The distal radial physis is the most common site of physeal injury, accounting for 28% to 43% of all physeal injuries.\(^1\)\(^2\) Treatment usually consists of closed reduction with a short period (2 to 4 weeks) of cast immobilization. In most cases, the fracture heals uneventfully, and normal growth resumes promptly. Only rarely is a distal radial physeal injury so unstable that internal fixation is undertaken. We have found only three cases in our files where such internal fixation was performed. In all three cases, subsequent partial premature closure of the distal radial physis occurred.

**Case Report**

**Case 1.** At age 11 years, 8 months, a boy suffered a displaced Salter and Harris Type 1 injury to his left distal radius after falling during play (Figs 1A-B). His initial treatment elsewhere consisted of hematoma-block anesthesia, closed reduction, and application of a long arm cast.

On the fourth day post-injury, the patient was referred to the Mayo Clinic with suspected compartment syndrome. He underwent immediate partial fasciotomy of the volar forearm and carpal tunnel release. Three days later, the fasciotomy was extended. The wound could not be closed primarily. A split thickness skin graft was performed 7 days after the initial procedure. Cultures of specimens taken during these procedures were all negative. The initial anatomic reduction was lost during the surgical procedures. During the skin grafting procedure on day 11 post-injury, the epiphysis was reduced closed and held with a single smooth Kirschner wire (Figs 1C-D) placed perpendicular to the physis in the dorsal radial quarter. The wire was removed under local anesthesia 3 weeks later.

Radial deviation of the hand was first noted 10 months after the injury. Radiographs at that time demonstrated a physeal bar in the radial side of the growth plate (Figs 1E-F). The bar was removed 1 month later; at this operation the bar was noted to occupy >50% of the physis. Cranoplast (Cranoplast, L.D. Caulk Co, Milford, Del, distributed by Codman and Shurtleff, Randolph, Mass) was placed in the defect. Details of this case with an 8-year

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**Fig 1A-F:** Salter and Harris Type 1 injury in an 11-year, 8-month-old boy. AP and lateral radiographs of the left wrist show complete dorsal displacement of the epiphysis (A-B). Eleventh day post-injury, showing reduction and Kirschner wire internal fixation. Note dorsal radial placement of wire, with soft tissue swelling volarly. A cast was applied (C-D). Ten months post-injury, showing premature closure of the radial side of the left distal radial physis (E) and normal right wrist (F). Note relative lengths of radius and ulna. (From Hernandez and Peterson.\(^3\) Reprinted with permission of Raven Press).

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**Fig 1A:**

**Fig 1B:**

**Fig 1C:**

**Fig 1D:**

**Fig 1E:**

**Fig 1F:**

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Figs 2A-F: Salter and Harris Type 2 fracture of the distal radius in 9 year, 4-month-old girl. AP and lateral radiographs show severely dorsally displaced fracture (A-B). Placement of Kirschner wire through the radial aspect of the physis. It was removed 3 months later (C-D). Scanograms of both forearms at 25 months post-injury, showing obvious physeal bar in the right distal radius. The ulnae were equal in length. The right radius was 17 mm shorter than the left (E-F).

Figs 3A-G: Salter and Harris Type 1 fracture in 11-year, 5-month-old boy. AP and lateral radiographs of left wrist showing moderate dorsal displacement of the epiphysis (A-B). Day 24 post-injury, AP and lateral radiographs demonstrated progression of dorsal displacement (C-D). Radiographs showing radial volar placement of Kirschner wire through the physis (E-F). At 9 months post-injury, a physeal bar can be seen across the radial side of the physis. Note mild relative overgrowth of the ulna (G).

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Case 2. A 9-year, 4-month-old girl sustained two fractures of her right upper arm in a fall from playground equipment. One was an open and severely displaced supracondylar fracture with a transient median nerve palsy. This was reduced under general anesthesia and held by Kirschner wire fixation. The other fracture was a Salter and Harris Type 2 of the distal radius (Figs 2A-B). It was also severely dorsally displaced, but closed. Wrist swelling made palpation of the radial pulse difficult, but the circulatory status of the hand was deemed adequate. The fracture was reduced through a volar incision and fixed with a single Kirschner wire (Figs 2C-D) placed obliquely across the radial aspect of the physis. The pin was removed 3 months later, at which time the physis were open radiographically, and there was no clinical abnormality.

At 16 months post-injury, dorsiflexion was limited to 45° on the right compared with 80° on the left; supination was 70° on the right and 90° on the left. Radiographs showed irregularity of the volar portion of the physis. Observation was continued.

The patient was referred to us 25 months post-injury for a second opinion (Figs 2E-F). Repeat tomograms done perpendicularly to the physis (as opposed to perpendicularly to the radius) combined with magnetic resonance imaging showed what was actually a small volar bar of approximately 10%. The bar was removed surgically at 28 months post-injury, combined with a volar opening wedge osteotomy. The physeal defect was filled with cranioplast. Follow up at 12 months postoperatively showed 110% growth of the distal radial physis (the radial-ulnar length discrepancy is diminished), as well as excellent healing of the osteotomy and remodeling of the distal radius.

Case 3. An 11-year, 5-month-old boy suffered a Salter and Harris Type 1 fracture of the left distal radius (Figs 3A-B). Initial treatment elsewhere consisted of a forearm “brace” that
was used because of an eczematous dermatitis. Three weeks later, dorsal displacement and angulation of the epiphysis had increased (Figs 3C-D). Then, open reduction of the fracture and fixation with a single Kirschner wire placed obliquely through the radial volar aspect of the physis was performed (Figs 3E-F). Five weeks later the wire was removed. Nine months after injury there was a definite physeal bar across the radial side of the physis (Fig 3G).

The patient was referred to us for evaluation 1 year post-injury. The ulnar styloid was slightly more prominent on the left, and the left radius was 0.8 cm shorter than the right. The patient was asymptomatic. Tomograms suggested that 50% of the physis was involved. Excision of the physeal bar was performed and revealed the bar to be 60% of the physeal area. Cranioplasty was placed in the defect. This procedure resulted in no growth, and subsequent surgical arrest of the distal ulnar physis and ulnar portion of the distal radius was performed.

**DISCUSSION**

The possibility of subsequent growth arrest following the placement of pins across the physes in children is well known to all pediatric orthopedists, yet there are no published series of patients attempting to determine etiologic or prognostic factors. The anecdotal case reports found in specific fracture series usually give few or no details of the specific case.

In the veterinary literature, one report documents the placement of cancellous lag screws across the physis in three foals with Salter and Harris Type 2 fractures of the proximal tibia with no adverse effects on growth. 4 In another report, 24 Salter and Harris Type 2 and 4 fractures of the distal femur in 21 puppies and three kittens were treated by multiple pins (11 cases) or single intramedullary pins (13 cases) across the physis. 5 In all 17 cases with radiographic follow up, the fractures healed and the physes "closed" in 3 to 4 weeks, regardless of the age of the animal.

In one experimental work, 6 a small (diameter not specified) chromium-cobalt alloy nail was placed perpendicularly across the center of one distal femoral physis of five rabbits aged 3 to 4 weeks. The rabbits were sacrificed 21 weeks later. The nailed femurs were the same length as the femurs not nailed. Microscopic observations revealed new bone formation along the edges of the nail defect, but no interference with growth. In humans, normal growth has been found to occur after placement of smooth pins across the physis of some locations: distal humerus, 2 proximal radius, 2 and distal tibia. 2 Pins across the physis of the distal femur 4 and proximal tibia, 8 on the other hand, frequently result in premature growth arrest.

The vast majority of distal radial physeal injuries are Salter and Harris Type 1 or 2. 1,2,9 Damage to the germinal layer of the physis is rare but on occasion it cannot be prevented, being due to the fracture, displacement, or reduction. Repeated forceful reductions result in a higher rate of premature closure. 10 Nevertheless, premature closure of the distal radial physis is uncommon, accounting for only 7% of all partial closures treated by excision of a physeal bar (nine of 130 bar excisions at the Mayo Clinic through 1989).

Distal radial physeal injuries usually can be
Table

<table>
<thead>
<tr>
<th>Wire Entry into Physis</th>
<th>Time Wire in Place (Weeks)</th>
<th>Region of Bar Formation</th>
<th>Time From Injury to Bar Recognition (Months)</th>
</tr>
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<tbody>
<tr>
<td>Case 1</td>
<td>3</td>
<td>Dorsal radial</td>
<td>10</td>
</tr>
<tr>
<td>Case 2</td>
<td>12</td>
<td>Volar</td>
<td>16</td>
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<tr>
<td>Case 3</td>
<td>5</td>
<td>Radial half</td>
<td>3</td>
</tr>
</tbody>
</table>

Potential contributing factor to premature physeal closure. If a wire is placed, early wire removal and close follow up are prudent. Early detection of a bar may increase the success rate of surgical bar excision.

Because there were multiple factors for premature physeal arrest in these three patients, it is possible that the Kirschner wire fixation did not play a part in the arrest. We encourage future authors to report cases in which Kirschner wires were inserted across the physis and arrest did not occur.

REFERENCES


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Congenital Hallux Valgus

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Hallux valgus is a hereditary deformity whose natural history is influenced by intrinsic and extrinsic factors. The deformity is infrequently noticed in newborns and infants because of its trivial nature that does not draw attention. More often hallux valgus is noticed in older children.