Review

Are you pulling my leg? Does the use of traction splints in the pre-hospital management of patients with femoral fractures reduce the incidence of complications compared to traditional splinting?

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Abstract

Introduction

Femoral shaft fractures are a serious but infrequently seen injury in the pre-hospital environment. Management of these fractures includes immobilisation, analgesia, fluid administration and appropriate conveyance. Despite traction splints being widely used since World War I, there has been no systematic review published to date. In order to support evidence-based practice this systematic review will attempt to determine if the use of traction splints in the pre-hospital management of patients with femoral shaft fractures reduces the complications compared to traditional splinting.

Methods

A systematic review using the MEDLINE database (1946 to 27 August 2019) using a combination of keywords and medical subject headings. The reference lists of all relevant papers were reviewed to identify further papers. The title and abstracts of all records retrieved by the search strategy were reviewed by one independent author to identify potentially relevant papers. All potentially relevant papers were read in full text.

Results

A total of 42 papers were identified from the search strategy; 10 met the inclusion criteria and informed the results of this paper. Five key themes were identified: inappropriate application; on-scene times; effect on pain; vascular complications; and nerve complications.

Conclusion

Traction splints are frequently applied incorrectly but no statistical increase in on-scene times was found. A statistically significant decrease in the need for blood transfusions was demonstrated with the application of a traction splint.

Keywords:

emergency medical services; femoral fractures; traction; splints

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Introduction

Fractures represent the most common type of injury hospitalised in Australia (38%) and of these, fractures of the femur are subsequently admitted 95.5% of the time (1). In addition to the hospital stay, there is considerable mortality and morbidity associated with femoral fractures (2). Femoral shaft fractures are generally considered the result of a high energy mechanism of injury, including road traffic collisions, falls from height and assaults. Despite this, low mechanism injuries accounted for the majority (77%) of femoral shaft fractures in a 2006 study (3). The presence of osteoporosis and metastatic disease increases the incidence in low mechanism injuries, such as falls from a standing height (4). Of the 15,745 femoral fractures in Australia during 2013-2014, only 1456 (9.24%) were coded as femoral shaft fractures occurring in the diaphysis of the bone (5). International incidence estimates of femoral shaft fractures range from 2 to 18 per 100,000 people, while an Australian study, which included all patients (age, treatment, died pre-hospital) reported a higher incidence of 21 per 100,000 (3,6-8).

Pre-hospital management focusses on immobilisation, analgesia, fluid administration and conveyance to an appropriate facility. Early immobilisation of the femur is reported to significantly reduce complications including haemorrhage, nerve injury and compartment syndrome (4). The risk of haemorrhage appears to be a primary reason for the application of traction splints, with a belief that blood loss from a femoral fracture 'may be adequately controlled only by using fixed traction splints' (9). Blood loss as a result of femoral shaft fracture is reported between 1000–2500 mL, and due to the vascular nature of the femur, exsanguination may occur (10). Immobilisation for femoral shaft fractures is primarily accomplished with traction splints, however if concomitant leg, ankle or pelvic injuries are present, traction splints are often contraindicated (11). The alternative is traditional static splinting, which can be done using a range of commercial or improvised splints.

Traction splints for femoral fractures made their pre-hospital debut in 1915 during World War I (12). It is during this war that the Thomas traction splint created its lasting legacy, reportedly reducing mortality from military femoral fractures from 80% to 15.6% by 1918 (13). The traction splint has evolved to be more portable, with lighter materials and improved pulley systems, while still maintaining the same treatment principle. Manufacturers of modern unipolar traction splints claim they can be used with suspected pelvic fractures and binders, however there is little literature available to support this (14). Traction splints were once the main definitive treatment for femoral fractures, however in an evidence-supported move, surgical interventions are now almost always performed (15). The traction splint remains primarily a pre-hospital intervention.

Despite widespread usage of traction splints, they can be time consuming and difficult to apply along with reported complications that have led some to question their continued use (16). Conversely, reports of success from World War I are significant and there are plenty of personal anecdotes of improvement to patients' reported pain levels after application of a traction splint (17). To date, there has been no published systematic review on the pre-hospital use of traction splints. Pre-hospital practitioners are infrequently exposed to femoral shaft fractures (18), and despite the wide use of traction splints, there appears to be questions regarding the evidence supporting their use (16). This comprehensive systematic review will attempt to determine if the use of traction splints in the pre-hospital management of patients with femoral fractures reduces the complications compared to traditional splinting.

Methods

A comprehensive search strategy was conducted using MEDLINE (1946 to 27 August, 2019) with a combination of the following keywords and medical subject headings (MeSH): 'traction'; 'splint'; 'CT6'; 'CT-6'; 'CT-EMS'; 'Thomas'; 'Sager'; 'Hare'; 'Donway'; 'Kendrick'; 'Faretec'; 'Fernotrac'; 'Reel'; 'Prometheus'; 'Slisman'; 'immobilisation'; 'immobilization'; 'pre-hospital'; 'prehospital'; 'out-of-hospital'; 'out of hospital'; 'EMT'; 'EMS'; 'paramedic'; 'ambulance'; 'emergency medical service'; 'femur'; 'femoral'; 'fracture'; 'mid-shaft'; 'midshaft'; 'diaphyseal'; 'midthigh'; 'mid-thigh'. Search terms were combined with appropriate Boolean terms and truncation symbols. No limitations were placed on the search. The reference lists of all relevant papers were reviewed to identify further papers. The title and abstracts of all records retrieved by the search strategy were reviewed by one independent author to identify potentially relevant papers. All potentially relevant papers were read in full.

Results

The selection of papers for inclusion in this review is outlined in Figure 1. The comprehensive search strategy designed for this review identified a total of 42 papers. A title and abstract search of these records identified that 33 were potentially relevant for inclusion in this review. A full text appraisal of these 33 papers identified 10 that met the inclusion criteria for this systematic review. Analysis of these papers identified five key recurring themes reported in the literature: inappropriate application; on-scene times; effect on pain; vascular complications; and nerve complications. Due to the heterogeneity of the results, no attempts at meta-analysis were made.

Discussion

All of the identified literature is low-level evidence with no previous randomised control studies or systematic reviews.

Half of the papers are retrospective reviews, two case studies, one prospective and one epidemiological and experimental study. Only one study was solely a paediatric population, five were adults only and four studies covered both paediatric and adults. All included studies were single country, with seven studies from the United States, and the remaining three from Iran, Sweden and South Africa. Sample size varied greatly from a single case study to large retrospective review of 828 patients. The type of traction splint utilised was not disclosed in two studies. Three studies used more than one type of traction splint, three exclusively used the Hare traction splint and two used the Thomas traction splint (Table 1).

Inappropriate application

Of the 10 studies included, seven discussed the application of the traction splint. They found that despite being indicated, traction splints were frequently not applied (3,19). Less than half of the patients for whom the treatment was indicated were treated with a traction splint in the pre-hospital setting (3,19). None of the identified literature discussed why responders did not apply traction splints when indicated. Despite similarly low rates of application, a survey of pre-hospital practitioners found that they viewed traction splint use as only mildly or moderately problematic, suggesting there is a disconnect between perceptions and practice (18).

When traction splints were applied, they were regularly applied incorrectly (11) or inappropriately to patients with contraindicating injuries (11,20,21,22). In one retrospective review of paediatric femoral shaft fractures, 66% (n=77) of traction splints were found to be incorrectly fitted (11). The

mechanism required to cause a femoral shaft fracture generally results in multiple injuries, making it essential that practitioners are aware of when concurrent injuries may interfere with the use of a traction splint. In one paper 38% (n=15) of patients with a traction splint were found to have contraindicating injuries, most commonly concomitant pelvic fractures (n=6, 15%) (22). Other contraindicating injuries include pelvic or knee ligamentous injury, patella fracture or dislocation and tibia or fibula fracture (22). Contraindicated injuries were found to be present in two case studies that resulted in peroneal nerve damage and a third who developed compartment syndrome (20,21). Only one study reported there was no inappropriate or incorrect application of traction splints (23).

As a result of incorrectly or inappropriately applied tractions splints, patients appear to be more likely to experience complications including pain, nerve damage and vascular compromise. This raises significant concerns regarding the ability of pre-hospital practitioners to screen patients for other relevant injuries while dealing with a 'distracting injury'. The continued application of traction splints may necessitate change in training or removal of this skill for some levels of responders in order to ensure patient safety.

On-scene times

Three papers discussed the effect of traction splint application to on-scene times (3,19,24). No statistical significant difference was found in any of these studies. This was corroborated with the third paper also reporting statistically similar on-scene times with application of traction splints compared to static splinting (p=0.0001) (24). However, it is worth noting that there was a

Figure 1. PRISMA flow diagram (29)

Table 1. Study characteristics

Study	Year published	Type of study	Age group	Country of study	Type of traction splint utilised	Sample size
Abarbanell (23)	2001	Retrospective	All ages	Evanston, Illinois, US	Hare	16
Daugherty, Mehlman (11)	2013	Retrospective	Paediatric population 3–16 years	Cincinnati, US	Hare	464
Hoppe, Keel (27)	2015	Retrospective	All ages	Johannesburg, South Africa	Thomas	106
Irajpour, Kaji (24)	2012	Quasi-experimental	15–65 years	Isfahan, Iran	Not disclosed	64
Mansson, Ruter (3)	2006	Epidemiological and experimental study	Adult >18 years	Sweden	Hare, Sager, Qvicksplint & Nordic Arms	57
Mihalko, Rohrbacher (20)	1999	Case study	Adult	US	Sager x1 Thomas x1	2
Nackenson, Baez (19)	2017	Retrospective	Adult >16 years	Miami-Dade County, Florida, US	Hare	170
Spano, Campagne (26)	2014	Retrospective	All ages	California US	Sager and Hare	579
Watson and Kelikian (21)	1998	Case study	Adult	Pittsburgh, Pennsylvania, US	Thomas	1
Wood, Vrahas (22)	2003	Descriptive prospective	All ages	US	Not disclosed	828

non-significant increase in on-scene times with application of traction splints. In the two studies that published on-scene times there was an increase of 9 and 1.6 minutes ($p=0.96$ and $p=0.285$, respectively) (3,19).

Notwithstanding the statistically non-significant time difference, both studies with published averages corroborated that the application of a traction splint does prolong time on-scene. This may be of clinical significance as previous research has identified that increased on-scene time in trauma, particularly penetrating trauma, is linked with increased mortality (25). The current research regarding on-scene times is insufficient to recommend change, but must be considered. Some ambulance services have strict trauma guidelines with on-scene time restrictions that could be difficult to achieve with traction splint application.

Effect on pain

The use of splinting to provide analgesia is an important treatment principle in femoral shaft fractures. Application of static splints and traction splints were shown to decrease reported pain levels in two studies (19,24). Static splints and traction splints demonstrated a significant decrease in pain by the twelfth hour post-application; however, traction splints consistently had a more significant decrease compared to static splints at first, sixth and twelfth hour post-application ($p=0.0001$, $p=0.0001$ and $p=0.02$, respectively) (24). Despite collecting data on morphine administration this was not included in the paper. No association was found between

traction splint utilisation and morphine administration in a second study ($p=0.708$) (19).

One patient reported increased pain after application of the Hare traction splint, necessitating removal (23). After removal, the pain returned to baseline level and the patient was conveyed in a position of comfort. It is worth noting that this patient had contraindicating injuries, further highlighting the need for thorough assessment of possible concomitant injuries. It is difficult to draw any conclusions from this limited data, however, it does challenge the assumed belief that traction splints provide superior analgesia over splinting methods. If static splinting provides similar analgesic benefits as traction splints, it may be the safer option in the pre-hospital environment where the assessment of concomitant injuries proves difficult.

Vascular complications

The application of traction splints is thought to improve peripheral perfusion by realigning the femur, reducing swelling and haemorrhage. Peripheral perfusion to the affected leg improved in one patient (23), but deteriorated in a second patient (21) after the application of a traction splint. No significant difference was found in the occurrence of vascular complications when traction splints were compared to static splinting (one vs. 10, $p=0.2$) (26). There was a similar incidence of vascular complications in a second study comparing early versus late application of traction splints (27).

While vascular complications weren't further defined, compartment syndrome was reported separately in three papers. Of the three papers, with a total population of 786 patients (280 with traction splints, 406 without traction splints), four patients (1.43%) with traction splints developed compartment syndrome and five without traction splints (1.23%) (21,26,27). In the one study comparing traction splints and static splints, no significant difference was found ($p=0.8$) (26). A single case study describing the incidence of compartment syndrome post-traction splint application noted that the patient had a contraindicating injury of the ankle that, combined with the ankle cuff of the traction splint, compromised arterial blood flow (21). Although in this case study the complication was likely associated with inappropriate use, no contraindicating injuries were noted in the other cases described (26). Compartment syndrome has extreme consequences for the patient, but from the limited data available it appears the application of traction splints does not increase the risk of compartment syndrome over static splinting. Provided the patient has been screened and assessed for other injuries, the application of traction splints appears unlikely to cause vascular complications.

A further vascular complication associated with femoral fractures is massive haemorrhage. Any femoral fracture is likely to cause damage to the perforating femoral arteries, and particularly in penetrating trauma there is risk of femoral artery disruption (4). Blood transfusion requirements were discussed in two studies (26,27). When a traction splint was used, on average the patient required significantly less blood transfusions in the first 24 hours compared to static splinting (1.6 units vs. 3.8 units) (26). The second paper found the risk of needing a blood transfusion was halved when traction splints were applied pre-hospital compared to once in hospital (27). If reduced blood requirements in early traction splint application were to be demonstrated in a larger multicentre study, this would be of clinical significance. A decrease in blood loss would be an outcome for which the application of a traction splint would be worthwhile. Conversely, more data is needed on the correlating injury severity scores, as it may be that the patients receiving traction splints are less injured and therefore require fewer units of blood.

Nerve complications

Three papers discussed nerve complications as a result of traction splints (20,26,27). Nerve complications, specifically peroneal nerve palsies, were described in two papers (20,26). Peroneal nerve palsy typically presents with a degree of foot drop which, when left uncorrected, will affect a patient's quality of life. When comparing static and traction splints no statistical significant difference was found ($p=0.7$) (26).

It appears from the identified literature that nerve complications from traction splints are a rare complication. Perhaps the true incidence is under reported due to the frequent transient nature.

Despite this, complications to nerves may affect motor and sensory function affecting a patient's quality of life. The data regarding nerve complications is limited to the peroneal nerve and is insufficient to draw any conclusions.

Implications for practice

The evidence appears to show traction splints decrease the need for blood transfusions and decrease pain levels, however this is weak and non-conclusive and more research is required. Traction splints are also often applied incorrectly or to patients with contraindications. This review highlights the need for frequent training on application of traction splints and in particular assessing for contraindicated injuries that may lead to complications. The assessment of other less distracting injuries such as ligament damage, may pose many challenges in the pre-hospital setting. This is a challenge that needs to be addressed by training institutes.

As an infrequently utilised skill, practitioners must take the time to maintain a level of familiarisation and comfort in applying traction splints as skill-fade is recognised as a real clinical problem (28). In order to prevent skill-fade, traction splints must become a skill that pre-hospital practitioners regularly revisit and practise.

It is not unreasonable to believe that traction splints may become a tool of the past due to the potential for harm. With the increasing use of tranexamic acid in the pre-hospital setting and static splinting providing similar analgesic effects, alternative options are available. As a result of this review and the apparent benefits of traction splints, the continued use in the pre-hospital environment is likely appropriate, while the research gap is further narrowed.

Pre-hospital care has historically been a difficult setting in which to conduct randomised controlled trials, and largely the 'evidence' was from hospital guidelines and research. A randomised controlled trial comparing traction splints with static splinting could provide more insight into splinting and the complications associated with femoral shaft fractures. The inclusion of injury severity scores or similar would be a strength for ensuring appropriate matching of cases, particularly with the blood transfusion requirements as highlighted earlier. Although it would be impossible to blind pre-hospital practitioners, patients and hospital staff to the intervention.

A second avenue for further research is the attitudes of pre-hospital practitioners toward traction splints. It appears that even when indicated, the application of traction splints is often withheld. It is unclear from the current literature why there isn't more pre-hospital use of traction splints, particularly considering their historic use. A qualitative, grounded theory approach may help readers explore the decision-making behind the application of a traction splint.

Limitations

This comprehensive systematic review is not without its limitations. The results were reviewed by one independent author and despite best efforts there is the possibility of some selection bias. Second, this review did not consider conference abstracts, grey literature or literature published in languages other than English and as such more information is likely available but not reported here. Finally, the search results identified studies (primarily in the US) that due to differences in training and education pose a question of generalisability of the findings within this review. Despite these limitations the results of this review provide an important contribution of knowledge by demonstrating that for the right patients, traction splints provide analgesia and a degree of haemorrhage control.

Conclusion

Femoral shaft fractures are often the result of a high mechanism of injury and have a high mortality rate, however, they are not frequently seen in the pre-hospital setting. Management focusses on immobilisation, analgesia, fluids and conveyance to an appropriate facility. Immobilisation has been associated with a lower rate of complications and the use of traction splints demonstrated a significant decrease of mortality in World War I, but are generally only utilised in the pre-hospital setting today. A comprehensive search strategy of the MEDLINE database, reviewed by one independent author sought to determine if traction splints decrease complications compared to static splints. 10 papers were included in this review and five themes became apparent: inappropriate application, on-scene times, effect on pain, vascular complications and nerve complications.

Despite being indicated, traction splints were frequently not applied, and when applied, it was often incorrect placement or to patients with contraindicating injuries. No statistical increase in on-scene times was found when traction splints were used and there was a good analgesic effect. A statistically significant decrease in the need for blood transfusions was demonstrated while there was no significant increase in vascular or nerve complications with traction splint application. There is a clear need for pre-hospital providers to maintain familiarisation with traction splints, although they may become a tool of the past. More research is needed to determine the extent of benefits and provider attitudes toward traction splints.

Competing interests

The author declares no competing interests. The author of this paper has completed the ICMJE conflict of interest statement.

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