The purpose of this retrospective case control study was to evaluate the results of intrafocal pinning for distal radius metaphyseal fractures in children and to compare these results with conventional pinning. Data were collected from medical records and radiographs from patients who underwent closed reduction and percutaneous pinning for distal radius fracture in a Level I trauma center at the authors’ institution between 2008 and 2010. Inclusion criteria included a dorsally angulated metaphyseal fracture without physeal involvement, an open distal radius physis, and a follow-up to radiographic union.

A total of 10 patients with intrafocal pinning were compared to 26 patients with conventional pinning. Preoperatively, angulation was greater in patients who received intrafocal pinning than conventional pinning based on anteroposterior radiographs. Postoperatively, the 2 groups did not differ in angulation on either anteroposterior or lateral radiographs. One malunion and 2 pin-related complications occurred in the conventional pinning group, and 1 pin-related complication occurred in the intrafocal pinning group. The 2 groups did not differ by age, sex, side of injury, days to surgery, or initial shortening.

This study affirms that the intrafocal pinning technique is an alternative to the conventional pinning technique for the stabilization of displaced metaphyseal distal radius fractures in children. Intrafocal pinning can also be used as a reduction tool for fractures that cannot be reduced by closed manipulation. The complications are comparable between the 2 techniques.

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A high rate of redisplacement occurs after closed reduction and casting of displaced distal radius fractures in children.\textsuperscript{1-7} Closed reduction and percutaneous pinning is an alternative treatment for displaced distal radius metaphyseal fractures in children who fail closed reduction and casting.\textsuperscript{3,8-12} The conventional pinning technique involves K-wire insertion just proximal to or through the distal radius physis (transphyseal) and transfixed across the fracture site.\textsuperscript{3,8} In 1976, Kapandji\textsuperscript{13} described a novel technique of intrafocal pinning of distal radius fractures that involved insertion of the K-wire through the fracture site and fixation in the proximal fragment to buttress the distal fragment. Since then, several studies have reported the results of using this technique in adults.\textsuperscript{14-18} To the authors’ knowledge, the use and results of this intrafocal pinning technique in children have not been reported.

The purpose of this study is to report the results of intrafocal pinning for distal radius fracture stabilization in children with an open distal radius physis and to compare the results of the intrafocal pinning technique with the conventional pinning technique. The authors hypothesized that intrafocal pinning would result in similar postoperative angulation and complications rates as the conventional pinning technique.

**Methods and Materials**

This study was reviewed and approved by the authors’ institutional review board with a waiver of consent. In a retrospective case control study undertaken from 2008 to 2010, ninety-two patients who underwent closed reduction and percutaneous pinning for distal radius fracture were identified. Thirty-six patients met the inclusion criteria of a dorsally angulated metaphyseal fracture, open distal radius physis indicative of skeletal immaturity, and adequate follow-up until radiographic union. The metaphysis was defined as the region encompassing the distance from the physis equivalent to the measurement of the widest part of the physis of distal radius and ulna on anteroposterior radiograph (Figure 1).\textsuperscript{11} Exclusion criteria included patients with distal radius fractures involving the physis, intra-articular fractures, open fractures or skeletally mature patients. Conventional pinning was performed in 26 patients (Figure 2A, B), whereas intrafocal pinning was performed in 10 patients (Figure 2C, D). Intrafocal pinning was performed by 2 surgeons (S. N. P., V. V. J.), especially for difficult or delayed fracture reduction. Demographic data, radiographic measurements, and complications of each treatment were reviewed and analyzed. Malunion at last follow-up was defined as angulation greater than 10° on anteroposterior or lateral view in children 10 years or older. For children younger than 10 years, malunion was defined as angulation greater than 20°.\textsuperscript{19}

**Surgical Technique**

After induction of general anesthesia while the patient is in a supine position, the patient’s arm is placed on a hand table. Preoperative antibiotics are administered. A tourniquet is applied but is not routinely used during surgery. Under fluoroscopic guidance, the fracture is closed reduced by manipulation, if possible, on both anteroposterior and lateral views. A 0.062-inch K-wire is placed on the dorsum of the wrist to identify and mark the fracture site. A 1-cm longitudinal stab incision is placed just distal to the fracture site. Blunt dissection is performed using a hemostat until the fracture site is reached.

The K-wire is inserted perpendicular to the fracture site. Once the K-wire is on the proximal fracture fragment, it is slid distally on the bone until the fracture site is felt. The K-wire is then inserted into the fracture site. A volar tilt at the fracture site by the assistant opens the dorsum of the fracture and facilitates the insertion of the K-wire. Once in the fracture site, the K-wire outside the skin is angled toward the hand to lever the distal fragment in anatomic volar flexion. A drill is placed on the K-wire, and the K-wire is advanced to penetrate the volar cortex of the proximal fragment.
A second dorsal K-wire can be inserted, if needed, using a similar technique through a separate incision. A radial K-wire is used to restore the radial tilt of the distal fragment and maintain the reduction in the coronal plane, if needed. For the radial K-wire, a 1-cm incision is placed between the first and second dorsal compartment (just distal to the fracture site), blunt dissection is performed down to bone, and a 0.062-inch K-wire is inserted into the fracture site. The distal fracture fragment is levered to restore the radial tilt, and the K-wire is then advanced to engage the proximal ulnar cortex. One to 3 K-wires are used for fracture stabilization. If the fracture is irreducible by closed manipulation, the intrafocal K-wire is used as a shoehorn to achieve reduction, thus avoiding an open reduction (Figure 3). The number and size of the K-wires depends on the size of the radius and the fracture geometry.

Once stabilized, the skin is checked and, if needed, release incisions are made to ensure that the skin does not remain tented. This happens frequently with intrafocal pinning because the angle of initial insertion of the K-wires and its final position are different. The K-wires are bent and cut over a felt placed on the skin. A well-padded below-elbow cast is applied. Postoperatively, elbow and hand movement is encouraged. Once radiographs confirm adequate fracture healing approximately 4 weeks postoperatively, the cast is removed, and the K-wires are pulled out. A removable splint is applied for comfort. A range of motion assessment is performed 4 to 6 weeks after cast removal. Additional radiographic follow-up is performed based on the amount of residual angulation at the fracture site and for confirmation of remodeling.

**Statistical Analyses**

Nonparametric statistical tests were performed with medians reported instead of means due to the small sample size and skewedness of the data. The categorical data between the 2 groups were compared using the Fisher’s exact test, and the continuous data between the 2 groups were compared using the Wilcoxon rank-sum test. Statistical significance was set at \( P \) value less than .05.

**RESULTS**

The 2 groups did not differ by age, sex, side of injury, days to surgery, or initial shortening (\( P > .05 \)) (Table). Groups included 19 men and 7 women in the conventional pinning group and 5 men and 5 women in the intrafocal pinning group (\( P = .13 \)) and 14 left- and 12 right-sided injuries were in the conventional pinning group and 7 left- and 3 right-sided injuries were in the intrafocal pinning group (\( P = .23 \)). Of the 26 patients in the conventional pinning group, 23 had a distal ulnar fracture (16 complete and 7 incomplete; 13 metaphyseal, 7 diaphyseal, 2 physeal, and 1 ulnar styloid process fracture). Of the 10 patients in the intrafocal pinning group, 9 had a distal ulnar fracture (8 complete and 1 incomplete; 7 metaphyseal, 1 diaphyseal, and 1 ulnar styloid process fracture).

Based on anteroposterior radiographs, the patients receiving an intrafocal pin had greater preoperative angulation than patients receiving a conventional pin (15° vs 10°, respectively; \( P = .007 \)) (Table). The 2 groups did not differ in postoperative angulation (0.5° vs 0°; \( P = .78 \)) on anteroposterior radiographs or in preoperative angulation (11.5° vs 20.5°; \( P = .12 \)) or postoperative angulation (3° vs 2°, \( P = .82 \)) on lateral radiographs. In the conventional pinning group, 17 patients had 1 pin (4 were transphyseal) (Figure 2A, B), 7 had 3 pins (1 pin was transphyseal), and 2 had 3 pins (3 pins in 2 patients were transphyseal). In the intrafocal pinning group, 2 patients had 1 pin, 7 had 2 pins, and 1 had 3 pins (Figure 2C, D).

In 5 of 10 patients in the intrafocal pinning group, the fracture was irreducible...
by closed manipulation and the pins were used to achieve fracture reduction (Figure 3). In the remaining 5 patients, a closed reduction was initially obtained by fracture manipulation, and the intrafocal pins were used to maintain the reduction.

The pins were removed at a mean of 30±10 days postoperatively in the conventional pinning group and at a mean of 29±4 days in the intrafocal pinning group. At 4- to 6-week follow-up after pin removal, all fractures had healed, and all patients had achieved full range of motion without any pain or activity restrictions. Specifically, no limitation in supination or pronation of the involved extremity was observed when compared with the contralateral extremity in any patient in either group. Patients were followed until they regained full range of motion (8 to 10 weeks postoperatively) or until remodeling was confirmed in those with malunion. Therefore, the mean follow-up was variable, with 148±22 days in the conventional pinning group and 85±53 days in the intrafocal pinning group.

One malunion and 8 pin-related complications were observed in the conventional pinning group. A 14-year-old girl had loose pins and a loss of reduction from 6° of dorsal angulation at the time of pinning to 32° of dorsal angulation at follow-up (Figure 4A). Sixteen months later, she had 18° of dorsal angulation on the radiographs but no clinical symptoms (Figure 4B). Of the 8 pin-related complications, 3 superficial infections resolved with oral antibiotics after K-wire removal. One patient had loose pins that led to malunion, and 4 pin migrations were observed, 1 of which required return to the operating room for pin removal (Figure 4C, D). Complications in the intrafocal pinning group included 1 superficial pin site infection that was treated with pin removal, oral antibiotics, and dressing changes. Although the conventional pinning group had a higher percentage of pin-related complications, the difference between the 2 groups was not statistically significant (31% vs 10%, respectively; \( P = .29 \)).

### Discussion

Closed reduction and casting remains the mainstay of treatment for displaced distal radius fractures in children because the fracture heals quickly and has an excellent remodeling capacity with growth. The radiographic criteria for an acceptable reduction are less than 20° of angulation of the fracture in children younger than 10 years and less than 10° of angulation for children older than 10 years.\(^{18,22}\) Bayonet apposition is considered acceptable for children up to 8 to 10 years.\(^19\) Besides radiographic criteria, other decision-making variables include clinical deformity, skeletal age, sex, and family perceptions of deformity and fracture remodeling. Loss of fracture reduction and redisplacement is the most common complication after reduction of these fractures, reported in about one-third of all fractures.\(^1,7,22\) The risk factors related to loss of reduction include fracture characteristics (initial displacement of the fracture, obliquity of the fracture, and isolated radius fracture), inadequate initial closed reduction, poor casting technique, and resolution of initial swelling in the cast.\(^2,4,6,7,22,25\) Alternate treatment options have to be considered when there is failure to achieve or maintain reduction following closed treatment of these fractures.

Several techniques of percutaneous pinning for distal radius fractures in children have been described.\(^3,8,9,11,26\) The technical challenges in pinning metaphyseal distal radius fractures in children are due to the presence of physis, the size of the bone, and the required obliquity of the pin.\(^11\) Transphyseal pinning may be appropriate for certain physesal and distal metaphyseal fractures, but the crossing of the physis with a pin is a cause of concern for growth arrest.\(^11,27-29\) The more proximal the metaphyseal fracture, the narrower the size of the bone, making it difficult to insert 1 or more pins. If more than 1 pin is inserted, their spread at the fracture site may not be sufficient to achieve the necessary stability. Intrafocal pinning has the

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Abbreviations: AP, anteroposterior; deg, degrees; IQR, interquartile range; postop, postoperative; preop, preoperative.

\(^a\) Wilcoxon rank-sum test.

\(^P<.05\).
The other reported complication is seen in the majority of 4D. The current authors recommend the malunion in the 1 patient. The advantage of leveraging the smaller distal fragment instead of transfixing it. As the pins go through the fracture site, the distal radial physis is spared. When a closed reduction of the fracture is obtained by manipulation, the intrafocal pins are used to maintain the reduction. If a closed reduction of the fracture cannot be obtained by manipulation, the intrafocal pins are used to achieve fracture reduction and stabilization, as described by Kapandji.13

The rate of redisplacement of distal radius fractures after closed reduction and casting could be as high as 60%.2 The presence of ipsilateral distal ulnar fractures has been reported as a contributing factor to redisplacement after cast treatment,2,30 as seen in the majority of the current patients who failed closed treatment. It is recommended that weekly radiographs should be performed when completely displaced fractures have been reduced to identify loss of reduction. It is not uncommon to see late (more than 2 weeks) displacement of such fractures. In younger children (younger than 10 years), initial callus may form around the fracture site when the loss of reduction is recognized. One option for these patients is to allow their fracture to unite and remodel and to perform an osteotomy later if needed.31 The other option is to attempt closed reduction and pinning of the fracture when loss of reduction is identified. In the latter circumstance, the intrafocal pinning has an advantage over conventional pinning in that it can be used as a reduction tool. The K-wire is inserted into the fracture site, and callus, if present, can be partially disrupted by manipulation of the K-wire, allowing reduction of the fracture. The same K-wire is then used to stabilize the fracture.

A similar technique can also be used to reduce acute fractures with significant overlapping by inserting the K-wire in the fracture site and levering the distal fragment to gain the appropriate length (Figure 3). The authors have described this shoehorn technique for distal radius fracture reduction using stout instruments,21 but a K-wire can work equally well. Such an intrafocal technique has been described for children for reduction of supracondylar fractures32 and phalangeal neck fractures,33 but its use for distal radius fractures in children has not been reported.

Although 1 advantage cited with the use of the intrafocal pinning technique in adults was immediate wrist motion without the need for immobilization,13,15 the current authors recommend a below-elbow cast for 4 weeks postoperatively as a supplement to pinning. In cases of excessive swelling, a below-elbow splint is applied that is changed to a below-elbow cast after the first postoperative week. The cast helps to alleviate pain and anxiety, support the fracture, and decrease the risk of recurrent injury. An above-elbow cast could be used, although prospective randomized studies have shown no difference between below- or above-elbow cast treatment for distal radius fractures in children.34-36 In children, motion of the wrist after removal of the cast and pins has not been an issue, and formal physical therapy is not used. A removable splint is generally not used unless a pin-site infection or lack of circumferential callus exists at the time of cast removal.

The complications in the current study were minor and related to the pins, including pin-site infection, pin migration, and pin loosening. These are similar to other studies that reported pin-site complications as the most common complications.3,8 The current authors recommend adequate skin release around the pin insertion site to prevent tenting and pressure on the skin and early removal of the pins at postoperative week 4. The other option of leaving the pins buried under the skin can prevent pin-tract infections but would require subsequent procedures for pin removal.15 The other reported complications, such as tendon and nerve injury, can be prevented by making a skin incision and performing blunt dissection down to bone instead of inserting the pins percutaneously.

The definition of malunion in children is variable.5,9,26 The malunion in the 1 patient in the current study was likely inconsequential due to the remodeling potential and lack of functional limitations. If malunion was defined as greater than 10° of angulation irrespective of patient age, then the current results would have been different. In the conventional pinning group, 2 patients had more than 10° of angulation on final fluoroscopic images at the time of surgery. At the time of pin removal, 5 patients had more than 10° of angulation, which indicates a loss of reduction in 3 patients. At last follow-up, 3 of 5 patients had remodeled, and 2 patients had residual malunion. In the intrafocal pinning group, no patient had more than 10° of angulation on final fluoroscopic images at the time of surgery. At the time of pin removal, 2 patients had more than 10° of angulation, which indicated the loss of reduction in 2 patients. At last follow-up,
REFERENCES


