Review Article

How to manage tibial shaft fractures? Current therapeutic options

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Abstract

Tibial fractures are the most common fractures of the long bones. Complications of tibial shaft fractures potentially include neurovascular compromise, compartment syndrome, delayed union, nonunion, or malunion, and osteomyelitis. Therefore, the management of tibial shaft fractures is very important for orthopedic surgeons. There are operative and non-operative options for the treatment of tibial shaft fractures. Non-surgical treatment is applied on closed (not open) tibial shaft fractures, naming as closed reduction and cast immobilization. Surgical treatments include external fixation, intramedullary nailing (IMN), and percutaneous locking plate (PLP). Surgery for tibial shaft fractures seems to have many benefits, such as better appearance, less pain, and discomfort after surgery, maintaining the length of the fractured bone, and faster recovery and return to work for the patient. Although non-surgical methods also have advantages, such as lower initial cost of treatment, no need for anesthesia and inexistence of possible complications of the surgery, the surgical procedure has better clinical results and better acceptance by the patients and it is more cost-effective and more affordable in terms of period of hospitalization and time to return to work. For these reasons, it is recommended to be considered as a more acceptable and more common treatment method. Concerning surgical options, IMN still seems to be the main acceptable method for the treatment of tibial shaft fractures, although PLP and external fixation have benefits too. Altogether, the final choice of management for each patient is specifically related to his/her condition, fracture type and the surgeon's decision.

Keywords: Fracture, Tibia, Treatment, Surgery

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Introduction

Tibial fractures are the most common fractures of the long bones due to its location and being a subcutaneous bone. Every year, about 17 tibial fractures occur in every 100,000 people, and these fractures are three times more common in men than in women(1-3). There are two types of tibial fracture based on injury of the skin around the fracture, including closed (intact skin) and open fractures (punctured skin). Most parts of the tibia bone are subcutaneous. For this reason, the open fracture is also common in this bone. The blood flow of tibia is also lesser than the bones that are surrounded by muscles. The presence of two hinge joints (knee and wrist) at the above and below of tibia does not allow any rotational deformity at the fractured area of the bone and should be considered during treatment(4, 5).

There are classifications for both closed and open tibia fractures. Regarding closed fracture, Oestern and Tscherne Classification is mainly used with four grades from 0 to 4(6). Concerning open fracture, Gustilo-Anderson Classification is principally used with three types from I to III (including IIIA, IIIB, IIIC)(7). In both classifications, the grade is directly associated with the severity of the injury.

It has long been acknowledged in many medical texts and articles that whenever different and multiple ways of treating disease have been provided, the nature of the disease may not be fully understood(8). This issue is entirely applicable for tibial fractures, because despite significant improvements in the development of orthopedic techniques and devices, in severe and comminuted cases of tibial fractures, many surgeons are still uncertain about choosing between surgical and non-surgical methods(9, 10). Each orthopedic surgeon sets specific criteria for the acceptability of the outcome of a treatment for fractures. In addition to the bone tissue, soft tissue (skin, muscles, nerves, vessels and ligaments) may be damaged during fracture(11). Both fractured bone and soft tissue damage must be treated together. In many cases, surgery is needed to restore strength, movement and stability in the leg and reduce the risk of arthritis. The bone can be fractured transversely, spiral, obliquely, or comminuted(12). Sometimes these fractures extend to the knee joint and divide the bone surface into several parts. Complications of tibial shaft fractures potentially include neurovascular compromise, compartment syndrome, delayed union, nonunion, or malunion, and osteomyelitis(13). Therefore, the management of tibial shaft fractures is very notable for orthopedic surgeons.

Regarding the necessity of reviewing the results of surgical and non-surgical treatments for tibial shaft fractures and identifying strategies to reduce exposure to these fractures, this study aimed to review the surgical and non-surgical treatments for tibial shaft fractures.

2. Non-surgical treatments

Non-operative treatment is applied on closed (not open) tibial shaft fractures, naming as closed reduction and cast immobilization(14). Non-surgical treatment mainly includes the use of a Patellar Tendon Bearing cast. Its indications are closed low energy fractures with acceptable alignment and/or the patients who may be non-ambulatory or those who are suitable for surgery (e.g., due to poor health conditions)(15, 16). In this method, the cast is placed firstly, then, it is converted to the functional brace at 4-6 weeks.

Non-surgical treatment for tibial shaft fractures can have a high success rate if acceptable alignment is maintained, however, the risk of nonunion and malunion is not unexpected, which can cause disabilities. In the majority of the studies in which fixation and leg fracture surgeries performed with the intramedullary nail, results were better compared to studies that used plaster cast(17). As stated, the use of plaster cast or brace in the treatment of tibial fractures is limited to fractures with low energy trauma in young people, where the surgeon's inference is that he/she can open the plaster as soon as possible after a fracture. Younger people’s bones will union sooner and less often they experience hindfoot stiffens. Generally, heel pins for stretching or pin and plaster cast should not be used in treating tibial fractures unless in the abovementioned cases.

Other non-operative options have been suggested, including the electrical stimulator/electromagnetic fields (through stimulating growth factors) and the low-intensity pulsed ultrasound (increase in osteoblastic response by low sine waves), however, conflict results exist on their efficacy(18-21).

3. Surgical treatments

Surgery may be recommended for open fractures, fractures not healed with non-surgical treatment, fractures with displacement, or fragment fractures. Operative options for treatment of closed tibia fractures include external fixation, intramedullary nailing and percutaneous locking plate.

3.1. External fixation

In this technique, after reposition of the broken bone pieces (usually by closed reduction) into their normal alignment, metal screws and/or pins are transversely inserted into the bone fragments above and below the fracture site and attached to a stabilizing bar structure outside the skin. This method can keep the bones in the proper position to be healed.

3.1.1. Indications

An external fixator can be used until the end of treatment, usually requiring bone grafting to obtain the union or converting the treatment into an internal fixator (usually with an IMN) after a period(22-24). External fixation can be useful for proximal or distal metaphyseal fractures and/or in children with open physis(25).

3.1.2. Outcomes

A common complication of the use of external fixation is an infection of the tissue around the pins, which requires careful pin insertion technique and post-operative care of pin dressing to prevent infection(26). Although this infection is usually localized and rarely causes osteomyelitis, the intramedullary rods should be used cautiously if infection occurs at the pin area(26).

3.2. Intramedullary nailing (IMN)

IMN is currently the most method used for the treatment of tibia fractures, although there are indications and contraindications as well. During this procedure, after a closed or open reduction of bone fragments, an especial metal rod (usually made of titanium) is placed into the canal of the tibia. The intramedullary rod is screwed to the bone at both ends, keeping nail and bone in proper position during healing.

3.2.1. Indications

IMN is used in both closed and open tibia fractures. About closed fractures, IMN is potentially indicated when closed reduction and casting were not efficient in alignment. This method is also used for segmental, comminuted, or bilateral tibia fractures. Another indication for IMN is ipsilateral limb injury. Contraindications for IMN include any bone deformities preventing the procedure, and/or previous total knee arthroplasty(27-29). In open tibia fractures, IMN can be curative for most fractures within 24 hours. A contraindication for IMN is in children with open physis, in whom external fixation is indicated(30). Surgeons formerly stated that tibia proximal end fractures are not suitable for using IMN, and if IMNs are used, caution should be exercised, because malunion may occur in these fractures(31, 32). However, recent developments and modifications in nail design and reduction techniques (e.g., interlocking screws) have expanded the indications for IMN to include proximal and distal third tibial fractures(32).

3.2.2. Outcomes

According to the existing results, IMN can decrease malalignment and time to union. Studies have also shown that in closed tibia fractures, the use of canal reaming in IMN insertion has better outcomes than in cases where insertion of IMN is performed without canal reaming(33). It has been mentioned that canal reaming with IMN insertion increases periosteal blood flow and reduces endosteal blood flow for a short time, although its clinical effect is minimal. In relation to open tibia facture, there is controversy about the choice of reamed or unreamed IMN. Some results showed better outcomes for reaming, but some reports are in favor of unreaming(34, 35). Altogether, no clear indications or contraindications exist to select either option. It seems that the outcomes of the insertion of reamed and unreamed IMN are probably similar in open tibia fractures. However, due to the ease of performing the technique and the decreased operative time, unreaming method is recommended. The most common complication of IMN in fractures of the tibia is knee pain, which is mild in most cases and it relieves when the intramedullary rod is removed(17). A recent meta-analysis showed that suprapatellar IMN decreases total blood loss, postoperative knee pain, and fluoroscopy times compared to infrapatellar approach(36). The reason for this pain is not exactly understood, but it may be because of the prominent end of the rod and the anterior-posterior curve of the proximal end of the rod or soft tissue injury(23).

A recent meta-analysis by Giovannini et al. (37), including five randomized controlled trials involving 239 patients with Gustilo type III open tibial shaft fractures, showed that infection and fracture healing problems were less prevalent following IMN compared with external fixation. On the other hand, rates of other complications, such as vascular injury, revision surgery, soft tissue damage, mechanical failure, and tibial malalignment, were not different between the two methods. Therefore, IMN was recommended as the therapeutic choice for Gustilo type III fractures(37). Another meta-analysis showed that superficial infection and malunion after fixation in open tibial fractures are less prevalent following unreamed IMN compared with external fixation(38). The results were similar for both methods about postoperative deep infection, delayed union and nonunion. Thus, unreamed IMN was recommended to be superior to external fixation for the treatment of open tibial fractures(38).

3.3. Percutaneous locking plate (PLP)

In this method, the bone fragments are first repositioned by closed or open reduction. Then, an incision is made on the skin and the plates are entered through it, and then, the plates are attached to the bone by some screws to hold the bone segments together.

3.3.1. Indications: PLP is used in proximal/distal tibia fractures with insufficient fixation form IMN. Regarding distal fractures of the leg bone, it is recommended that both the tibia and fibula be fixed, although there is a controversy between some orthopedic surgeons(39, 40). However, in many cases, poor skin and soft tissue conditions and poor blood flow can complicate the decision to undergo surgery and may have numerous complications. In elderly patients with osteoporosis and comminuted fractures with multiple fragments, lack of proper volume and size of bone is a challenge for firm fixation. In this method for fixing the tibia, a locking plate and pro-fibula screws can be used(41, 42).

3.3.2. Outcomes: Non-union or delayed union, and wound infection have been reported as potential postoperative complications of PLP(43). There are limited and inconsistent studies comparing outcomes between PLP and IMN. A recently published meta-analysis showed that PLP can shorten fracture healing time and lead to lower rates of postoperative delayed union and pain compared with interlocking IMN in the treatment of tibial shaft fractures in adults(44). On the other hand, no difference was found between the two methods in the rates of excellent and good Johner-Wruh scoring(44). Altogether, it seems that there is roughly equal therapeutic efficacy between PLP and IMN, and PLP can be considered as an effective alternative to nailing in selected patients. However, more high quality and multicenter randomized controlled trials need to be done to compare the outcomes between the two methods, helping for better management of the patients.

4. Postoperative care

Tibial shaft fractures mostly heal within 4-6 months, however, it may take longer especially when the fracture is open or broken into several pieces. Overall, postoperative management is efficient in healing the fracture. "Weight-bearing" is recommended to the patients early in the recovery period. In fact, surgeons encourage the patients to put weight on their injured leg as much as possible after surgery. This is an exercise in which mechanical loading causes bone modeling and remodeling by integrins, cytoskeleton, membrane channels, and auto- and paracrine factors(45). In addition to weight-bearing, "physical therapy" can help to restore normal muscle strength, joint motion and flexibility. It is also helpful to manage postoperative pain. Physical therapy can be done in both hospital and home, even by using crutches or a walker.

5. Conclusion

The goal of surgical treatment is to return the patients with fractures as quickly as possible to their work and former life, with full attention to principles. Nowadays, due to injuries caused by accidents, falls and improper high-energy dynamic exercises, the number of tibial fractures and dislocation of tibial joints are on the rise. Surgery for tibial shaft fractures seems to have many benefits, such as better appearance, less pain and discomfort after surgery, maintaining the length of fractured bone and faster recovery and returning to work for the patient. Although non-surgical methods also have advantages, such as lower initial cost of treatment, no need for anesthesia and inexistence of possible complications of the surgery, the surgical procedure has better clinical results and better acceptance by the patients and it is more cost-effective and more affordable in terms of period of hospitalization and time to return to work. For these reasons, it is recommended to be considered as a more acceptable and more common treatment method. With respect to surgical options, IMN still seems to be the main acceptable method for the treatment of tibial shaft fractures, although PLP and external fixation have benefits too. Altogether, the final choice of management for each patient is specifically related to his/her condition, fracture type and the surgeon's decision.

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References:

1. Court-Brown C, Rimmer S, Prakash U, McQueen M. The epidemiology of open long bone fractures. Injury. 1998;29(7):529-34.
2. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37(8):691-7.
3. Larsen P, Elsoe R, Hansen SH, Graven-Nielsen T, Laessoe U, Rasmussen S. Incidence and epidemiology of tibial shaft fractures. Injury. 2015;46(4):746-50.
4. Veitch S, Findlay S, Hamer A, Blumsohn A, Eastell R, Ingle B. Changes in bone mass and bone turnover following tibial shaft fracture. Osteoporos Int. 2006;17(3):364-72.
5. Penzkofer R, Maier M, Nolte A, von Oldenburg G, Püschel K, Bühren V, et al. Influence of intramedullary nail diameter and locking mode on the stability of tibial shaft fracture fixation. Arch Orthop Trauma Surg. 2009;129(4):525.
6. Ibrahim DA, Swenson A, Sassoon A, Fernando ND. Classifications In Brief: The Tscherne Classification of Soft Tissue Injury. Clin Orthop Relat Res. 2017;475(2):560-4.
7. Kim PH, Leopold SS. In brief: Gustilo-Anderson classification. [corrected]. Clin Orthop Relat Res. 2012;470(11):3270-4.
8. Hasenboehler E, Rikli D, Babst R. Locking compression plate with minimally invasive plate osteosynthesis in diaphyseal and distal tibial fracture: a retrospective study of 32 patients. Injury. 2007;38(3):365-70.
9. O'Brien T, Weisman DS, Ronchetti P, Piller CP, Maloney M. Flexible titanium nailing for the treatment of the unstable pediatric tibial fracture. J Pediatr Orthop. 2004;24(6):601-9.
10. SOOMRO NA, KHAN KM, BHATTI A. Outcome of Open Diaphyseal Tibial Fracture Managed with Intra Medullary Inter Locking Nail. Journal of Pakistan Orthopaedic Association. 2018;25(2):14-8.
11. McQueen MM, Duckworth AD, Aitken SA, Sharma RA. Predictors of compartment syndrome after tibial fracture. J Orthop Trauma. 2015;29(10):451-5.
12. Li Y, Luo E, Feng G, Zhu S, Li J, Hu J. Systemic treatment with strontium ranelate promotes tibial fracture healing in ovariectomized rats. Osteoporosis international. 2010;21(11):1889-97.
13. Griffin M, Malahias M, Hindocha S, Khan W. Update on the management of compound lower limb fractures. Open Orthop J. 2012;6:518-24.

14. Ho CA. Tibia shaft fractures in adolescents: how and when can they be managed successfully with cast treatment? J Pediatr Orthop. 2016;36:S15-S8.
15. Rudge W, Newman K, Trompeter A. Fractures of the tibial shaft in adults. Orthopaedics and Trauma. 2014;28(4):243-55.
16. Fabry J, Casteleyn P-P. Non-operative treatment of long bone fractures in adults. In: Bentley G, editor. European Surgical Orthopaedics and Traumatology: The EFORT Textbook. Berlin, Heidelberg: Springer; 2014. p. 139-58.
17. Obremskey WT, Cutrera N, Kidd CM, Southeastern Fracture C. A prospective multi-center study of intramedullary nailing vs casting of stable tibial shaft fractures. J Orthop Traumatol. 2017;18(1):69-76.
18. Massari L, Benazzo F, Falez F, Perugia D, Pietrogrande L, Setti S, et al. Biophysical stimulation of bone and cartilage: state of the art and future perspectives. Int Orthop. 2019;43(3):539-51.
19. Brinker MR, O'Connor DP, Monla YT, Earthman TP. Metabolic and endocrine abnormalities in patients with nonunions. J Orthop Trauma. 2007;21(8):557-70.
20. Harrison A, Lin S, Pounder N, Mikuni-Takagaki Y. Mode & mechanism of low intensity pulsed ultrasound (LIPUS) in fracture repair. Ultrasonics. 2016;70:45-52.
21. Schandelmaier S, Kaushal A, Lytvyn L, Heels-Ansdell D, Siemieniuk RA, Agoritsas T, et al. Low intensity pulsed ultrasound for bone healing: systematic review of randomized controlled trials. BMJ. 2017;356:j656.
22. Esmaeilnejad Ganji SM, Bahrami M, Joukar F. Ilizarov Versus AO External Fixator for the Treatment of Tibia Open Fractures. Iran Red Crescent Med J. 2011;13(12):868-72.
23. Cheng W, Li Y, Manyi W. Comparison study of two surgical options for distal tibia fracture—minimally invasive plate osteosynthesis vs. open reduction and internal fixation. Int Orthop. 2011;35(5):737-42.
24. Bahrami M, Jan Mohammadi N, Esmaeil Nejad Ganji S, Rouhi M. Treatment of Tibial open fractures with external fixator. Journal of Babol University Of Medical Sciences. 2006;8(1):96-100.
25. Dai J, Wang X, Zhang F, Zhu L, Zhen Y. Treatment of distal metaphyseal tibia fractures using an external fixator in children. Medicine (Baltimore). 2019;98(36):e17068.
26. Kazmers NH, Fragomen AT, Rozbruch SR. Prevention of pin site infection in external fixation: a review of the literature. Strategies Trauma Limb Reconstr. 2016;11(2):75-85.
27. Wood GW, 2nd. Intramedullary nailing of femoral and tibial shaft fractures. J Orthop Sci. 2006;11(6):657-69.
28. Yoo JD, Kim NK. Periprosthetic fractures following total knee arthroplasty. Knee Surg Relat Res. 2015;27(1):1-9.
29. Rouhi, M, Bahrami M, Haji Ahmadi, M, Shah Hosseini R. TREATMENT OF OPEN TIBIA FRACTURE WITH FLEXIBLE MEDULLARY NAILING. Journal of Babol University Of Medical Sciences. 2008;10(2):62-7.
30. Popkov D, Lascombes P, Journeau P, Popkov A. Current approaches to flexible intramedullary nailing for bone

lengthening in children. J Child Orthop. 2016;10(6):499-509.
31. Hsu C-J, Chang W-N, Wong C-Y. Surgical treatment of tibial plateau fracture in elderly patients. Arch Orthop Trauma Surg. 2001;121(1-2):67-70.
32. Zelle BA, Boni G. Safe surgical technique: intramedullary nail fixation of tibial shaft fractures. Patient Saf Surg. 2015;9:40.
33. Li C-x, Zhao H-j, Zhao W-q, Xu Y-q. System evaluation on reamed and non-reamed intramedullary nailing in the treatment of closed tibial fracture. Acta cirurgica brasileira. 2013;28(10):744-50.
34. Choudary D, Kanthimathi B. A Prospective Comparative Study of Reamed vs. Unreamed Nailing in Fractures Shaft of Tibia. Malays Orthop J. 2012;6(3):21-6.
35. Yokoyama K, Itoman M, Uchino M, Fukushima K, Nitta H, Kojima Y. Immediate versus delayed intramedullary nailing for open fractures of the tibial shaft: a multivariate analysis of factors affecting deep infection and fracture healing. Indian J Orthop. 2008;42(4):410-9.
36. Yang L, Sun Y, Li G. Comparison of suprapatellar and infrapatellar intramedullary nailing for tibial shaft fractures: a systematic review and meta-analysis. J Orthop Surg Res. 2018;13:146.
37. Giovannini F, de Palma L, Panfighi A, Marinelli M. Intramedullary nailing versus external fixation in Gustilo type III open tibial shaft fractures: a meta-analysis of randomised controlled trials. Strategies Trauma Limb Reconstr. 2016;11(1):1-4.
38. Fu Q, Zhu L, Lu J, Ma J, Chen A. External Fixation versus Unreamed Tibial Intramedullary Nailing for Open Tibial Fractures: A Meta-analysis of Randomized Controlled Trials. Sci Rep. 2018;8:12753.
39. Berlusconi M, Busnelli L, Chiodini F, Portinaro N. To fix or not to fix? The role of fibular fixation in distal shaft fractures of the leg. Injury. 2014;45(2):408-11.
40. Gupta A, Anjum R, Singh N, Hackla S. Outcome of distal both bone leg fractures fixed by intramedulary nail for fibula & MIPPO in tibia. Arch Bone Jt Surg. 2015;3(2):119-23.
41. Said GZ, El-Sharkawi MM, Said HG, Refai OA. Fibula-pro-tibia in plating tibial non-unions. Int Orthop. 2011;35(11):1713-8.
42. Bukata SV, DiGiovanni BF, Friedman SM, Hoyen H, Kates A, Kates SL, et al. A guide to improving the care of patients with fragility fractures. Geriatr Orthop Surg Rehabil. 2011;2(1):5-37.
43. Sitnik AA, Beletsky AV. Minimally invasive percutaneous plate fixation of tibia fractures: results in 80 patients. Clin Orthop Relat Res. 2013;471(9):2783-9.
44. He G-C, Wang H-S, Wang Q-F, Chen Z-H, Cai X-H. Effect of minimally invasive percutaneous plates versus interlocking intramedullary nailing in tibial shaft treatment for fractures in adults: a meta-analysis. Clinics (Sao Paulo). 2014;69(4):234-40.
45. Zernicke R, MacKay C, Lorincz C. Mechanisms of bone remodeling during weight-bearing exercise. Appl Physiol Nutr Metab. 2006;31(6):655-60.