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ORIGINAL ARTICLE • LOWER LIMB - FRACTURES

The impacts of internal versus external fixation for tibial fractures with simultaneous acute compartment syndrome

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Abstract

Purpose High-energy tibial fractures may cause compartment syndrome, which needs fasciotomy. However, in this procedure, close fractures become an open wound and choosing the best type of fixation for this situation has been a problem. We assumed early open reduction and internal fixation (ORIF) instead of late internal fixation or external fixation, or stage-based approach is a better method.

Methods We collected fifty-seven medical records from 2012 to 2017 stored in Alzahra and Kashani University Hospital databases. We selected important information of their medical files, called the submitted phone numbers, and asked them to come to our clinic and examined their leg for any malunion and/or movement restriction postoperatively. We asked about pain and paresthesia in their leg. Twelve cases were excluded.

Results Demographic variables were not significantly different between these two groups. Deep infection, malunion, decreased range of motion in both knee and ankle joints, pain and paresthesia mainly occurred in external fixation group, except malunion (p value = 0.032), other variables were not statistically significant between two groups. More surgeries were performed predominantly for external fixation group (p value < 0.001). External fixation stayed 4.7 days longer at hospital although it was not statistically significant (p value = 0.108).

Conclusion It is better to perform fasciotomy and ORIF simultaneously in one surgery to lower the number of surgeries, days of hospitalization, decrease the risk of deep infection, malunion and movement restriction although its postoperative outcomes were not considerably different from external fixation. We indicate that stage-based approach is accompanied by poor outcomes and lesser satisfaction.

Keywords Compartment syndrome · Tibial fractures · Fracture fixation · Internal fracture fixation · Postoperative complications · Fasciotomy

Introduction

High-energy tibial fractures can be associated with significant soft tissue injury and may be resulted in compartment syndrome. Compartment syndrome is defining as elevated osteofascial compartment pressure, which can cause dramatic ischemic damages. Therefore, urgent fasciotomy must be performed to avoid muscle necrosis and functional impairment of the leg. Fasciotomy makes close fracture into an open one; thus, choosing the best and appropriate type of fixation (internal or external) comes to a complex and controversial situation [1–5].

Several studies mentioned that stage-based external fixation (EF) protocol is better for tibial fractures with compartment syndrome since early open reduction and internal fixation (ORIF) has been associated with some postoperative complications [2, 6, 7]. A meta-analysis suggested there is no priority in treating complex tibial plateau fractures and choosing the best method is based on other factors [8]. However, this debate remains controversial in current evidences, and thus, it would be surgeon's decision to choose the best method; temporary versus definitive [2, 6–10].

To help solve this problem, we hypothesized that not only early ORIF does not increase postoperative complications

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rate but also stage-based protocol may make poor outcomes due to having increased number of surgeries and more soft tissue manipulation.

Hence, we aim to compare postoperative complications and outcomes of early ORIF and EF (late internal fixation) in tibial fractures with concomitant compartment syndrome and fasciotomy.

Methods

We searched "compartment syndrome," "fasciotomy," "tibial fracture" and "fixation" keywords in Alzahra and Kashani University Hospitals medical records databases (as the third level referral trauma centers) from January 2012 to January 2017 and found 25 cases of EF and 32 cases of ORIF with high-energy tibial fracture and concomitant compartment syndrome for which fasciotomy was performed for all of them by the attending orthopedic surgeon. Open fractures were excluded from the case collection process.

Compartment syndrome diagnosis protocol in our hospitals is based on clinical judgment of the attending physician. Severe leg pain more than what we anticipated in correlation to the leg injury and painful passive and active range of motion in fingers and ankle joints are major clues to diagnose compartment syndrome.

According to the Tscherne soft tissue injury classification, all of our patients were put in type C3 group. All external fixators further converted to ORIF after closing fasciotomy. EF device was simple uniplanar EF, and ORIF device was appropriate plate and screw. Intramedullary nailing (IMN) was excluded from database search. Wide or narrow dynamic compression plate (DCP) was used for tibial shaft fractures and proximal or distal tibial fractures, which were near joints fixed with their special plates.

We called submitted phone numbers and asked them to come to our clinic. Ten EF and two ORIF did not come to the clinic, and/or there were a few invalid information in their files. We extracted injury date, location of tibial fracture, number of surgeries performed for the fractured leg, plastic surgery consultation, days of hospitalization and postoperative deep infection from their medical records. Deep infection defined as any infection needing hospitalization or reoperation for surgical debridement in which purulence found to be deep to the fascia and patient received intravenous antibiotics.

In their medical interview, we asked about their complaints (pain and/or paresthesia) related to the operated leg. We examined the leg for any malunion and/or movement restriction. Malunion defined as more than five-degree deviation from normal tibial anatomical axis in their last postoperative X-ray. To evaluate movement restriction, we assessed knee flexion–extension and ankle plantar–dorsiflexion range of motion with goniometer and considered positive in case of detecting more than fifteen- and five-degree difference, respectively, between two legs.

We used IBM SPSS statistics software version 22.0 (Chicago, USA) for data analysis. We used *t* test and chi square test for comparison of normal distributed quantitative variables between ORIF and EF groups and Man–Whitney and Wilcoxon test for not normal distributed variables.

This work commenced after receiving its approval from the Department of Medical Ethics and Human Resources of Isfahan University of Medical Sciences.

Results

All of cases were admitted in orthopedics ward due to accident traumas. Past medical history and demographic data are summarized in Table 1. Above variables were not significantly different between these two groups.

Table 2 indicates postoperative outcomes of these two groups. More deep infection rate noticed in EF group; however, it was clinically (40 vs. 16.7%) but not statistically significant (*p* value 0.086). All of our patients underwent fasciotomy due to their compartment syndrome. Malunion, movement restriction, pain and paresthesia mostly occurred in EF group. No nonunion detected postoperatively. However, malunion rate was significantly higher in EF group (*p*

Table 1 Demographic data in each type of fixation

	Internal fixation ($n=30$)	External fixation ($n=15$)	*p* value
Age (mean ± SD)	37.43 ± 17.79	31.67 ± 12.35	0.267
Sex (male %)	90%	93.3%	0.711
Smoking (%)	10%	13.3%	0.737
Anemia (%)	3.3%	0%	0.475
Diabetes mellitus (%)	6.7%	0%	0.306
Femoral fracture[a] (%)	23.3%	6.7%	0.168
Location of fracture (%) (metaphyseal–diaphyseal–both)	43.3–40–16.7%	40–46.7–13.3%	0.903

[a]All patients had tibial fractures

Table 2 Postoperative outcomes of each type of fixation

	Internal ($n=30$)	External ($n=15$)	p value
Plastic surgery (%, graft)	20%, 6	26%, 3	0.612
Deep infection (%)	16.7%	40%	0.086
Malunion (%)	16.7%	46.7%	0.032*
Pain (%)	26.7%	46.7%	0.180
Paresthesia (%)	26.7%	53.3%	0.078
Movement restriction (%)	13.3%	33.3%	0.114
Number of surgeries (mean ± SD)	2.50 ± 0.509	4.07 ± 1.10	< 0.001*
Hospitalization days (mean ± SD)	11.43 ± 8.012	16.13 ± 10.901	0.108

*Statistical significant is considering p value ≤ 0.05

value = 0.032). Significantly, more surgeries were performed for EF group (p value < 0.001). Additionally, patients with external fixator stayed 4.7 days longer at hospital although our analysis did not show significant difference between these two groups (p value = 0.108).

Discussion

The most common etiology of lower limb acute compartment syndrome is tibial fractures [1–4]. Current assumption in treating high-energy tibial fractures with concomitant compartment syndrome is increased soft tissue damages and postoperative bone complications after converting close to open fracture by fasciotomy. Thus, orthopedic surgeons try to fix the fracture temporarily with external fixator after wound closure, which may take 2–4 weeks, fix the fracture with ORIF forever. Hence, we tried to compare these two treatment methods of fixation (early vs. late internal fixation) in this complicated situation.

Our results suggested that deep infection, malunion, decreased range of motion in both knee and ankle joints, pain and paresthesia in fractured leg mainly occurred in EF group. Nonunion did not occurred in our patients. These results are clinically important and should be noticed by orthopedic surgeons, and patients should be informed before surgery; however, except malunion, other variables were not statistically significant between the two groups, which can be due to our limited sample size. All of our patients had mature skeleton, and their past medical histories (smoking, anemia and diabetes mellitus) were not significantly different between these two groups. Early ORIF patients had significantly lower number of surgeries. A higher number of plastic surgeries (skin graft) were performed for EF group (26 vs. 20%; $p = 0.612$). None of our patient suffered from nonunion. Therefore, all of those surgeries were performed due to their severe soft tissue injury. All of our patients had Tscherne-type C3 soft tissue injury; therefore, patients who treated with EF suffered more than ORIF group due to higher rate of complications, staying much longer in the hospital, had more surgeries and spent a high price for their fractured leg. EF makes patients stay approximately 4 days longer although it was not statistically significant ($p = 0.108$); nevertheless, longer hospitalization has many disadvantages for families, hospitals and insurance companies. Therefore, as our results revealed, both of these methods are the same in their outcomes and they do work similarly for tibial fractures with compartment syndrome. Through this research, we suggest that it is better to perform fasciotomy and ORIF simultaneously in one surgery and after the wound healing, close the skin with or without plastic surgery to lower the number of surgeries, days of hospitalization and avoid the higher risk of deep infection, malunion and movement restriction. Although ORIF is more cost-effective for most of the countries, we suggest it does not have significant difference with EF. The Tscherne classification helps clinician to choose the appropriate therapeutic approach for their patients with closed fractures and soft tissue injury, which affects the patient's overall outcome. All of our patients had type C3 soft tissue injury; however, our results suggest different outcomes, which indicate the importance of fixation methods.

Numerous researches studied risk factors of infection after fixating fractures and mentioned a long list. Although there is controversy in these factors, the most relevant factors to our study are smoking, compartment syndrome requiring fasciotomies, operative time and open injuries, which are shown to be associated with higher infection rate [7, 11–14]. In another study, compartment syndrome and using external fixation did not predict postoperative infection rate [7]. Fasciotomy makes close fracture wound into an open bed, as it can be construed, EF needs much more surgeries and longer surgery time, and therefore, it is not out of mind that this method is one of the complex treatment approaches [7]. Other disadvantages of fasciotomy are delayed union and nonunion, which patients should be aware of it [1, 15].

In previous surveys, Hak et al. compared early ORIF in two groups of tibial plateau fractures. A group of 14 patients had compartment syndrome with treating fasciotomy, and second group had only fracture without compartment

syndrome. They did not find any increased infection rate in fasciotomy group who were treated with early ORIF [16]. In addition, Zura et al. [9] study evaluated postoperative infection rate of 30 early fixed severe tibial fractures and concluded infection rate was not increased. In our study, we included all types of tibial fractures with compartment syndrome and they were randomly allocated between two groups. We included more cases and detected higher deep infection rate in EF group although it was clinically noteworthy, but not statistically significant. One meta-analysis comparing EF versus. ORIF for bicondylar tibial plateau fractures revealed although different fixations have different postoperative complications, higher infection rate occurred in EF. It has been previously mentioned that although articular architecture remains intact with ORIF it makes more deep infection and delayed wound healing due to disrupting the soft tissue envelope in contrast to EF. However, the functional results of these procedures remained unclear in tibial plateau fractures [6]. According to our study, which is a mixture of all kinds of tibial fractures, infection rate was higher in EF group and this kind of method resulted in more malunion and movement restriction. Another study advocated our results and determined spite EF is a staged protocol, and deep infection arises more in this group which needed wide-spectrum intravenous antibiotics [11]. Another meta-analysis compared EF and ORIF for complex tibial plateau fractures and revealed the final decision should be based on multiple factors like fracture pattern, soft tissue condition and stage of injury, and both of the methods are recommended strongly [8]. Kim et al. [10] did not find any beneficences in changing from EF to ORIF for treating compartment syndrome-affected tibial fractures. A study in 2016 reviewed 80 patients with high-energy tibial fractures who received EF with subsequent ORIF before 12 h after trauma or later than that. They came to this conclusion that infection rate, frequency of compartment syndrome, numbers of secondary procedures and length of hospitalization were not significantly different between early and delayed EF groups [2]. Although they challenged the timing of treating lower extremity fractures with stage-based protocol, we compared early ORIF and early EF and highlighted their differences.

We have some limitations in our study. We could not evaluate exact union time due to long intervals between postoperative follow-up X-rays. We searched our 5-year-database and could not find more than 57 cases. We suggest this condition replicate in randomized controlled trials with sufficient sample size and precise inclusion and exclusion criteria.

In conclusion, external fixation did not affect postoperative pain, paresthesia, deep infection, movement restriction rate and days of hospitalization statistically although our results showed these rates worthwhile to be reviewed clinically. However, malunion risk and number of surgeries performed for them were significantly higher. We suggest ORIF for simultaneous tibial fractures and compartment syndrome to avoid high chances of pain, paresthesia, malunion, movement restriction, and deep infection postoperatively and decrease number of surgeries, anesthesia and days of hospitalization. Finally, ORIF is more cost-effective for most of the countries although its postoperative outcomes were not significantly different from EF.

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Compliance with ethical standards

Conflict of interest The authors declare no potential conflict of interests.

Ethical approval This study started after receiving its ethical approval from Isfahan University of Medical Sciences, department of medical ethics in research with registered inquiry of IR.MUI.REC.1395.1.066.

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