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Original Article

Treatment of Acute Type I Proximal Fifth Metatarsal Fracture; Casting vs Bracing

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Abstract

Introduction: The acute type I proximal fifth metatarsal fracture is one of the most common fractures of the small bones of the foot. The current study aimed to compare the results of two non-invasive treatment methods namely casting with ultrasound and bracing with ultrasound.

Methods: Patients with acute type I proximal fifth metatarsal fracture were divided into two groups namely casting and bracing based on a randomized complete block design and were followed at six, 12, and 18 weeks. The variables studied included age, gender, body mass index (BMI), mechanism of trauma, sports activity level, visual analogs scale (VAS), re-fracture, nonunion, the average time to clinical and radiographic union, as well as AOFAS (the American Orthopedic Foot and Ankle Society hind-foot) and short form-36 satisfaction scores, which were collected via questionnaires by the participant and the physician.

Results: Of 117 patients, 57 were treated by casting and 60 by bracing and were followed up for 18 weeks. The mean age of patients was 27.5 ± 1.25 years. There were no significant differences between the groups at the time of radiographic and clinical union, degree of AOFAS at all-time points, and the level of pain at 12 and 18-week follow-ups. The VAS score in the casting group was lower than that of the bracing group at the six-week follow-up. The mean times for radiographic and clinical union in both groups were 70 and 40-41 days respectively. Based on SF-36, the level of satisfaction was higher at all-time points with bracing.

Conclusion: According to the results of this study, both methods used had acceptable results, but, given the greater satisfaction reported by the subjects in the bracing group, it seems that the bracing is an appropriate alternative to the casting technique in the treatment of this type of fracture.

Keywords: Fifth Metatarsal, Fracture, Casting, Bracing.

Introduction

In 1902, Dr. Robert Jones described the horizontal fracture of the proximal diaphysis of the fifth metatarsus as the Jones fracture [1,2]. The type I proximal fifth metatarsal fracture (Jones fracture) is the commonest among acute metatarsal fractures, which account for 35% of all foot fractures [1,2].

Bones of the foot fractures, especially the fifth metatarsal fracture, are among the most common lower limb fractures and are more common in athletes than in the general population. The fifth metatarsus is divided into three anatomical parts; Zone one: tuberosity, zone two: junction of metaphysis and diaphysis, and zone three: proximal diaphysis. Fractures in the second region are referred to as Jones fractures, which occur in 40 to 75% of all metatarsal fractures and are one-fifth of these fractures [2,3]. Jones fracture occurs in an area that receives less blood than other foot areas and, therefore, is difficult to heal [3]. Surgical and non-surgical treatments for this type of fracture are intramedullary rod screw fixation, short leg casting, and bracing.

Various studies show that non-surgical methods, despite the prolonged time to union, have fewer complications and costs, while surgical procedures are

invasive and the patient bears a higher expense. Surgical complications such as infection and bleeding should also be considered [4-6]. Two types of casts, plaster and fiberglass, are used [7]. Bracing is also used to fix a damaged organ (i e, broken, dislocated, or bruised) as well as Jones fractures [8]. Casting can cause deep vein thrombosis (DVT) due to immobilization of the limb and inactivation of ankle and calf muscle pump function [9], limitations that are not associated with bracing [10].

Nevertheless, there are still controversies about the most appropriate non-surgical treatment for Jones fracture among orthopedic surgeons; they should consider several factors in this regard. The current study aimed to evaluate the employment of two non-surgical treatments bracing and casting of patients with type I proximal fifth metatarsal fracture referred to our university hospital from 2013 to 2016.

Methods

Study protocol

The current randomized clinical trial included patients referred to a university orthopedic center for the treatment of acute type I proximal fifth metatarsal fracture from 2013 to 2016. This study is an open-label RCT study, and only patients are divided into two groups based on randomization, and the researcher and patients were aware of the type of intervention. The patients were assigned into two groups casting with ultrasound or bracing with ultrasound-based on a randomized complete block design. Subjects in both groups were followed-up at 6, 12, and 18 weeks.

Ethical considerations

All patients underwent surgery by a surgeon who is the first author of this study. The protocol was approved by the Ethics Committee of the university. The study was also registered in the Iranian Registry of Clinical Trials (No. IRCT201708127274N14). Patients signed the consent form, and their personal information was stored confidential.

Inclusion criteria

- Acute type I proximal fifth metatarsal fracture confirmed by radiography.
- Age 18-60 years

Exclusion criteria:

- Tuberosity fracture
- Distal to proximal fifth metatarsal fracture
- Multiple simultaneous fractures
- Anomaly of the ankle or history of ankle surgery
- Simultaneous neurovascular injury
- Any underlying disease or risk factor for nonunion, such as diabetes and smoking

Formulation of the questionnaire

The variables studied included: age, gender, body mass index (BMI), mechanism of injury (fall, accident, running, etc.), sports activity level (regular sport activity: exercising at least three times per week for a minimum of 20 minutes; irregular sports activity: exercising less than three times per week for a minimum of 20 minutes; sports inactivity) AOFAS: (American Orthopedic Foot and Ankle Society hind-foot score), visual analogs scale (VAS: this scale includes of a straight line with the endpoints describe extreme limits such as ‘no pain at all’ and ‘pain as bad as it could be’.

The patient is requested to mark his pain rate on the line between the two endpoints), re-fracture, nonunion, mean time to clinical union (easy walking), mean time to radiographic union (trabecular bone exceeds three of the four cortices), and satisfaction score based on short form-36 completed by the participant and the physician in the questionnaire. Variables such as VAS, SF-36 (the SF-36 is designed to measure the health status of patients and includes physical functioning, physical role, pain, general health, vitality, social function, emotional role, and mental health), and AOFAS, re-fracture, nonunion, mean times to clinical and radiographic union in six-, 12-, and 18-week follow-ups were measured, and the results were recorded. VAS pain was also measured at baseline. All follow-ups were driven by a physician who was blind to the type of treatment.

Of the 228 patients with acute type I proximal fifth metatarsal fracture, 134 were eligible to participate in the study, of which 68 subjects were treated by bracing and 66 by casting. But finally, 117 patients (60 patients in the bracing group and 57 in the casting group) with complete records, filled questionnaires, and total

follow-up data were enrolled in data analysis (Fig. 1). Due to the gradual referral of patients to the orthopedic clinic (consecutive sampling), patients who had the inclusion criteria (n = 134) based on four random blocks, were divided into two groups A (n = 67, Bracing) and group B (Casting, n=67) (randomized allocation). It should be noted that the sample selection sequence was selected based on 34 random blocks through random block online software.

The sequence list of patients was kept in a sealed envelope in the Orthopedic Research Center and was read daily after the start of the study. According to the list, patients were divided into two groups, A and B. Orthopedic intervention (Casting or Bracing) was performed by one assistant and AFOAS score reading as well as union time by another assistant in follow-up.

Treatment protocol

In the casting with ultrasound group: Patients were treated with a fiberglass short leg cast (Removable rigid boot splint) for six weeks and then underwent 15 three-minute sessions of physical therapy as pulsating ultrasound with 1 MHz frequency and power of 0.5 w/cm2 in situ of acute type I proximal fifth metatarsal fracture. The bracing with ultrasound group: The patients were treated with a removable brace, and physical therapy was started based on the aforementioned protocol from day 10. Weight-bearing was formed in both groups at the end of week three and partially completed until week five, and then fully completed.

Statistical analysis

The collected data were entered into SPSS version 21. The Chi-square test was used to compare the frequency distribution of personal, social, and disease-related variables in the study groups, and the repeated-measures ANOVA was used to analyze the changes in the scores. For all quantitative variables such as AFOAS score and times to radiographic and clinical union Shapiro–the Wilk test was used to study normality. AFOAS had a normal distribution, but the times to radiographic and clinical union did not follow a normal distribution, so RM ANOVA and Mann-Whitney tests were used. The significance level in this study was considered $P < 0.05$. The sample size required to compare the results of two groups of patients treated by casting and bracing in acute fracture of type 1 proximal metatarsus 5, in a 2-tailed test with 95% confidence and 80% test strength, based on the results [17]. According to the average union time and considering the minimum clinical difference of three weeks, 57 people were determined in each group.

$1-\alpha = 95\%$ $Z\ 1-\alpha/2 = = Z\ 0.975 = 1.96$
$1-\beta = 80\%$ $Z\ 1-\beta = Z\ 0.85 = 0.84$
Mean ±SD (KOOS score) in revision group= 13.22 ± 5.75
d= 3 weeks
$n = 2\times [(Z\ 1-\alpha/2 + Z\ 1-\beta)\ 2\ (SD)\ 2]/\ d\ 2$
$2\times [(1.96 + 1.04)2 \times 5.75] / (3)2 = 57$ cases per group

The same number of sample sizes was considered to measure other scores and variables. Power analysis was performed at the end of the study.

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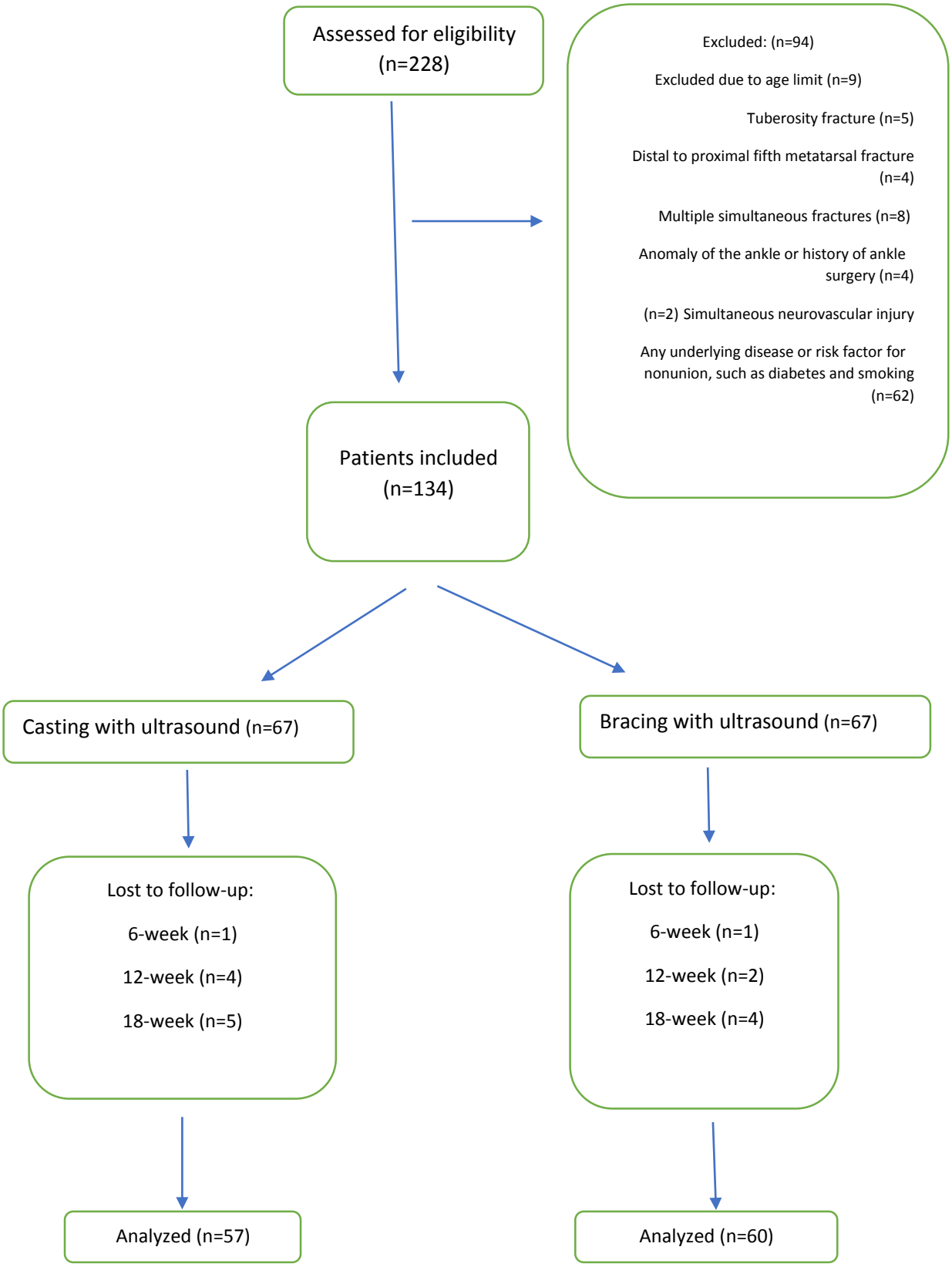

Figure 1: Participant flow chart.

Results

In the current study, 117 patients with acute type I proximal fifth metatarsal fracture referred to an orthopedics center from 2013 to 2016 were examined. Of these, 57 patients were treated by casting with ultrasound and 60 others by bracing with ultrasound and then were followed up for 18 weeks. The mean age of the patients was 27.5 ± 1.25 years, and the majority of patients (42.7%) belonged to the age group of 18-30 years. Of the patients examined, 45.2% were male, and 17.54% had regular sports activities (P=0.913) (Table 1).

Table 1. Demographic characteristics of the study participants in the casting and bracing groups

		all patients	casting	Brace
		N (%)	N (%)	N (%)
Number of patients		117(100)	57 (48.7)	60 (51.2)
Sex	Male	53(45.2)	25 (43.8)	28 (46.6)
	Female	64(54.7)	32 (56.1)	32 (53.3)
	P	0.760		
Age (years)	18-30	50(42.7)	24(42.1)	26(43.3)
	31-40	38(32.4)	18(24.5)	20(33.3)
	41-50	20(17.0)	10(17.5)	10(16.6)
	51 -60	9(7.6)	5(8.7)	4(6.6)
	P	0.983		
BMI	≤20	5(4.2)	3 (4.2)	2 (3.3)
	20-25	50(42.7)	24 (42.1)	26(43.3)
	25-30	56(47.8)	26(45.6)	30(50)
	30 ≤	6(5.1)	4 (5.6)	2(3.3)
	P	0.704		
Sports activity level	Regular sports activities	20(17.54)	10(17.5)	10(16.6)
	Irregular sports activities	16(13.6)	9(15.7)	7(11.6)
	Sports inactivity	81(69.2)	38(66.6)	43(71.6)
	P	0.913		
Mechanism of damage	Fall	22(18.8)	10(17.5)	12(20)
	Running	58(49.5)	29(50.8)	29(48.3)
	Crash	18(15.3)	9(15.7)	9(15)
	Other	19(16.2)	9(15.7)	10(16.6)
	P	**0.984**		

According to the obtained results, one subject from the bracing group and one from the casting group had nonunion (Table 2). Also, a comparison of the score and degree of AOFAS showed no significant differences between the study groups in any of the follow-up time points. However, a significantly tangible trend was observed in the AOFAS score of both groups from weeks six to 18 (Table 3). Based on the VAS score of patients at 6-week follow-up, the level of pain was higher in the bracing group than in the casting group (Table 4) (P <0.001). However, there was no significant difference between the two groups in 12- and 18-week follow-ups; no significant difference was also reported in this regard at baseline between the groups.

Table 2. Times to radiographic and clinical union in the bracing and casting groups

	Casting (Mean ±SD)	Brace (Mean ±SD)	P*
Average Time of Radiologic union (day)	67.84±5.24	70.23±6.84	**0.072**
Average Time of Clinical union (day)	39.92±4.99	41.35±4.96	**0.182**
Nonunion (number of patients)	1	1	**0.999**

*MANN WHITNEY U TEST

In examining the level of satisfaction, SF-36 score of the bracing group was higher than that of the casting group at three follow-up time points (Table 5) (P <0.001). Also, re-fracture was not reported in the study groups.

Table 3. AOFAS score at different fallow-up time points in the bracing and casting groups

	follow-up (wk.)	< 69 (poor)	69-79 (fair)	80-89 (good)	90-100 (excellent)	AOFAS average score	*p (group effect)	*p (interaction group & time)
		N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**		
casting	6	0	5(8.77)	8 (14.03)	44 (77.19	90.0±7.9	0.082	0.373
	12	0	0	3 (5.26)	54 (94.73)	92.7±7.0		
	18	0	0-	2(3.50)	55(96.49)	97.4±2.7		
	p (time effect)	0.001				0.001		
brace	6	-	3(5.0)	9(15.0)	48 (80.0)	90.3±		
	12	-	-	4 (6.6)	56(93.3)	94.0±		
	18	-	-	3(5)	57 (95)	96.6±		
	*p (time effect)	0.001				0.001		
***RM ANOVA**								

Table 4. VAS score at different follow-up time points in the bracing and casting groups.

VAS	Casting (Mean ±SD)	Brace (Mean ±SD)	P (group effect)	P (interaction group & time)
before	9.0±1.07	8.8±0.99	**0.001**	0.001
6wk	2.9±0.94	4.0±0.69		
12wk	1.5±0.77	1.4±0.96		
18wk	0.4±0.50	0.4±0.49		
P (time effect)	**0.001**	**0.001**		

Table 5. SF-36 score at different follow-up time points in the bracing and casting groups

SF-36	Casting (Mean ±SD)	Brace (Mean ±SD)	P (group effect)	P (interaction group & time)
6wk	83.5±2.5	89.6±2.24	**0.001**	0.001
12wk	85.1±2.6	94.7±2.40		
18wk	86.3±2.1	97.4±2.31		
P (time effect)	**0.001**	**0.001**		

Discussion

In the current study, 117 patients with acute type I proximal fifth metatarsal fracture referred to an orthopedic center from 2013 to 2016 were examined. Of these, 57 patients were treated by casting with ultrasound and 60 by bracing with ultrasound. There was no significant difference between the groups in terms of age, gender, BMI value, level of sports activity, and mechanism of trauma; therefore, both groups were matched by these variables. Both casting and bracing methods, in contrast to surgical procedures, are associated with lower costs and complications. Complications such as infection and bleeding should be considered in surgical procedures [11-13]. Konkel et al. on non-surgical treatment of Jones fracture, ten fractures were treated by non-surgical and immediate weight-bearing techniques, and a 98.5% union rate was reported. According to the results of their study, immediate weight-bearing and non-surgical treatment, cost-effectiveness and non-invasive nature, had fewer complications and more desired results [14]. Also, in a systemic study, Dean et al. stated that surgical intervention is associated with complications such as infection and bleeding [15]. Therefore, non-surgical treatments can be used in some cases to reduce the risk of complications. But which casting or bracing method is more suitable and safer? Studies show that casting can cause DVT due to immobilization of the limb and inactivation of ankle and calf muscle pump function [16]. Therefore, in this type of treatment, foot joint stiffness and delay in return to the function should be considered, while bracing is not associated with such problems [17] and might be preferable to casting in such cases. However, no complication such as DVT was observed in the subjects of the casting group. Studies show that the incidence of the DVT increases with age increase, and only 8% of the current study patients were above 50. No reports of DVT in the casting group can be attributed to the younger ages of the majority of the subjects in the current study.

Although the absence of surgical complications is one of the most prominent advantages of casting and bracing techniques, the increased risk of nonunion in patients with Jones fracture is one of their disadvantages [15,18,19]. In a study, 37.5% of patients with Jones fracture treated by casting reported treatment failure (three cases had nonunion, and three cases had delayed union) [19]. In another study, of 18 patients with proximal fifth metatarsal fracture treated by casting, eight subjects had problems: five cases of nonunion, one case of delayed union, and two cases of re-fracture (totally of 44% treatment failure) [17]. Nevertheless, in the current study, only two cases had nonunion, one from the bracing group and the other from the casting group, which were better and more acceptable results than most similar studies. There was no significant difference between the results of bracing and casting techniques in the current study. Also, no cases of re-fracture were reported. The results of the investigation by Konkel et al. were similar to those of the present research, with a 98.5% union rate following non-surgical treatments and immediate weight-bearing [14].

In the treatment of Jones fracture, in addition to union, the time to union, especially in athletes, is of great importance. Therefore, the employed method, especially in athletes, should be associated with the shortest time to union and subsequently the shortest interval to return to sport. Many studies investigated the time to union in Jones's fracture using different methods. In an analysis by Mologne et al., the meantime to union and return to sport was 7.5 and 8 weeks, respectively, in the fixation surgery group and 14.5 and 15 weeks, respectively, in the casting group [17]. In a study by Konkel et al., the meantime to the union after non-surgical treatment and immediate weight-bearing was 3.7 months [14]. In a study, the meantime to union and return to daily activities in the surgery group was eight and nine weeks, and in the casting group, 12 and 14 weeks, respectively [19]. Similar studies also reported that the time to union and return to sport was longer in patients treated with non-surgical methods such as bracing and casting against surgical procedures [11,15,18]. In the current study, the meantime of the clinical and radiographic union was 41.35 and 70.23 days in the bracing group and 39.92 and 67.84 days in the casting group, respectively; there was no statistically significant difference between the two groups. The results of the

current study in this regard were more satisfactory than most similar studies [14,17,19]. In general, various studies suggested that owing to fewer complications, non-surgical methods are the treatment of choice for non-athlete patients, and surgical procedures, due to the shorter time to union, are the treatment of choice for athletes who need less time to return to sport [15,20]. Since, in the current study, most patients had no sport activities (68.4%), non-surgical treatment had satisfactory results. The AOFAS score was evaluated to assess the quality of the ankle function. According to the results, the score had an increasing trend from week six to 18 in follow-up, and in the 18th week, the AOFAS score was 96.6 for the bracing group and 97.4 for the casting group, which showed no significant difference between them.

Although there were no significant differences in baseline VAS scores between the two groups, it was significantly lower in the casting group compared to the bracing group during week six after treatment. But there was no statistically significant difference between the groups in terms of VAS pain score at other follow-up intervals. Probably the static immobilization of the cast, in comparison with the brace that is associated with less restricted fixation, is the reason for less pain with casting in the first six weeks of treatment.

There was a significant difference between the two methods in the SF-36 questionnaire, and at all follow-up time points, the SF-36 satisfaction score was higher in the bracing group. Psychometric analyzes show that the SF-36 is a reliable instrument and, in addition to its applicability to different cultures, can differentiate between distinct groups in terms of age, gender, economic status, geographical area, and clinical status. In the study of Konkel et al., patients' satisfaction with non-surgical techniques and immediate weight-bearing in the treatment of Jones fracture was 100% [14]. One of the complications associated with the casting method, particularly during warm seasons or in sultry areas, is the patients' complaints from sweating. This problem, along with complications such as difficulty in bathing and the limb swelling, sole and shiny skin, is definitely of the most important reasons for less satisfaction in the casting group. However, the brace can be removed, and the patient can take a bath while using it. The current study did not investigate the treatment cost imposed on patients in each group, which was one of the limitations of the study. Another limitation can be the relatively small groups since the current study only included the information of patients who were referred for follow-ups and had complete and accurate information.

Conclusion

Based on the results of the current study, both the methods (casting or bracing) had acceptable effects, but considering the more significant satisfaction with bracing, it seems the brace is an appropriate alternative to the casting in the treatment of this type of fracture.

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Conflict of Interest Disclosures

It is not declared by the author.

Funding Sources

It is not declared by the author.

Authors' Contributions

Dr. M.M and Ms. Z.A participated in the study design, and Dr. M.M performed all the surgeries. Dr. M.M and Ms. Z.A Participated in data collection and evaluation, drafting, and statistical analysis, and Ms. Z.A contributed extensively to the interpretation of the data and the conclusion. All the authors performed editing and approved the final version of this paper for submission, also participated in the finalization of the manuscript, and approved the final draft.

Ethical Statement

Informed consent was obtained from all individual participants included in the study. The study was also registered in the Iranian Registry of Clinical Trials (No. IRCT201708127274N14).

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