Evaluation of Commercially Available Traction Splints for Battlefield Use

Nicholas M. Studer, MD, EMT-P; Seth M. Grubb, BS;
Gregory T. Horn, MD; Paul D. Danielson, MD, FACS, FAAP

ABSTRACT

Background: Femoral fracture is a common battlefield injury with grave complications if not properly treated. Traction splinting has been proved to decrease morbidity and mortality in battlefield femur fractures. However, little standardization of equipment and training exists within the United States Armed Forces. Currently, four traction splints that have been awarded NATO Stock Numbers are in use: the CT-6 Leg Splint, the Kendrick Traction Device (KTD), the REEL Splint (RS), and the Slishman Traction Splint (STS). **Objective:** The purpose of this study was to determine the differences between the four commercially available traction devices sold to the U.S. Government. **Methods:** After standardized instruction, subjects were timed and evaluated in the application of each of the four listed splints. Participant confidence and preferences were assessed by using Likert-scaled surveys. Free response remarks were collected before and after timed application. **Results:** Subjects had significantly different application times on the four devices tested (analysis of variance [ANOVA], $p < .01$). Application time for the STS was faster than that for both the CT-6 (*t*-test, $p < .0028$) and the RS ($p < .0001$). Subjects also rated the STS highest in all post-testing subjective survey categories and reported significantly higher confidence that the STS would best treat a femoral fracture ($p < .00229$). **Conclusions:** The STS had the best objective performance during testing and the highest subjective evaluation by participants. Along with its ability to be used in the setting of associated lower extremity amputation or trauma, this splint is the most suitable for battlefield use of the three devices tested.

Keywords: ***combat medic, medical training, traction splinting, Tactical Combat Casualty Care, femoral fracture***

Introduction

Battlefield medicine has changed markedly since the American Expeditionary Force deployed to France in June 1917 as part of World War I. Tactical Combat Casualty Care (TCCC) doctrine has revolutionized how the wounded are stabilized, evacuated, and treated, especially in the recent conflicts in Southwest Asia.[1] However, the recommendation to initially treat traumatic femoral fractures with splinting has not changed significantly since this time.[2] Before the modern reintroduction of tourniquets, traction splinting held the honor of being the only prehospital intervention shown to improve survival for limb-injured combat casualties.[3]

A review of the Joint Theater Trauma Registry indicated that approximately 2% of those wounded in combat in Iraq and Afghanistan from October 2001 through January 2005 sustained a femoral fracture.[4] Eighty-six percent of these fractures were open with accompanying soft tissue injury. A single closed femoral fracture alone can lead to 1000 to 2000mL of internal blood loss.[5] An open fracture may be less amenable to hemorrhage control with a tourniquet due to multiple wound fragments and impaired ability to compress vessels. The substantial blood loss frequently associated with femoral fractures might require transfusion before entry into the medical evacuation system.[3] Those casualties presenting with extremity wounds are more likely to be injured by gunshot (20.5% versus 11.5%) and to have a higher Injury Severity Score (21.4% versus 11.9%) than those injured elsewhere in the body.[6] Non–battle-related injuries such as motor vehicle accidents and falls may also result in femoral fractures. Traction splinting of a femoral fracture is recommended to help reduce pain, hemorrhage, and the risk of fat emboli syndrome while also preventing further soft tissue injury during transport.[7]

The Committee on TCCC (CoTCCC) has identified traction splinting as an appropriate skill for Combat Lifesavers and more advanced providers.[8] Little standardization of equipment and training exists for traction splinting in the U.S. Armed Forces. Four traction splints are in use to some degree and have been awarded NATO Stock Numbers: the CT-6 Leg Splint (FareTec, Painesville, OH; http://www.faretec.com/CT-EMS-traction-splint.html), a component of Army Medical Equipment Set (MES)–Combat Medic; the Kendrick Traction Device (KTD, Kendrick EMS, Mooresville, NC; http://www.kendrickems.com/), formerly part of the MES–Ground Ambulance and Special Forces Tactical; the REEL Splint (RS, Reel Research and Development, Ben Lomond, CA; http://splints.webs.com/), a component of the MES–Tactical Combat Medical Care, as well as Special Forces Tactical, Civil Affairs Treatment, Ground and Air Ambulance, Forward Surgical Team, and Combat Support Hospital sets; and the Slishman Traction Splint (STS, Rescue Essentials, Salida, CO; http://www.rescue-essentials .com/slishman-traction-splint-1/), awarded a

NATO Stock Number but not currently part of an MES. The Coast Guard authorizes the KTD, RS, or Hare Traction Splint to be selected by individual unit preference.[9] The Navy currently includes the RS in the Authorized Medical Allowance List (AMAL)-636 Battalion Aid Station and had in the past listed the KTD as an intended component of the AMAL-653 Corpsman Assault Pack.[10] The Air Force commonly uses the Hare or RS but also includes the KTD as part of the Expeditionary Medical Support (EMEDS) system.[11] See Table 1 for a summary of splint specifications.

Table 1 *Device Specifications*

Splint	Manufacturer	NSN	GSA Price	Image	Carrying Dimensions (in.)	Weight (oz)	Material	Carrying Option	Splint Design
CT-6	FareTec	6515-01-521-5730	$83.00		11 × 4 × 3	13	Carbon fiber pole with nylon straps	11 × 4 × 3 "Cinch" bag or MOLLE pouch	Unipolar
Kendrick Traction Device (KTD)	Multiple including: Kendrick EMS, Rapid Deployment Products, Emergency Products & Research, North American Rescue Products	6515-01-346-9186	$125.94		9.5 × 3.5	20	Aluminum pole with nylon straps	9.5 × 3.5 storage pouch. Some available with MOLLE	Unipolar
Reel Splint (RS)	Reel Research and Development Corp.	6515-01-250-8936	$466.00		17 × 10 × 11	176	Steel poles, foam padded steel crossbars, and nylon straps	17 × 10 × 11 carrying bag	Bipolar
Slishman Traction Splint (STS)	Rescue Essentials	6515-32-083-5266	$180.00		22 × 3 × 3	21	Aluminum pole, nylon straps, neoprene ankle hitch, and midleg strap	22 × 3 × 3 MOLLE pouch	Unipolar

The purpose of this study is to determine the differences between the four commercially available devices sold to the U.S. Government. Specific outcomes tested included time to application, proportion of successful application as defined by instructions for use, amount of traction applied (ideally 10% of body weight), and provider confidence and preference as measured by survey. No previous studies have evaluated these devices and their suitability for the military environment. The authors hypothesized that comparison of the use of these devices would demonstrate a significant difference in the objective performance data and provider preference/confidence to allow the authors to provide a recommendation for standardization of a single splint for battlefield use.

METHODS

Participants

Twenty-one Army Health Care Specialists (Military Occupational Specialty 68W), 29 Aerospace Medical Technicians (Air Force Specialty Code 4N), one Navy Hospital Corpsman (HM rating), and six Coast Guard emergency medical technicians (Health Services Technician and Aviation Survival Technician ratings) participated in the surveys and data collection during January 2014. One Coast Guard and four Army Servicemembers participated in the initial survey but did not complete the study due to conflicts with mission requirements. Thus, 57 total subjects participated in some part of the study with 53 completing both surveys and testing on all four devices.

Procedure

Brief standardization training on traction splinting was delivered via PowerPoint slides using the instructions for use provided by the manufacturer. This was followed by a demonstration of the correct application of each splint on a commercially available femoral traction training manikin (Simulaids, Saugerties, NY) by a member of the research team. Every participant applied each splint in random order to the manikin with an assumed weight of 150 lb. Timed testing for each splint was graded as pass/fail with regard to proper application based on the manufacturer's instructions for use and the ability to create measurable traction. Participants were timed with a digital stopwatch starting with the instruction "Go" and ending when the participant indicated that he was finished. A quantitative measure of traction applied was indicated by the manikin's digital display. This display was not visible to the participant, but participants could note lengthening of the shortened limb and improvement of deformity if the correct traction was applied. The participants were given the quick-reference instructions included with each splint if needed during testing.

This study was reviewed by the University of South Florida Division of Research Integrity & Compliance and was determined to be exempt quality improvement research that did not meet the definition of human subjects research.

Data and Analyses

Fifty-three participants completed two surveys and a single timed trial with each traction splint. An initial survey was conducted after the standardized presentation but before hands-on skills practice. A second survey was conducted after students had received instruction and placed all devices on the manikin without assistance in timed trials.

Each participant's time in seconds, traction in pounds, and confidence responses were recorded. Times of students failing to apply a splint completely or generating zero traction were not used in analyses so that failures by subjects who quit the application procedure could not benefit a device's average times. Times on each device were compared using a one-way ANOVA with 158 degrees of freedom (*df*) within groups and 3 *df* between groups. Two-tailed Student's *t*-tests were used to determine the magnitude of differences between each device group as well.

The post-skills survey contained statements with corresponding 5-point bipolar Likert scoring scales (1 = "strongly disagree," 3 = "neutral," 5 = "strongly agree") to measure student confidence and preference to perform traction splinting. A space for free responses was provided for each splint. No attempts were made to influence these responses and all instructors were blinded to any responses until after conclusion of the course and analyses. Comparisons of mean values between corresponding questions from the four sections of the post-skills survey were performed using matched-pairs Student's *t*-tests given 52 *df*.

RESULTS

The 57 Armed Forces medical personnel who participated averaged just less than 8 years of service, 5.3 years of medical experience, and 7 months of deployment experience. The average participant also had treated two battlefield casualties. Approximately one in five (20%) had used their medical training on battlefield casualties, and one in 11 (9%) had treated a casualty with a femoral fracture on the battlefield. One in six (16.7%) had used a traction splint on a live patient, while one in 20 (5%) had used a traction splint on a combat casualty. One in five (20%) had treated a femoral fracture in some setting. Subjects had previously trained on traction splints an average of approximately 6 times. Subjective and demographic data from the initial survey are summarized in Table 2.

Aggregated results of the initial survey showed that participants self-reported the most training experience with the RS and the most patient experience with the KTD. The most commonly selected splint reported as the "most effective" treatment for a suspected femoral fracture was the CT-6. Participants were also most confident in their ability to apply the CT-6. The CT-6 was selected as best designed for dismounted carry and most appropriate overall for battlefield use on the initial survey.

Of all the splints tested, the average application time for the STS was the fastest (242.1 seconds), followed by the KTD (265.9 seconds), the CT-6 (314.6 seconds), and

Question	Average or Mode
Years of service	7.97

Years as a field medical provider	5.38
Total months you have served deployed to the AOR	7.08
Have you treated a casualty on the battlefield? Yes = 1, No = 0	0.21
If yes, how many?	2.11
Have you encountered a casualty with suspected femoral fracture? Yes = 1, No = 0	0.09
Have you performed traction splinting on a combat casualty? Yes = 1, No = 0	0.05
If yes, which traction splint did you use?	RS
Have you encountered a patient with suspected femoral fracture in another setting? (e.g. EMS, hospital ER) Yes = 1, No = 0	0.19
Have you performed traction splinting on a live patient? Yes = 1, No = 0	0.16
If yes, which traction splint did you use?	KTD
How many times have you conducted training on traction splinting?	5.98
Which traction splint do you have the most training experience with?	RS
Which traction splint do you have the most live patient experience with?	KTD
Which traction splint do you believe most effectively treats a suspected femoral fracture if properly applied?	CT-6
Which traction splint are you the most confident in your ability to properly apply?	CT-6
Which traction splint do you believe is best designed for dismounted carry?	CT-6
Which traction splint do you believe is overall most appropriate for battlefield use?	CT-6

Table 2 *Initial Survey*

is significantly different (ANOVA, F factor of 8.529 and $p < .01$). Individual *t*-tests reveal these differences with comparisons between each device STS versus KTD ($p = .19$), STS versus CT-6 ($p = .0028$), STS versus RS ($p < .0001$), CT-6 versus RS ($p = .032$), and KTD versus RS ($p < .0001$). These data show that the STS was significantly faster than all other devices except the KTD where the results were trending toward significance. Application times of all the splints were statistically superior to the RS. Objective data are displayed in Table 3.

The participants had high numbers of failures on all devices, with the fewest (10) failures on the CT-6, followed by 11 failures on the KTD, 12 failures on the RS, and 15 failures on the STS. The STS had significantly more failures than the KTD ($p = .044$) and CT-6 ($p = .024$) but not the RS.

With failures removed, average traction force applied in pounds was within the target range (10% of patient's weight) without significant difference across all four splints (CT-6 16.1 lb, KTD 15.7 lb, RS 15.0 lb, and STS 14.88 lb).

On the post-testing survey, the STS was the highest rated splint across all four reported categories. The STS (4.34/5) was rated as the splint participants felt most confident to apply compared with the CT-6 (4.23/5, $p = .459$, not significant) versus the KTD (3.89/5, $p = .011$) and versus the RS (3.45/5, $p = .00037$). The STS (3.98/5) was also rated the highest as the device that best treated a suspected femoral fracture compared with the CT-6 (3.70/5, $p = .00229$) versus the RS (3.70/5, $p = .00363$) and the KTD (3.34/5, $p < .0001$). The STS (4.25/5) was also rated as best designed for dismounted carry compared with the CT6 (4.21/5, $p = .85522$, not significant) versus the KTD (3.60/5, $p = .00249$) and the RS (1.79/5, $p < .0001$). The RS was rated as having the worst design for dismounted carry with significance versus the CT-6 ($p < .0001$) and the KTD ($p < .0001$). Last, the STS (4.17/5) was rated as the overall most appropriate traction splint for battlefield use compared with the CT-6 (3.92/5, $p = .28455$, not significant) versus the KTD (3.15/5, $p < .0001$) and the RS (1.94/5, $p < .0001$). The RS was rated overall significantly worse than the other splints as well versus the CT-6 ($p < .0001$) and the KTD ($p < .0001$). Subjective data from the post-testing survey are summarized in Table 4.

Table 3 *Timed Testing Results*

Traction Splint Device	Mean Time (seconds)	Mean Time Without Failures (seconds)	Number of Failures (N = 53)
CT-6	314.6	301.3	10 (18.9%)
KTD	265.9	258.7	11 (20.1%)
RS	361.3	351.9	12 (22.6%)
STS	242.1	225.3	15 (28.3%)

the RS (361.3 seconds). With failing times removed, the average student still applied the STS the fastest (225.3 seconds), followed by the KTD (258.7 seconds), then the CT-6 (301.3 seconds) and finally the RS (351.9 seconds). Statistical analysis of the times between these four groups

Participant quotes on the CT-6 included: "The pulley system made pulling traction very easy but it seems like it might get

tangled easily"; "This splint was easily assembled, had minimal loose parts, and was compact, lightweight, and easy to use"; "The CT-6 was quick and easy to use even though this was my first time seeing it."

Table 4 *Self-Reported Post-Testing Survey Results*

Post-Testing Survey Question	Mean Response (Likert Value Range 1–5)			
	CT-6	KTD	RS	STS
Confidence of proper application	4.23	3.89	3.45	4.34
Best treatment for femoral fracture	3.70	3.34	3.70	3.98
Best designed for dismounted carry	4.21	3.60	1.79	4.25
Overall most appropriate for battlefield use	3.92	3.15	1.94	4.17

Quotes on the KTD included: "I like the light weight and ease of use. I would prefer if all the parts came attached to prevent loss"; "This splint is not very durable and feels like it would break under heavy movement and usage"; "The colored pull tabs and straps make remembering the steps easy, but the splint does not seem to be durable enough for a combat setting."

Quotes on the RS included: "This splint does an outstanding job with traction and immobilization. However, size, weight, and the requirement to have assistance with application remove its relevance from the battlefield"; "This is too bulky and heavy. In combat/emergency situations it takes too much time to assemble and place on the patient. I would not want to have this as a deployment item"; "The size and weight of this device hinders combat effectiveness. Simply just not practical for dismounted operations."

Quotes on the STS included: "Considering the nature of a GSW/IED blast, this traction splint is applicable to multiple battlefield injuries"; "Very easy, self-contained, could almost do it one handed if needed. If not supplied, I would buy my own for down range"; "This is lightweight, sturdy, and easy to apply with minimal training. It is collapsible into a small footprint which aids in portability and availability." Advantages and disadvantages of each splint noted by participants are summarized in Table 5.

Discussion

Battlefield Experience With Traction Splinting

On the modern battlefield, TCCC interventions focusing on the predominant causes of battlefield preventable mortality—airway obstruction, external hemorrhage, and tension pneumothorax—have saved numerous lives.[12] As these "low hanging fruit" decrease in incidence due to improved care, attention must also turn to lesser contributors in order to minimize morbidity and mortality. Junctional and pelvic hemorrhage has received much attention as of late due to their association with battlefield death.[13] However, the treatment of femoral fractures—once a major emphasis of battlefield care—has received scant attention.[14] Reference to orthopedic care in the CoTCCC Guidelines is simply to "splint fractures and recheck pulse" in the Tactical Field Care phase and to reassess in Tactical Evacuation Care.[1]

Despite their long history of use in both military and civilian prehospital care, surprisingly little recent outcomes data are available on the use of traction splints. Most of the literature comes from World War I, where a considerable degree of the decreased mortality from femoral fracture is credited to the deployment of the Thomas splint into the European theater.[15] Estimates of femoral fracture incidence as comprising 1.7% of wounded, a proportion similar to today, do not convey scale when those casualty counts were routinely measured in tens of thousands. So many femoral fractures were encountered by the Allies during the war that a special hospital in Bastogne was dedicated to femoral fractures. Over 5000 femoral fracture casualties were treated in the last 9 months of the war by the British Army alone.[16] In 1916, famed British military surgeon Colonel Sir Henry Gray calculated the mortality rate of femoral fracture as roughly 80%. The primary field treatment at the time was the Liston splint, a wooden board device in use with the British for almost a century by that time. This device was considered easy to apply, and its effect is comparable to rigid splinting methods used today.

The Thomas splint was invented by Welsh physician and bone-setter Hugh Owen Thomas in 1875 for the treatment of tuberculosis of the knee. It had a full-ring ischial pad and used cravats in a clove hitch around the ankle (later a special attachment to the combat boot's sole was developed) to pull traction on the femur.[17] Thomas' nephew and former apprentice, Sir Robert Jones, became consultant orthopedic surgeon to the British Army in 1914. He soon advocated the splint's use for fractures of middle and lower thirds of the femur, knee, and upper tibia.[18] Introduction to the combat zone was slow, and it was not until 1917 that the Thomas splint was officially distributed as the standard. Sir Henry Gray reported during one battle in spring 1917 that the Thomas splint was used near-universally for femoral fracture and the mortality at casualty clearing stations had dropped to 15.6% of 1009 cases. Another review of 3141 patients indicates a 14% mortality following the intervention of the Thomas splint. Physicians at the special femur fracture hospital in Bastogne noted a drop in mortality from 13% in 1916 to 7% in 1918.[16] While it is certain that the Thomas splint played a large role in saving lives, it must be noted the introduction of motorized ambulances, casualty clearing stations, and other concurrent advances cloud the effect.

Table 5 *Participant-Reported Advantages and Disadvantages*

CT-6	Kendrick Traction Device (KTD)	REEL Splint (RS)	Slishman Traction Splint (STS)
ADVANTAGES			
• Pulley system used for traction gives distinct mechanical advantage • All components come attached to the device for easy accountability • Carbon fiber pole is desirable for strength and weight savings • Lowest unit cost • Lightest unit weight • Compact MOLLE pouch	• Labeled/color-coded straps may aid in recall under stressful conditions • Compact storage design with some manufacturers offering external MOLLE • Knee strap application prior to pulling traction prevents pole bowing	• Can be adjusted and used for patients with disarticulation injuries • Bipolar design keeps the leg immobilized to a high degree	• Only splint that can be applied on a patient with lower leg injury or amputation • Components do not extend below the foot allowing for increased ease of transportation • Slim profile is ideal for dismounted carry • Fewer components and adjustments than other splints • Strong, rigid pole that is also lightweight
DISADVANTAGES			
• Pulley system may become tangled, which increases application time and reduces traction applied • Multiple hook & loop components can become attached to one another and cause difficulty in application • No color coding of straps	• Per manufacturer, the KTD is a traction "device" and other splinting materials may be required • Multiple components that are not attached increase risk for loss • Plastic and thin aluminum components provide questionable durability in combat situations • Multiple manufacturers	• Contraindicated on patients with coexisting pelvic fracture • Undesirable weight and dimensions for dismounted use • Requirement for assistance with application removes another man from the fight • Multiple sites of adjustment found to be confusing	• The ability to completely separate poles when adjusting coarse traction due to lack of internal stopping device may make application more difficult • Field repair would be difficult if the internal mechanism is damaged • No color coding/labeling of straps

During World War II, the Thomas splint was again used as a mainstay of care, its success in World War I believed to be obvious. Allied forces fighting in the rough terrain of North Africa modified the Thomas splint by wrapping it in padding and plaster-of-Paris to create the "Tobruk splint."[17] This allowed for greater stabilization during medical evacuation through rough terrain and better conservation of limited supplies than the previously-used plaster-of-Paris spica. In 1961, the American College of Surgeons recommended that traction splints be included in every ambulance in the United States.[19] Glenn Hare, a Los Angeles policeman and ambulance attendant, developed the familiar Hare traction splint in 1969 by adding a ratchet mechanism to a Thomas splint.[20] The first unipolar traction splint, the KTD, was first introduced in 1986.

Civilian Sector Concerns

More recently, the utility of traction splints in civilian emergency medical services (EMS) with short transport times has been questioned. In a "low-volume urban EMS system" in Illinois, only five of 4513 (0.11%) patients seen in 1 year presented with injuries suspicious to field personnel for femoral fracture. In 87.5% of cases, these patients were treated by placement on a long backboard alone without negative sequelae noted.[21] This led the author to conclude that femoral fracture in civilian EMS was a rare event and that rigid splinting or long backboard immobilization alone was acceptable, making traction splints an expensive luxury if not unnecessary. Another study in Sweden found only 57 patients with femoral fractures over 5 years for one urban EMS system. Seventy-seven percent of fractures were caused by low-velocity trauma such as household falls, predominantly in an elderly population.[22]

A retrospective review of 40 multisystem trauma patients transported by a helicopter EMS program in Massachusetts found that 38% of traction splints had been applied to patients with contraindications to Hare-type splints.[23] The primary contraindication listed was an associated pelvic fracture, not a concern with unipolar splints (CT-6, KTD, or STS) which do not rely on an intact pelvic ring to function. A descriptive article attempted to popularize the position that traction splints in civilian EMS were a little-used "relic" that should be removed from civilian ambulances. These authors argued there was a paucity of data for their necessity, and there was evidence of harm with the rare complication of temporary peroneal nerve palsy associated with the Hare-type bipolar splints most commonly used in the civilian setting.[24,25] Another article reported an instance of popliteal skin breakdown in a frail,

elderly patient following 3 days of Thomas splint use with a tight adhesive skin bandage while she awaited definitive surgery.[26]

A review of 115 children seen in a pediatric trauma center with a Hare splint applied in the prehospital setting noted that 66% were misapplied when viewed on radiography.[20] Due to these pressures asserting lack of recent evidence, the latest "Equipment for Ground Ambulances" policy statement by the American College of Surgeons Committee on Trauma and others lists femoral traction splints as merely optional for civilian EMS.[27]

Contemporary Military Considerations

While few disagree that traction splinting is an effective treatment for femoral fracture, controversy exists in the civilian sector over whether this treatment can be delayed during the projected "Golden Hour" or less that exists as patients move from the prehospital phase of care to that of the hospital. While rigid splinting alone may be adequate in the short-term of civilian EMS or even be extrapolated to the current medical evacuation system, this conclusion does not carry over to when battlefield casualties may be delayed transport to definitive care for many hours or days. It is essential to understand the mortality benefit seen with the Thomas splint in World War I was observed by comparison with what was essentially a rigid splinting technique.

Obviously, in a complicated trauma patient with a short transport time, care providers should focus on immediate life threats with the critical TCCC interventions like tourniquets and cricothyrotomy. However, as the military, and its Special Operations Forces in particular, adapts to fighting in a less-developed operational environment, the concept of "Prolonged Field Care" has surfaced.[28] No longer may first responders expect immediate evacuation of the wounded to surgical care within the "Golden Hour." Combat medics and corpsmen may be required to manage the critically injured for indefinite periods, much like their counterparts in America's previous wars.

In a prospective study of 64 patients with femoral fracture randomized to either traction or simple/rigid splinting in an Iranian EMS system, there was no significant difference between groups in pain level immediately after application. However, pain was significantly decreased in those with traction splints compared with simple splinting at 1, 6, and 12 hours post application.[29] The authors of that report attributed this late-appearing difference in pain control to increasing contraction of the thigh muscles that was overcome with the application of traction but left unabated in those assigned to simple splints alone. The authors of an Australian retrospective study of 95 pediatric patients with isolated femoral fracture came to similar conclusions regarding the short-term benefit of traction splinting on pain control.[30] However, this article's conclusion was limited by the early administration of femoral nerve block anesthesia in all cases and the fact traction by Thomas splint was used as definitive care on admission regardless of the splint originally applied.

Recent studies focusing on pain control alone are also inadequate in examining the primary outcome of traction splinting on the battlefield—reducing hemorrhage. Traction is hypothesized to reduce hemorrhage in a closed fracture by creating a smaller elliptical area surrounding the fracture site, which would hold less blood than the roughly spherical area expected before traction. Traction stabilization helps prevent movement of the jagged fractured bone ends, thereby minimizing soft tissue damage, decreasing the risk of vascular injury, and preventing the conversion of a closed to an open fracture.[6] This concern is almost nonexistent in the civilian setting, where transport to a waiting ambulance mere feet away is the most likely scenario.

However, the risk for further injury in a casualty carried a long distance by litter through rough terrain to an evacuation vehicle is just as real today as it was on the battlefields of France in 1917. Reduction of open fractures caused by a gunshot wound was a primary impetus for Thomas splint use in World War I. The Thomas splint served to decrease the risk of infection from leaving bone ends exposed in the austere environment and to better control hemorrhage from the wound. In general, it is recommended today to also irrigate the wound of an open fracture and to give prehospital antibiotics. It is also expected that realignment of the fracture will decrease the incidence of fat embolism. Unfortunately, it has proved difficult to evaluate these hypotheses in the civilian setting, and the data available in the military setting remain much the same as it was prior to the recent conflicts. Notably, Royal Army Medical Corps surgeons with the 202 Field Hospital reported successful use of the Thomas splint for treatment of seven casualties with femoral fractures in the first week of Operation Iraqi Freedom and strongly advocated for continued use.[31] While much of the data from World War I are almost 100 years old, the benefit of traction splinting for battlefield femoral fracture remains unequivocal.

Against the backdrop of controversy over the necessity of prehospital traction splinting as a general principle, the Department of Defense's selection of traction splints for field use has not been previously based on rigorous scientific review. One group from San Francisco's ambulance service in the early 1980s reported 11 femoral fractures (among other injuries) treated with the RS, concluding it to as superior to the Thomas splint as a matter of subjective provider preference.[32] A single article in the literature has compared multiple traction splints sold commercially to civilian first responders. This article compared the Hare, Sager, a civilian packaged variant of the CT-6, and an improvised technique using straps, cordage, and a stick. It did not examine time to application or provider preferences. Its primary outcomes included a

measure of pounds of traction applied as well as a simulated patient's self-rating of "stability" and comfort after 30 minutes of continuous application. Under these criteria, the authors of this study concluded there was no significant difference between any of these devices, including the improvised splint.[33]

Study Findings

First, overall competence in traction splinting among enlisted field medical providers in this cohort was poor. Although participants reported an average of six iterations of training with traction splints during their career, roughly one in five (20%) splint applications in this study failed to produce any traction or the participant "gave up" and asked to terminate the application. It was common for participants who failed to obtain traction with one device to fail to do so with multiple devices. Subjective overall confidence was low, with many participants reporting little or no experience with traction splinting in training, and only one in six (16.7%) had used a traction splint on a patient. This was most pronounced with the most junior Air Force participants fresh from initial training. Many reported they had no hands-on time with traction splinting and may have only seen them demonstrated once.

Because the civilian National Registry of Emergency Medical Technicians exam does not currently include traction splinting, it is often not taught at initial training nor is it included in sustainment training conducted at the assigned unit. As with many other procedures, such as cricothyrotomy and tourniquets, the priority is different on the battlefield than in the civilian sector. The needs of civilian certification and testing should not be the primary influence on the training provided to those who will care for wounded in combat. While field medical providers must maintain many skills, traction splinting should be an expected competency for initial and refresher training. There should be no difference within the Armed Forces in the training of enlisted field medical personnel, when all except Coast Guardsmen are trained at the joint Medical Education and Training Campus at Fort Sam Houston, Texas.

The REEL Splint is, by doctrine at least, the most widely used traction splint within the Armed Services, authorized for use by the Army, Navy, Air Force, and Coast Guard. The RS had replaced the previous canvas-cased Thomas splint kits—"Splint Set, Telescopic Splints"— ubiquitous on field litter ambulances and similar even into the 1990s. The RS was the most common device with which participants had training experience. Despite this, it had the second-highest failure rate and a significantly longer time to successful application than all other splints. Participants had a very negative outlook on the RS. Participants rated the RS least of all four splints for ease of use and suitability for dismounted carry. Its use is contraindicated with associated pelvic fracture, a limitation not found with the other three splints but noted in up to 38% of civilian multisystems trauma patients. Further, 9.4% of casualties in the current conflict who were wounded in the lower extremity had an associated pelvic injury.[6]

Of the splints tested, the RS is the heaviest and bulkiest device. In addition, it is more than twice as costly as the next most expensive splint. It should be noted the device is advertised as a multipurpose splint for other lower extremity injuries, but this function could be replicated with the disposable foam/aluminum "SAM"-type splints that are all but universal in field medical kits. The authors believe that the RS has persisted for so long due to its length of service and due to the continuing use in civilian EMS systems of Hare-type splints. Due to the multitude of negative factors and poor performance in this study, the authors recommend the RS be removed from military service.

Of the remaining three splints, the STS had the fastest average application time, both overall and with all splint failures removed. Testing showed no significant difference between the quantities of traction applied between splints, with all splints applying adequate traction. The STS was ranked highest in all four categories of participant confidence and preference evaluated in the posttesting survey. It had the greatest participant confidence in their ability to apply the splint and that it would effectively treat femoral fracture. It was ranked as the best design for dismounted carry and had the highest rating for being the most appropriate splint for battlefield use.

It is interesting to note that these beliefs changed from the initial survey where the most common selection for free-response in these categories was the CT-6. The CT-6 objectively performed and was subjectively rated as the next highest performing splint. In addition, the CT-6 has the lowest price of all splints tested. The STS is able to be used with a concomitant pelvic fracture, similar to KTD and CT-6. However, it stood alone among the four splints with the ability to apply the "ankle hitch" high on the calf in the event of an amputation or other foot/ankle/calf injury that would preclude the use of the others. This situation is not unusual with dismounted complex blast trauma that has typified the modern battlefield. In the authors' opinion, the STS's construction of multiple aluminum poles within each other, coupled with the mid-leg strap securing both lower extremities to each other, provides a degree of stability not seen with the CT-6 and KTD. Additionally, it is the only splint that does not extend past the end of the leg, allowing easier carriage in Stokes or SKED litters commonly used in current conflicts. With its superior objective performance in testing, best subjective rating in all four categories assessed in the post-testing survey, and its unique ability to be used with a lower extremity amputation, the authors recommend the STS as the single-best traction splint for military use.

Unfortunately, the generalized poor performance and overall low confidence with traction splinting slightly decrease the value of the participants' subjective comments. However, the

population included in this study generally represented the typical enlisted field medical provider for the Armed Forces, and thus their opinion is of the most practical value. It must also be noted the STS had 15 failures, which is statistically significant compared to 10 for CT-6 and 11 for KTD. However, the STS and its application technique are markedly different from those any of the other three devices. Thus, participants could not improve their performance by completing a prior iteration with another splint, as is possible for the other devices. Only one participant reported previous awareness of the STS's existence. A single brief demonstration followed by a single tested iteration without opportunity for practice is hardly enough time to demonstrate proficiency with a new technology. This fact alone would tend to skew both objective performance and self-reported preference in favor of the more familiar devices. Despite this, the STS's participant selfratings after a single application were superior across all four domains assessed, with the fastest time implying greatest ease of use. Lack of familiarity is coupled to the overall high rate of splint failures among participants, showing generalized poor traction splinting skills even with devices for which they reported long-standing experience. Total failures for each splint included multiple iterations where participants requested termination of the event prior to attempting full application of the device due to a high level of frustration with their skills. Most STS failures were accompanied by failures on at least one other device. Thus, the authors believe this higher failure rate on single timed trial is due to initial familiarization with the device and could be overcome with a focused training package that would be required with implementation of a new device to the field.

Conclusion

Femoral traction splinting is an essential battlefield skill that has decreased in recent popularity within the civilian EMS community. Traction splints and the tourniquet have the distinction of being the only prehospital measures proven to save lives on the battlefield in casualties with extremity injury. The STS had the best objective performance during testing and highest subjective evaluation by participants. Along with its ability to be used in the setting of associated lower extremity amputation or trauma, it stood above the other commercially available femoral traction splints in suitability for battlefield use. Further study of all aspects of battlefield femoral traction splinting is warranted with greater attention paid to this skill in initial and sustainment training.

Acknowledgments

The research team for this project would like to acknowledge Simulaids for the loaned use of the Traction Splint Trainer manikin. FareTec and Rescue Essentials, respectively, donated several CT-6 and Slishman Traction Splints that were used in the study. REEL Splints and Kendrick Traction Devices were provided by the USF Health Center for Advanced Clinical Learning. The authors would like to thank CMSgt Joseph Powell, SMSgt Chruleeporn Carter, and Mr. James Norbech with the MacDill Regional USAF Hospital (6th Medical Group) as well as MAJ Thomas Larkin and SFC Richard Caton with the 256th Area Support Medical Company (Florida Army National Guard) for their support without which this project would not have been possible. Capt Lynette Studer generously provided editorial guidance. CDR William Quillen, USN (Ret) and Col John Curran, USAFR (Ret) are a continuing inspiration to us and all our colleagues at USF College of Medicine. No funding was accepted for this study.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily reflect the official position or policy of the U.S. Army, Department of Defense, or U.S. Government.

Disclosures

The authors have nothing to disclose.

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CPT Studer, MC, FS, USA, is a recent graduate of the USF College of Medicine (Class of 2014) and a transitional intern at San Antonio Military Medical Center. A critical care paramedic with 10 years' experience in prehospital care, he has extensive experience in medical simulation and training. During his time at USF in Tampa, he oversaw trauma and critical care training offered to personnel stationed at MacDill AFB and in the surrounding area. He is interested in emergency medicine as a specialty. E-mail: nicholas.m.studer2.mil@mail.mil. **2LT Grubb, MS, USAR** is a third-year medical student in the
Health Professions Scholarship Program (HPSP) at the USF College of Medicine (Class of 2016). Prior to pursuing a career in medicine, he spent over 5 years on active duty as an infantryman with the 82nd Airborne Division, including three combat deployments to Iraq and Afghanistan. While at USF he has helped to mentor fellow HPSP scholarship recipients with their transition to military life. He is interested in emergency medicine as a specialty.

CPT Horn, MC, USA is a recent AOA graduate of the USF College of Medicine (Class of 2014) and an anesthesiology intern at Walter Reed National Military Medical Center. He has published papers on surgical education and critical care topics. He also volunteered to provide medical and trauma training to military personnel and his peers while at USF. He is interested in the subspecialty of interventional pain management and continuing research.

COL Danielson, MC, USAR is an Army Reservist serving in the 912th Forward Surgical Team. He is a veteran of multiple combat deployments to Iraq and Afghanistan in support of both conventional and special operations. Double board- certified in adult and pediatric surgery, Dr. Danielson is currently the vice chairman of Surgery and director of Trauma Services at All Children's Hospital Johns Hopkins Medicine.