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Case Report

Antegrade Intramedullary Screws in Metacarpal Fractures of Pediatric Patients

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Metacarpal fractures are common injuries in pediatric patients. In adults, cannulated intramedullary screws are an excellent stabilization option for metacarpal fractures and are widely used, but in pediatric patients with open physes, their use is a relative contraindication. The risk of injury to the physis in classic retrograde screw placement makes this type of osteosynthesis not an option. We present the case of an 8-year-old patient with fractures of two adjacent metacarpals with rotational malalignment and scissoring, in which closed reduction was performed, and stabilization with cannulated intramedullary screws using antegrade placement to avoid injury to the physis.

Metacarpal fractures are common injuries in pediatric patients and account for 10% to 39% of all hand fractures in children.[1] Finger metacarpal fractures are most common in 13–16-year-old patients. Most of these fractures achieve excellent outcomes with nonsurgical treatment, although some benefit from surgical treatment.[1]

In the adult population, intramedullary cannulated screw (ICS) fixation is an alternative to open reduction internal fixation for metacarpal fractures and is widely used.[2] This technique combines the advantages of a minimally invasive procedure, similar to percutaneous pinning, with the inherent advantage of the stability of open reduction internal fixation. Intramedullary cannulated screw fixation utilizes a minimal skin incision and tendon dissection with preservation of the periosteum. It has a shorter surgery time than that of plate fixation and allows early mobilization.[3,4] Over the last decade, the use of ICS is gaining more indications. However, fractures in patients with open physes are still a contraindication for this technique.[5] Inserting the screw in the classic retrograde fashion can damage the physis. Moreover, recent systematic reviews reflect this fact as the population of this techniche has a mean age of 32 years and the youngest patient operated on with this method was 15 years old.[2,4]

In this report, we describe an alternative method for surgical treatment of metacarpal fractures with ICSs in pediatric patients with open physes that involves inserting the ICS in an antegrade direction to avoid and protect the physis.

Case Report

An 8-year-old right hand–dominant male presented to the emergency department with closed fractures of middle and ring finger metacarpals of his left hand (Fig. 1A, B). Both fractures involved the shaft of the metacarpals, were spiral, and had rotational malalignment with scissoring (Fig. 2). In the operating room and under general anesthesia, we performed closed reduction of both fractures. First, we performed longitudinal traction of the ring finger in order to separate both fragments. Second, we placed rotational force opposite to the displacement of the finger to correct the scissoring (Fig. 3). We performed the same procedure to correct the middle finger metacarpal fracture. The correct reduction was confirmed by passive flexion and extension of the wrist, creating finger flexion through tenodesis. When flexed, the digits pointed toward the scaphoid tubercle and nails appeared parallel to the hand and neighboring digits. We also confirmed reduction with intraoperative imaging.

To identify the entrance point at the base of the ring finger metacarpal, we maximally flexed the wrist. We identified the base

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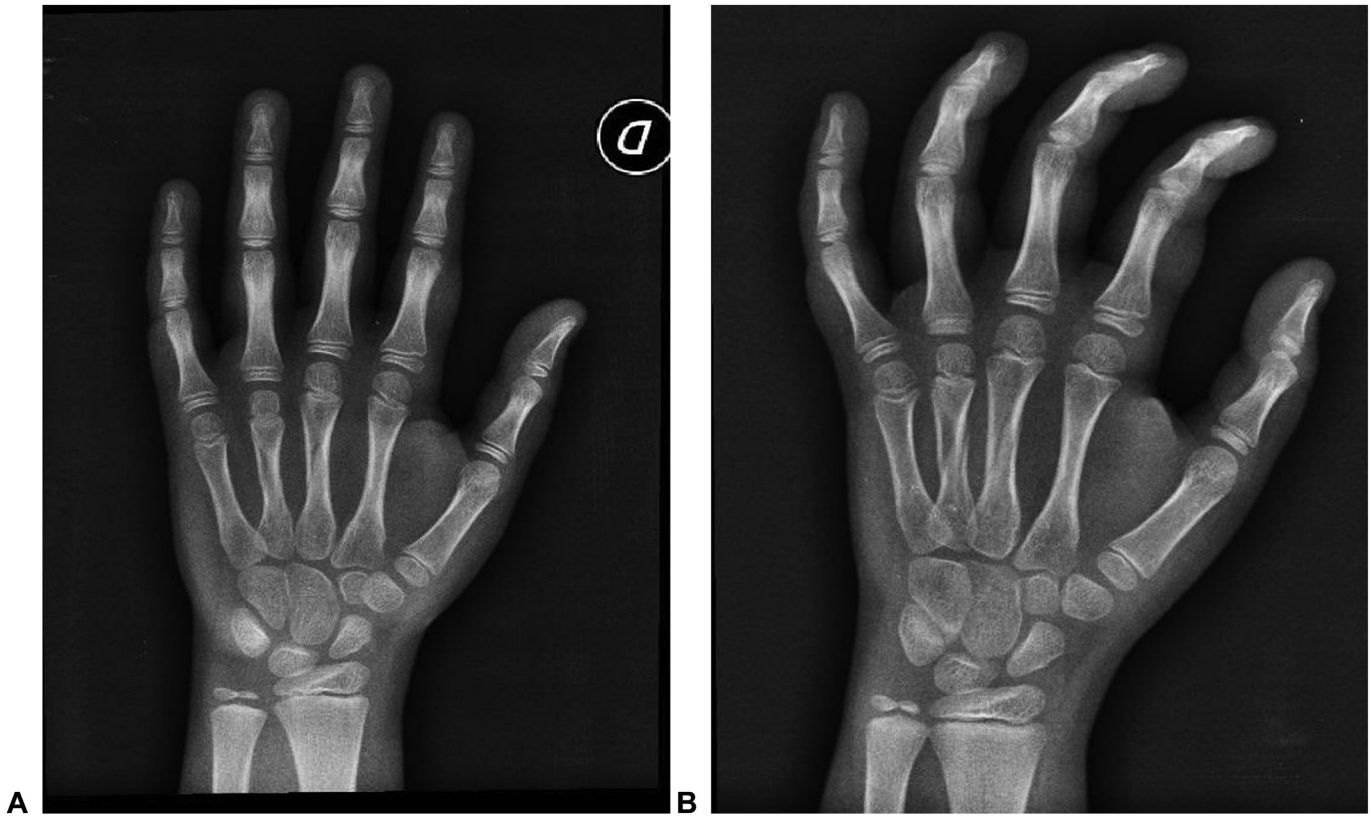

Figure 1. **A** Preoperative posteroanterior view demonstrating spiral fractures of the middle and ring finger metacarpals. **B** Preoperative oblique view demonstrating spiral fractures of the middle and ring finger metacarpals.

Figure 2. Rotational malalignment with scissoring in our case report.

by placing the tip of a 14-gauge angiocath at the dorsum of the hand and under fluoroscopic guidance. Through this angiocath, a guide wire was introduced into the medullary canal stopping short of the physis (Fig. 4). The first millimeters of the wire were introduced using a drill (Colibri, Synthes). After entering the medullary canal, only manual force was applied in order to keep the physis intact and safe from heat and direct trauma. For calculating the length of the screw, we placed a screw on the dorsal aspect of the hand over the fractured metacarpal (Fig. 5). This comparison was performed with fluoroscopic guidance. Based on this, a 30-mm–length headless screw was deemed suitable to achieve adequate purchase in the medullary canal of the ring finger metacarpal and a 32-mm screw was deemed suitable for the middle finger metacarpal. Both were 2.4 mm in diameter (Synthes).

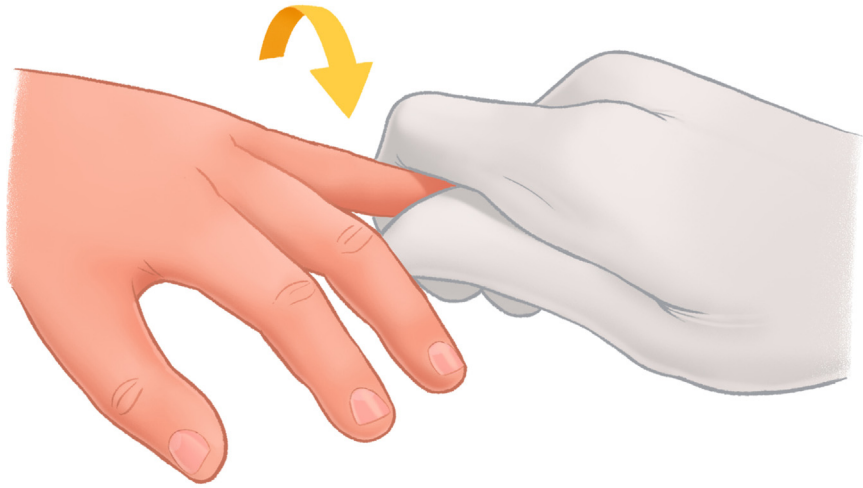

Figure 3. Reduction maneuver applying rotational force opposite to the displacement of the finger to correct scissoring.

Figure 4. The guide wire was introduced through the abbocath into the medullary canal.

The diameter of the screw was previously chosen according to the size of the canal shaft in the preoperative x-ray (3.03 mm for the middle finger metacarpal and 3.17 mm for the ring finger metacarpal). Opening the canal with a drill was not necessary because the metacarpal was not as hard as an adult metacarpal and we could place the ICS, taking advantage of its self-drilling characteristics. While the surgeon was introducing the screw with the wrist flexed, the assistant maintained the reduction achieved by holding the fractured fingers steady (from the base of the finger through the fingertip) (Fig. 6). If there was any doubt of losing reduction, we stopped introducing the screw and checked the digits' orientation to the scaphoid tubercle and nail parallelism as mentioned above. We repeated the same steps with the middle finger metacarpal (Fig. 7). After placing both ICSs, we confirmed full passive range motion and performed tenodesis maneuvers in case displacement occurred after placing the screws (Fig. 8A, B). Median, ulnar, and radial nerve blocks were performed with 0.25% bupivacaine to prevent postoperative pain.

A splint was utilized for 1 week. The follow-up continued for 6 months with no complications and no rotational displacement. Radiographic bony union was observed (Figs. 9, 10). The patient denied pain or any limitations in daily activities. The patient answered the Quick Disabilities of the Arm, Shoulder, and Hand questionnaire in Spanish and resulted in a score of zero. Written informed consent was obtained from the patient's parents for publication of this case report and accompanying images.

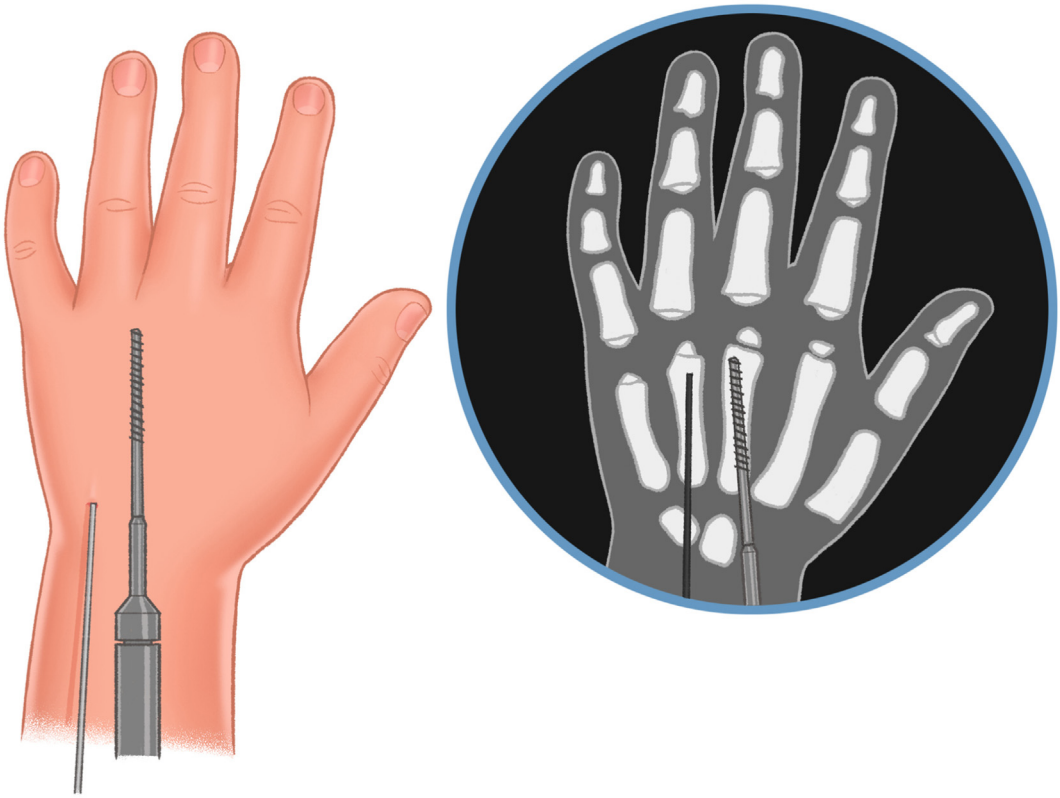

Figure 5. Placing the screw on the dorsal aspect of the hand and next to the fractured metacarpal for calculating the length of the screw on the posteroanterior view x-ray.

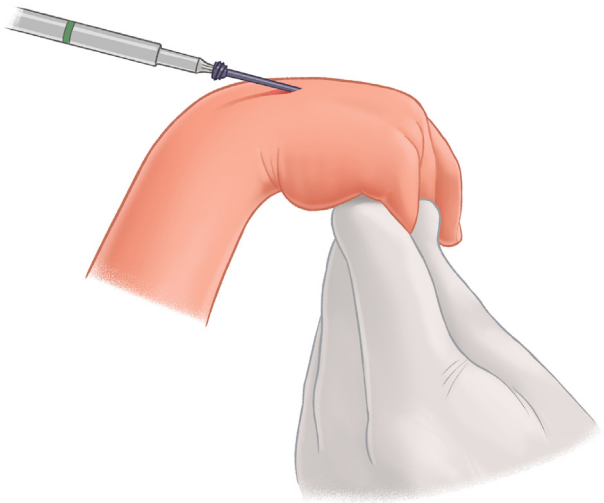

Figure 6. Introducing the screw with the wrist flexed and the assistant maintaining the reduction achieved by holding the fractured fingers steady (from the base of the finger through the fingertip).

Discussion

Metacarpal shaft fractures are not common in children; they represent <10% of all metacarpal fractures.[1,6] The most affected fingers are the middle, ring, and little fingers, and these fractures occur especially between ages 13 and 16 years.[6,7] When

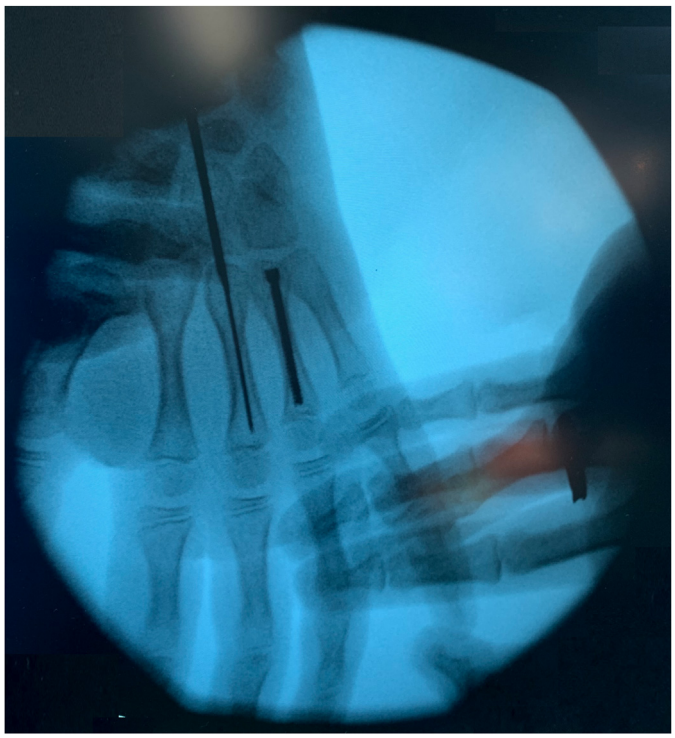

Figure 7. X-ray with the ICS of the ring finger metacarpal placed and introduction of a K-wire on the middle finger metacarpal. Neither the K-wire nor the ICS reached the physis of the middle finger metacarpal.

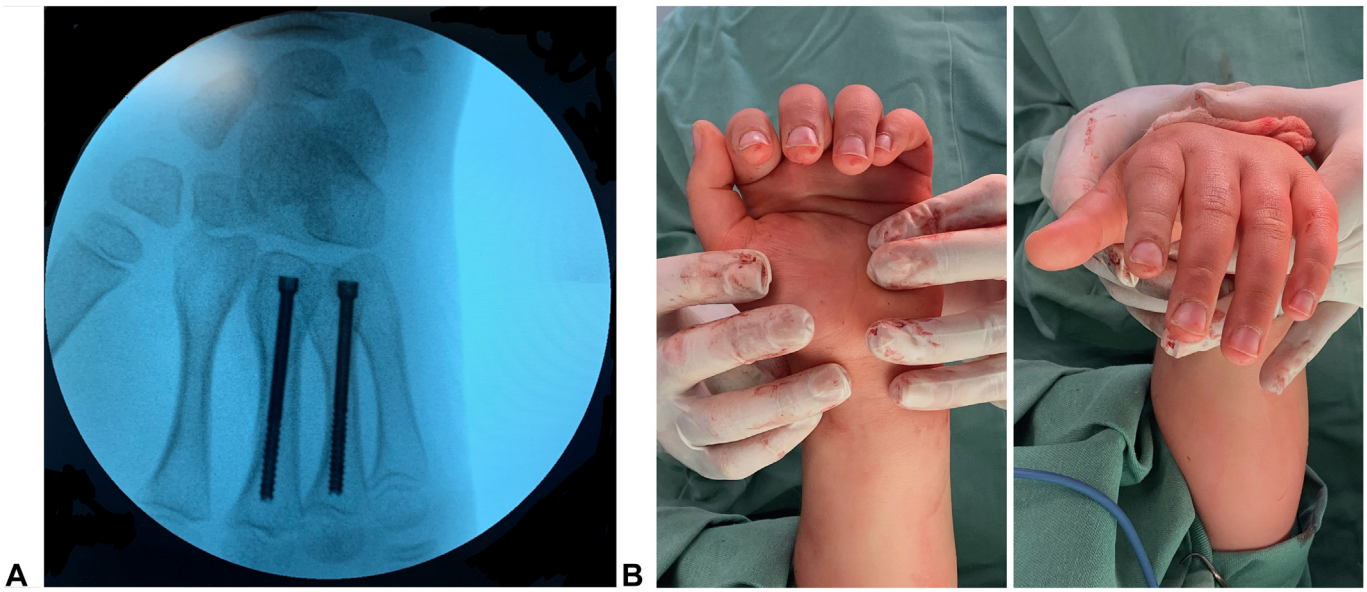

Figure 8. **A** Both ICSs are placed. Notice that the growing plate is intact. **B** Tenodesis maneuvers show correct alignment and no scissoring.

Figure 9. Six-month follow-up posteroanterior, oblique, and lateral x-ray images showing adequate radiographic bony union and no displacement.

the fracture involves the shaft of the metacarpal, a spiral pattern is most frequently present, indicating a torsional mechanism of injury.[1]

Nondisplaced metacarpal shaft fractures can be treated by closed immobilization with good results. Shaft fractures can be slower to heal compared with those of the base or neck, and immobilization should continue for 4–6 weeks.[1] Also, most displaced metacarpal shaft fractures in children are amenable to cast immobilization after closed reduction.[1,6,7] However, rotational deformities are common, especially in spiral fractures. Spiral, long oblique, and multiple metacarpal fractures are candidates for surgical treatment. These patterns have a tendency to shorten, and displacement is difficult to control with immobilization.[1]

Surgical treatment for metacarpal fractures in pediatric patients includes percutaneous pinning, lag screws, or plate fixation.[1] However, there is limited data for intramedullary cannulated headless screw fixation in metacarpal fractures of pediatric patients with open physes.

The technique of using an ICS for a metacarpal fracture was first described by Boulton et al.[8] Since then, this type of osteosynthesis has widely spread because of the advantages it aims to achieve. This

Figure 10. Six-month follow-up pictures of the hand of the patient demonsrating scissoring, no clinical displacement, and minimal scarring.

type of fixation is associated with high bony union and low complication rates, has a minimal skin incision and minimal tendon dissection, and leaves the periosteum intact.[2,3] It also allows early mobilization.[4] Although this method was initially indicated for transverse and short oblique fractures, ICSs are also used in spiral and long oblique fractures in the adult population.[4]

The original retrograde method of fixation of metacarpal fractures with ICSs could damage the physis and could result in growth arrest. This fact made fixation with ICSs a contraindication for patients with open physes.[5]

According to Hug et al[2] and their systematic review of 837 patients, the mean age of surgery for metacarpal and phalanx fixation with ICSs was 31 years and ranged between 15 and 84 years. Morway et al[4] in their systematic review in 2023 analyzed the retrograde fixation technique for ICSs in metacarpal fractures and reported almost the same mean age of 31 years; none of the patients had open physes. Soldado and Farr[6] have mentioned retrograde intramedullary cannulated headless compression screws as the preferred method of fixation when dealing with short oblique or transverse metacarpal fractures in children when the growth plate is closed.

The advantage of antegrade fixation with ICSs is that neither the guide wire nor the screw is placed through the physis. Therefore, the contraindication for using ICSs in pediatric patients is no longer applicable. This case of a pediatric patient with two spiral metacarpal fractures with displacement and scissoring could have been treated with lag screws or plate fixation.[6,7] Both methods require a larger skin incision and periosteal and tendon dissection, with the associated risks of stiffness and tendon adhesions, which are reported in 32% to 36% of these cases.[2] Despite not being a major concern in pediatric patients compared with adults, these complications are described and should be avoided when possible. When a metacarpal fracture is not treated with plating, the risk of a secondary surgery is lower than in those cases where plating is the fixation method preferred.[6] We believe this technique could also be performed if the spiral fracture was counterclockwise. However, the role of the assistant in maintaining reduction and holding the finger in the reduced position is more crucial.

The ICS used in this case had a 2.4-mm diameter because it was the smallest screw in our market. In our patient, the measures of the canal shaft of the middle and ring finger metacarpals were 3.03 and 3.17 mm, respectively. It is important to have smaller screws because their unavailability could be a limitation for using ICSs in smaller metacarpals or phalanx fixation. However, serial drilling of the canal can be performed to allow placement of a larger diameter screw.[9] Three-dimensional planning could also be an option for planning the diameter of the screw.

Even having avoided crossing the physis and with no reason for developing any disorder that could stop or slow down the growing plate, the patient will continue be followed until the growth plate is closed. Antegrade fixation with ICSs in metacarpal fractures allows ICS fixation to be performed in pediatric patients with open physes. This method provides stability and minimizes skin incision, tendon adhesion, and stiffness while respecting the growing plate.

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