

# Pediatric Distal Double Bone Forearm Fracture Remodeling

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*Children's bones differ from those of adults in their capacity for ongoing growth and their ability to adapt to a changing body habitus. Similarly, pediatric fractures generally heal more rapidly and have the ability to reshape deformities, a process known as remodeling. The following case exemplifies the remodeling process of a distal radius fracture over time.*

## CASE

An 11.2-year-old boy fell while snowboarding and sustained a left, non-dominant distal double bone forearm fracture. The X-rays demonstrated good fracture alignment. A long arm cast was applied without reduction with the forearm in neutral rotation (Figure 1). One month after injury the cast was removed and X-rays showed 22° of apex dorsal fracture angulation (Figure 2). The patient was mildly tender at the fracture site and advanced to a short arm cast with an interosseous mold. Two months after injury cast immobilization was discontinued. A radiograph taken 3 months after injury (Figure 3) revealed persistent apex dorsal angulation. Periosteal new bone formation was evident on the palmar (concave side) of the fracture. The dorsal (convex, tension side) of the fracture appeared to be rounding off.

Five months postinjury (Figure 4) the patient had full return of forearm motion and was clinically asymptomatic. Radiographs revealed a very thick palmar cortex with further flattening of the dorsal radial bony surface.

One-year postinjury (Figure 5) the apex dorsal angulation was diminished as the bone had remodeled. The distal radius appeared straighter.

Three years after injury the patient had developed early secondary sexual characteristics and had

no symptoms referable to the arm, wrist, or hand. Radiographs (Figure 6) revealed that the distal radius was straight. The distal radial and ulnar growth plates remained open. The intramedullary cavity appeared more uniformly tubular in shape.

## DISCUSSION

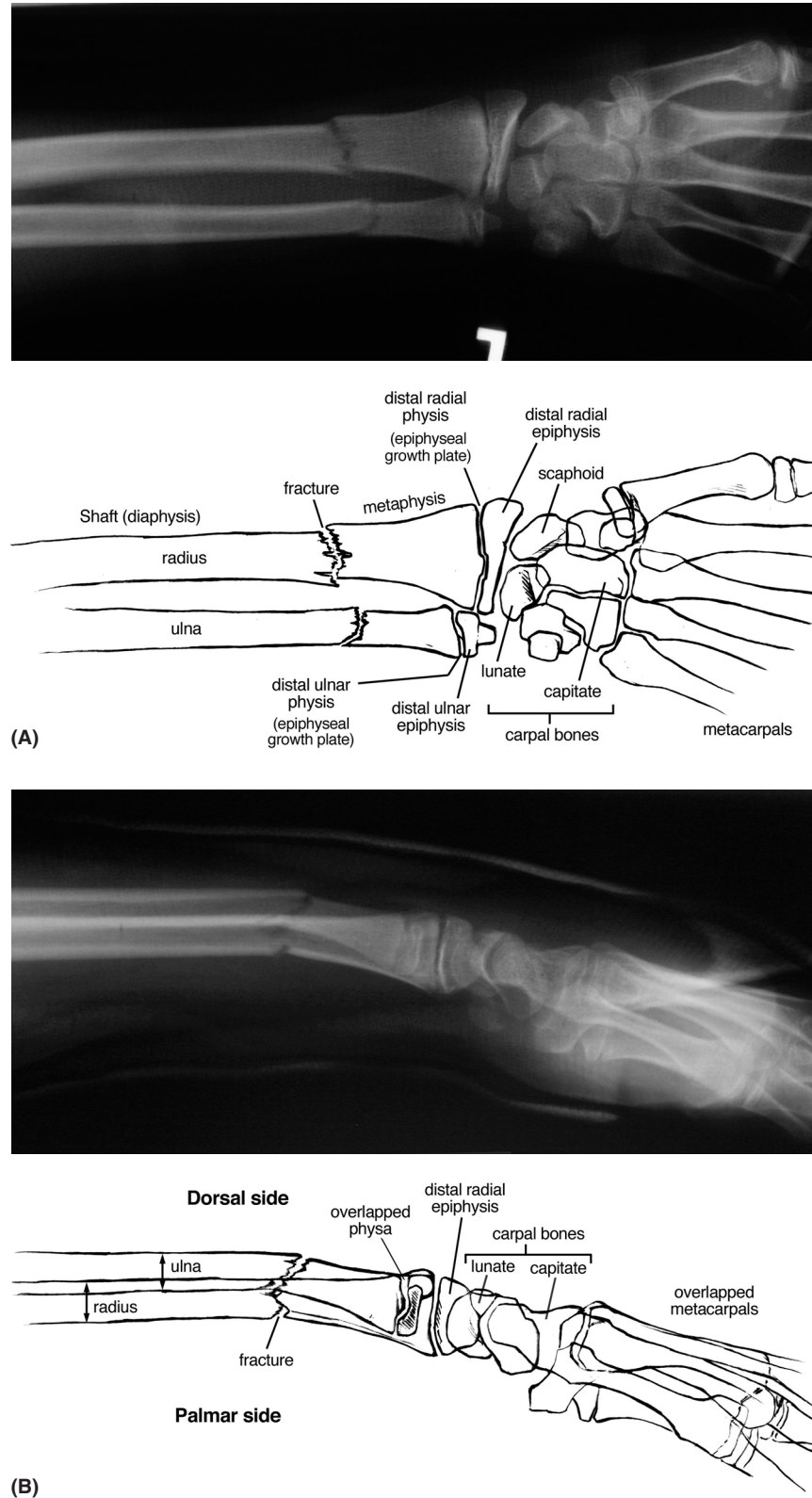
Fracture healing involves the same repair process, or sequence of biological events, regardless of patient age (Buckwalter, Einhorn, Bolander, & Cruess, 1996); however, fracture healing occurs more rapidly and completely in children. The periosteum is a sleeve of fibrous tissue that surrounds long bones and contributes to the circumferential growth of bones in children. It is a stout structure in children, being up to 3 mm. thick, whereas in adults, especially the elderly with osteoporosis, it can be thin and easily disrupted. This thick periosteum resists bone displacement and is a source of new bone formation. In children long bones grow lengthwise from special growth zones at each bone end called epiphyseal plates or physis. Bone growth occurring at the epiphyseal growth plate undergoes a cartilaginous phase called enchondral (meaning from cartilage) ossification. Bone formation from the periosteum does not undergo a cartilage stage and is described as intramembranous bone formation (Buckwalter et al., 1996).

Although fracture healing in children occurs more rapidly, the sequence of biological events is the same as in an adult. The fracture initiates a three-phase process that restores injured bone. Phase one involves inflammation, phase two involves repair, and phase three involves remodeling.

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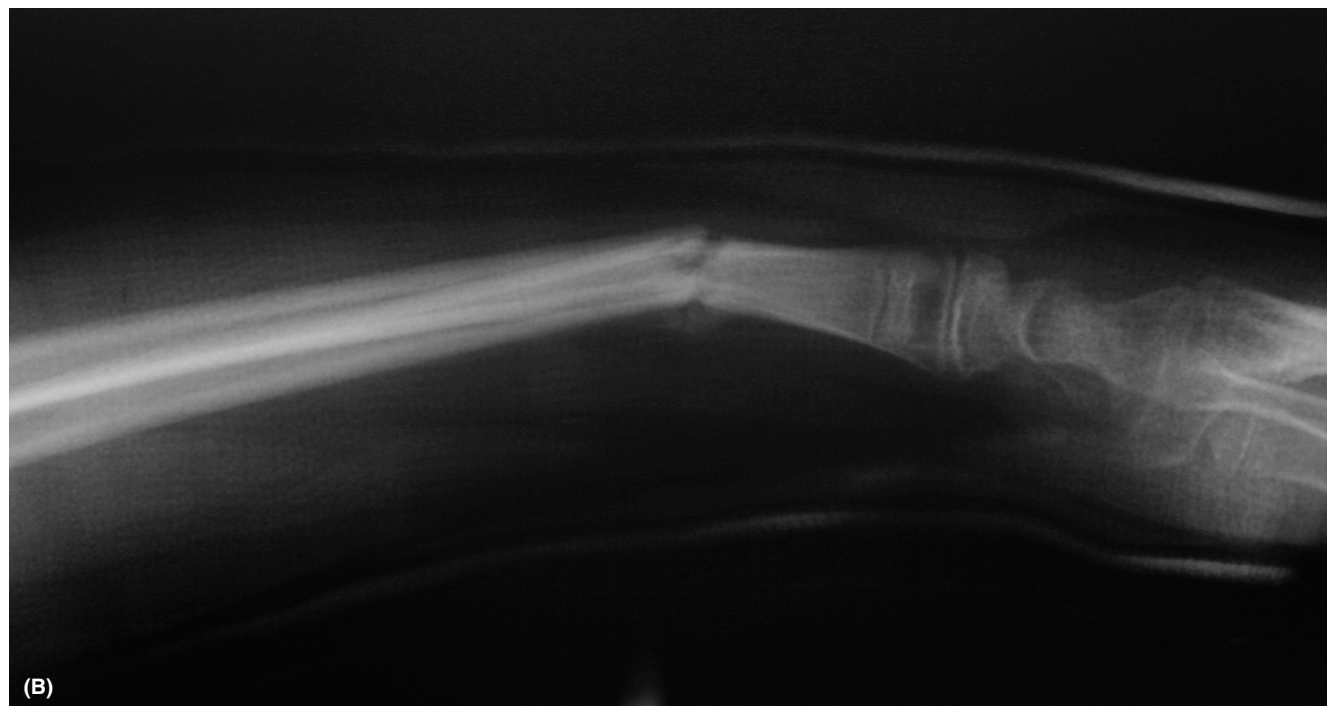
**Eugene E. Berg, MD, FACS**, N. H. Bone & Joint Institute, Bedford.  
From Berg EE. Pediatric distal double bone forearm fracture remodeling. *Orthopaedic Nurs.* 2005;24:55-59. Reprinted with permission.

## PEDIATRIC DISTAL DOUBLE BONE FOREARM FRACTURE REMODELING



**FIGURE 1.** (A) Anterior-posterior (AP) and (B) lateral radiograph demonstrate a splinted distal double bone forearm fracture through the metaphysis, proximal to the growth plate. The fracture is in excellent alignment. After the initial swelling subsided the fracture was immobilized in a long arm cast.

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**FIGURE 2.** Radiographs of the same fracture at 1 month postinjury. **(A)** The anterior-posterior (AP) view shows no change in fracture alignment, whereas the **(B)** lateral image depicts 20 degrees of apex dorsal angulation of the fracture.

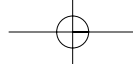
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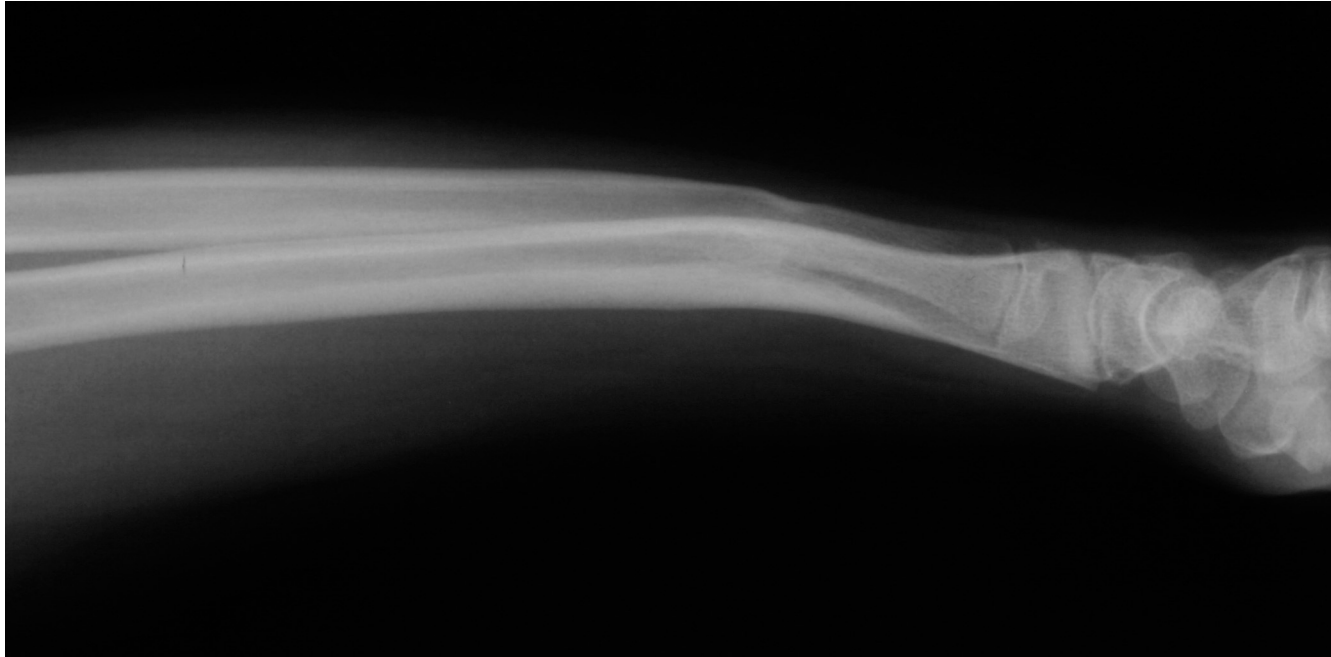
**FIGURE 3.** A lateral radiograph taken at 3 months postinjury. The dorsal angulation persists; however, on the palmar side there is abundant periosteal new bone fill. There is bone absorption and rounding of the dorsal (convex) bone surface.



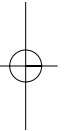
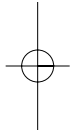
**FIGURE 4.** Five months postinjury, the lateral radiograph shows thickening of the palmar cortex with abundant dense new bone formation. The convex dorsal, tension side of the fracture continues to atrophy and straighten.



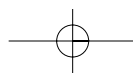
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**FIGURE 5.** A lateral radiograph at 1 year postinjury shows absence of angulatory deformity with straightening (remodeling) of the radius.



**FIGURE 6.** At 3 years postinjury, the distal radius is straight and the intramedullary canal is cylindrical throughout. There is minimal residual deformity. The distal radial and ulnar epiphyses remain open and continue longitudinal growth of the limb. The extent of the remodeling process is evident when these films are compared to the earlier (Figure 2) X-rays.



### Inflammation Phase

When a bone is broken, the injury zone is concentrated at the fractured ends. The local blood supply to the bone is disrupted and the bone cells adjacent to both fracture ends die. Intramedullary blood vessels spill hematoma at the fracture site. Inflammatory cells (polymorphonucleocytes initially, followed by macrophages and lymphocytes) enter the fracture releasing cytokines and growth factors, which stimulate angiogenesis. These growth factors, one of which is bone morphogenic protein, attract cells and cause them to differentiate into reparative bone and fibrous cells. Approximately 2 weeks after injury the fracture hematoma contained by the periosteum becomes thickened and rubbery, making the fracture difficult to manipulate.

### Reparative Phase

The reparative phase follows the inflammatory phase. Repair cells, fibroblasts, osteoblasts, and angiocytes lay down new collagen and amorphous bone matrix. The conditions of the fracture encourage greater bone cell proliferation and bone matrix synthesis. The repair phase of fracture healing is best identified in Figures 1 and 3 where new bone (also called callus) formation is thick, and is seen on X-ray as a wad of new reparative bone that bridges and stabilizes the injured bone ends.

### Remodeling Phase

The final phase of fracture healing involves remodeling in which the fracture is reorganized. Excessive amounts of poorly organized bone matrix are reshaped. Cell density is increased and vascularity is decreased. The collagen fibrils become tighter and are aligned along the lines of mechanical stress. The fracture callus becomes more streamlined assuming the efficient shape of the original bone. The remodeling process occurs slowly and is part of bone homeostasis in which the bone is not subjected to stress atrophies and thins, whereas in areas of high mechanical stress of everyday use the bone hypertrophies becomes stronger and denser. The remodeling phase of bone healing involves a homeostatic

process that occurs over longer time intervals, months to years.

As this case illustrates, fractures in growing children with open physes do not require an anatomic or surgical reduction to unite and reestablish normal bone contours (Buckwalter et al., 1976; Dvonch, 1986; Friberg, 1979; Jones & Weiner, 1999; Noonan & Price, 1998). The remodeling potential or spontaneous correction that occurs with healing bones in children is dependent upon the child's age, the magnitude of fracture angulation, and the distance of the fracture to the epiphyseal plate. (Remodeling potential is best in younger patients and the closer the fracture is to the growth plate.) Fracture deformity that is in the plane of adjacent joint motion is also more likely to remodel. Remodeling occurs with bone resorption of the convex (tension) side of the bone with increased bone formation on the concave (compression) side.

Fracture deformity at the distal radius will roughly remodel 10° per year as a result of epiphyseal growth and remodeling (Friberg, 1979). Because wrist motion is in a dorsal-palmar (extension-flexion) plane, dorsal and volar angulation of the distal radial fracture is likely to remodel. Rotational deformities do not correct well; therefore, rotational alignment must be restored whereas angular deformity can be tolerated depending upon the patient's maturity and growth remaining (Dvonch, 1986; Friberg, 1979; Jones & Weiner, 1999; Noonan & Price, 1998).

Many patients and parents wish to view their X-rays during treatment; however, they can often be disappointed and skeptical when observing residual fracture displacement. It can be very helpful and instructive to have a sequence of radiographs depicting fracture remodeling such as these to illustrate the principles of fracture remodeling. Sharing these images with patients and parents may dispel worry and skepticism and will serve to assure parents that remodeling is expected to occur (Dvonch, 1986).

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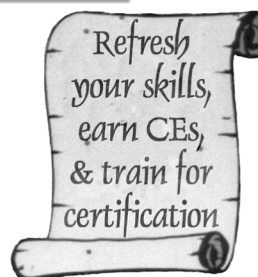
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