ELSEVIER

JEMS

JOURNAL OF EMERGENCY MEDICAL SERVICES

July 2004
Vol. 29
No. 7
U.S. $5
CAN $6

THE CONSCIENCE OF EMS

EMS ARMOR, p. 56

2001-2004 AWARD WINNER
BEST MAGAZINE

ARTICULATING KNEE INJURIES

PHOTO REEL RESEARCH & DEVELOPMENT

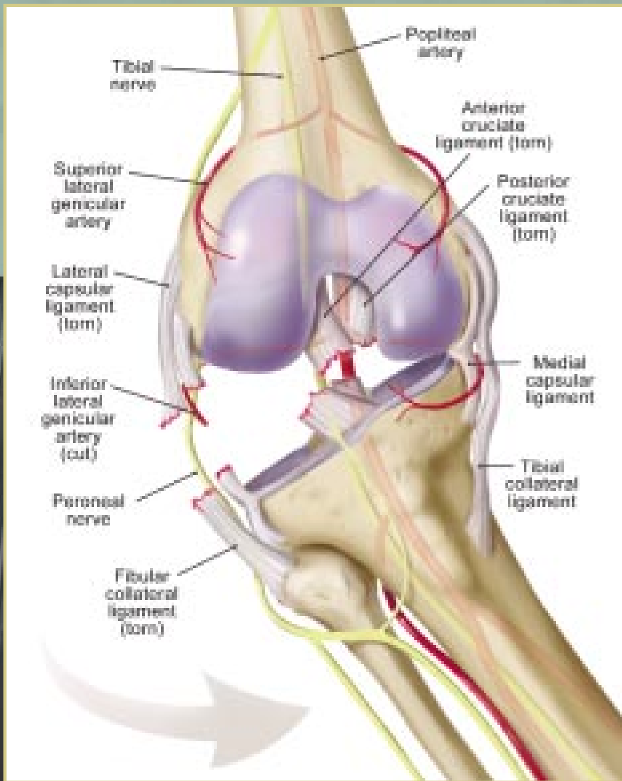


ILLUSTRATION WAINWRIGHT MEDIA

The Reel Splint's unique triple cross-member design offers padded patient movement and extrication handles that are used to lift and move the immobilized extremity.

Placing proper emphasis on the recognition & stabilization of severely dislocated knees

By A.J. Heightman, MPA, EMT-P

While attending my first EMT instructor training program at East Stroudsburg (Pa.) University in 1976, I heard professor Earl Shive, a gifted educator and dedicated EMT instructor, make introductory comments that I've never forgotten. He told the class of eager educators that EMS curricula reflect key topics and content as prioritized by educators of the time. However, he told us to be alert for future events and issues that would surface and require us to educate EMS personnel about topics and techniques that could reduce patient morbidity.

This article represents my attempt to do just that and follows up on an article I wrote for November 2003 *JEMS* ("Dislocated Care") that addressed the need for better care and management of severely dislocated knee injuries. In that article, I wrote about a gruesome, dislocated knee sustained during a high school football game. The case took on special relevance for me because I knew the player involved and was privy to the outcome of his case.

His knee was so severely dislocated and angulated that it literally stopped the EMS personnel dead in their tracks as they struggled to decide whether to straighten his leg or fixate it in the awkward position in which it was locked by the injury. Twisted at nearly a 90° angle from its normal position, the crews ended up simply resting it on a pillow and securing it with a single stretcher strap.

The patient required surgery for multiple torn ligaments and had a severely stretched peroneal nerve, resulting in footdrop, a condition characterized by significant weakness of the ankle and an inability to dorsiflex, or evert, the foot.

The objective of prehospital management of orthopedic injuries is to splint injured extremities appropriately in an effort to restore and maintain vascular patency and limb viability and then to rapidly transport the victim to an appropriate trauma facility.[1]

Although the crew I encountered rendered exceptional ALS care and eliminated the patient's pain, they did little to freeze his battered knee in place and prevent unnecessary movement of the limb.

This case frustrated me for two reasons: First, the crews involved did not appear to understand the complexity and potential seriousness of a dislocated knee. And second, they lacked an appropriate splint to fully immobilize the angulated extremity in position.

Textbooks lack emphasis

After this case, I reviewed multiple BLS and ALS textbooks to determine how much they discussed the nerve and vascular components of the knee, and methods for immobilizing severely angulated knee injuries. I found little or no reference to any of these key areas in the current textbooks. In fact, I found only two EMS texts that mentioned the popliteal artery and none that mentioned the peroneal nerve or footdrop at all.

Each text took a 1970's two-page approach to knee immobilization: If the knee is straight, use padded board splints extending from the hip to the ankle. If the knee is flexed and there are pulses present, apply padded board splints with the knee in the flexed position. There were no recommendations or equipment options presented for the immobilization of severely distorted knees and legs.

Important anatomy

The first way to appreciate the significance of knee injuries is to understand the complex anatomy of the knee. As a joint, the knee consists of the femur, tibia and fibula. The joint is protected in front by the patella (kneecap). The knee joint is cushioned by articular cartilage that covers the ends of the tibia and femur, as well as the underside of the patella. The lateral meniscus and medial meniscus are pads of cartilage that further cushion the joint, acting as shock absorbers between the bones.[2]

The bones in contact with the knee joint are held in place by ligaments, muscles and a muscle-tendon complex, in which the muscle is located on one side of the joint but extends its influence to a bone on the other side of the joint by a tendon.[3]

Ligaments help stabilize the knee. The collateral ligaments run along the sides of the knee and limit sideways motion. The anterior cruciate ligament, or ACL, connects the tibia to the femur at the center of the knee. Its function is to limit rotation and forward motion of the tibia. The posterior cruciate ligament, or PCL, is located just behind the ACL and limits backward motion of the tibia.[4]

Muscles attach to bones on either side of the knee joint. As agonist muscles shorten and antagonist muscles lengthen, they pull the two bones together and increase or decrease the angle of the knee joint. If an injury pulls the joint surfaces out of contact, the joint becomes dislocated and can no longer move through its full range of motion—if at all.[5]

Understanding the complexities of dislocations

Dislocations occur when the joint moves beyond its normal range of motion with great force.[6] When this occurs, bone ends displace from their normal joint positions and the joint then flexes in an abnormal position with noticeable deformity (see Photo 1, p. 48). Fluid inside a joint capsule keeps joint surfaces lubricated as they rub against each other. Therefore, when dislocated, the knee joint becomes swollen, immobile and extremely painful.[7]

By its nature, a knee dislocation has serious associated ligament damage and may involve injury to the joint capsule, nerves, arteries and articular cartilage.[8] Dislocations can be extremely dangerous because they can entrap, compress or tear blood vessels and nerves that run over and behind the knee joint and disrupt distal circulation.[9]

The popliteal artery and peroneal nerve are two structures that EMS personnel must become familiar with because mismanagement of dislocations or the failure to properly immobilize knee injuries can cause significant, and often permanent, damage to them.

The popliteal artery

The popliteal artery is the continuation of the femoral artery and courses through the popliteal fossa. It's the major blood vessel traversing the knee and less mobile than blood vessels in other joints. Therefore, a dislocation—or excessive handling by an EMS crew after an injury—can easily occlude or injure it (see illustration, p. 3).


PHOTO ED DICKINSON, MD

Anterior knee dislocation.


PHOTO A.J. HEIGHTMAN

MPL full-leg model modified for dislocation education.


PHOTO A.J. HEIGHTMAN

Close-up of nerve and artery lightstick tubes added to knee/leg model.

The peroneal nerve

The peroneal nerve supplies movement and sensation to the lower leg, foot and toes. It originates from the sciatic nerve in the posterior aspect of the upper leg and travels around the head of the fibula bone at the fibula neck, just below the knee. After it leaves the pelvis, the nerve travels down the front and outer side of the leg on its way to the foot. It runs along the lateral (outer) side of the knee and passes over the head of the fibula where it's vulnerable to pressure injury (see illustration, p. 3).[10]

Damage to this nerve destroys the covering of the nerve cells (the myelin sheath) or causes degeneration of the entire nerve cell. This causes a loss of muscle control, loss of muscle tone and eventual loss of muscle mass due to the lack of nervous stimulation to the muscles.

Peroneal nerve dysfunction & footdrop

An entrapment neuropathy or peroneal nerve dysfunction may occur when the peroneal nerve becomes compressed or entrapped as it winds around the neck of the fibula. An injury to the peroneal nerve at the head of the fibula causes numbness over the top of the foot. The muscles controlled by the peroneal nerve extend and evert (move outward and up) the foot and toes.

Causes of entrapment include stretching or traction of the nerve, Baker's cysts, total knee replacement, tight casts, ganglion and a normal or abnormal fabella. Impaired dorsiflexion may lead to footdrop.

Common peroneal nerve dysfunction is characterized by loss of movement or sensation in the foot and leg. A patient may experience both sensory and motor losses if the peroneal nerve is damaged and can frequently lose sensation over the dorsum (top) of the foot. Peroneal palsy due to injury to the nerve at knee level results in loss of the ability to evert (swing outward) and extend the foot and toes.

Treatment is aimed at maximizing mobility and independence. The cause should be corrected, if possible, to reduce further movement and damage.

Post-damage prognosis

The outcome of peroneal nerve injury depends on the underlying cause. Successful treatment of the underlying cause may resolve the dysfunction. It may take several months for a damaged peroneal nerve to regenerate.

If nerve damage is severe, disability may be permanent. Damage to the peroneal nerve can result in permanent decrease in sensation, weakness or paralysis in the legs or feet.[11]

4

PHOTO A.J. HEIGHTMAN

Leg model positioned in an STI PneuSplint inflated to simulate skin and muscle mass and placed in a pair of pants modified with Velcro® outer seams.

Common causes of damage to the peroneal nerve include:

- Trauma or injury to the knee;
- Fracture of the fibula;
- Use of a tight cast or splint on the lower leg ;
- Habitual leg crossing;
- Regularly wearing high boots; and
- Pressure to the knee from positions during deep sleep or coma.

Symptoms of peroneal nerve damage[10]

- Decreased sensation, numbness or tingling at the top of the foot;
- Weakness of the ankles or feet;
- Walking abnormalities;
- "Slapping" gait (walking pattern);
- Footdrop (unable to hold foot in a horizontal position); and
- Toes drag while walking.

Improving provider knowledge & skills

After reading my call for improved educational aids in my November article, Laerdal Medical Corp, STI Medical Products and Medical Plastics Laboratories (MPL) offered assistance in developing training aids to better prepare EMS students to manage severe knee dislocations and avoid damage to the popliteal artery and peroneal nerve. An MPL full leg model offered a good platform for modification into a severe dislocation model (see Photos 2 and 3, p. 48).

After adding a PVC impediment in the knee joint, tubing to simulate the path of the popliteal artery and peroneal nerve and a football kneepad to simulate a kneecap, I had a working model to test the ability of EMS personnel to properly immobilize an angulated knee dislocation. I further enhanced the model by sliding thin Cyalume lightstick rods in the tubing, designed to break if moved more than one-quarter inch.

The new model was dressed for realism by wrapping it in an STI full leg PneuSplint, inflated to simulate skin and muscle mass and placing it in a pair of pants modified with Velcro® outer seams (see Photo 4, p. 5).

This lower extremity model was tested and proved highly effective in keeping students focused on their assigned task—handling the injured extremity with care and preventing even minute movement that could cause further pain and injury (see Photos 5 and 6, p. 6).

Discovering the perfect splint for the task

Dislocations should be immobilized in the position found unless distal circulation, sensation or motor function is disrupted. Although such splints as ladder, SAM and adjustable air or vacuum splints can be used to immobilize a dislocated knee (see Photos 7 and 8, p. 6), if the knee is severely rotated and requires elevated packaging or transportation, these conventional splints may not adequately immobilize or support the extremity both above and below the joint.

After writing my November article, I discovered an articulating splint that's perfect for the immobilization of severely dislocated or fractured bones and joints. The flexible Reel Splint Immobilizer, made by Reel Research and Development, is a multi-angle immobilizer with a unique multi-hinge system that allows it to be adjusted and molded to fit almost any fracture or dislocation angle.

The Reel Splint stores folded in a compact 14" x 10" x 9" space and weighs just 5.5 lbs. Its key components are the two bilateral and multi-directional hinges (see Photo 9, p. 6).

Once applied, padded cross-member handles provide for easy limb movement, and its support straps allow for wound access, monitoring and treatment (see Photo 10, p. 6). The two hinges provide angulation of the splint's midsection, allowing angulation at the knee in either the lateral or medial direction to 45° and in the direction of flexion (posterior) to 90°. Hyperextension (anterior) at the knee is essentially unlimited. A proximal articulation allows the thigh to be splinted at angles of up to 45° in a medial-lateral deviation from the midline.[13]

The Reel Splint is most often positioned on the anterior side of the extremity but can also be applied to the dorsal or lateral aspect. It's attached with combination polypropolene and elastic webbing straps, fastened by snap-release buckles. The straps are permanently attached to the splint and are stored fastened together on top of the splint. A single nylon ankle strap, referred to as the Harding strap, attaches to the ankle with a Velcro closure to prevent footdrop (see Photo 11, p. 7).

In extrication cases, the Reel Splint is affixed on the leg's anterior side and can be repositioned after extrication, if necessary, to restore circulation, improve comfort and relieve pain. The splint's triple cross-member design provides you with padded patient movement and extrication handles you can use to lift and move the immobilized extremity (see Photo, p. 2, and Photo 12, p. 7).

If rapid extrication is required, the splint can be rapidly formed around the extremity, the ischial strap scissored, connected and tightened, and the hands of two rescuers used in place of the straps until the patient is free of entrapment.

Reel's exclusive Harding strap ensures the distal stabilization of the foot by securing the patient's foot to the bottom cross member (see Photo 13, p. 7). If necessary for support, packaging or patient comfort, the Reel Splint can be suspended from IV poles via a clip-on support system (see Photo 14, p. 7).

The U.S. military, frequently the proving ground for innovative EMS products, has more than 40,000 of these splints in use today.

5

PHOTOS 5–8 A.J. HEIGHTMAN

EMS personnel carefully immobilize the model so the lightstick does not get bent and activate.

6

This extremity model allows students to see and feel the exact location of the popliteal artery and its branches.

7

Two SAM splints, tri-folded and padded with towels and sheets, secure the joint in place. A separate SAM, flexed in a triangular shape and padded with a towel, is used to support the leg in the position of comfort.

8

Vacuum splints can be molded to support or elevate an angulated dislocation.

9

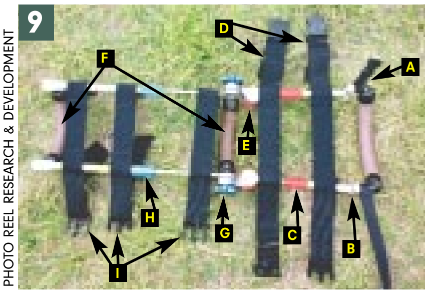


PHOTO REEL RESEARCH & DEVELOPMENT

REEL SPLINT COMPONENTS

A) Ischial bar & strap
B) Ischial pivoting knobs
C) Proximal length twist adjuster
D) Two proximal straps
E) Proximal hinge knob (red)
F) Padded patient movement and extrication handles
G) Distal hinge knob (blue)
H) Distal length twist adjuster
I) Three distal straps

10

PHOTO REEL RESEARCH & DEVELOPMENT

The adjustable support straps are stored on top of the splint. The padded patient movement and extrication handles ensure proper movement of a completely fixated extremity.

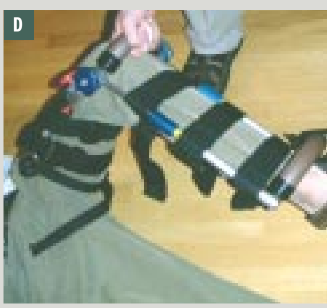
Reel Splint Application Procedure

1. Determine appropriate placement position for your patient (e.g., anterior, posterior, lateral or medial).
2. Loosen the two red (proximal) and the two blue (distal) hinge knobs enough to allow controlled articulation of the splint.
3. Adjust the hinge angle to match the extremity position, and position the splint on the injured limb.
4. Fine tune the splint angle, and retighten the red and blue hinge knobs.
5. Apply a centrally located (proximal) strap to hold the splint in place.
6. Loosen the red (proximal) length adjusters, and adjust for the proper length from the patients inguinal crease.
7. Apply the remaining proximal strap and ischial strap, scissoring the ischial strap in place while tightening.
8. Loosen both blue (distal) length adjusters and slide the distal end to the patient's ankle area and tighten the adjusters.
9. Apply the three distal support straps.
10. Wrap the Harding strap under the patient's foot and secure it to the lower (distal) padded cross member.
11. Before moving the patient, reevaluate the splint's placement and make sure all straps and adjustment knobs are tightened.

A


B


C


D


PHOTOS A.J. HEIGHTMAN

A) The Reel Splint adjusted to fit the deformed extremity.
B) The blue distal length adjuster and hinge knob are tightened once the splint is formed to the leg.
C) The straps are buckled and tightened to secure the leg to the splint.
D) The padded patient movement handle is used to move the immobilized extremity.

11


PHOTO REEL RESEARCH & DEVELOPMENT

The Reel Splint can be applied to the posterior side. Note the Harding strap used to prevent foot drop.

13


PHOTO A.J. HEIGHTMAN

The splint can be adjusted to fit the extremity of a nine-year-old as shown here. The Harding strap ensures distal stabilization of the foot by securing the patient's foot to the bottom cross member.

12


PHOTO REEL RESEARCH & DEVELOPMENT

The Reel Splint is affixed on the anterior side of a soldier's leg in a Humvee.

14


PHOTO A.J. HEIGHTMAN

The Reel Splint can be suspended from IV poles via a clip-on support system for elevation, support, packaging or patient comfort.

Conclusion

It's the field provider's job to properly splint fractures and dislocations, make patients as comfortable as possible and avoid causing additional injury. To do this, they need the proper education and immobilization devices. It's the educator's job to prepare providers to recognize and stabilize these complicated and challenging injuries. The use of realistic training aids and appropriate splinting devices will accomplish this. JEMS

A.J. Heightman, MPA, EMT-P is the editor-in-chief of JEMS, *a former regional EMS director and EMS operations director. Contact him via e-mail at a.j.heightman@elsevier.com.*

References

1. Auerbach PS, Geehr EC, Ryu RKN: "The Reel Splint: Experience with a new traction splint apparatus in the prehospital setting." *Annals of Emergency Medicine*. 13:419–422, 1984.
2. www.scoi.com
3. McSwain NE, Paturas JL: The Basic EMT: *Comprehensive Prehospital Patient Care, Revised Second Edition*. MosbyJems. St. Louis, 2003.
4. www.scoi.com
5. McSwain
6. Bledsoe BE, Porter RS, Cherry RA: *Paramedic Care: Principles & Practices, Volume 4, Trauma Emergencies*. Brady/Prentice Hall Health. Upper Saddle River, N.J., 2004.
7. McSwain
8. Beebe RW, Funk DL: *Fundamentals of Emergency Care*. Delmar Thompson Learning. Albany, N.Y., 2001.
9. Beebe
10. www.health.allrefer.com/health/common-peroneal-nerve-dysfunction
11. www.amershamhealth.com
12. www.microsurgeon.org/peroneal_nerve
13. Auerbach

REEL RESEARCH

"This TORTOISE is gaining on a familiar old HARE"

REEL Research's Innovative Splinting Solutions

Pivot-trac Traction Splint

REEL RESEARCH

Real Problems REEL Solutions

Pad follows the true anatomical *"Ischial Pathway"*™

Pivot-Trac's Patented Ischial Pad is getting noticed, because seeing is believing.

Our exclusive pivot feature captures the true "ISCHIAL PATHWAY" angle; a logical way to avoid displacing important proximal fracture sites.

Comfortable and correct traction is here today... in a format you already know.

THE REEL SPLINT

REEL'S FULLY ADAPTABLE HINGE MAKES FOR IDEAL KNEE SPLINTING

REEL'S application speed combined with a VERY ridged hinge is why the REEL is deployed in 1000's of U.S. and other military sets worldwide

- Critical below knee stabilization using our special ankle strap method
- NEW! Moveable splint straps for severe wound monitoring and access
- Foamed crossmembers provide unique hand grips for movement to a backboard
- NSN: 6515-01-514-1347

REEL RESEARCH

Phone 800-348-7335 · Fax 831-336-3532