CHAPTER 13

Musculoskeletal Injury

Learning Objectives

- ✔ Distinguish between stable and unstable musculoskeletal injuries.
- ✔ Describe the immediate and long-term treatment of unstable injuries.
- ✔ Describe the process of restoring alignment in deformed injuries.
- ✔ Check for problems with circulation, sensation, and movement.
- ✔ Apply the principles of splinting to unstable musculoskeletal injuries.
- ✔ Describe the treatment of stable injuries.
- ✔ Recognize high-risk musculoskeletal problems and describe the field treatment.

Introduction

If your scene size-up and primary assessment reveal no existing or anticipated critical system problems, you have the luxury of time to perform a secondary assessment. You can develop a problem list and plan, and safely evacuate your patient to medical care hours or days later. Like most backcountry medical problems, musculoskeletal injuries are more often a logistical dilemma than any kind of emergency.

Structure and Function

The structure of the musculoskeletal system is composed of bone, cartilage, tendon, ligament, muscle, and synovial fluid. Its function is support, protection, and mobility. The problems can be described generically as stable injury, unstable injury, and associated neurovascular injury.

Bone provides structural support and protection for soft tissue, and leverage for mobility. It is living tissue with a rich blood supply and an overlying membrane called the periosteum, which is abundantly supplied with sensory nerves. As with any other tissue, bones bleed and hurt when injured.

Bones meet at joints, and are held together by ligaments. Some joints are highly mobile, and some do not move much (FIGURE 13-1). Cartilage provides the smooth surface and padding for bones to slide or pivot against each other. The synovial fluid contained inside the ligamentous joint capsule lubricates the surfaces.

Tendons are cord-like connective tissue that join muscle to bone, crossing joints in the cable and pulley

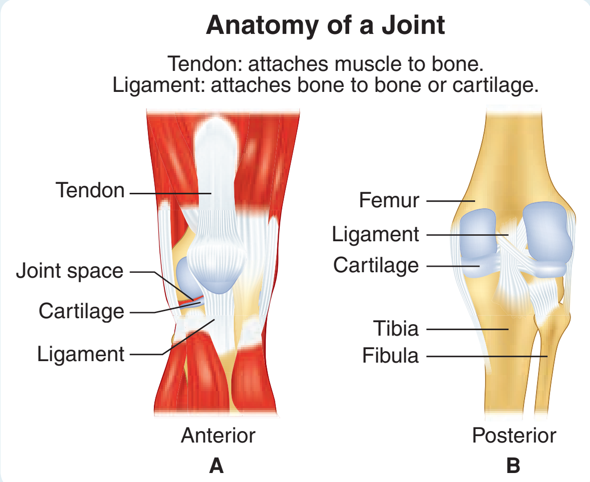

FIGURE 13-1 Anatomy of a joint. **A.** Anterior. **B.** Posterior.

system that effects movement. The muscle tissue itself is encased in connective tissue compartments called *fascia*. This structure in cross section resembles a steak: the muscle is like the steak's soft red tissue, and the fascia is the tough white grizzle that you don't eat.

Because muscle contraction is active, and elongation is strictly passive, muscle groups must work in balanced opposition. One group is responsible for pulling a bone one direction, and the opposite group is responsible for pulling the bone back. For example, the contraction of your biceps flexes your elbow, and the contraction of your triceps extends it. Balanced opposition is an important concept to remember when splinting an injured joint or reducing a dislocation.

There are many types of bones and joints, and many forms of injury. The mechanism can be direct or indirect force, overuse, infection, or even frostbite. Chronic conditions such as arthritis also affect structure and function. Knowing all types of injury in detail is interesting, but not required for effective field treatment.

The medical practitioner's primary concern is whether an injured bone or joint can still safely perform its function, or must be stabilized and protected.

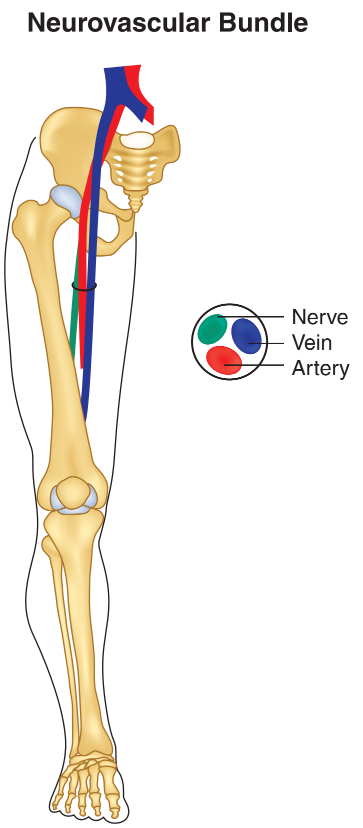

FIGURE 13-2 Arteries, veins, and peripheral nerves tend to run together in a neurovascular bundle.

This explains our generic assessment for the wilderness context: stable or unstable.

When the structure and function of the system are compromised, surrounding soft tissue is also at risk. Of primary concern in extremity injuries are the arteries, veins, and peripheral nerves that run adjacent to bones and joints (**FIGURE 13-2**). They tend to be grouped in a *neurovascular bundle*, much the way electrical wires and plumbing are fixed together as they run through a ship. These unprotected structures can be damaged during the initial injury, or pinched by misalignment or swelling after the injury.

Unstable Injury

Fractures, sprains, strains, and dislocations in extremities can be caused by a variety of mechanisms reflecting the different ways force can be applied to bones and joints. The injury may be caused by leverage, twisting, direct impact, or a piece of bone being pulled away at the site of attachment of a tendon or ligament.

High-velocity injuries, dissipating tremendous kinetic energy in a short period of time, tend to cause ligament and tendon rupture and bone fractures. Low-velocity injuries are more prone to cause partial tears of ligament and tendon, and are less likely to fracture bones. For field purposes, defining the mechanism of injury can be generalized to a yes-or-no question: Was there sufficient force to cause a fracture or to rupture a ligament or tendon?

Signs *and* Symptoms

Unstable Injury

- Instability by history or exam
- Crepitus by history or exam
- Inability to use, move, or bear weight
- Deformity or angulation
- Impaired circulation, sensation, and movement

The signs and symptoms of an unstable musculoskeletal injury are sometimes very obvious. Gross deformity, crepitus, and instability on exam make the assessment rather clear. Also, the patient may report gross instability by telling you that his knee gives out every time he tries to walk. These criteria are very specific, and indicate an injury that is definitely unstable.

Sometimes you will have to rely on nonspecific signs and symptoms. Rapid swelling, for example, indicates significant bleeding at the injury site. The inability to use a joint or extremity after trauma indicates a more serious injury. Impairment of circulation, sensation, and movement (CSM) distal to the injury implies damage to the neurovascular bundle. The patient may report a snap or pop at the time of injury. Although these nonspecific criteria are less definitive, you might choose to treat the injury as unstable pending more information or response to treatment.

It is worth noting that the amount of pain is not a reliable sign. For example, a minor grade I ligament sprain will hurt much more than an unstable grade III ligament rupture. The primary pain receptors in ligaments are stretch receptors. Because the ruptured ligament is no longer being stretched, pain is minimal. The primary complaint is often instability rather than discomfort.

It is important to protect any injury in which an unstable fracture or ligament rupture may exist. Manipulation or use of extremities with fractured bones and loose or dislocated joints can cause further damage to surrounding soft tissue like the organs, muscles, and neurovascular bundle. This potential for damage is especially important to evaluate whenever the associated soft tissue is part of a critical system, such as the spinal cord running through damaged vertebrae, or the femoral artery lying adjacent to a fractured femur.

Assessment for neurovascular bundle injury involves checking distal CSM. Problems with circulation are found by observing for signs of ischemia—such as cool and pale skin or a weak or absent pulse—in the distal extremity. Problems with sensation are reported by the patient as numbness and tingling. Because nervous system tissue is exquisitely sensitive to oxygen deprivation, these are usually the first symptoms. The examiner can further evaluate the problem by checking the patient's ability to distinguish sharp from dull touch on the distal extremity. Often sharp and dull sensation is fully intact even with the complaint of numbness and tingling. Ultimately, ischemic injuries can become very painful, with loss of motor control developing later in the process.

Impaired CSM can be caused by various mechanisms, including the following:

- Deformity
- Swelling
- Tight splints, boots, jewelry
- Vasoconstriction from cold exposure
- Tight litter straps, pressure points
- Artery laceration

Extremity tissue can usually survive up to two hours of ischemia with minimal damage. Beyond this, the risk of tissue death and permanent damage increases quickly with time. Ischemia also increases the risk of frostbite in freezing weather and makes infection more likely in open wounds. *If your treatment efforts do not succeed in restoring CSM, you have a limb-threatening emergency. Immediate evacuation is indicated if conditions permit.*

Treatment of Unstable Injury

The process of stabilization has three distinct phases:

1. Traction into position
2. Hands-on stable
3. Splint stable

Before you begin, check and document the status of the neurovascular bundle (check CSM). You will want to know that your treatment has improved the situation, or at least not made it worse. Most of the time, CSM will remain normal throughout the process.

Sometimes, an extremity feels numb or cold immediately following trauma, especially if a fracture or dislocation results in deformity, pain, and acute stress reaction. Your treatment should result in a significant improvement in CSM status as circulation is restored. Beware, however, that distal CSM may become impaired later as swelling develops under a splint or bandage. Detecting and correcting ischemia is an important function of continued care throughout your treatment and evacuation.

Traction into Position

Injured bones and joints, and the soft tissues around them, are much more comfortable and much less likely to be damaged further if splinted in normal anatomic position. Although many injured extremities remain in good position or return there spontaneously, some will require manual realignment.

To restore anatomic position, the first step is to apply traction. This separates bone ends and reduces pain. Then, while traction is maintained, position is restored (**FIGURE 13-3**). Shaft fractures of long bones are returned to the "in-line" position so that the effect of opposing muscles is most balanced and the neurovascular bundle is least likely to be compressed.

The amount of force necessary depends on the structure being realigned. Forearm and lower leg fractures usually require only gentle traction. Femur fractures, with the large surrounding muscle mass, may require significant traction to restore length and

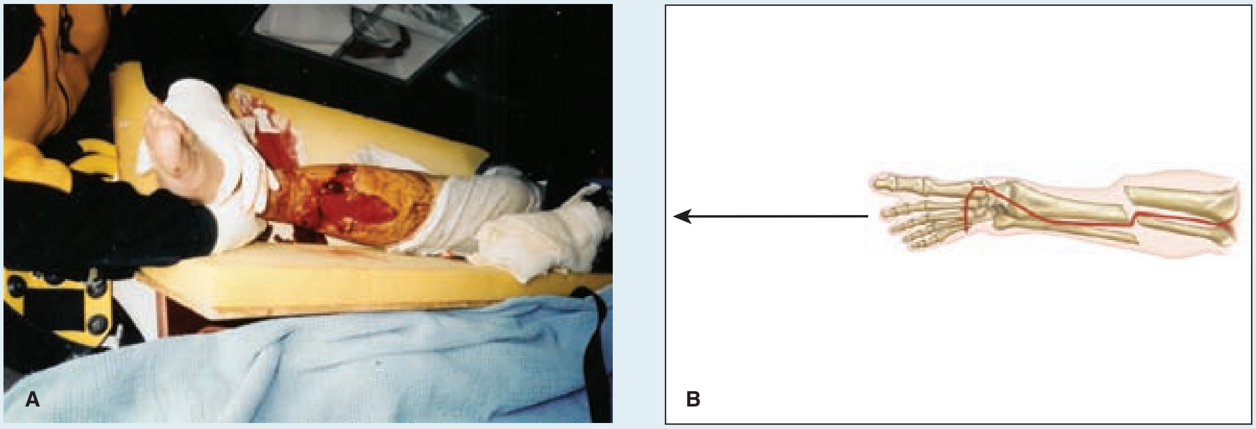

FIGURE 13-3 Traction into normal anatomic position reduces pain and improves perfusion.

alignment. Deformed wrist fractures may also require significant traction because the bone ends tend to lock against each other (**FIGURE 13-4**).

Injured joints without dislocation usually do not need to be repositioned. If the patient is conscious and mobile, he or she will have already found the most comfortable position for the injured joint. If not, stabilize it in place unless there is impaired CSM or the position prevents safe packaging.

In joint dislocations, there is likely to be some loss of CSM distal to the injury (**FIGURE 13-5**). Under these conditions, traction and repositioning are used until circulation is reestablished. In specific cases, covered in the *Simple Dislocations* chapter, repositioning can be used to completely reduce dislocations of the shoulder, digits, and patella with a significant improvement in comfort and circulation. The use of traction on more complex dislocations, such as the elbow, wrist, or ankle, is indicated only for restoration and preservation of perfusion.

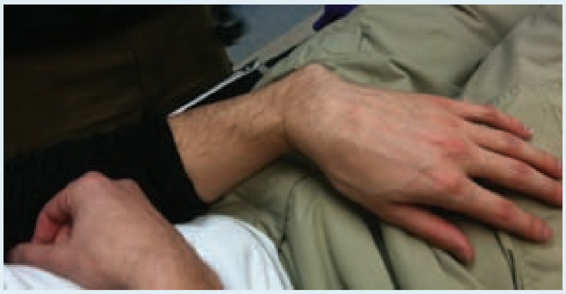

FIGURE 13-4 Complex joint injuries, like this fracture dislocation of the wrist, are manipulated in the field only when necessary to restore perfusion or enable a safe evacuation.

Spine injuries are also realigned by considering the stacked vertebrae of the spine to be a single long bone with a joint at the pelvis and the skull. However, traction should not be used. Spine alignment and protection are discussed in more detail in the spine injury chapter.

FIGURE 13-5 This ankle fracture shows obvious deformity, but not enough to require TIP for perfusion or splinting.

Treatment

Unstable Injury: Long Bones

- Traction into position
- Hand stable
- Splint stable
- Check CSM before and after

Traction and repositioning is a safe procedure if done properly. To be successful at reducing pain and restoring position, it is critical to have the cooperation and confidence of the injured person. Muscle groups in spasm, or a patient fighting your efforts, will vastly complicate the procedure. Your patient will be reassured to hear that repositioning is intended to be a slow and gentle process. It will also help to let the patient know that he or she is in control, and that you will stop the process if asked.

The therapeutic effect of a calm voice and reassuring manner is truly amazing. What this treats is the patient's acute stress reaction, as well as yours. Pain medication is valuable, but it can be dangerous to use in the backcountry setting at the dosage necessary to completely relax a scared and uncomfortable patient. Field treatment, combining reassurance with the lowest effective dose of medication, can offer less risk with equal benefit.

Open shaft fractures with bone ends protruding through the skin are still managed with traction and repositioning following thorough cleaning of the exposed bone ends and surrounding skin (see the chapter on soft-tissue injury). To keep skin from becoming trapped under the bone as you realign the fracture, you may have to pull it free with forceps or a gloved finger as the bone is manipulated back into the wound.

Occasionally it will be impossible to restore position comfortably and safely. You should discontinue traction and stabilize the injury in the position found if traction causes a significant increase in pain or resistance. These rare situations represent a limb-threatening emergency if deformity is significant or ischemia is detected.

Hand Stabilization

Once you have repositioned an extremity injury, stability must be maintained until the splint can take over. This may mean having someone hold gentle traction on the extremity while you prepare for splinting. If you are alone, you can use snow, rocks, or pieces of equipment to hold the limb in place.

Splint Stabilization

Whether a commercially manufactured product, or something improvised from your equipment, a splint should be complete, comfortable, and compact.

- *Complete.* Long bones should be splinted in the in-line position, and the ideal splint should immobilize the injured bone as well as the joint above and below the injury. To splint a lower leg fracture effectively, the ankle and knee should be immobilized. Joint injuries are splinted in the mid-range position, including the bones above and below the injury. To splint the elbow, for example, the forearm and upper arm are included in the splint.

For splinting purposes, the stacked vertebrae of the spine may be viewed as a long bone with joints at the pelvis and base of the skull. Splinting an unstable spine injury would require stabilizing the pelvis, shoulders, and head. Unstable pelvis injuries require stabilization of the spine and femur. Femur fractures require stabilization of the pelvis and knee. For these spine, pelvis, and femur injuries, the ideal treatment is whole-body stabilization in a litter or vacuum mattress.

- *Comfortable.* Splints should be well-padded, strong, and snug. There should be no movement of the injured bones or any pressure points or loose spots. A splint should allow you to monitor distal CSM, and should be easily adjustable if ischemia or pain develops. A good splint decreases pain and preserves CSM; attention to this principle is critical to prevent pressure sores and infection during long-term care and transport.
- *Compact.* For wilderness use, a splint should be no larger or more complex than absolutely necessary (**FIGURE 13-6**). It should not inhibit the

FIGURE 13-6 Wrist splint–complete, comfortable, and compact–in the position of comfort.

evacuation you have in mind. A simple sling and swathe, for example, splints everything from the clavicle to the elbow. This simple structure can be created with a safety pin and the patient's shirt. No additional material is necessary.

Once an injury is stabilized, the most important anticipated problem for long-term care becomes distal ischemia caused by compression of the neurovascular bundle as swelling develops inside splints or bandages (**FIGURE 13-7**). Treatment should include medication, rest, and elevation to reduce swelling and pressure. This is essentially the same as the generic treatment for stable injuries. As long as distal CSM remains normal or continues to improve, you can take your time planning a safe and comfortable evacuation.

Special Wilderness Considerations

Femur Fracture

Shock and distal ischemia are anticipated problems due to the proximity of the neurovascular bundle to the femoral shaft. The usual treatment for a femoral shaft fracture in the EMS setting is the application of a traction splint and urgent evacuation to a hospital. This may be appropriate for short-term care, but the risks outweigh the benefits in long or difficult evacuations.

In many backcountry situations, it can be impossible to distinguish a femoral shaft fracture from a femoral neck or pelvis fracture that might be further deformed by the application of traction. Even when properly applied, traction splints are notoriously difficult to monitor and package. When the proper amount of traction is applied to the femur, the pressure at the anchor points will inevitably cause skin and soft tissue ischemia. For these reasons, the use of a traction splint may not be appropriate or safe for backcountry rescue or long-term care. In this setting, femur fractures are best stabilized in a litter, vacuum mattress, or well-padded backboard.

Pelvic Fracture

Shock and distal ischemia are anticipated problems due to the proximity of the iliac arteries and veins. Pelvic binding with a padded strap or wide compression bandage may be useful to help stabilize a pelvic fracture and reduce the space available for internal blood loss. This can be accomplished by wrapping a tarp or backpack hip belt around the pelvis and tightening gently to restore anatomy. The patient is then further stabilized by a litter, vacuum mattress, or well-padded backboard. Urgent evacuation is indicated.

Compartment Syndrome

Swelling due to bleeding or edema inside a muscle compartment can increase intra-compartment pressure to the point that perfusion is impaired. The mechanism is usually blunt trauma or collateral damage from a fracture. It is also possible to see compartment syndrome develop from repetitive motion injury. Ischemia develops, with necrosis of muscle and nerve tissue as the anticipated problem. Symptoms include pain out of proportion to the apparent injury, distal numbness, and pain on passive stretching of the affected muscle group. Compartment syndrome can develop hours to days after the initial

FIGURE 13-7 A quick splinting job may help with extrication from a dangerous spot, but it needs to be carefully fitted and padded later for long-term use.

injury (FIGURE 13-8). Field treatment includes anti-inflammatory medication, rest, elevation, and cooling of the extremity. Urgent evacuation is indicated if immediate improvement is not noted.

Open Fracture

Fractures may be open (compound) or closed (simple). In an open fracture, the site is exposed to the outside environment through a wound in the skin. This opening can be produced from inside by sharp bone ends, or from outside by the same object that caused the fracture (such as a bullet). Fortunately, open fractures are uncommon (FIGURE 13-9).

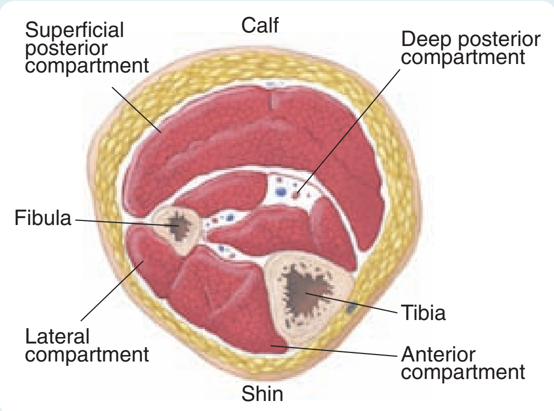

FIGURE 13-8 Compartment syndrome occurs when swelling of injured muscle tissue increases compartment pressure to the point that perfusion becomes impaired. It is most common in the lower leg and forearm.

FIGURE 13-9 An open fracture is a high-risk problem that can be hidden by layers of clothing.

Distal ischemia and infection are anticipated problems. Aggressive debridement (removal of foreign material and dead tissue) and irrigation with clean water are necessary before bone ends are pulled under the skin. Early use of prophylactic antibiotics should be considered as part of the ideal field treatment. In cases such as crush injuries where bones remain exposed, moist dressings over the wound will help preserve tissue. Urgent evacuation is indicated.

Joint Infection

The symptoms of joint infection (also called *septic arthritis*) include swelling, redness, pain, and warmth. The patient may develop a fever. Joint infection usually develops shortly after a laceration or puncture wound that penetrates the joint space, but it may develop after a minor abrasion or without any skin defect being visible. These infections have the potential to become systemic, and result in life-threatening vascular shock.

Impending Surgery

Serious fractures, infections, and compartment syndromes will be likely candidates for immediate surgery upon arrival at the hospital. The anesthesiologist preparing the patient for surgery will anticipate patient vomiting because it is a problem associated with general anesthesia and intubation. For that reason, EMS personnel in the ambulance context do not give any fluids, food, or medications by mouth to such patients. This is referred to as keeping the patient *NPO*, an abbreviation for the Latin *nil per os*. Intravenous (IV) fluids and IV or intramuscular (IM) medications are used instead.

During a long evacuation, priority must be given to maintaining hydration, perfusion, and body core temperature. Fluid replacement by IV line is ideal, but oral intake of fluids will be necessary if the IV route is not available or is impractical. Food is important in maintaining calories for heat production. You can help the anesthesiologist by giving your patient easily digested and absorbed simple sugars and carbohydrates and avoiding protein and fat when possible. NPO is not an option in most prolonged evacuations.

Stable Injury

Stable musculoskeletal injuries have none of the specific signs and symptoms associated with instability. Often, the patient will be able to move, use, or bear weight with the extremity within a short time after injury, and there will be no history of instability. Any swelling will develop slowly over several hours. You will find no deformity, crepitis on movement, or instability on exam.

Treatment is designed to reduce and control swelling and pain and includes using anti-inflammatory medication as well as rest, ice if available, compression, and elevation (RICE). Because a stable injury is safe to use within the limits of discomfort, the patient is allowed pain-free activity.

Elevation and rest are the most effective elements of RICE and most useful early on when the swelling is likely to be the worst. Ice can also be helpful if it is available, but not so much that it is worth carrying chemical cold packs in a backcountry medical kit.

Compression of an injured extremity with an elastic bandage is intended to limit the space available for swelling or to force accumulated fluid out of the extracellular space. Sometimes this is helpful, but it can also contribute to compartment syndrome and increase swelling of the distal extremity. Compression bandages may also be employed to provide some support to a sore joint. Frequent monitoring of the distal CSM is important when using a compression bandage.

Medication such as aspirin, ibuprofen, or acetaminophen can help reduce discomfort. A regular dose over several days will raise an appreciable level of the drug in the body and may work better than just taking it occasionally in response to pain. Because aspirin and ibuprofen inhibit blood clotting and increase swelling from bleeding, acetaminophen may be preferred in the immediate post-injury period.

Pain-free activity is allowed after the first 24 hours, or when most of the pain and swelling has resolved. The patient may perform whatever activity is possible as long as pain is not increased. This may include skiing, or it may require very limited use around camp for several days.

Following these treatment guidelines, all stable injuries should show steady improvement. If not, your patient is being too active, or your assessment may be wrong. It *is* possible to have a stable injury with a small fracture causing prolonged discomfort. Medical follow-up is indicated if rapid improvement is not noted or if symptoms persist at the end of the trip.

Signs *and* Symptoms

Stable Injuries

- No deformity or instability on exam
- No sense of instability reported by patient
- Able to move and bear weight after accident
- Distal CSM intact
- Slow onset of swelling
- Pain proportional to apparent injury

Treatment

Stable Injuries

- Rest, ice, compression, elevation (RICE)
- Pain-free activity
- Splint or sling for comfort
- NSAIDs for pain and swelling
- Monitor CSM
- Medical follow-up when possible

Wilderness Perspective

Musculoskeletal Injury

High-risk problem:

- Pain out of proportion to apparent injury
- Critical system injury
- Unstable fracture of pelvis or femur
- Persistent impaired CSM
- Compartment syndrome
- Open fracture
- Joint infection

Overuse Syndromes

Bursitis, tendonitis, and joint inflammation can be symptoms of overuse. These injuries develop over time without an obvious precipitating traumatic event other than repetitive motion. A long hike or bike ride can bring on pain and near-complete disability. You should be able to rule out unstable injury by history, but that may not make the patient any more functional.

You will note pain, swelling, and sometimes redness over an inflamed muscle, tendon, or joint structure. Moving it will hurt, and you may be able to feel crepitus as a damaged tendon slides roughly through an irritated tendon sheath. Resting it will bring relief. These symptoms are typical of all kinds of repetitive motion injury. Bikers get it in the knee, hikers in the foot, and rowers in the wrists.

To treat an overuse syndrome effectively, you have to break the cycle of injury and inflammation. Treatment includes RICE and anti-inflammatory medication. If travel is required, functional splinting for support and mobility will be necessary. As pain subsides, remove the splint two or three times a day and do gentle exercises, taking the part through its normal range of motion as pain allows. Apply heat after the initial inflammation has settled down. Use warm soaks four times a day for 15 minutes at a time. This is good to do just before range of motion exercises.

Change the way your patient performs the repetitive motion. This will put the stress on different muscle/tendon groups. For example, using a short loop of webbing as a handle on a kayak paddle can allow the paddler to pull with the wrist held vertically instead of horizontally. This may not be ideal, but it may allow the group to continue its travel.

The patient should take the full therapeutic dose of anti-inflammatory medication. For ibuprofen, this is 2400 mg a day. Gastrointestinal and kidney problems can be minimized by taking these drugs with ample water and food. The stomach may allow a couple of days of this, which can suppress the inflammation enough to prevent complete disability. Reduce the dose as soon as improvement is noted.

Using tape and padding, you can create a soft splint that will help reduce the stress on the irritated structure. Joint taping is another technique for providing support and limited mobility (FIGURE 13-10). Encourage the patient to rest frequently, letting pain be the signal to stop. Continue only after the pain is under control.

FIGURE 13-10 Joint taping can provide support and limited mobility.

Risk Versus Benefit

Traction into position to restore alignment in significantly deformed fractures and dislocations can be painful for the patient and intimidating for a practitioner inexperienced in the procedure. It is worth remembering that significant deformity represents a high risk of ischemia to infarction and increased bleeding and tissue damage. It is also more painful and difficult to stabilize and evacuate safely. Gentle repositioning is a low-risk procedure for a high-risk problem.

Procedures that seem to cause intolerable pain or require a lot of force are more dangerous. When you meet significant resistance, you should stop and reassess. Wait a few minutes or modify the technique and try again. If you are still unsuccessful, consider the persistent deformity and severe pain to indicate a high-risk problem and the need for urgent evacuation.

Even stable injuries, with continued use, run the risk of becoming worse. This must be balanced against the benefit of continued mobility and self-sufficiency. Moderating activity with splinting or wrapping to minimize the increase in pain and swelling is a reasonable goal for early treatment in a difficult situation.

Splints and wraps are applied where necessary to reduce the risk of further soft-tissue trauma in unstable musculoskeletal injury. At the same time, they can create an increased threat to the patient's safety and survival. A sling and swathe, for example, can inhibit a skier's ability to negotiate a cliff band safely. Backboard or litter stabilization can drown a patient on an overturned boat. Sometimes the benefit of a stabilized injury does not match the overall risk to the patient and the plan must be modified.

Chapter Review

- ✔ Musculoskeletal injuries alone are not emergencies, but they can affect critical system function, causing ischemia, respiratory distress, and shock.
- ✔ Unstable injuries present risk of injury to surrounding soft tissue, including the neurovascular bundle, and should be protected and stabilized.
- ✔ Deformed long bone fractures should be restored to normal alignment using traction into position.
- ✔ Unstable joint injuries should be splinted as found unless circulation is impaired or the position will inhibit safe evacuation.
- ✔ Splints, if needed, should be complete, comfortable, and compact.
- ✔ Stable injuries are safe to use and move within the limits of pain-free activity.
- ✔ High-risk musculoskeletal injury should be evacuated urgently to definitive medical care.