force on the opposite side of the distractor. It has been also shown that distraction at the fracture site is poorly tolerated by the tibia and may cause higher delayed union or non-union rates.[27,28] The TORS technique is a non-invasive technique which uses only force of gravity and minimal manipulation in the reduction of tibial fractures. Our results confirm that satisfactory reduction can be achieved by the TORS frame without increasing the risk of complications related to over distraction or pin application.

A tibial triangle device recently has been used for tibial nailing (InnoFromm Triangles, Innomed, Inc, Savannah, GA, USA). This device is limited to four heights: 8.5'', 11'', 14'', and 16''. Its' knee flexion limit is about 70–90°.[22] However, intraoperatively the TORS frame can be adjusted to the individual length of patients' tibia with any limitation by simply loosing a few numbers of nuts. It allows for knee flexion of about 125° (which is theoretically suggested) when required during the reduction, rimerization, and nailing. Another significant disadvantage of this triangle device is that it may not be available worldwide, and it also requires an additional owning cost while TORS can be constructed with cost free re-used tubular external fixators.

The limitations of this study include its retrospective nature, which increases the possibility that some episodes were missed. In addition, the sample size was small, further investigations with larger participants are needed to support the effect of this reduction support in the management of UTF. Finally, the surgery times can be collected in further investigations to compare whether TORS technique has any effect on surgical time.

Conclusion

The TORS frame is an easy to install, simple, safe and cheap technique that can reduce the need for assistant support without sacrificing the quality of reduction and should be considered when treating an unstable tibia fracture by locked intramedullary nailing.

Ethics Committee Approval: This study was approved by the Kırıkkale University Faculty of Medicine Non-Interventional Research Ethics Committee (Date: 29.04.2020, Decision No: 2020/04/05).

Peer-review: Internally peer-reviewed.

Authorship Contributions: Concept: İ.D.C.; Design: İ.D.C., M.C.; Supervision: B.O.; Resource: F.S., B.O.; Materials: M.C.; Data: B.O., F.S.; Analysis: C.B.; Literature search: İ.D.C., M.C.; Writing: İ.D.C., M.C.; Critical revision: İ.D.C., M.C., C.B., B.O., F.S.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Anstabil tibial kırıkların intramedüller çivileme ile tedavisinde yeni redüksiyona yardımcı destek çerçevesi: İlk sonuçlar

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AMAÇ: Anstabil tibial kırıkların yönetimi, proksimal ve distal metafizer bölgenin geniş olması, yumuşak doku problemleri ve zayıf damarlanma nedeniyle zor olabilir. Kullanılmış tübüler eksternal fiksatör sistemleri ile oluşturulan yeni tibial ortopedik redüksiyon desteği (TORS) çerçevesinin redüksiyon ve kırık iyileşmesinin kalitesi açısından etkisini manuel traksiyon tekniği ile karşılaştırmayı amaçladık.
GEREÇ VE YÖNTEM: Anstabil tibial kırık ile başvuran ve intramedüller çivileme yapılan toplam 65 hasta değerlendirildi; 43 hastaya manuel traksiyon tekniği, 22 hastaya TORS tekniği uygulandı. İlk ameliyat sonrası radyografilerde sagital ve koronal düzlem açılanmaları değerlendirildi ve takip röntgenlerinde tibia kırıkları için radyolojik kaynama skorları (RUST) karşılaştırıldı.
BULGULAR: Hastaların ortalama yaşı manuel traksiyon grubunda 43.49±19.09, TORS grubunda 43.41±16.8 yıl idi. Manuel traksiyon grubunda ortalama koronal düzlem açılanması 1.84±3.16, TORS grubunda ise 1.86±4.21 idi. Manuel traksiyon grubunda ortalama sagital düzlem açılanması 1.19±1.93 ve TORS grubunda 0.32±0.65 idi. Manuel traksiyon grubunda koronal ve sagital düzlem açılanması >5° olanların sayısı TORS grubuna göre daha yüksekti. 6., 9. ve 12. ay kontrollerindeki ortalama RUST skorları TORS grubunda manuel traksiyon grubuna göre anlamlı olarak daha yüksekti. 9. ve 12. ay kontrollerinde TORS grubunda kaynama oranları daha yüksekti.
TARTIŞMA: TORS çerçevesi basit ve ucuz bir tekniktir ve stabil olmayan tibial kırıkların intramedüller çivileme ile tedavisinde redüksiyon desteği olarak düşünülmelidir.
Anahtar sözcükler: İntramedüller çivileme; redüksiyon cihazı; redüksiyon çerçevesi; tibia kırıkları.

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