[Orthopaedic Surgery]

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Return to Sport After Tibial Shaft Fractures: A Systematic Review

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Context: Acute tibial shaft fractures represent one of the most severe injuries in sports. Return rates and return-to-sport times after these injuries are limited, particularly with regard to the outcomes of different treatment methods.

Objective: To determine the current evidence for the treatment of and return to sport after tibial shaft fractures.

Data Sources: OVID/MEDLINE (PubMed), EMBASE, CINAHL, Cochrane Collaboration Database, Web of Science, PEDro, SPORTDiscus, Scopus, and Google Scholar were all searched for articles published from 1988 to 2014.

Study Selection: Inclusion criteria comprised studies of level 1 to 4 evidence, written in the English language, that reported on the management and outcome of tibial shaft fractures and included data on either return-to-sport rate or time. Studies that failed to report on sporting outcomes, those of level 5 evidence, and those in non–English language were excluded.

Study Design: Systematic review.

Level of Evidence: Level 4.

Data Extraction: The search used combinations of the terms *tibial, tibia, acute, fracture, athletes, sports, nonoperative, conservative, operative*, and *return to sport*. Two authors independently reviewed the selected articles and created separate data sets, which were subsequently combined for final analysis.

Results: A total of 16 studies (10 retrospective, 3 prospective, 3 randomized controlled trials) were included (n = 889 patients). Seventy-six percent (672/889) of the patients were men, with a mean age of 27.7 years. Surgical management was assessed in 14 studies, and nonsurgical management was assessed in 8 studies. Return to sport ranged from 12 to 54 weeks after surgical intervention and from 28 to 182 weeks after nonsurgical management (mean difference, 69.5 weeks; 95% CI, −83.36 to −55.64; $P < 0.01$). Fractures treated surgically had a return-to-sport rate of 92%, whereas those treated nonsurgically had a return rate of 67% (risk ratio, 1.37; 95% CI, 1.20 to 1.57; $P < 0.01$).

Conclusion: The general principles are to undertake surgical management for displaced fractures and to attempt nonsurgical management for undisplaced fractures. Primary surgical intervention of undisplaced fractures, however, may result in higher return rates and shorter return times, though this exposes the patient to the risk of surgical complications, which include surgical site infection and compartment syndrome.

Keywords: tibial; shaft; fractures; sport; treatment; outcome

Acute tibial shaft fractures represent one of the most severe injuries in sports, resulting in the longest return-to-sport timing among sports fractures.[26,27] Accounting for 4% of all acute sports-related fractures, this injury comprises a major source of morbidity for affected athletes.[6] One-quarter of all tibial shaft fractures are incurred during sporting activity, and, with rapidly increasing participation levels in sports, the incidence of this injury will likely continue to rise.[4] As such, it is necessary for surgeons to be able to manage these fractures optimally and to be able to inform patients on the likelihood and time frame of return to sports activity after such injuries.

As with any acute fracture, the management of tibial shaft fractures involves anatomical fracture reduction with adequate fracture immobilization to allow optimal fracture healing, followed by timely rehabilitation to facilitate the return of normal physiological functioning.[5] Current recommendations

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The authors reported no potential conflicts of interest in the development and publication of this manuscript.
DOI: 10.1177/1941738115601425

advocate nonsurgical management for undisplaced fractures and surgical management for displaced fractures.[5] Recommended management techniques are patellar tendon–bearing casting for nonoperative intervention and intramedullary (IM) nailing for operative intervention.[5] Other treatment methods included open reduction and internal fixation (ORIF),[5] external frame fixation,[5] cerclage wire fixation,[12,13] and manipulation of the fracture under anesthesia (MUA) followed by cast immobilization.[1] While studies have ascertained the effectiveness of these methods in terms of rate and time to union and rate of persisting symptoms, few studies have assessed the influence of these techniques on return rates and return time to sports.[5] With one-quarter of all tibial shaft fractures occurring during sports, this is a significant limitation in the literature.[4]

The aims of this review were to systematically review the return rates and times to sport for acute tibial shaft fractures as well as to assess the influence of treatment modality on the outcome of these injuries in athletes.

METHODS

Literature Search

A comprehensive literature search was performed in February 2015 using OVID/MEDLINE (PubMed), Embase, CINAHL, Cochrane Collaboration Database, Web of Science, Physiotherapy Evidence Database (PEDro), SPORTDiscus, Scopus, and Google Scholar. This search aimed to identify articles published in English in peer-reviewed journals, reporting data and information on return to sports after acute tibial shaft fractures without any distinction for type and severity of fracture, level, and type of sports activity. The titles of all articles were initially reviewed to assess for relevance to the topic, with further review of the abstract and article performed as required (Figure 1). The references of all articles retrieved in full text were also reviewed to identify articles not included in the first electronic search. In total, 152 unique abstracts and 49 unique articles were assessed.

The search was performed using the keywords *tibial, tibia, acute, fracture, athletes, sports, nonoperative, conservative, operative*, and *return to sport*, with no limit for year of publication.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for the reporting of systematic reviews and meta-analyses were followed.[17] The authors independently assessed the abstract of each publication, deciding whether it was suitable for inclusion on the basis of its content. The inclusion and exclusion criteria, designed in accordance with the PRISMA protocol, are detailed in Table 1 and Figure 1. Expert opinions, literature reviews, case reports, biomechanical reports, letters to editors, instructional courses, and technical notes were excluded unless they contained original patient data to fulfill the inclusion criteria. Similarly, studies reporting on stress fractures of the tibial shaft were excluded, as this topic has been reviewed in a separate article.[25] When inclusion or exclusion was not possible based on the abstract, the full-text versions were downloaded. The search results and the relative selection process are shown in the Quality of Reporting of Meta-Analyses flow diagram (Figure 1). As this study was a systematic review that did not involve human subjects, institutional review board approval was not required.

The primary outcome measures of interest were return-to-sport rate and time. Secondary measures included rate of return to full-level sport, rate of fracture union, time to fracture union, rate of reintervention, and rate of recorded complications. The time to return to sport was measured from commencement of nonsurgical modalities for conservatively managed patients and from primary surgical treatment for operatively managed patients. Where fractures were managed with casting alone, with no intervention, they were presumed to be undisplaced unless otherwise stated.

The modified Coleman methodology score was used to assess the quality of the studies, as described by Robertson and Wood[25] (see Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). This has previously been used to assess the quality of studies reporting outcomes on sport-related fractures[8,25] as well as in multiple other domains of sports medicine.[7,18-23] The authors independently reviewed the selected articles and created separate data sets, which were subsequently combined for final analysis.

Statistical Analysis

The included patient cohorts were pooled, where possible, and are discussed in the Results. When cohort sizes were of sufficient size, meta-analysis comparisons were made between the synthesized data. The meta-analysis was performed using RevMan version 5.3 (The Cochrane Group). Dichotomous data were analyzed by risk ratios (RRs) and using a random-effects model. Continuous data were analyzed by mean difference using a random-effects model. Heterogeneity was assessed by using I^2 and judged to be significant if I^2 was greater than 50%. The significance level was set at $P < 0.05$.

RESULTS

Return to Sport

Surgically Managed Fractures

Of the 165 patients with surgically managed fractures for which return-to-sport rates were reported, 151 (91.5%) returned to sport (Figure 2 and Table 2; Appendix Table 1, available at http://sph.sagepub.com/content/by/supplemental-data).[1,9,10,14,26-28]

Of the 120 patients with fractures treated with IM nailing alone, 106 returned to sport (88.3%) (Table 2).[9,10,14,26-28] Of the 45 patients with fractures treated with ORIF, 45 (100%) returned to sport (Table 2).[1]

For the surgically managed cohorts, return rates to the same level of sport ranged from 55% to 100% (mean, 75.4%).[9,10,14,16,26-29]

Nonsurgically Managed Fractures

Of the 120 patients with nonsurgically managed fractures with reported return-to-sport rates, 80 (66.7%) returned to sport (Figure 2 and Table 2; Appendix Table 2, available at http://sph.sagepub.com/content/by/supplemental-data).[1,15,24,26] Of the 29

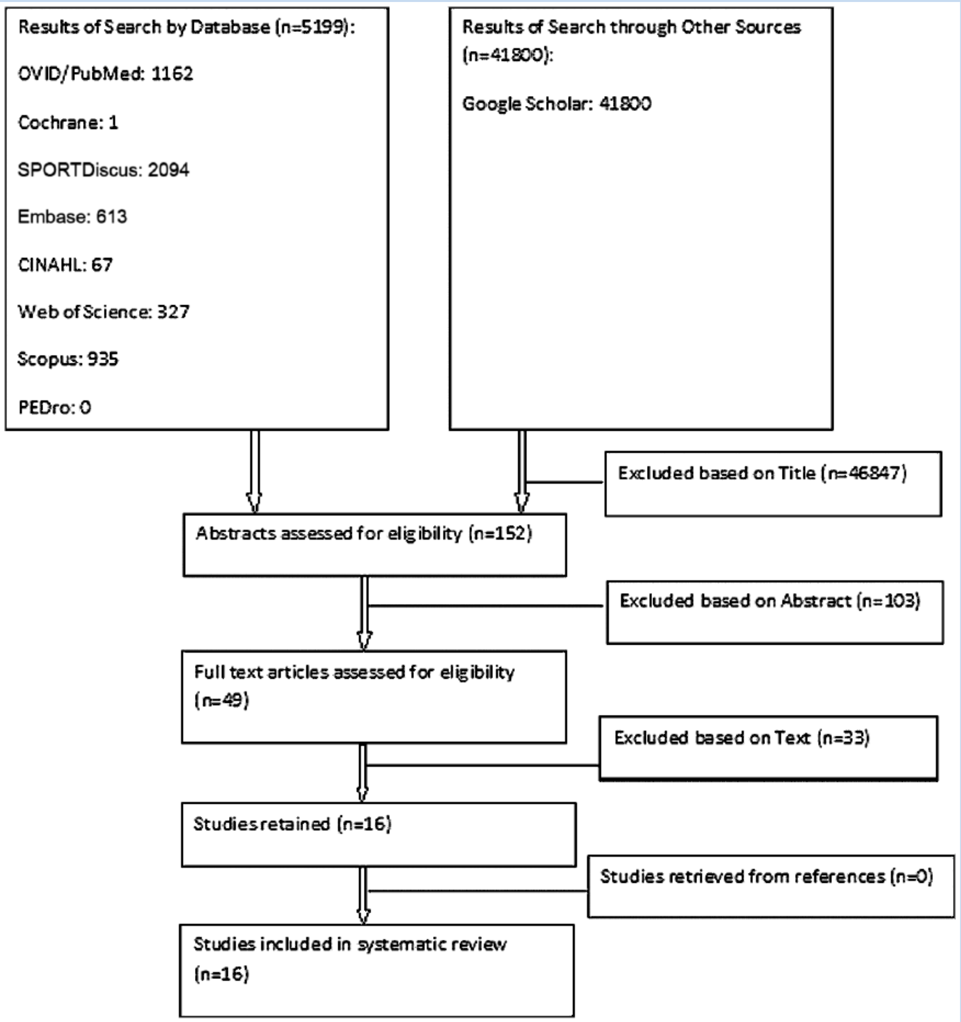

Figure 1. Selection of articles for inclusion in the review in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Acute tibial shaft fracture	No sporting outcome data reported
Elite or recreational athletes	Pediatric fractures (age <15 years)
Rate of return to sporting activity reported	Fractures with metaphyseal or intra-articular extension
Time to return to sporting activity reported	Fractures with concomitant femoral fractures
Two or more fractures reported	Stress fractures
Peer-reviewed journals	Reviews, case reports, abstracts, or anecdotal articles
English language	Animal, cadaver, or in vitro studies

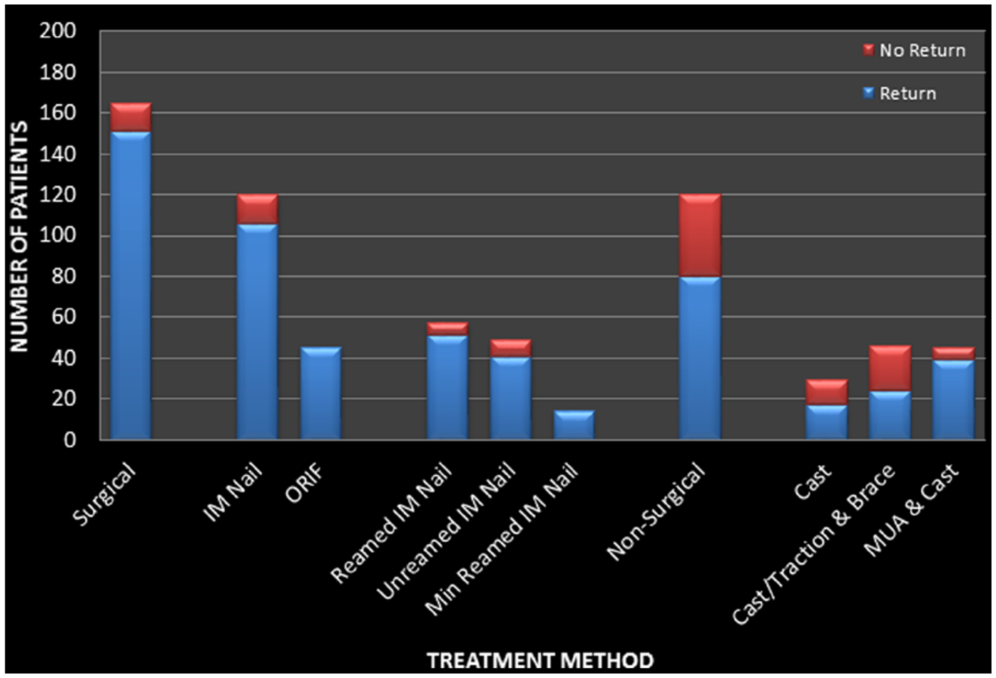

Figure 2. Return-to-sport rates for tibial shaft fractures. IM, intramedullary; MUA, manipulation of the fracture under anesthesia; ORIF, open reduction and internal fixation.

patients with fractures treated with casting alone, 17 returned to sport (58.6%) (Table 2).[15,26] Of the 46 patients with fractures treated with Sarmiento bracing, 24 returned to sport (52.2%) (Table 2).[24] Of the 45 patients with fractures treated with MUA and casting, 39 returned to sport (86.7%) (Table 2).[1]

For nonsurgically managed cohorts, return rates to the same level of sport ranged from 13% to 67% (mean, 40%).[15,26]

Return rates for the nonsurgically managed fractures[1,15,24,26] were significantly lower than those for surgically managed fractures[1,9,10,14,26-28] (RR, 1.37; 95% CI, 1.20 to 1.57; $P < 0.01$; $I^2 = 0\%$) (Figure 2). Return times for nonsurgically managed fractures[1,3,24,26] were significantly greater than those for surgically managed fractures[1,3,9-13,26-29] (mean difference, 69.5 weeks; 95%CI, –83.36 to –55.64; $P < 0.01$) (Figure 3).

Complications

For patients managed surgically, the rate for reintervention ranged from 2% to 100% (mean, 33%) (Appendix Table 3, available at http://sph.sagepub.com/content/by/supplemental-data).[1-3,9-14,16,26-29] For those managed with IM nailing, the rate of reintervention ranged from 2% to 52% (mean, 34%), with noted complications including compartment syndrome (range, 0%-33%), wound infection (range, 0%-10%), deep vein thrombosis (0%-5%), fat embolism (0%-9%), and postoperative knee pain (20%-54%).[2,3,9-11,14,16,26-29] For patients managed with ORIF, the rate of reintervention ranged from 0% to 40%, with noted complications including wound infection (0%-4%).[1,3,16]

For patients managed nonsurgically, the rate of reintervention ranged from 0% to 50% (mean, 19%) (Appendix Table 3).[1-3,15,16,24,26,29] For those managed with casting alone, the rate of further intervention ranged from 0% to 50% (mean, 24%), with noted complications including fracture displacement (0%-36%), refracture (0%-25%), and malunion (0%-6%).[2,3,15,16,26,29] For those managed with MUA and casting, the rate of reintervention was 29%, with noted complications including fracture displacement (31%), malunion (13%), compartment syndrome (2%), and shortening (2%).[1] The requirement for wedging in casting with this technique was 16%.[1]

Predictive Factors

Factors found to be associated with a decreased return-to-sport rate included increased Tscherne grading[11,29] and the presence of an open fracture.[29] Factors found to be associated with an increased return-to-sport time included the presence of a fibular fracture[2,11] and a lower preinjury level of sport participation.[29] Factors found to show no association with rate or time to return to sport included AO (Arbeitsgemeinschaft fur Osteosynthesefragen) classification,[11,16] Winquist classification,[11] fracture location,[11] age of patient,[11,16] sex of patient,[11] previous tibial shaft fracture,[11] and causative sporting activity.[11,16]

DISCUSSION

The main findings of this review are that most patients with an acute tibial shaft fracture will return to sports activity; however, only a limited proportion will return to their preinjury level of sport, and those treated with conservative measures demonstrate longer return times and decreased return rates.

Table 2. Summary of the return-to-sport times and rates and union times and rates by treatment modality

Mode of Treatment	n (Total)	Mean Return-to-Sport Time (Range), wk	Mean Return-to-Sport Rate, n (%)	Mean Time to Union (Range), wk	Rate of Union, n (%)
All[1-3,9-16,24,26-29]	782	48.5 (12-182)[1,3,9-13,24,26-29]	231/285 (81.1)[1,9,10,14,15,24,26-28]	18.0 (10-30)[1,3,9,10,12,14,15.24,28]	577/595 (97.0)[1-3,9,10,12-16,24,26-28]
Surgical[1-3,9-14,16,26-29]	568	38.2 (12-55)[1,3,9-13,26-29]	151/165 (91.5)[1,9,10,14,26-28]	18.8 (11.3-30)[1,9,10,12,14,28]	414/423 (97.9)[1,2,9,10,12-14,16,26-28]
IM nailing[2,3,9-11,14,16,26-29]	287	40.8 (29-53.5)[9-11,26-29]	106/120 (88.3)[9,10,14,26-28]	20.9 (11.3-30)[9,10,14,28]	143/152 (94.1)[2,3,9,10,14,16,26-28]
IM nailing and cerclage wire[12]	37	12[12]	NA[12]	12[12]	37/37 (100)[12]
Cerclage wire and cast[13]	186	28.4[13]	NA[13]	NA[13]	186/186 (100)[13]
ORIF[1,3,16]	50	52[1]	45/45 (100)[1]	16[1]	48/48 (100)[1,16]
External fixation[29]	8	55[29]	NA[29]	NA[29]	NA[29]
Reamed IM nailing[3,10,11,14,16,26-29]	214	41.1 (29-53.5)[10,11,26-29]	51/57 (89.5)[10,14,26-28]	21.8 (13.5-30)[10,14,28]	85/89 (95.5)[3,10,14,16,26-28]
Unreamed IM nailing[9,14]	49	40.9[9]	41/49 (83.7)[9,14]	21.5 (11.3-28.5)[9,14]	44/49 (89.8)[9,14]
Minimally reamed IM nailing[10]	14	34[10]	14/14 (100)[10]	19[10]	14/14 (100)[10]
Nonsurgical[1-3,15,16,24,26,29]	201	107.7 (27.6-182)[1,3,24,26]	80/120 (66.7)[1,15,24,26]	16.2 (10-21)[1,3,15,24]	163/172 (94.7)[1-3,15,16,24,26,]
Cast[2,3,15,16,26,29]	110	36.3 (27.6-45)[3,26]	17/29 (58.6)[15,26]	14.3 (10-19)[3,15]	79/81 (97.5)[2,3,15,16,26,]
Cast/traction and brace[24]	46	34[24]	24/46 (52.2)[24]	12.9[24]	45/46 (97.8)[24]
MUA and cast[1]	45	182[1]	39/45 (86.7)[1]	21[1]	39/45 (86.7)[1]
Treatment not specified[29]	13	NA[29]	NA[29]	NA[29]	NA[29]

IM, intramedullary; MUA, manipulation under anesthesia; NA, not available; ORIF, open reduction and internal fixation.

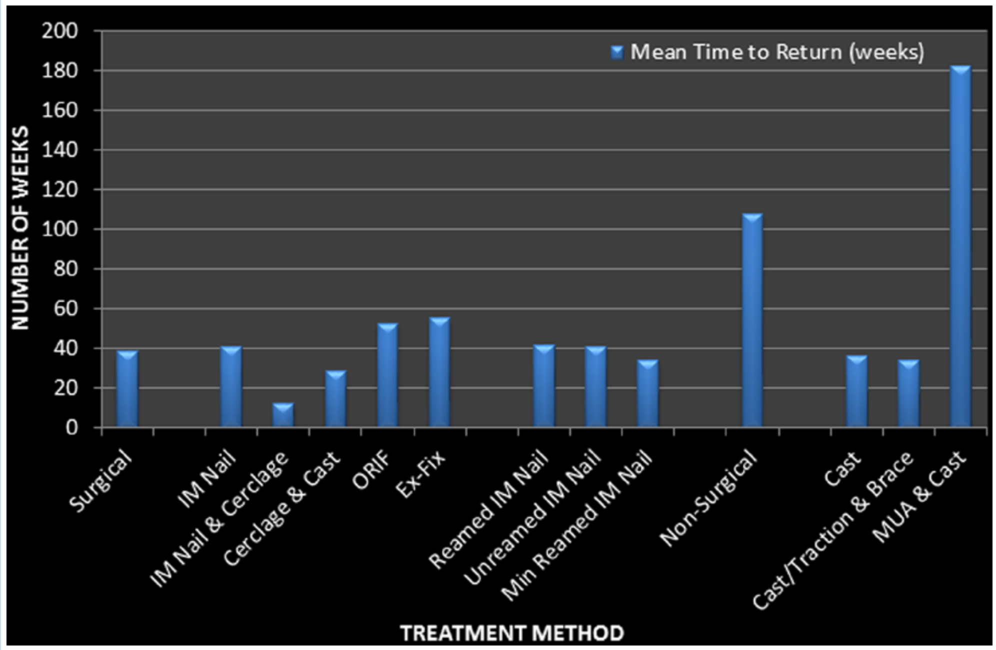

Figure 3. Return-to-sport times for tibial shaft fractures. Ex-Fix, external frame fixation; IM, intramedullary; MUA, manipulation of the fracture under anesthesia; ORIF, open reduction and internal fixation.

Meta-analysis of the study results confirms that surgical intervention offers significantly improved return-to-sport rates and significantly decreased return-to-sport time. However, the choice of surgical management exposes the patient to the risk of surgical complications, which include infection, compartment syndrome, and neurovascular injury.

In comparison with previous similar systematic reviews, the methodological quality of the studies in this review was improved, with a mean modified Coleman methodology score of 62 (see the Appendix).[8,25] However, there were only 3 randomized studies, with the majority of studies comprising level 2 or 3 evidence. Thus, despite established management principles for tibial shaft fractures,[5] the optimal modalities for management and rehabilitation of these injuries have yet to be ascertained.

For the different surgical techniques, IM nailing demonstrated a high return rate (88%) with favorable return times (mean, 41 weeks). ORIF demonstrated a high return rate (100%) yet with prolonged return times (mean, 52 weeks). External frame fixation demonstrated further prolonged return times (mean, 55 weeks).

To note, Habernek[12] reported the fastest return to sport (12 weeks) with the combination of IM nailing and cerclage wiring. However, this technique is only of benefit with spiral fractures.[12] Additionally, there is potential for damage to the periosteal blood supply and the surrounding neurovascular structures with this technique.[12] If such damage to the periosteal blood supply was combined with the damage incurred to the intramedullary blood supply by intramedullary reaming, such a technique could result in significant complications.[5] As such, it remains difficult to recommend such a technique without further evidence.

Despite lower return rates and increased return times compared with surgical intervention, conservative management of undisplaced fractures remains an acceptable management technique, as this can avoid the potential complications associated with surgery. However, when attempting conservative management, clinicians must remain aware that dedicated regular follow-up is required to assess for fracture displacement, with surgical intervention offered in a timely fashion when required.[5] Clinicians must not only counsel patients that surgical intervention can result in improved return rates and decreased return times, but clinicians must also explain the risks associated with surgery. MUA and casting for displaced tibial shaft fractures resulted in the longest return time of all modalities—4 times longer than most surgical techniques.[1] This is usually not an acceptable management plan for displaced fractures.

The rates of compartment syndrome were noted to be high among some cohorts managed with IM nailing.[2,9,10,16,26] This may be a reflection of more sensitive monitoring, with several of these studies employing invasive compartment monitoring pre- and postoperatively.[10,26] Nevertheless, patients must be warned of this as a significant potential complication, and clinicians must have a high index of suspicion for this when treating such patients.

To note, open fractures and fractures with a high degree of soft tissue damage demonstrated decreased return-to-sport rates, while those with associated fibular fractures demonstrated increased return-to-sport times.[2,11,29] This likely reflects an increased energy of injury, creating greater damage to the surrounding musculature and requiring an increased recovery period.

From this review, it appears that surgical management is a requirement for displaced tibial shaft fractures, with reamed IM nailing being the most validated technique. Nonsurgical management remains an acceptable first-line management plan for undisplaced tibial shaft fractures. However, displacement can occur in up to one-third of cases, and should this occur, surgical intervention should be considered. Primary surgical intervention of such injuries, however, may result in higher return rates and shorter return times.

Despite thorough analysis of the principles of management in these studies, descriptions of the rehabilitation protocols used in the studies were often limited.[1-3,9-16,24,26-29] As such, the evidence on the optimal modality of rehabilitation for these injuries remains limited.

There are several limitations to our review. First, because of the diversity of the included cohorts, the synthesis data could not be pooled for severity of fracture, fracture location, fracture classification, or level of sporting activity. Second, the majority of studies only briefly referred to return to sports, with very few providing comprehensive definitions regarding level of sporting return, limiting our ability to determine final sporting function achieved. Furthermore, the reporting of functional outcome was entirely subjective, with no formal validated outcome score employed throughout. Lastly, with the multiple treatment modalities employed, combined with the limited cohorts included, it was not possible to draw definite conclusions on the optimal treatment methods for the different fracture types.

CONCLUSION

Most athletes who suffer an acute tibial shaft fracture can expect to return to sport; however, only a proportion of these individuals will return to their preinjury level of sport. Surgical management is the gold standard treatment for displaced tibial shaft fractures, offering high return rates and reduced return times, with IM nailing being the most validated surgical technique. Nonsurgical management forms the first-line treatment for all undisplaced tibial shaft fractures, with conversion to surgical management if fracture displacement occurs. However, primary surgical intervention may result in higher return rates and shorter return times.

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