JEMS Article/1985

Why Traction?

by Anthony G. Borschneck, MD

Prehospital care professionals and first responders understand that the purpose of traction on a fractured femur is to align the fragments, relieve pain, prevent damage to nerve or vascular structures and minimize blood loss. Serious shock and blood loss occurs with a fractured femur. How this hemorrhage occurs and the importance of early treatment has received little scientific explanation. This article will review modes of traction used historically and at the present time, and review the various types of traction splints available today.

One of the earliest recorded treatments for fractures was advocated by Hippocrates, who used two strong men to apply traction and counter traction.[1] In the 13th century, Guy De Chauliac devised a mechanical appliance to provide continuous traction on a fractured femur. He used a drum and crank arrangement similar to that used for torture in the Spanish inquisition.[2] It was not until the late 1800s that more sophisticated treatment of long bone fractures was developed by Sir Hugh Owen Thomas.[3] Thomas, an outstanding doctor who made many contributions to the science of medicine, is chiefly known for the full ring splint named after him. Thomas' full ring traction splint was not an emergency treatment device, but rather an excellent device for alignment and reduction of fractured femurs (Fig. 1).

His nephew, Sir Robert Jones, along with other surgeons of the British and American forces in World War I, soon realized that soldiers suffering from gunshot, blast or other mechanisms of injury did much better if traction and immobilization of the injured limb was applied immediately after the injury. Together they modified the Thomas full ring splint to a half ring splint to make application easier (Fig. 2). It was soon recognized that traction and immobilization stopped the continuing hemorrhage in the thigh after fracture of the femur. A study done at that time revealed that mortality was reduced from 80 percent to about 15 percent when femoral fractures were promptly splinted and tractioned.[4]

How can traction of a fractured femur prevent blood loss or hemorrhage in a leg? The answer may be apparent when one considers the anatomy and pathophysiology of a fractured femur. The largest muscle mass in the human body is located in the thigh. These muscles can exert tremendous forces and are contained in an inelastic sheath composed chiefly of the superficial fascia and the fascia lata which forms a prominent layer over the entire thigh.

In the intact human limb a positive tissue pressure is established because the fascia forms a cylinder which maintains its shape due to the internal support of the femoral bone. When the femur breaks, spasm and pain ensues, fragments may override and the thigh may lose its cylindrical shape, causing the thigh to deteriorate to a globular or spherical shape (Fig. 3. a, b).

For the purpose of illustrating this theory, the intact thigh can be represented by a cylinder and the fractured femur depicted as a sphere. In physics it is known that if two objects have the same surface area and one is a cylinder and the other is a sphere, the sphere has the greater volume.

In a malleable system, if the structure changes from a cylindrical toward a spherical shape, a volume increase occurs. It then follows that any given pressure in the cylindrical shape will therefore decrease in the spherical shape. Tissue pressure decrease in an injured limb will therefore allow a free flow of blood into the fractured area. Traction causes alignment and brings the femoral fragments back to the original position and restores the tissue pressure in the leg, inhibiting further hemorrhage. Blood loss of two to four units is not uncommon with femoral fractures.

Traction is a valuable therapeutic tool and can be applied in several ways. The various modes for traction can be divided into three broad groups:

- Continuous traction
- Static traction
- Dynamic traction

An example of *continuous traction* is a rope, pulley and weight system as seen in the orthopedic ward of a hospital. An example of *static traction* is the drum, rope and crank arrangement used to raise a pail of water from an open well. In emergency medicine this arrangement is used with the ischial bar-type traction devices (Fig. 4). An example of dynamic traction is seen with the use of a resilient member such as the Spanish Windlass (Fig. 5).

A rope, pulley and weight system provides a known amount of traction (an important feature), but has the undesirable property of providing continuous traction, which may lead to separation of the bone fragments. Application of this system requires close monitoring and judicious reduction of weight as spasm releases and lengthening occurs. This system is most properly used by orthopedic surgeons or other experienced medical personnel and is least desirable because of swinging weights and the cumbersome mechanism associated with it. Continuous traction is not a system that can easily be used in field treatment and transport.

The drum, rope and crank apparatus has the disadvantage of not providing a known amount of traction force. Many specialists in orthopedic care indicate that the force necessary for traction varies, but should rarely exceed 15 lbs. of pull. This method is gentle traction, and the least amount of force necessary is the amount that should be employed.[5] With the use of the drum and crank system, the traction force applied is unknown and a function of length of the patient's leg interposed between points of traction and countertraction.

If the leg lengthens as a result of spasm release, the tractive force disappears. This system requires continuous adjustment and cranking as leg lengthening occurs. Since the amount of traction force used is unknown, undesirable separation of the

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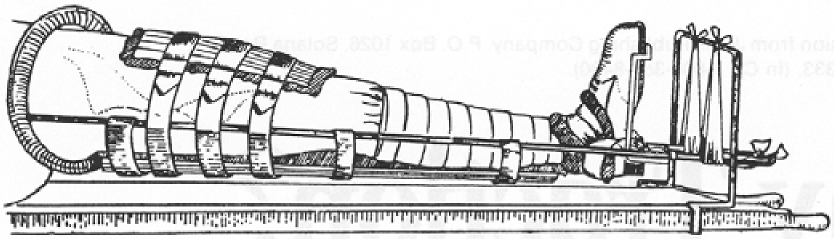

Figure 1: *A fractured femur put up in a Thomas full ring splint on a soldier, World War I. Circa 1916.* Modern Surgery, *8th Edition, Da Costa, 1921 p. 671. W. B. Saunders.*

Figure 4: *Ischial Bar type traction device.*

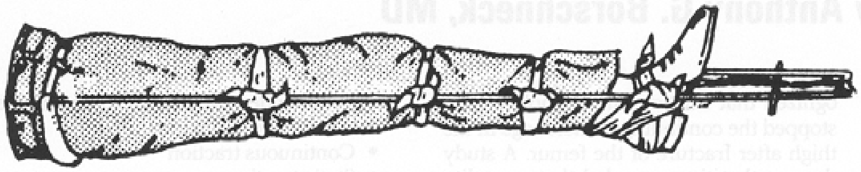

Figure 2: *Drawing of a fractured leg in a Thomas half ring splint.*

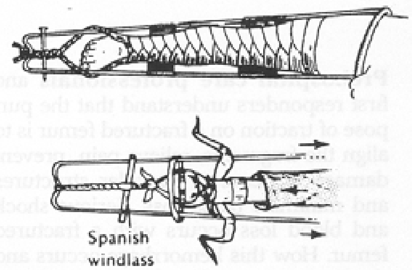

Figure 5: *Thomas full ring splint with Spanish Windlass traction in place as used in Military Orthopedic field treatment during World War I. Inset of later civilian use of Spanish Windlass traction arrangement.*

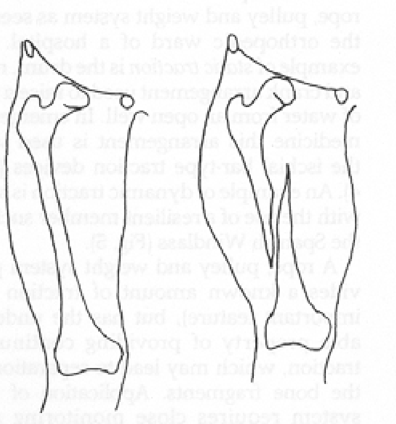

Figure 3A: *Line drawing of a thigh silhouette with intact femur bone. Line drawing of thigh silhouette with fractured femur showing shortening and thickening of the thigh.*

Figure 3B: *Photograph of accident victim with intact left leg and fractured right femur. Note leg shortening and enlargement of right thigh.*

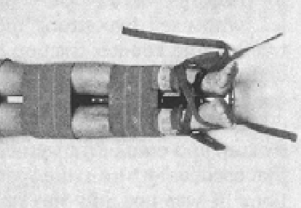

Figure 6: *Spring traction as illustrated by the SAGER™ 204 Emergency Traction Splint.*

fragments can occur, especially in the hands of an enthusiastic or inexperienced operator.

Traction applied by the Spanish Windlass type of resilient member, as used with the Thomas half-ring splint in World War I, has the advantage of providing dynamic traction which decreases as the muscle spasm releases in the injured limb and the leg lengthens, but it also has the disadvantage of the static traction because its traction force is not known or quantifiable. Another disadvantage of the Spanish Windlass is the twisting force it applies to the leg, promoting internal or external rotation.

Manual traction by a first responder or paramedic falls in the category of dynamic traction, but has the drawback of unknown tractive force, and additionally has the limitation of human endurance. The dynamic traction force provided by a calibrated spring allows emergency personnel the opportunity to provide traction in a known, quantifiable, reproducible amount. It has the added advantage and safety of dynamic graded reduction in tractive force as the spasm disappears and the leg lengthens. The spring also eliminates the torque forces of the Spanish Windlass permitting a torque-free pull.

Examples of splints providing unquantified static traction still in use in the field today are the Hare Traction splint, Trac 3, Klippell splint and Reel splint. Examples of unquantified dynamic traction are the half-ring and full-ring Thomas splints equipped with a Spanish Windlass, occasionally still in use today. An example of quantifiable dynamic traction is the Sager emergency traction splint (Figure 6).

In 1916, the lives saved by using the Thomas devices were a result of decreased blood loss and prevention of shock. In 1985, with exotic communication and advanced life support treatments for field situations some may feel fracture care is not a priority. The maxim that optimal treatment is prevention really holds true. Recognition of the potential for hypovolemic shock accompanying a femur fracture and minimizing the blood loss with prompt traction and immobilizaton must continue to be the standard of care. □

Notes

1. Hippocrates, 350 B.C.

2. Guy De Chauliac, 1300 -1368

3. H.O. Thomas, 1834 - 1891

4. a) Cannon, Walter B., Traumatic shock, 1922

b) Dorey, H., Thomas and orthopedic surgery, Nord Medicine Hist., Arsb. 1971, pg. 153.

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SAGER®
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Sager Versus Ischial Pad/Cross Bar Splints
These are the facts.

Sager Emergency Traction Splints:	Ischial Pad/Cross Bar Splints:
Only the Sager® provides Quantifiable Dynamic Traction™. Sager Splints have been designed to continuously show the exact amount of safe, quantifiable traction applied – with no possibility of overtraction. They also permit documentation of the traction force applied – a plus for medical/legal purposes! In addition to being quantifiable, the traction force is dynamic. The dynamic function permits the traction to decrease automatically and appropriately as the spasm releases. Traction is variable – as the spasm decreases, traction decreases.	Ischial Pad Traction Splints *do not provide Quantifiable Dynamic Traction.* There is no way of knowing if the traction applied is adequate, inadequate or dangerous.
Sager's countertraction design permits movement and lifting without loss of traction.	Movement and lifting can result in slippage off the ischial tuberosity, leading to sudden loss of traction, with potentially dangerous results.
Can be applied on a patient in any position – allowing patient to be nursed in any position (eg. supine, lateral or prone).	Traction can only be maintained with patient supine – limiting nursing and therapeutic options by Emergency Care Personnel.
Sager model S304 Super Sager Form III Bilateral – *traction and immobilization is contained entirely within an adult's body silhouette.*	*Ischial Pad Splints are bulky and have a potential for tipping over.* Overhang with these splints can be as much as 12 inches or more beyond the patient's foot.
Sager Splints – one person application which can be completed in 1-2 minutes.	Ischial Pad Splints require two person application and can take twice as long.
Sager Splints mate perfectly and provide good traction inside or outside Anti-shock Trousers.	Ischial Pad Splints are awkward and difficult to apply with Anti-Shock Trousers. These splints will not work as a traction device placed over Anti-Shock Trousers.
Universal: one size fits all (5th–99th percentile), single or bilateral, one or two fractured femurs. Sager model S300, Infant Bilateral has been specifically designed for infants and children up to six years of age.	Requires two (2) splints, adult and pediatric and is not adequate for extra large or obese individuals. These devices also require two (2) splints for two fractures femurs.
Sager's provide compact packaging and transportation on ambulance cot, stretcher or spine board, helicopter and air transfer/rescue.	It is almost impossible to transport patient's wearing two (2) Ischial Splints on anything but a wide ambulance cot or stretcher.
Maximizes patient comfort.	Ischial Pad Splints are *uncomfortable* to wear and can result in further nerve, muscle or vascular injuries in a patient with a proximal third fracture.

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The Science of Traction Splinting

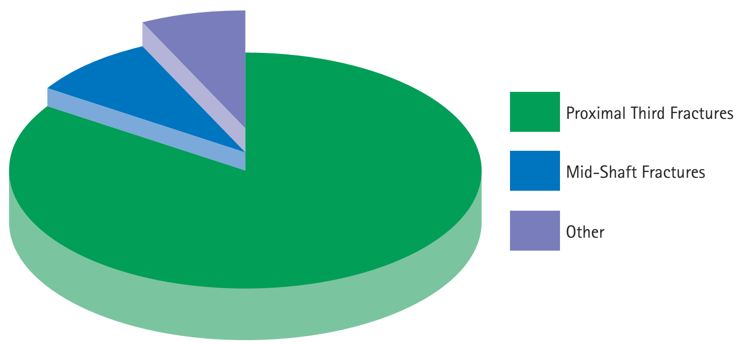
Did you know?

Sager Splints are indicated for 93% of all Femoral Fractures.

Ischial Pad Splints are indicated for 9% of all Femoral Fractures.

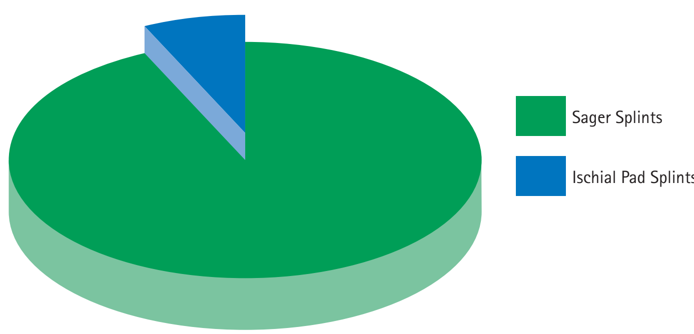
USA ICD9 1997 Projections

Total Femoral Fractures	474,551	
Total Proximal Third Fractures	399,484	(84%)
Total Mid-Shaft Fractures	41,012	(9%)
		= 93%
Other (No Traction Indicated)	34,055	(7%)



Femoral Fratures Types

Proximal Third
Mid-Shaft
Other



The actual reportage of incidences involving total femoral fractures for the year 2002 was 438,496.

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Emergency Orthopedics, The Extremities, 3rd Edition
Treatment of Fractures.

Initial Management:

The initial assessment of a fracture must answer a number of important questions. Is the fracture stable or unstable? An unstable fracture must be stabilized by some form of external splinting or traction before any movement of transport of the patient. The second question that one must address is whether or not there are any associated injuries to surrounding vessels, viscera, skin or nerves. A well-documented neurovascular examination must be performed before any further assessment can be made of the patient with a suspected or clinically obvious fracture.

Emergency Splinting:

The purpose of emergency splinting is threefold; to prevent further soft tissue injury by the fracture fragments, for pain relief, and to lower the incidence of critical fat embolism.

Perhaps the most commonly known splint used in the past was the Thomas splint… *The new sager traction splint (Minto Research & Development, Inc.) is the author's preference for emergency splinting of all proximal femoral and femoral shaft fractures in both the pediatric and adult age group.* The splint is shown in Fig. 1-7C and D. It can be applied to the outer side of the leg or the inner side as shown. *The splint does not have a half-ring posteriorly, which eliminates any pressure on the sciatic nerve and most importantly eliminates the angulation of the fracture site, which occurs with half-ring splints.* The advantages of this splint over half-ring splints currently in use are detailed.

1. No sciatic nerve compression, which may occur with half-ring devices.
2. No flexion of the mid-shaft of proximal femoral segment, as occurs with half-ring splint devices, thus resulting in more acceptable alignment.
3. Over traction, a common problem with half-ring devices resulting in knee edema and injury to epiphyseal growth centers in children, is eliminated because the precise weight of traction can be applied based on 10 percent of the patient's body weight. The traction is shown on a circular meter at the ankle portion of the splint. Traction should never exceed 22 pounds.
4. The same splint can be used for children and adults.
5. The splint can be used with trousers in place.
6. The splint can be used in patients with groin injuries by strapping it to the other side of the hip.
7. The splint can be used in patients with pelvic fractures.
8. The ankle straps are placed so that one can monitor the dorsalis pedis pulse with the splint in place.
9. The splint includes a cross bar that permits splinting of bilateral fractures with one splint between the legs.
10. Splinting of the fracture is done in a more anatomic position resulting in less outward rotation of the proximal fragment.

Emergency Orthopedics, The Extremities, Third Edition
Simon, Robert R., MD, Koenigsknecht, Steven J., MD, Norwalk, CT, Appleton & Lange, 1995, pg.:8

SAGER® Emergency Traction Splints

On the Scene
Traction Force Challenge.

by Anthony G. Borschneck, MD & Charles Spotts, MA

It is generally accepted that the least amount of traction force necessary to treat a fractured femur is the amount of traction force to be applied. This traction force should rarely exceed 15 lbs.

A proper assessment of the amount of traction to be applied to treat a fractured femur depends on a number of factors, such as age of the patient, general physical condition and body size. It may be noted that patients who are excessively obese likely do not have a large muscle mass and therefore probably can be completely controlled with a maximum of 15 lbs. traction. On the other hand. an athletic, muscular, young male weighing 250 lbs. may need additional traction force in excess of the initial 15 lbs. In the case of a thin, elderly, osteoporotic female, alignment and control of spasm is often obtained with 5-7 lbs. of traction force. However, there are many types of traction splints on the market today that we have no means of accurately applying traction. In most of these cases, instructions are to crank in traction until the patient obtains some pain relief, but there are some problems with this type of treatment: 1. There is no way to know if too much traction has been applied; 2. Obtunded or unconscious patients cannot respond; 3. Patients may have other trauma pain response unrelated to a fractured femur.

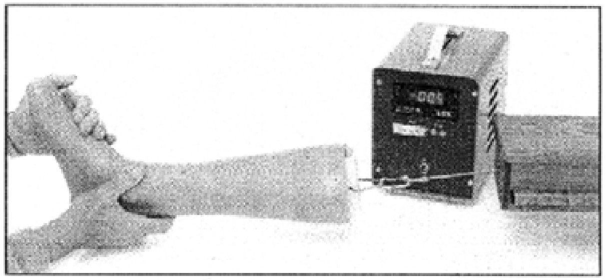

Figure 1: Experimental traction apparatus using load cell transducer

Excess traction can result in too much distraction of the bony elements. This can result in tearing of the muscle, fascia, nerve and vascular tissue, as well as distraction stress on the ligaments and capsule of the knee joint. In the case of children, excess traction can result in damage to the epiphyseal growth centers, which can lead to permanent growth deformity of the injured limb.

An experiment was set up to determine the amount of manual traction that prehospital providers would apply in a traction force challenge. A mechanism was designed consisting of a load cell entity with a digital readout in pounds traction force attached to the lower leg of a manikin and secured to a table (see *figure 1*). The mechanism was designed so there was axial movement of the manikin's leg when traction was applied (see *figure 2*). The electronically controlled digital readout mechanism was manufactured by A.L. Design of Buffalo, NY, and has the following specifications: The program calculates the non-linearity, hysteresis, repeatability and best-fit straight line through the actual calibration point of this transducer. Range of accuracy is absolute from 1-100 lbs.

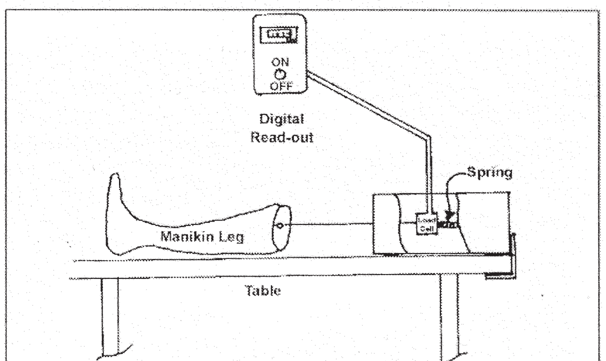

Figure 2: Load cell mechanism

The Challenge

Booths were set up for a traction force experiment at two EMS conferences. The participants in the traction force challenge were offered an incentive of $200 for the person who came closest to manually pulling 15 lbs. of traction on a simulated human leg. This traction force challenge was taken under very favorable conditions. Contestants were asked to pull the manikin's leg with a force of 15 lbs. They were told to take their time and cautioned that 15 lbs. was not a large force. When they thought they had a pull of 15 lb force, they were told to indicate "now" so it could be recorded. The digital readout and the recorded force by each contestant was covered so that contestants and observers waiting to take the challenge would not know the results.

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The Challenge *(Cont.)*

Of the total 181 contestants, three paramedics tied equally, pulling 15.2 lbs. of force. Contestants consisted of 55 EMTS, 93 paramedics, 12 nurses and 27 others (doctors, military and administrators). The highest amount of traction pulled was 111 lbs; the lowest amount was 3.5 lbs. The average force applied was 37.99 lbs.

Conclusion

It is possible, under actual field conditions with real trauma patients in life-and-death situations, that due care may be compromised by the urgent, and often necessary, hurried attendance or prehospital personnel. Adrenaline rush can compound strengths and consequently may create excessive traction for application.

Manual traction by personnel has been shown to vary greatly and can result in unacceptable, possibly injurious levels of force. Safe treatment of patients is a prime concern. The need to apply safe, acceptable traction and then document it for medical, as well as legal, purposes is abundantly clear in today's litigious society.

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2. *Emergency Care and Transportation of the Sick and Injured*, 5th Ed., p.304-305. American Academy of Orthopedic Surgeons.
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Important Economical Considerations

Sager Emergency Traction Splints:	Ischial Pad/Cross Bar Splints:
S300, Super Sager Infant Bilateral: One (1) splint treats infants and children up to age 6, with one or two fractured femurs.	**Ischial Pad Traction Splints:** No infant model available. Pediatric models require two (2) splints to treat two fractured femurs.
S301, Super Sager Form III Single: One (1) splint treats an adult or child (from 5th to 99th percentile). The Form III Articulating Base is hinged so that it swings left or right to apply countertraction more directly on the ischial tuberosity in all types of body habitus.	**Ischial Pad Traction Splints:** Require two (2) splints — an adult and pediatric model to treat an adult or child.
S304, Super Sager Bilateral: One (1) splint treats single or bilateral lower limb fractures for both an adult or child (from 5th to 99th percentile). The Form III Articulating Base is hinged so that it swings left or right to apply countertraction more directly on the ischial tuberosity in all types of body habitus. The entire splint stays within an adult's body silhouette. Designed for optimal transportation, including helicopter and air transfer/rescue.	**Ischial Pad Traction Splints:** Require four (4) splints to treat an adult or child with two fractured femurs (eg. need two adult Ischial Pad Splints and two pediatric Ischial Pad Splints). Extensive overhang with these splints. No equivalent model available.

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