Review Article

The Effectiveness of Functional Brace in the Treatment of Tibia Fracture: A Review of Literature

Mohammad Taghi Karimi, Mostafa Kamali[1]

Department of Orthotics and Prosthetics, Rehabilitation Faculty, Shiraz University of Medical Sciences, Shiraz, Iran, [1]Musculoskeletal Research Center, Rehabilitation Faculty, Isfahan University of Medical Sciences, Isfahan, Iran

ORCID:

Mohammad Taghi Karimi: https://orcid.org/0000-0001-6162-8131

Mostafa Kamali: https://orcid.org/0000-0002-8994-9196

Abstract

Background and Objectives: Various treatment methods have been used to manage tibia fracture, including conservative and surgical treatment. Various studies investigated the effects of functional brace on fracture of tibia. This review was aimed to summarize the evidence on the effectiveness of functional brace on tibia fracture. **Methods:** An electronic search was carried out through internationally published scholarly articles in EBSCO, Medline, PubMed, Embase, and ISI Web of Knowledge (from 1950 to 2020) with the following keywords: tibia fracture, healing, conservative treatment, functional orthosis, brace, and patellar tendon-bearing orthosis. The quality of the papers was assessed using the Down and Black tool. **Results:** On the basis of the keywords, 50 articles were found, of which 11 articles were selected in accordance with the selection criteria. Most of studies support the use of orthosis for tibial fracture. The scores of reporting, external validity, internal validity (bias), and internal validity (confounding) varied between 2–7, 1–2, 1–5, and 2–4, respectively. **Conclusions:** One of the most important treatment methods for tibia fracture is use of functional brace. Based on the results of the available literature, use of functional brace is a good approach for stable tibia fracture. Some parameters, such as the condition of surrounding muscles, initial shortening, angulations of tibia, and intact of fibula, play significant roles in this regard.

Keywords: Brace, conservative treatment, functional orthosis, healing, patellar tendon-bearing orthosis, tibia fracture

Introduction

The National Center for Health Statistics cites 492,000 tibial fractures per year in the United States.[1] Various treatment methods have been used to manage tibia fracture, including conservative and surgical treatment.[2-4] Conservative treatment consists of closed reduction and immobilization, close reduction, and easy weight bearing. There is no doubt that the goal of tibia shaft fracture treatment is attainment of body union with a resultant fully functional and painless extremity. This is done by reduction of fracture segments and proper immobilization. Fracture bracing is one of the commonly used conservative treatments used to manage tibia fractures.[3,4] It was originated by Chinese ancient doctors and was developed by Dehne, Sarmiento, and Latta. The key points behind the use of this orthosis are to maintain alignment, to control motion allowed at the fracture site, and to facilitate healing of fracture.[5-7] It has been shown that the hard shell of the brace compresses the soft tissue and creates a hybrid pressure like effects which not only exaggerates the osteogenesis but also immobilize the fracture sites.[8]

Various studies investigated the effects of functional brace on healing of tibia fracture.[2-8] Pandey *et al*. showed that the subjects with fracture at distal third of tibia have acceptable loss of reduction with the use of functional brace.[9] Sarmiento and Latta in their research on 434 patients with fracture of the middle third of tibia showed that satisfactory results in terms

Access this article online

Quick Response Code:

Website: www.archtrauma.com

DOI: 10.4103/atr.atr_74_20

Address for correspondence: Prof. Mohammad Taghi Karimi, Department of Orthotics and Prosthetics, Rehabilitation Faculty, Shiraz University of Medical Sciences, Shiraz, Iran.
E-mail: karimi@rehab.mui.ac.ir

How to cite this article: Karimi MT, Kamali M. The effectiveness of functional brace in the treatment of tibia fracture: A review of literature. Arch Trauma Res 2021;10:109-13.

Received: 14-08-2020, **Revised:** 20-10-2020,
Accepted: 17-11-2020, **Published:** 11-10-2021.

of length shortening and varus angulations can be achieved by use of functional brace.[10] This review article was aimed to summarize the evidence on the effectiveness of functional brace. Moreover, it was aimed to determine the protocol of using functional brace based on the available literature.

Methods

An electronic search was done in a period between 1960 and 2020. The search was done in Google Scholar, ISI Web of Science, PubMed, and Embase. Some keywords such as tibia fracture, healing; conservative treatment, functional orthosis, brace, and patellar tendon-bearing (PTB) orthosis were used. The first selection of the papers was based on the title and abstract. The second selection of the papers was done based on the following criteria:

1. The paper published in English language
2. Focused on conservative treatment
3. Only tibia fracture was considered.

The technical notes and case studies were deleted from the list. Figure 1 depicts the diagram of article selection procedure in the current review article. Methodological quality of papers was assessed using Down and Black tool. Reliability and validity of Down and Black tools in the evaluation of quality of research papers have been proved.[11] The quality of each paper was evaluated by two expert reviewers (the authors) separately, and the correlations of results were assessed using Pearson's correlation coefficient. The Statistical Package for the Social Sciences (SPSS) software (version 20) IBM company, USA was used for statistical evaluation.

Some information such as the method of evaluation, number of studies, type of studies, number of subject, follow-up period, and a brief review of outcome are provided in Tables 2 and 3.

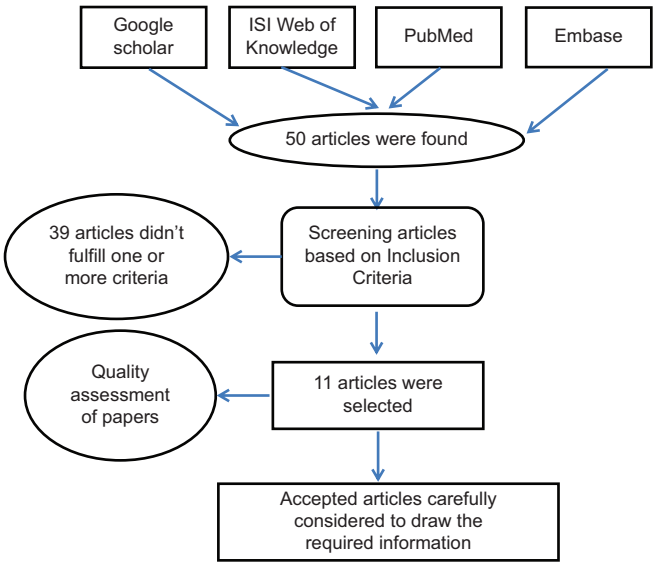

Figure 1: The diagram of article selection procedure used in the current review article

Results

Fifty papers were selected based on the aforementioned keywords. Finally, 11 papers were selected for final analysis. The quality of the studies is summarized in Table 1. As can be seen from this Table 1, the quality of the studies varied between 16 and 24. One study was on the fractures of the middle part of tibia, 2 on the fracture of distal of tibia, and only one study on the fracture of proximal part of tibia (no information regarding the rests). There was only one article on the comparison between orthosis and surgical treatment. Most of studies support the use of orthosis for tibia fracture.

Discussion

The incidence of tibia fractures is high and is classified into open and close fractures.[16,17] Various methods have been used to treat tibia fracture including surgery and conservative treatment.[9] Use of functional brace is one of the effective conservative methods used to treat tibia fracture, which seems to be cost-effective. The aim of this review article was to review the evidence to support the effectiveness of brace use in this regard.

As shown in Tables 2 and 3, there were 11 papers on the effectiveness of functional brace on tibia fracture. The quality of the most of papers was high due to the number of subjects and follow-up duration [Table 1]. There was also one study compared the efficiency of use of brace and surgical procedure.[7] As can be seen from the most of these studies, the final output compared with a range obtained from other research. Therefore, the main question posted here is that what is the optimum and acceptable results for treatment of tibia fracture. In other words, what is the acceptable score for shortening and angulations of the tibia?

The acceptable range of tibia shortening and angulations follow tibia fracture is based on the results of various studies.[3,4,6,8,13] Sarmiento has shown that shortening between 0 and 26 mm is acceptable in the treatment of tibia fracture. However, he emphasized that it should be tried to not exceed shortening more than 12 mm.[2,3,14,18,19] Regarding the angulations, it would be in an acceptable range if it is <8°.[19] As shown in Table 2, the outputs of treatment of most of the studies are less than aforementioned threshold. Therefore, it can be concluded that the use of functional brace is acceptable approach in this regard.

The second question posted here is that is there any differences between the outputs of orthotic treatment used for fracture of tibia in various levels? In the research done by Sarmiento *et al*. on 780 patients with tibia fracture at various levels of tibia, it was shown that there was no association between fracture healing and the location of fracture.[4]

There were also two researches on the healing of fracture of distal part of tibia.[9,14] In the research done by Pandey *et al*. on 39 fracture of distal part of tibia, PTB brace was used for the period of 6–8 weeks.[9] The results showed that the average shortening was 6.8 mm with 3.72° and 3.32° angulations in

Table 1: The results of quality assessment (Down and Black tool)

References	Author	Level of evidence	Reporting	External validity	Internal validity-bias	Internal validity confounding (selection bias)	Total score
[12]	Swenson *et al*.	5	5	2	3	4	19
[9]	Pandey *et al*.	3	6	2	4	5	20
[4]	Sarmiento *et al*.	5	8	2	4	5	24
[10]	Sarmiento and Latta	5	7	2	4	4	22
[7]	Kuzgun *et al*.	5	4	3	4	4	20
[13]	Sarmiento	5	7	2	4	5	23
[14]	Jafari *et al*.	3	5	2	4	4	18
[8]	Sarmiento *et al*.	3	7	2	4	5	21
[3]	Sarmiento *et al*.	3	6	2	4	4	19
[2]	Martinz *et al*.	5	6	2	4	5	22
[15]	Al-Shadedi *et al*.	3	4	2	4	3	16

Table 2: The main clinical findings of the studies on tibia fractures

Researcher	Method	Results and finding
Pandey *et al*.[9]	39 fractures of tibia fractures were treated with reduction and long leg cast for 6 to 8 weeks. Then PTB brace was used for 6-8 weeks. The fracture was in distal third of tibia	Immediate post reduction average angulations were 3.72° in sagittal plane and 3.32 in coronal plane Average limb shortening: 6.8 mm Full range of motion of ankle and knee joints was achieved Conservative treatment of nonarticular fracture of distal third of tibia has acceptable loss of reduction
Sarminento *et al*.[3]	48 close reduction of tibia Fractures were stabilized for 33 days by above knee cast. Then functional brace was used	Initial shortening and angular deformity were 12 mm and 7° before treatment All fracture healed at a medium of 15 days. Final shortening and deformity were 4.7 mm 59°, respectively
Sarminento and Latta[10]	434 patients with fracture of the middle third of tibia were treated by functional brace (80 female, 354 male. Average age was 31.5±12.7) 32.9% of fracture was comminuted, 25.8% was oblique, 8.7% was spiral, 28.8% was transverse, and 3.7% was segmental. The brace was used 26.3±2.2 days after injury	In mediolateral plane, 97% of fractures healed with 8 or less angulations. In anteroposterior, 93.4% healed with 8° or less angulations. The final shortening was 4.3 mm Satisfactory results were obtained in most of the subjects using functional brace
Al-Shadedi *et al*.[15]	19 patients with tibia shaft fracture were classified according to AO/ASTF classification. Fracture brace was applied after pain and swelling has subsided. The brace was used for 4.8 weeks for closed and 6.1 weeks for opened fractures	The shortening was obtained with average of 8.6-13.4 mm Angulations were between 1° and 7.5° which was inacceptable range
Swenson *et al*.[12]	A pneumatic lower leg brace was used for patients with delayed union stress fracture of anterior tibia. The mean age of the patients was 28 years. The mean duration of symptoms was 9 months	Use of pneumatic leg brace avoided the need for surgery in this group of patients and allowed to unrestrict actively on average of 12 months

PTB: Patellar tendon bearing, AO: Arbeitsgemeinschaft für Osteosynthesefragen

sagittal and frontal planes, respectively. They confirmed that use of PTB brace has acceptance reduction for fracture of distal part of tibia. In contrast in another study done by Jafari and Nozarnejad, 92.3% of patients had shortening of <1 cm for fractured treated with functional brace (for an average of 13.7 weeks).[14] The final deformation was seen in 30.77%. They concluded that the outcome was not satisfactory.

The healing of tibia fracture located in the middle part, treated by the use of functional brace, was studied by Sarmiento and Latta.[10] This study was done on 434 patients and the brace was used for a period of 26.3 days after injury. Based on the results of this research, 97% of fractures healed with 8° or less angulations in mediolateral plane. Moreover, 93.4% of them had angulations with 8 or less. The final shortening was reported as 4.3 mm. Based on the acceptable values of shortening mentioned in previous research, it can be concluded that the output of treatment of tibia fracture in the middle part is acceptable.[3,4,6,12,13] In other words, it can be used as one of the main treatment approaches for tibia fracture.

What are the main criteria for the use of functional brace for the treatment of tibia fracture?

It should be noted that use of functional brace is based on this hypothesis that immobilization of the joint above and below fracture is not necessary for fracture healing and maintain alignment. Furthermore, the motions at the fracture site should be controlled.[5,12] The brace harvested the soft tissue of the

Table 3: The main clinical findings of the studies on tibia fractures

Researcher	Method	Results and finding
Sarmiento *et al*.[8]	943 patients with tibia fracture (211 female and 732 male). Mean of their age was 33±13 years. Prefabricated functional brace was applied between 1.4 and 23 weeks (mean 3.7 weeks) after injury	41% of fractures healed with no angulations in sagittal plane. 95% of them healed with angulations <6°. Posterior angulations were seen in 30% of the subjects
Jafari and Nozarnejad[14]	26 subjects with mean age of 27.46±7.58 years Follow-up was 9.12±2.36 months The classification of fractures was done using AO/OTA classification (38.5% A1, 26.9% A2, 34.6% A3.1) Most of fractures were sustained in lower third of tibia (53.85%)	All fractures eventually healed in an average of 13.7 weeks. In 12.3% of patients, shortening of bone was <1 cm. Anterior or posterior angulations were more than 10° in 2 patients In 4 patients varus angulations was more than 5°. Final deformity was observed in 8 patients (30.77%). The non-surgical treatments outcomes were not satisfactory, despite considering all principles for conservative treatment
Sarmiento *et al*.[4]	780 tibia fractures treated with prefabricated functional braces were followed. The average time before applying a brace was 3.8 weeks for closed fractures and 5.2 weeks for opened fracture	Close fractures healed in an average of 17.4 weeks and opened fractures in an average of 21.7 weeks. 90% with shortening <10 mm. No association between fracture healing and age, mechanism of injury and fracture location. Degree of soft tissue damage influences the success of and speed of fracture healing. The condition of fibula and the time from injury to bracing also appeared to affect the speed of union
Martinez *et al*.[2]	108 closed fractures located in the proximal third of tibia were treated with functional brace	88% of the subjects were treated with <6° of angular deformity and final shortening was 3.5 mm. Use of functional brace is a valuable method for tibia fracture healing at the proximal part
Sarmiento[13]	1000 closed tibia fractures treated with prefabricated functional below knee brace	The mean final shortening before treatment was 4.28 mm compared to initial shortening of 4.25 mm. The final shortening did not increase beyond the acceptable range
Kuzgun *et al*.[7]	35 subjects with tibia plate fracture were recruited in this study. They were treated by surgery or by use conservative treatment The type of fracture was determined based on Hohl classification. Pain, walking capacity, total range of motion of knee joint and stability were the evaluated criteria	There was compression of 0-5 mm in 21 cases, 5-10 mm in 12 cases, and 10 mm in 2 cases. Both methods have satisfactory results. The period of immobilization was averaged 6.6 weeks in conservative treatment and 5 weeks in surgical. The weight bearing was allowed after 2-4 weeks

AO: Arbeitsgemeinschaft für Osteosynthesefragen

fracture and finally creates a hydraulic pressure. Therefore, the health status of the muscles surrounding the fracture is an important key to use a functional brace. The other parameter related to condition of fibula. It has been shown that the intact of fibula has a negative influence on the output of orthotic treatment follow tibia fracture. Initial displacement and initial shortening also play a significant role in this regard.[12]

Conclusions

One of the most important treatment methods used for tibia fracture is functional brace. Although there were 11 studies on the effectiveness of this treatment, most of the available studies have an acceptable quality due to high number of the subjects. Based on the results of the available literature, functional brace is a good approach for stable, fracture of tibia. Some parameters such as the condition of surrounding muscles, initial shortening, angulations of tibia, and intact of fibula play a significant role in this regard.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Yelin EH, Felts WR. A summary of the impact of musculoskeletal conditions in the United States. Arthritis Rheum 1990;33:750-5.
2. Martinez A, Sarmiento A, Latta LL. Closed fractures of the proximal tibia treated with a functional brace. Clin Orthop Relat Res 2003;417:293-302.
3. Sarmiento A, Burkhalter WE, Latta LL. Functional bracing in the treatment of delayed union and nonunion of the tibia. Int Orthop 2003;27:26-9.
4. Sarmiento A, Gersten LM, Sobol PA, Shankwiler JA, Vangsness CT. Tibial shaft fractures treated with functional braces. Experience with 780 fractures. J Bone Joint Surg Br 1989;71:602-9.
5. Sarmiento A, McKellop HA, Llinas A, Park SH, Lu B, Stetson W, *et al*. Effect of loading and fracture motions on diaphyseal tibial fractures. J Orthop Res 1996;14:80-4.
6. Sarmiento A, Latta L. The evolution of functional bracing of fractures. J Bone Joint Surg Br 2006;88:141-8.
7. Kuzgun U, Ozturk I, Kabukcuoglu Y, Ordveri M. The results of conservative and surgical treatment of tibial plateau fractures. Acta Orthop Traumatol Turc 1991;25:391-3.
8. Sarmiento A, Sharpe FE, Ebramzadeh E, Normand P, Shankwiler J. Factors influencing the outcome of closed tibial fractures treated with functional bracing. Clin Orthop Relat Res 1995;315:8-24.
9. Pandey BK, Manandhar RR, Sharma S, Pradhan RL, Lakhey S, Rijal KP. Conservative treatment of nonarticular fractures of distal third tibia. JNMA J Nepal Med Assoc 2009;48:292-5.
10. Sarmiento A, Latta LL. Fractures of the middle third of the tibia treated with a functional brace. Clin Orthop Relat Res 2008;466:3108-15.
11. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol

Community Health 1998;52:377-84.
12. Swenson E, DeHaven K, Sebastianeli W. Pneumatic leg brace after tibial stress fracture for faster return to play. Am J Sports Med 1997;25:322-8.
13. Sarmiento A. On the behavior of closed tibial fractures: Clinical/radiological correlations. J Orthop Trauma 2000;14:199-205.
14. Jafari D, Nozarnejad P. Outcomes of the isolated closed tibial shaft fractures treated nonsurgically. Med J Islamic Rep Iran 2011;25:21-6.
15. Al-Shadedi A, Adnan H, Luay M. Functional bracing in the management of diaphyseal fractures of Tibia. Iraqi Postgrad Med J 2008;7:295-303.
16. Madadi F, Vahid Farahmandi M, Eajazi A, Daftari Besheli L, Madadi F, Nasri Lari M. Epidemiology of adult tibial shaft fractures: A 7-year study in a major referral orthopedic center in Iran. Med Sci Monit 2010;16:CR217-21.
17. Bengnér U, Ekbom T, Johnell O, Nilsson BE. Incidence of femoral and tibial shaft fractures. Epidemiology 1950-1983 in Malmö, Sweden. Acta Orthop Scand 1990;61:251-4.
18. Sarmiento A, Latta LL. Functional fracture bracing. J Am Acad Orthop Surg 1999;7:66-75.
19. Sarmiento A, Sobol PA, Sew Hoy AL, Ross SD, Racette WL, Tarr RR. Prefabricated functional braces for the treatment of fractures of the tibial diaphysis. J Bone Joint Surg Am 1984;66:1328-39.