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Research Article

Study of the Healing of Tibial Fractures Treated with Dynamic Intramedullary Nailing

Afshin Sahebjamei[1,*], Habibollah Gorgani-Firoozjah[1], Omid Momen[1], Ozone Davaji Setare[2]

[1] Assistant Professor, Department of Orthopedic Surgery, School of Medicine, Golestan University of Medical Sciences, Gorgan, Iran
[2] Medical Student, School of Medicine, Golestan University of Medical Sciences, Gorgan, Iran

[*]Corresponding author: Afshin Sahebjamei; Department of Orthopedic Surgery, School of Medicine, Golestan University of Medical Sciences, Gorgan, Iran. Tel: +98-9155089335 Email: sahebjameiafshin@yahoo.com

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Abstract

Background: Dynamic nailing by placing only one screw on one side of the nail shortens the surgical time and reduces the complications during surgery and secondary dynamization. This study aimed to investigate the healing of dynamic intramedullary nailing (IMN) of tibial fractures.
Methods: This cross-sectional study was done on 67 patients with dynamic IMN in 5th Azar Hospital, Gorgan, Iran, in 2015-2018. Complications, union time, Radiographic Union Score of Tibia Fracture (RUST) score, and Johner-Wruhs criteria were analyzed based on their grouping in AO classification.
Results: The average age of the patients was 33.2 ± 13.0 years. Most of the fractures were closed type (71.6%), type C (43.4%). The mean healing time was 14.62 ± 4.38 weeks and RUST score was 8.90 ± 1.26. There was no significant difference between locations of fracture and the healing time or RUST score ($P > 0.05$). The healing time in the comminuted fractures (e.g., type C) and open tibial fractures was statistically longer than the simpler type (e.g., type A or B) and the mean radiological score in type C fractures was significantly lower ($P < 0.05$). The mean Johner-Wruhs criteria score of fractures was 46.31 ± 4.49, so that 61 patients had excellent results, four patients had good results, and two patients had fair results.
Conclusion: Dynamic IMN of closed and middle third tibial fractures and simpler types of fractures (e.g., type A or B) have faster healing. Nevertheless, it is better to be more cautious for fixation of open or comminuted fracture (e.g., type C).

Keywords: Fracture Healing; Fracture Fixation; Intramedullary Nailing; Leg; Tibial Fractures

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Background

Leg fracture is the most common fracture of long bones (36.7%). Annually, for every 100000 people, 26 people suffer tibia fractures. Its prevalence is three times higher in men than in women (1-3).

Theoretically, the use of dynamic intramedullary nailing (IMN) by placing a screw on one side of the nail (whichever is closer to the fracture site) does not have the complexity of static IMN and causes more contact between the fracture fragments during weight bearing and more periosteal callus formation and reduction of union time (4-6). On the other hand, in this method, the incisional length, operation time, the union time, exposure to C-arm radiation, and reoperation for secondary dynamization are less, but there is a fear of rotational instability and malalignment during follow-up. Therefore, although static IMN is the preferred method for leg fractures, we decided to examine the clinical and radiographic results of the treatment of leg fractures with dynamic IMN (7, 8).

Methods

This cross-sectional study was done by collecting information from the files of patients admitted to 5th Azar Hospital in Gorgan, Iran, between 2015 and 2018 who were treated with dynamic IMN due to tibia fractures. The intramedullary nails used were from Pooyandegan Pezeshki Pardis Company, Gorgan. In this study, those under 18 years of age, fractures involving the knee or ankle joints, cases admitted to intensive care unit (ICU), pathological fractures, or patients who had IMN after ten days of the injury were excluded from the study. Only patients who had a locking screw in distal or proximal of nail were included. This screw was placed in the place closest to the fracture. Patients with a history of congenital, neuromuscular, or rheumatology diseases were excluded from the study. The patients entered the study voluntarily by giving their informed form of consent. Demographic, radiographic, and complications information was recorded and collected in a checklist.

In this study, non-union was defined as the failure of the union process after 6 months. During the examination, limb shortening of more than one centimeter, more than 15 degrees, varus-valgus deformity, and rotation changes of more than ten degrees compared to the opposite side were defined as malunion. Healing was defined as rigidity and no pain, tenderness at the fracture site, or the ability to walk without pain and without the help of a cane, or the appearance of bridging callus in three cortexes (radiological healing) (9, 10).

Johner-Wruhs criteria were used in the last follow-up to evaluate the clinical outcome of the patients. These criteria assess pain, mobility of joints, deformity, walking, and complications such as non-union and vascular disorder in 12 items, each of which gets four points. In this method, patients get 12 to 48 points and are placed in Excellent-Good (36-48), Good-Fair (24-36), and Fair-Poor (12-24) groups (11).

Like Whelan study, Radiographic Union Score of Tibia Fracture (RUST) scoring is based on the presence or absence of bridging callus and the visibility or non-

visibility of the fracture line for each level (anterior, posterior, lateral, and medial) of the fracture (2). In this method, the absence of a callus gets one point, a callus with a visible broken line gets two points, and a callus without a visible broken line gets three points. From the total points for each level, the final RUST score is calculated. In this scoring method, the minimum score is four points, which means no healing, and the maximum score is 12, which means union or complete healing. Moreover, if the score is more than seven, it means that there are at least bridging calluses, which is considered as radiological fracture healing.

The protocol of this study was approved by the Ethics Committee of the Golestan University of Medical Sciences, Gorgan, under the code of IR.GOUM.REC.1398.217.

The collected data were analyzed using SPSS software (version 16, SPSS Inc., Chicago, IL, USA). Quantitative data were expressed as mean and standard deviation (SD), and qualitative data as frequency and percentage. To compare the means in two groups, independent t-test was used, and to compare before and after paired t-test, and if normality was not established, equivalent non-parametric tests, Mann-Whitney and Wilcoxon, were used. $P < 0.05$ was significance level.

Results

This study was conducted on 67 patients with tibial fracture treated by IMN method in the 5th Azar Hospital in Gorgan in 2015-2018. The average age of the patients was 33.20 ± 13.03 (18-61) years. 85.1% (57 people) of the patients were men and the rest were women. In other words, the male to female ratio in this study was 5:1.

The most common injury mechanism was accidents in 94% (63 people) and in the next category was falling from a height in 6% (three people). Fractures were mostly located in the middle (59.7%), distal (28.4%), and proximal (11.9%) thirds, respectively (Table 1).

Table 1. Location and type of leg fractures

Location of fracture	Fracture type*	n (%)
Proximal third of leg (n = 8)	A	3 (37.5)
	B	1 (12.5)
	C	4 (50.0)
Middle third of leg (n = 40)	A	16 (40.0)
	B	8 (20.0)
	C	16 (40.0)
Distal third of leg (n = 19)	A	8 (42.1)
	B	2 (10.5)
	C	9 (47.3)

*Based on AO classification

In this study, most of the fractures were of closed type (71.6%) and mostly of C type (43.4%) based on AO classification (Table 2).

The mean healing time was 14.62 ± 4.38 weeks (Table 3). The average score of RUST criteria was 8.90 ± 1.26. The average score of Johner-Wruhs criteria was 46.31 ± 4.49. Out of 67 patients, 61 patients (91%) had excellent results based on the above criteria, four patients had good results, and two patients had fair results, in other words, most of them had excellent or good results. In closed fractures and fractures of the proximal third of the shaft, this score was higher and in the range of 47.5, but no significant difference was observed in the average score of this criteria based on the AO classification (P = 0.560).

Table 2. Finding in open and closed fractures

Fracture type	n (%)	Union time (week) (mean ± SD)	RUST score (mean ± SD)	Johner-Wruhs score (mean ± SD)
Open	19 (28.4)	17.50 ± 4.16	8.21 ± 0.97	43.68 ± 6.78
Closed	48 (71.6)	13.76 ± 4.11	9.10 ± 1.27	47.35 ± 2.63
P-value*		0.002	0.100	0.001

*Mann-Whitney test
RUST: Radiographic Union Score of Tibia Fracture; SD: Standard deviation

The healing time in comminuted fractures according to AO classification (e.g., type C) was longer than simpler fractures such as type A and B, which was statistically significant based on the chi-square test (P = 0.013). Additionally, RUST radiological score had a significant relationship with fracture types based on AO classification (P = 0.020). But there was no significant relationship between fracture type and Johner-Wruhs score (P = 0.560).

According to the Mann-Whitney test in this study, the healing time in open fractures was statistically significantly higher (P = 0.002). Johner-Wruhs clinical score in open fracture was significantly lower (P = 0.001). The radiological score was lower in open fractures, which did not show a statistically significant difference (P = 0.100).

The healing of fractures in the middle third was earlier than the rest of the parts, followed by the fractures of the proximal third and distal third, respectively. There was no significant difference between fracture location (proximal, middle, distal) and fracture healing time (P = 0.250). The radiological score at the time of healing was also higher in the middle, proximal, and distal thirds than others, although it was not statistically significant (P = 0.370). But the score of Johner-Wruhs criteria in the proximal third was better than the others, which was statistically significant (P = 0.001), that is, in the fracture of the proximal third, the rate of malunion, pain, or stiffness was less and the function was better.

During the treatment of patients with dynamic IMN, there were no cases of compartment syndrome, neurovascular complications, fat embolism, pneumonia, or deep vein thrombosis (DVT), and 91.1% of patients with tibia fractures treated by dynamic IMN were treated without complications. Complications caused in this study, based on Pearson's chi-square test, had no significant relationship with fracture location (P = 0.370) and fracture form (based on AO classification) (P = 0.320).

Table 3. Findings in all types of fractures in AO classification

Fracture type*		n (%)	Union time (day) (mean ± SD)	RUST score (mean ± SD)	Johner-Wruhs score (mean ± SD)
A	A1	9 (13.4)	86.88 ± 18.27	10.33 ± 1.01	47.88 ± 0.33
	A2	11 (16.4)	87.72 ± 20.32	8.81 ± 0.87	48.01 ± 0.01
	A3	7 (10.4)	87.01 ± 17.68	9.57 ± 0.78	48.01 ± 0.01
	A	27 (40.2)	87.25 ± 18.27	9.51 ± 1.08	47.96 ± 0.19
B	B1	3 (4.5)	133.66 ± 40.67	8.01 ± 1.01	48.01 ± 0.01
	B2	3 (4.5)	91.01 ± 21.07	9.01 ± 1.01	48.01 ± 0.01
	B3	5 (7.5)	90.41 ± 31.58	8.40 ± 1.51	48.01 ± 0.01
	B	13 (16.5)	96.91 ± 30.65	8.45 ± 1.21	48.01 ± 0.01
C	C1	24 (35.8)	126.42 ± 31.86	8.26 ± 1.14	43.83 ± 6.71
	C2	4 (6.0)	113.01 ± 27.01	9.33 ± 1.52	45.01 ± 3.46
	C3	1 (1.5)	97.00 ± 0.00	8.00 ± 0.00	48.01 ± 0.01
	C	29 (43.4)	123.39 ± 30.84	8.29 ± 1.26	44.13 ± 6.20

*Based on AO classification
RUST: Radiographic Union Score of Tibia Fracture; SD: Standard deviation

There was no case of the malunion according to the predefined values or the complaint expressed by the patient about that. Three cases of complications occurred in the distal third and three cases in the middle third. In all six cases, the fractures were open and type C in the AO classification. Five patients had nonunion and one patient had an infection after surgery, and they underwent re-surgery. In this study, there was a significant relationship between the presence of complications and the duration of healing or the radiological score of the patients (P = 0.001 and P = 0.003, respectively).

Based on Spearman's test, the age of the patients had an inverse relationship with the healing time or the radiological score of the patients, but this relationship was not significant (P = 0.880). Besides, there was no significant relationship between age and Johner-Wruhs criteria score (P = 0.340).

Discussion

Tibia fractures in the present study, like other studies, were mostly in the age group of 30-40 years and in men, and were mostly caused by road accidents. It seems that the most important reason is that young men are more exposed to traffic accidents (12).

The mean healing time in fractures that were treated with dynamic nail was 14.62 weeks and this value was 14.2 weeks in Kreb et al. (13) study, 15.77 in Omerovic et al. (14) study, and 15.4 weeks in Gadegone et al. (15) study in closed fractures and 18.7 weeks in open fractures, but it was higher and about 21.97 weeks in Somani et al. (9) study. In Omerovic et al. study, static IMN was associated with less complications and earlier union than the dynamic method (14). In the study of Lee et al. (10) and Saruhan et al. (16), there was no significant difference in the healing time and malunion in two groups of locking and non-locking nailing.

Most of the fractures had excellent and good results according to Johner-Wruhs criteria, in other words, among 67 patients, 61 (91%) had excellent results, four patients had good results, and two patients had fair results. The mean of Johner-Wruhs criteria was 46.31 ± 4.49. The same investigation was done in Gadegone et al. study, in which 79 cases (70.54%) had excellent results, 29 patients (25.9%) had good results, and four patients had bad results (15). In the Saruhan et al. study, all 15 patients who had dynamic nail had good and excellent results (16).

In this study, the complications were mostly seen in type C fractures; it means in dynamic nailing, the more comminuted the fracture (e.g., type C), the longer the healing time and the lower the radiological score, but the treatment of simpler fractures according to AO classification (such as type A or B) by dynamic nailing was faster and with fewer complications.

The prevalence of complications in dynamic IMN was reported to be 22% in the study of Kreb et al. (13). In the current study, the complications of dynamic IMN were not more than other studies, and as in Hernandez-Vaquero et al. (12) study, the complication rate was about 9%, and as in Gadegone et al. (15) and Hernandez-Vaquero et al. (12) studies, the most frequent complications were non-union and infection.

Due to the fact that the dynamic IMN method is clearly associated with a shorter surgical time and less intraoperative complications (bleeding, etc.), dynamic IMN can be considered a good option for closed tibial fractures and simpler types of fractures based on the AO classification, because it is associated with a faster healing rate; however, based on this plan, a wide range of fractures, even type C, can be treated with dynamic nailing. But because the healing rate is lower in comminuted types (such as type C), it is better to be cautious in treatment of open or comminuted tibial fractures (e.g., type C) by dynamic nailing (13).

Conclusion

Dynamic IMN of closed and middle third tibial fractures and simpler types of fractures (e.g., type A or B) has faster healing. Nevertheless, it is better to be more cautious for fixation of open or comminuted fracture (e.g., type C).

Conflict of Interest

The authors declare no conflict of interest in this study.

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