Questions & Answers about . . .

Growth Plate Injuries

National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS)
National Institutes of Health
Public Health Service • U.S. Department of Health and Human Services

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This booklet contains general information about growth plate injuries. It describes what the growth plate is, how injuries occur, and how they are treated. At the end is a list of additional resources. If you have further questions after reading this booklet, you may wish to discuss them with your doctor.

What Is the Growth Plate?

The growth plate, also known as the epiphyseal plate or physis, is the area of growing tissue near the end of the long bones in children and adolescents. Each long bone has at least two growth plates: one at each end. The growth plate determines the future length and shape of the mature bone. When growth is complete—sometime during adolescence—the growth plates close and are replaced by solid bone.

Who Gets Growth Plate Injuries?

These injuries occur in children and adolescents. The growth plate is the weakest area of the growing skeleton, weaker than the nearby ligaments and tendons that connect bones to other bones and muscles. In a growing child, a serious injury to a joint is more likely to damage a growth plate than the ligaments that stabilize the joint. An injury that would cause a sprain in an adult can be associated with a growth plate injury in a child.

Injuries to the growth plate are fractures. They comprise 15 percent of all childhood fractures. They occur twice as often in boys as in girls, with the greatest incidence among 14- to 16-year-old boys and 11- to 13-year-old girls. Older girls experience these fractures less often because their bodies mature at an earlier age than boys. As a result, their bones finish growing sooner, and their growth plates are replaced by stronger, solid bone.

Approximately half of all growth plate injuries occur in the lower end of the outer bone of the forearm (radius) at the wrist. These injuries also occur frequently in the lower bones of the leg (tibia and fibula). They can also occur in the upper leg bone (femur) or in the ankle, foot, or hip bone.

What Causes Growth Plate Injuries?

While growth plate injuries are caused by an acute event, such as a fall or a blow to a limb, chronic injuries can also result from overuse. For example, a gymnast who practices for hours on the uneven bars, a long-distance runner, or a baseball pitcher perfecting his curve ball can all have growth plate injuries.

In one large study of growth plate injuries in children, the majority resulted from a fall, usually while running or playing on furniture or playground equipment. Competitive sports, such as football, basketball, softball, track and field, and gymnastics, accounted for one-third of all injuries. Recreational activities, such as biking, sledding, skiing, and

skateboarding, accounted for one-fifth of all growth plate fractures, while car, motorcycle, and all-terrain-vehicle accidents accounted for only a small percentage of fractures involving the growth plate.

Whether an injury is acute or due to overuse, a child who has pain that persists or affects athletic performance or the ability to move or put pressure on a limb should be examined by a doctor. A child should never be allowed or expected to "work through the pain."

Children who participate in athletic activity often experience some discomfort as they practice new movements. Some aches and pains can be expected, but a child's complaints always deserve careful attention. Some injuries, if left untreated, can cause permanent damage and interfere with proper growth of the involved limb.

Although many growth plate injuries are caused by accidents that occur during play or athletic activity, growth plates are also susceptible to other disorders, such as bone infection, that can alter their normal growth and development.

Additional Reasons for Growth Plate Injuries

- Child abuse can be a cause of skeletal injuries, especially in very young children, who still have years of bone growth remaining. One study reported that half of all fractures due to child abuse were found in children younger than age 1, whereas only 2 percent of accidental fractures occurred in this age group.

- Injury from extreme cold (for example, frostbite) can also damage the growth plate in children and result in short, stubby fingers or premature degenerative arthritis.

- Radiation, which is used to treat certain cancers in children, can damage the growth plate. Moreover, a recent study has suggested that chemotherapy given for childhood cancers may also negatively affect bone growth. The same is true of the prolonged use of steroids for rheumatoid arthritis.

- Children with certain neurological disorders that result in sensory deficit or muscular imbalance are prone to growth plate fractures, especially at the ankle and knee. Similar types of injury are seen in children who are born with insensitivity to pain.

- The growth plates are the site of many inherited disorders that affect the musculoskeletal system. Scientists are just beginning to understand the genes and gene mutations involved in skeletal formation, growth, and development. This new information is raising hopes for improving treatment of children who are born with poorly formed or improperly functioning growth plates.

Signs That Require a Visit to the Doctor

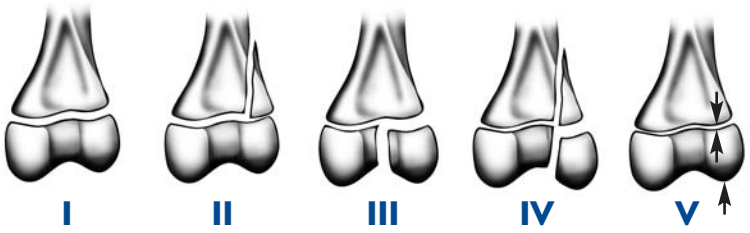
- Inability to continue play because of pain following an acute or sudden injury
- Decreased ability to play over the long term because of persistent pain following a previous injury
- Visible deformity of the child's arms or legs
- Severe pain from acute injuries that prevent the use of an arm or leg.

Adapted from *Play It Safe, a Guide to Safety for Young Athletes* with permission of the American Academy of Orthopaedic Surgeons.

How Are Growth Plate Fractures Diagnosed?

After learning how the injury occurred and examining the child, the doctor will use x rays to determine the type of fracture and decide on a treatment plan. Because growth plates have not yet hardened into solid bone, they don't show on x rays. Instead, they appear as gaps between the shaft of a long bone, called the metaphysis, and the end of the bone, called the epiphysis. Because injuries to the growth plate may be hard to see on x ray, an x ray of the noninjured side of the body may be taken so the two sides can be compared. Magnetic resonance imaging (MRI), which is another way of looking at bone, provides useful information on the appearance of the growth plate. In some cases, other diagnostic tests, such as computed tomography (CT) or ultrasound, will be used.

The Salter-Harris Classification of Growth Plate Injuries



Adapted from *Disorders and Injuries of the Musculoskeletal System, 3rd Edition*. Robert B. Salter, Baltimore, Williams and Wilkins, 1999. Used with the author's permission.

Since the 1960's, the Salter-Harris classification, which divides most growth plate fractures into five categories based on the type of damage, has been the standard. The categories are as follows:

Type I

The epiphysis is completely separated from the end of the bone or the metaphysis, through the deep layer of the growth plate. The growth plate remains attached to the epiphysis. The doctor has to put the fracture back into place if it is significantly displaced. Type I injuries generally require a cast to keep the fracture in place as it heals. Unless there is damage to the blood supply to the growth plate, the likelihood that the bone will grow normally is excellent.

Type II

This is the most common type of growth plate fracture. The epiphysis, together with the growth plate, is separated from the metaphysis. Like type I fractures, type II fractures typically have to be put back into place and immobilized.

Type III

This fracture occurs only rarely, usually at the lower end of the tibia, one of the long bones of the lower leg. It happens when a fracture runs completely through the epiphysis and separates part of the epiphysis and growth plate from the metaphysis. Surgery is sometimes necessary to restore the joint surface to normal. The outlook or prognosis for growth is good if the blood supply to the separated portion of the epiphysis is still intact and if the fracture is not displaced.

Type IV

This fracture runs through the epiphysis, across the growth plate, and into the metaphysis. Surgery is needed to restore the joint surface to normal and to perfectly align the growth plate. Unless perfect alignment is achieved and maintained during healing, prognosis for growth is poor. This injury occurs most commonly at the end of the humerus (the upper arm bone) near the elbow.

Type V

This uncommon injury occurs when the end of the bone is crushed and the growth plate is compressed. It is most likely to occur at the knee or ankle. Prognosis is poor, since premature stunting of growth is almost inevitable.

A newer classification, called the Peterson classification, adds a type VI fracture, in which a portion of the epiphysis, growth plate, and metaphysis is missing. This usually occurs with an open wound or compound fracture, often involving lawnmowers, farm machinery, snowmobiles, or gunshot wounds. All type VI fractures require surgery, and most will require later reconstructive or corrective surgery. Bone growth is almost always stunted.

What Kind of Doctor Treats Growth Plate Injuries?

For all but the simplest injuries, the doctor may recommend that the injury be treated by an orthopaedic surgeon (a doctor who specializes in bone and joint problems in children and adults). Some problems may require the services of a pediatric orthopaedic surgeon, who specializes in injuries and musculoskeletal disorders in children.

How Are Growth Plate Injuries Treated?

As indicated in the previous section, treatment depends on the type of fracture. Treatment, which should be started as soon as possible after injury, generally involves a mix of the following:

Immobilization

The affected limb is often put in a cast or splint, and the child is told to limit any activity that puts pressure on the injured area.

Manipulation or Surgery

If the fracture is displaced, the doctor will have to put the bones or joints back in their correct positions, either by using his or her hands (called manipulation) or by performing surgery (open reduction and internal fixation). After the procedure, the bone will be set in place so it can heal without moving. This is usually done with a cast that encloses the injured growth plate and the joints on both sides of it. The cast is left in place until the injury heals, which can take anywhere from a few weeks to two or more months for serious injuries. The need for manipulation or surgery depends on the location and extent of the injury, its effect on nearby nerves and blood vessels, and the child's age.

Strengthening and Range-of-Motion Exercises

These treatments may also be recommended after the fracture is healed.

Long-Term Followup

Long-term followup is usually necessary to monitor the child's recuperation and growth. Evaluation includes x rays of matching limbs at 3- to 6-month intervals for at least 2 years. Some fractures require periodic evaluations until the child's bones have finished growing. Sometimes a growth arrest line may appear as a marker of the injury. Continued bone growth away from that line may mean that there will not be a long-term problem, and the doctor may decide to stop following the patient.

What Is the Prognosis for Growth in the Involved Limb of a Child With a Growth Plate Injury?

About 85 percent of growth plate fractures heal without any lasting effect. Whether an arrest of growth occurs depends on the following factors, in descending order of importance:

- **Severity of the injury**—If the injury causes the blood supply to the epiphysis to be cut off, growth can be stunted. If the growth plate is shifted, shattered, or crushed, a bony bridge is more likely to form and the

risk of growth retardation is higher. An open injury in which the skin is broken carries the risk of infection, which could destroy the growth plate.

- **Age of the child**—In a younger child, the bones have a great deal of growing to do; therefore, growth arrest can be more serious, and closer surveillance is needed. It is also true, however, that younger bones have a greater ability to remodel.

- **Which growth plate is injured**—Some growth plates, such as those in the region of the knee, are more responsible for extensive bone growth than others.

- **Type of growth plate fracture**—The five fracture types are described in the section, How Are Growth Plate Fractures Diagnosed? (page 5). Types IV and V are the most serious.

Treatment depends on the above factors and also bears on the prognosis.

The most frequent complication of a growth plate fracture is premature arrest of bone growth. The affected bone grows less than it would have without the injury, and the resulting limb could be shorter than the opposite, uninjured limb. If only part of the growth plate is injured, growth may be lopsided and the limb may become crooked.

Growth plate injuries at the knee are at greatest risk of complications. Nerve and blood vessel damage occurs most frequently there. Injuries to the knee have a much higher incidence of premature growth arrest and crooked growth.

What Are Researchers Trying To Learn About Growth Plate Injuries?

Researchers continue to develop methods to optimize the diagnosis and treatment of growth plate injuries and to improve patient outcomes. Examples of such work include:

- Removal of a growth-blocking "bridge" or bar of bone that can form across a growth plate following a fracture. After the bridge is removed, fat, cartilage, or other materials are inserted in its place to prevent the bridge from forming again.
- The investigation of drugs that protect the growth plate during radiation treatment.
- Development of methods to regenerate musculoskeletal tissue by using principles of tissue engineering.

To improve the early diagnosis of growth plate injuries, the National Institute of Arthritis and Musculosketetal and Skin Diseases (NIAMS) is supporting a study to evaluate the use

of MRI to visualize young bones and enable prompt, appropriate treatment. In May 1997, the NIAMS, together with the National Institute of Child Health and Human Development (NICHD), the American Academy of Orthopaedic Surgeons (AAOS), and the Orthopaedic Research and Education Foundation, supported a conference on skeletal growth and development. The resulting publication, *Skeletal Growth and Development: Clinical Issues and Basic Science Advances,* can be obtained from the AAOS at the address listed near the end of this booklet. In March 2000, the NIAMS supported the First International Conference on Growth Plate.

The NIAMS is working with the NICHD, the National Institute of Dental and Craniofacial Research, and the National Institute of Diabetes and Digestive and Kidney Diseases to support a research initiative in the area of skeletal growth and development. The purpose of the initiative is to:

- Stimulate research to identify and understand the action of the genes that regulate skeletal development
- Evaluate factors that affect growth plate function
- Develop animal models to study disturbances in skeletal growth and development
- Find new ways to correct musculoskeletal deformities.

Where Can People Find More Information About Growth Plate Injuries?

- **National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS)**
  National Institutes of Health
  1 AMS Circle
  Bethesda, MD 20892–3675
  Phone: 301–495–4484 or
  877–22–NIAMS (266–4267) (free of charge)
  TTY: 301–565–2966
  Fax: 301–718–6366
  www.niams.nih.gov

  NIAMS provides information on arthritis and rheumatic disease and bone, muscle, joint, and skin diseases. It distributes patient and professional education materials and refers people to other sources of information. Additional information and updates can also be found on the NIAMS Web site.

- **American Academy of Orthopaedic Surgeons**
  P.O. Box 2058
  Des Plaines, IL 60017
  Phone: 800–824–BONE (2663) (free of charge)
  www.aaos.org

  The academy provides education and practice management services for orthopaedic surgeons and allied health professionals. It also serves as an advocate for improved patient care and informs the public about the science of orthopaedics. The orthopaedist's scope of practice includes disorders of the body's bones, joints, ligaments, muscles, and tendons. For a single copy of an AAOS brochure, send a self-addressed stamped envelope to the address above or visit the AAOS Web site.

- **American Academy of Pediatrics**
  141 Northwest Point Boulevard
  Elk Grove Village, IL 60007–1098
  Phone: 847–434–4000
  Fax: 847–434–8000
  www.aap.org

  The American Academy of Pediatrics (AAP) and its member pediatricians dedicate their efforts and resources to the health, safety, and well-being of infants, children, adolescents, and young adults. Activities of the AAP include advocacy for children and youth, public education, research, professional education, and membership service and advocacy for pediatricians.

- **American Orthopaedic Society for Sports Medicine (AOSSM)**
  6300 N. River Road, Suite 500
  Rosemont, IL 60018
  Phone: 847–292–4900 or 877–321–3500 (free of charge)
  Fax: 847–292–4905
  E-mail: aossm@aossm.org
  www.aossm.org

  The society is an organization of orthopaedic surgeons and allied health professionals dedicated to educating health care professionals and the general public about sports medicine. It promotes and supports educational and research programs in sports medicine, including those concerned with fitness, as well as programs designed to advance knowledge of the recognition, treatment, rehabilitation, and prevention of athletic injuries.

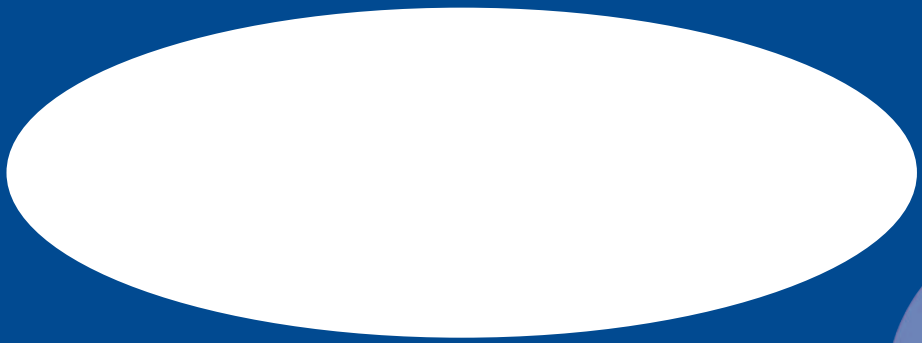
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The mission of the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), a part of the Department of Health and Human Services' National Institutes of Health (NIH), is to support research into the causes, treatment, and prevention of arthritis and musculoskeletal and skin diseases, the training of basic and clinical scientists to carry out this research, and the dissemination of information on research progress in these diseases. The National Institute of Arthritis and Musculoskeletal and Skin Diseases Information Clearinghouse is a public service sponsored by the NIAMS that provides health information and information sources. Additional information can be found on the NIAMS Web site at www.niams.nih.gov.



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