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CLINICAL RESEARCH

Antegrade Intramedullary Pinning Versus Retrograde Intramedullary Pinning for Displaced Fifth Metacarpal Neck Fractures

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Abstract
Background Severe angulation or shortening can be a surgical indication for fifth metacarpal neck fracture. In a previous meta-analysis, antegrade intramedullary pinning was shown to produce better hand function outcomes than percutaneous transverse pinning or miniplate fixation for treatment of fifth metacarpal neck fractures. However, the outcomes of retrograde intramedullary pinning, to our knowledge, have not been compared with those of antegrade intramedullary pinning.
Questions/purposes We asked whether the clinical and radiographic outcomes of antegrade intramedullary pinning are different from those of percutaneous retrograde intramedullary pinning for treating patients with displaced fifth metacarpal neck fractures.
Methods Forty-six patients with displaced fifth metacarpal neck fractures with an apex dorsal angulation greater than 30° were enrolled in our prospective study. Subjects were treated randomly by antegrade intramedullary pinning (antegrade group) or by percutaneous retrograde intramedullary pinning (retrograde group). Clinical evaluations, which included active ROM of the fifth metacarpophalangeal joint, VAS for pain, grip strength, and DASH score, were performed at 3 months and 6 months postoperatively. Radiographic evaluations of apex dorsal angulation and axial shortening were performed preoperatively and 6 months postoperatively.
Results Patients in the antegrade group achieved better outcomes than patients in the retrograde group for all clinical parameters at 3 months postoperatively (ROM: antegrade median 80° [range, 57°–90°] versus retrograde 69° [range, 45°–90°], difference of medians 11°, $p < 0.001$; VAS: antegrade median of 2 [range, 0–5] versus retrograde 4 [range, 0–7], difference of medians 2, $p < 0.001$; grip strength: antegrade median 81% [range, 60%–100%] versus retrograde 71% [range, 49%–98%], differences of medians 10%, $p < 0.001$; DASH: antegrade median 4.3 [range, 0–15.8] versus retrograde 10.3 [range, 0–28.4], difference of medians 6, $p < 0.001$), but these differences, with the numbers available, were not observed at 6 months postoperatively for any clinical parameters (ROM: antegrade median 88° [range, 81°–90°] versus retrograde 87° [range, 80°–90°], difference of medians 1°, $p = 0.35$; VAS: antegrade median 1 [range, 0–2] versus retrograde 1[range, 0–3], difference of medians 0, $p = 0.67$; grip strength: antegrade median 93% [range, 78%–104%] versus retrograde 91% [range, 76%–101%], difference of medians 2%, $p = 0.41$; DASH: antegrade median 3 [range, 0–12.5] versus retrograde of 4.3 [range, 0–15.8], difference of medians 1.3, $p = 0.48$). At 6 months postoperatively, there also were no differences, with the numbers available, in radiographic parameters between the antegrade and retrograde fixation groups. Residual

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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angulation was not different (antegrade median: 7° [range, 2°–11°], retrograde: 9° [range, 3°–13°], difference of medians 2°, p = 0.56). Shortening between the two groups also was not different (antegrade median: 1 mm [range, 0 mm–2 mm], retrograde median: 1 mm [range, 0 mm–2 mm], difference of medians 0, p = 0.78).

Conclusion Our study findings suggest antegrade intramedullary pinning has some clinical advantages during the early recovery period over percutaneous retrograde intramedullary pinning for treatment of displaced fifth metacarpal neck fractures, but the advantages are not evident at 6 months postoperatively. In addition, our study showed no differences in radiographic outcomes between antegrade and retrograde techniques. For patients who require an early return of hand function, such as athletes, antegrade intramedullary pinning can be recommended. Otherwise, treatment could be decided according to the surgeon's preference and patient status, and based on consideration of the need for an accessory procedure for pin removal after antegrade intramedullary pinning.

Level of Evidence Level I, therapeutic study.

Introduction

Fifth metacarpal neck fracture is a common injury that accounts for approximately 20% of all hand fractures [7]. Although the majority of these fractures can be treated nonoperatively, surgery may be indicated when there is shortening of the metacarpus by more than 3 mm or when severe apex-dorsal angulation is present [4, 6, 16, 18–21]. It remains controversial how much angulation can be tolerated without loss of hand function or hand pain [18]. A biomechanical study showed a fracture angle up to 30° is compatible with near-normal mechanics, but a fracture angle greater than 45° produces significant muscle shortening that can limit motion of the fifth digit [1]. Therefore, some surgeons use a fracture angle greater than 30° as a relative surgical indication for fifth metacarpal neck fracture [6, 16, 19, 20].

Several surgical techniques have been used to treat displaced fifth metacarpal neck fractures, including antegrade intramedullary K-wire, retrograde intramedullary K-wire, retrograde cross pinning with K-wire, transverse pinning with K-wire, external fixation, intraosseous wiring, and plate fixation [4, 6, 16, 18–21]. Since Foucher et al. [5] described the antegrade intramedullary K-wire technique, it has been widely used and produces reliable fracture reduction and excellent ROM of the fifth finger for patients with a fifth metacarpal neck fracture [4, 6, 16, 20, 21]. The retrograde intramedullary K-wire technique initially was advocated by Lord [13], and after introduction of the intraoperative C-arm, the retrograde intramedullary K-wire technique was modified to enable extraction of the end of the wire proximally and bending of the wire dorsally using a percutaneous technique [15]. The percutaneous retrograde intramedullary K-wire technique also produces reliable fracture reduction, excellent ROM of the fifth finger, and DASH scores [15].

A meta-analysis concluded that antegrade intramedullary pinning results in better outcomes than percutaneous transverse pinning or miniplate fixation for fifth metacarpal neck fractures [21]; however, to our knowledge, no study has compared results of treatment with the antegrade intramedullary K-wire and percutaneous retrograde intramedullary K-wire techniques. The purpose of our study therefore was to compare clinical (ROM, VAS, grip strength, and DASH scores) and radiographic (residual angulation and shortening) outcomes of antegrade intramedullary pinning compared with percutaneous retrograde intramedullary pinning in patients with displaced fractures of the fifth metacarpal neck.

Patients and Methods

Subjects

Our prospective study was approved by our institutional review board. The surgical indication for a fifth metacarpal neck fracture was apex dorsal angulation greater than 30° versus the contralateral uninjured side when measured on a 30°-pronated, oblique view on plain radiographs of both hands preoperatively. Actually, the preoperative median fifth metacarpal neck angle for an injured hand was 55° (range, 42°–80°) and preoperative median fifth metacarpal neck angle for an uninjured side was 12° (range, 7°–18°). Patients who met surgical indications were included and those with an open fracture, concomitant fractures, or younger than 18 years were excluded.

From January 2011 to January 2013, we identified 49 patients who met our criteria. However, three declined consent, thus 46 patients were enrolled in our study. All patients were men with a mean age of 29 years (range, 18–53 years).

A computerized random-number generator was used to formulate an allocation schedule using a permuted block method. A research assistant (GNK) sent the sealed envelopes containing the allocation schedule to the operating room just before the procedure. All patients were treated according to the allocation schedule and no patient discontinued the intended intervention during followup.

Patients were randomly allocated to an antegrade intramedullary K-wire group (n = 23, antegrade group) or a percutaneous retrograde intramedullary K-wire group (n = 23, retrograde group). All patients in the antegrade group and 21 in the retrograde group completed 3 months

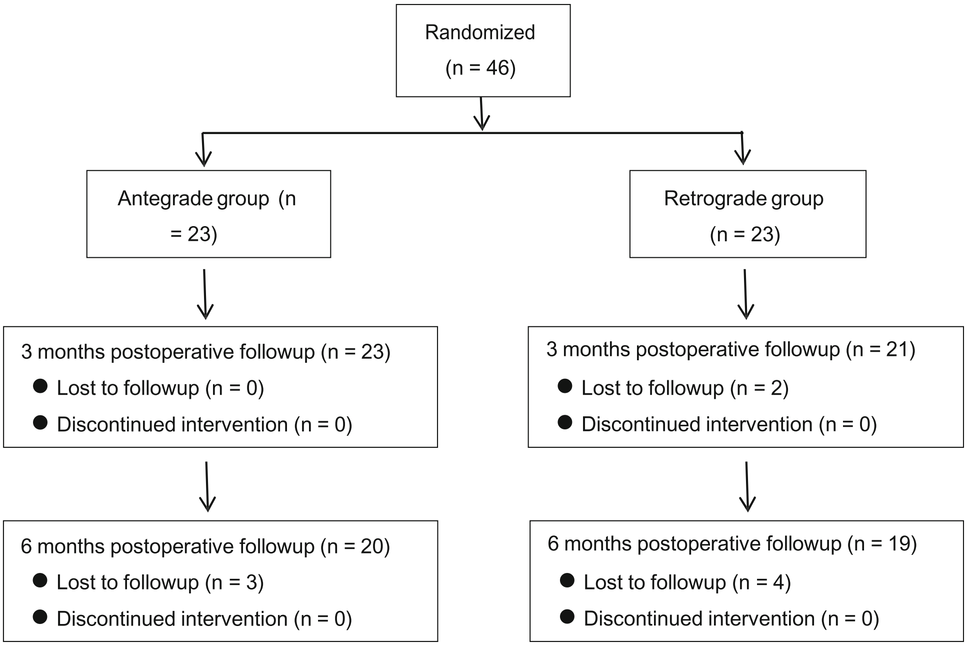

Fig. 1 The flow diagram shows the steps we used for patient selection and group outcomes at 3- and 6-month followups.

of followup; 20 patients in the antegrade group and 19 in the retrograde group completed 6 months of followup (Fig. 1). Missing data owing to loss of followup were handled by a simple imputation method using the mean values of the other group.

All patients in both groups were male (Table 1). Median age in the antegrade group was 32 years (range, 18–53 years) and in the retrograde group 31 years (range, 19–54 years) ($p = 0.78$). Twenty of the 23 patients in antegrade group had a dominant-sided fracture and 21 of the 23 patients in the retrograde group had a dominant-sided fracture ($p = 1$). Preoperatively, in the antegrade group, the median fifth metacarpal neck angle was 56° (range, 42°–80°) for the injured side and 12° (range, 8°–17°) for the uninjured side, which was equivalent to a median apex dorsal angulation of 44° (range, 31°–68°). In the retrograde group, the median fifth metacarpal neck angle was 55° (range, 42°–78°) for the injured side and 12° (range, 7°–18°) for the uninjured side, which was equivalent to a mean dorsal angulation of 44° (range, 31°– 66°). Thus, apex dorsal angulations in the two groups were similar preoperatively ($p = 0.59$). The preoperative median shortening in the antegrade group was 3 mm (range, 1 mm–5 mm) and that of retrograde group was 3 mm (range, 1 mm–5 mm) ($p = 0.75$).

Table 1. Demographic data for both groups*

Variable	Antegrade group	Retrograde group	p value
Sex (M/F)	23/0	23/0	0.88
Age (years)	31 (18–53)	32 (19–54)	0.78
Dominant hand	20/3	21/2	0.88
Apex dorsal angulation (degrees)	44 (31–68)	44 (31–66)	0.59
Shortening (mm)	4 (2–6)	4 (2–6)	0.75

* Median and range.

Surgical Techniques

All surgical procedures were performed by one surgeon (JKK) on patients who received either general anesthesia or axillary block. A pneumatic tourniquet and an intraoperative image intensifier were used in all cases.

For patients in the antegrade group, a small incision (approximately 5 mm) was made about the carpometacarpal joint area of the fifth finger. The entry point for the K-wire was made with a drill on the fifth metacarpal base. Two 1.4-mm K-wires were used and the distal tip of the K-wire was prebent by approximately 20° in the form of a hockey stick. The fracture then was reduced using the Jahss maneuver [8] as the metacarpophalangeal joint and proximal interphalangeal joint were flexed at an angle of 90° and upward pressure was applied on the flexed finger to correct apex dorsal angulation. The wires were held with a flyer and inserted in the intramedullary canal by tapping the flyer with a hammer in divergent directions through control of the flyer under image intensifier control. The skin was closed over cut pins after cutting the wires (Fig. 2).

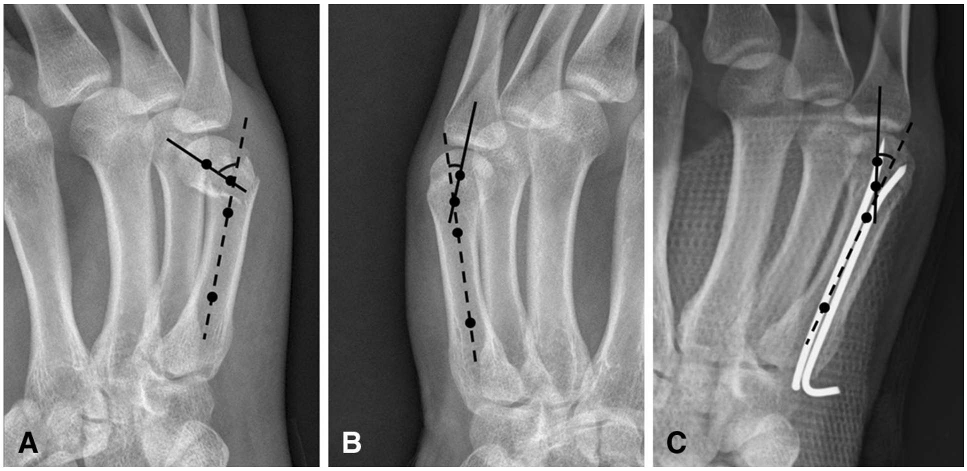

Fig. 2A–C The apex dorsal angulation of the fifth metacarpal neck on the oblique view was (**A**) 58° on the injured side and (**B**) 18° on the noninjured side. Therefore, the preoperative dorsal angulation of the fifth metacarpal neck fracture was 40°. (**C**) Apex dorsal angulation of the fifth metacarpal neck on the oblique view was 21° on the injured side after percutaneous retrograde intramedullary pinning, and postoperative angulation of the fifth metacarpal neck fracture was 3°.

For patients in the retrograde group, the fracture was reduced using the Jahss maneuver, and when fracture reduction was confirmed using an image intensifier, a 1.4-mm K-wire, mounted in a wire-driver drill, was inserted in the metacarpal head in a retrograde direction while maintaining the Jahss maneuver. The K-wire was inserted in the volar third in the sagittal plane of the metacarpal head and the location of the wire was checked under the image intensifier. After cutting the distal sharp end of the wire, its distal tip was hammered gently. The wire then was advanced in a slightly dorsal direction to the metacarpal base, and the second K-wire was inserted in the same manner as the first K-wire. Next, using a hammer and with the patient's wrist fully flexed, the wires were advanced farther through the dorsal cortex of the metacarpal base to emerge at dorsal skin. When the proximal end of the wire protruded from the dorsal skin, it was held with a wire holder and then hammered until its distal end was located at the subchondral bone of the metacarpal head (Fig. 3).

Postoperative Management

A well-molded ulnar gutter short-arm splint was applied in all cases. The splint was positioned with the wrist in 20° extension, the metacarpophalangeal joint at 60° flexion, and the interphalangeal joint in full extension in both patient groups. At 1 week postoperatively, the splint was changed to a short-arm splint; full ROM of the metacarpophalangeal and interphalangeal joints was allowed in both groups.

In the antegrade group, splints were removed 5 weeks after surgery and patients were encouraged to perform active and passive wrist and finger motions. Wires were removed through a small incision with the patient under local anesthesia in an outpatient operation room, approximately 3 months postoperatively.

In the retrograde patient group, wires were removed by drawing proximally. Removal was performed in an outpatient clinic without the use of local anesthesia after radiographic confirmation of bone healing, between 5 and 8 weeks postoperatively.

Clinical Evaluations

Clinical assessments were performed independently by a trained physiotherapist at 3 and 6 months postoperatively. These assessments included ROM of the injured fifth metacarpophalangeal joint, VAS for injured fifth metacarpophalangeal joint pain, grip strength, and DASH score. Active ROM for patients with injured fifth metacarpophalangeal joints was measured using a finger goniometer, and pain during daily activity was recorded using a VAS, in which 0 indicated no pain and 10 indicated the most severe pain. Grip strength was measured on both sides using a Jamar dynamometer (Sammons Preston, Bolingbrook, IL, USA), with the patient's shoulders in a neutral position, elbows flexed to 90°, and forearms in neutral rotation [2, 9]. Patients were instructed to squeeze the handle of the dynamometer maximally. Grip strength was measured twice on each occasion and results were averaged; grip strength values are expressed as percentages of those of the contralateral hands, but assuming 10% greater strength of the dominant hand when the right hand was dominant, and similar hand strengths when the left hand was dominant [3, 14]. The DASH questionnaire consists of 30 items: 21

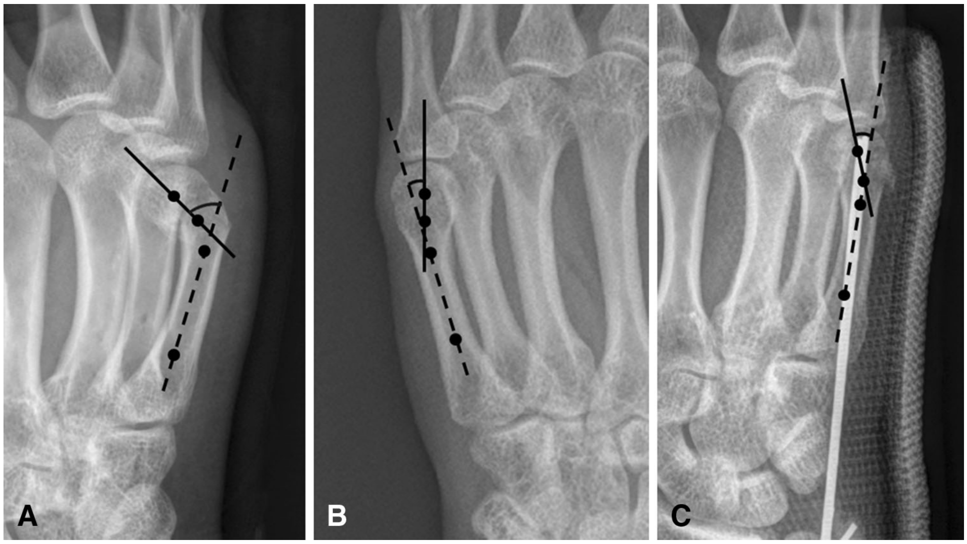

Fig. 3A–C Dorsal angulation of the fifth metacarpal neck on the oblique view was (**A**) 68° on the injured side and (**B**) 17° on the noninjured side. Therefore, the preoperative dorsal angulation of the fifth metacarpal neck fracture was 51°. (**C**) Apex dorsal angulation of the fifth metacarpal neck on the oblique view was 20° on the injured side after antegrade intramedullary pinning, and postoperative angulation of the fifth metacarpal neck fracture was 3°.

address the ability to perform specific activities and nine address symptoms. DASH responses are scored from 0 to 100, and higher scores indicate greater patient disability [11].

Radiographic Evaluation

Radiographic assessments were performed using a picture archiving and communication system, individually, by one of two fourth-year orthopaedic residents, and included apex dorsal angulation and shortening. Interobserver correlation coefficients for apex dorsal angulation and shortening based on the values of two observers (DJK and JYJ) were 0.81 and 0.89, respectively, therefore, the values of apex dorsal angulation and shortening were averaged values from two observers.

Metacarpal neck angles can be measured in the lateral or oblique view. Lamraski et al. [10] reported the reliabilities of both views were substantial, but that the oblique view had slightly greater reliability and produced significantly higher readings of 10.8° (SD, 11.6°). Sletten et al. [17] also found the reliabilities of the lateral and oblique views substantial, but the oblique view had slightly greater reliability and produced significantly higher readings of 9°. However, Leung et al. [12] concluded that the lateral view showed only fair reliability ($\kappa = 0.21$). Summarizing these studies, we measured dorsal angulation of the fifth metacarpal neck fracture on the oblique view with higher reliability, but we subtracted angulation of the contralateral uninjured side from the corresponding injured side to calculate true angulation. We found that the median dorsal angulation of the normal sides was 12°, which concurs with greater amounts of dorsal angulation on the oblique view as compared with the lateral view reported in previous studies [10, 17].

We defined apex dorsal angulation as the angle between the metacarpal neck and metacarpal shaft on the oblique pronated view (Fig. 4). We measured it by subtracting the angle of the noninjured fifth metacarpal neck from that of the injured fifth metacarpal neck preoperatively and at 6 months postoperatively. Shortening was measured on the AP view by subtracting the length of the injured fifth metacarpal bone from that of the noninjured fifth metacarpal bone preoperatively and at 6 months after surgery.

Sample Size

A prior power analysis showed that to detect a minimum loss of 10° in active ROM of the fifth metacarpophalangeal joint with a standard deviation of 10°, a 20% loss to followup, a type-I error rate of 0.05, a power of 0.8, and a minimum of 23 patients were needed per treatment group.

Statistical Analysis

Fisher's exact test was used to evaluate the significance of intergroup difference for categorical variables and the Mann-Whitney U test was used to evaluate the significance

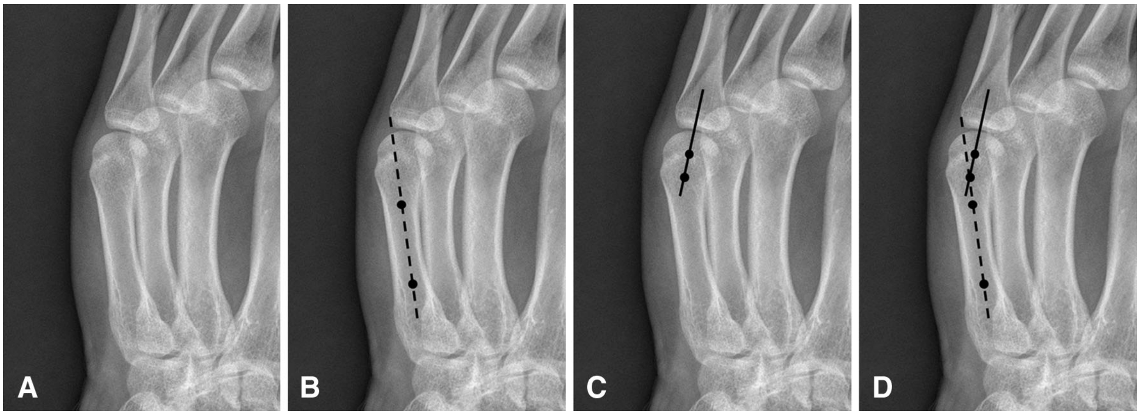

Fig. 4A–D (**A**) Anterior and posterior fifth metacarpal cortex lines are seen on the oblique pronated view. (**B**) The metacarpal shaft line (a straight line) is used to connect the dots of the center distal third of the fifth metacarpal shaft and the center proximal third of the fifth metacarpal cortex. (**C**) The metacarpal neck line is used to connect the dots of the center of the fifth metacarpal neck and head. (**D**) Apex dorsal angulation of the fifth metacarpal neck is defined as the angle of the metacarpal shaft line and neck line.

of intergroup differences for continuous variables. All statistical tests were two sided, and p values less than 0.05 were considered significant.

Results

Clinical Outcomes

At 3 months postoperatively, all clinical outcomes (Table 2) favored antegrade pinning. Median ROM of the fifth metacarpophalangeal joint was greater for patients in the antegrade group than in the retrograde group (antegrade: 80° [range, 57°–90°] versus retrograde: 69° [range, 45°–90°], difference of medians 11°, $p < 0.001$). The median VAS score of the antegrade group was lower than that of retrograde group (antegrade: 2 [range, 0–5] versus retrograde: 4 [range, 0–7], difference of medians 2, $p < 0.001$); median grip strength of the antegrade group was greater than that of retrograde group (antegrade: 81% [range, 60%–100%] versus retrograde: 71% [range, 49%–98%], difference of medians 10%, $p < 0.001$); and median DASH score for antegrade intramedullary pinning was smaller than that of the retrograde group (antegrade: 4.3 [range, 0–15.8] versus retrograde: 10.3 [range, 0–28.4], difference of medians 6, $p < 0.001$) for patients in the antegrade group compared with the retrograde group.

At 6 months postoperatively, clinical outcomes favored neither antegrade nor retrograde fixation. ROMs of the fifth metacarpophalangeal joint in both treatment groups (antegrade: 88° [range, 81°–90°] versus retrograde: 87° [range, 80°–90°], difference of medians 1°, $p = 0.35$) were not different. Similarly, median VAS scores (antegrade: 1 [range, 0–2] versus retrograde: 1 [range, 0–3], difference of medians 0, $p = 0.67$), grip strengths (antegrade: 93% [range, 78%–104%] versus retrograde: 91% [range, 76%–101%], difference of medians 2%, $p = 0.41$), and DASH scores (antegrade: 3 [range, 0–12.5] versus retrograde: 4.3 [range, 0–15.8], difference of medians 1.3, $p = 0.48$) were not different.

Radiographic Parameters

At 6 months postoperatively, radiographic parameters were similar between antegrade and retrograde fixation groups. Residual angulation was not different (antegrade median: 7° [range, 2°–11°], retrograde: 9° [range, 3°–13°], difference of medians 2°, $p = 0.56$). Median shortening in the treatment groups at 6 months postoperatively also were not

Table 2. Clinical data for antegrade and retrograde groups

Variable	Postoperative 3 months			Postoperative 6 months		
	Antegrade group	Retrograde group	p value†	Antegrade group	Retrograde group	p value†
ROM*	80 (57–90)	69 (45–90)	< 0.001	88 (81–90)	87 (80–90)	0.35
VAS (points)	2 (0–5)	4 (0–8)	< 0.001	1 (0–2)	1 (0–3)	0.67
Grip strength (%)	81 (60–100)	71 (49–98)	< 0.001	93 (78–104)	91 (76–101)	0.41
DASH score (points)	4.3 (0–15.8)	10.3 (0–28.4)	< 0.001	3 (0–12.5)	4.3 (0–15.8)	0.48

* ROM = active ROM of fifth metacarpophalangeal joint; †Mann-Whitney U test; data are median and range.

different (antegrade: 1 mm [range, 0 mm–2 mm] versus retrograde: 1 mm [range, 0 mm– 2 mm], difference of medians 0, $p = 0.78$).

Discussion

Antegrade intramedullary pinning has been a reliable and safe modality for treatment of displaced fifth metacarpal neck fractures [6], and some studies have shown that antegrade intramedullary pinning produces better outcomes than other surgical methods [5, 16, 20, 21]. Percutaneous retrograde intramedullary pinning also provides reliable fracture reduction and excellent hand function [15]. However, presumably because percutaneous retrograde intramedullary pinning was introduced relatively recently, the outcomes of retrograde and antegrade intramedullary pinning have not been compared, to our knowledge. In the current study, we investigated whether these two modalities differ with respect to hand function and fracture reduction in cases of displaced fifth metacarpal neck fractures.

Our study has several limitations. First, our patients had relatively short followup; however, fifth metacarpal neck fractures usually show early bone union and patients normally return to work within 3 months of surgery; thus, we believe that early postoperative outcomes are important. Nevertheless, our findings show that the clinical outcomes of treatment with antegrade intramedullary pinning and percutaneous retrograde intramedullary pinning at 6 months postoperatively are, from a practical view, identical. Second, the different postoperative management protocols used may have introduced bias. However, we followed recommended postoperative protocols, and in our opinion, comparisons based on common practice are more important than those based on artificial applications of identical protocols.

We found that antegrade pinning of fifth metacarpal neck fractures, when compared with retrograde pinning, provided better ROM, VAS, grip strength, and DASH scores at 3 months but not at 6 months. Similarly, Fujitani et al. [6], in a randomized study, compared the outcomes of antegrade intramedullary pinning with those of a low-profile miniplate for fifth metacarpal neck fractures and found that fifth finger ROM was better for antegrade pinning at 3 months but not at 6 months. Winter et al. [19], in a nonrandomized study, compared the outcomes of antegrade intramedullary pinning and percutaneous transverse pinning for fifth metacarpal neck fractures and found that antegrade pinning provided better finger ROM at 3 months postoperatively. Wong et al. [20], in a nonrandomized retrospective study, compared the outcomes of antegrade intramedullary pinning and percutaneous transverse pinning for fifth metacarpal neck fractures and found no difference between the two in terms of pain, fifth finger ROM, or grip strength after a mean followup of 24 months. However, Schädel-Höpfner et al. [16], in a randomized study, compared the outcomes of antegrade intramedullary pinning and percutaneous retrograde crossed pinning for displaced fifth metacarpal neck fractures and found that antegrade intramedullary pinning produced better ROM, pain scores, and Steel scores (a score comprised of pain, ROM, grip strength, and radiographic deformity) in the fifth metacarpophalangeal joint after a mean patient followup of 17 months. Facca et al. [4], in a randomized study, compared the outcomes of antegrade intramedullary pinning and the locking miniplate technique for treating patients with displaced fifth metacarpal neck fractures and also found antegrade intramedullary pinning produced significantly better ROM in the metacarpophalangeal joint after a mean followup of 4 months. Yammine and Harvey [21], in a meta-analysis, concluded that patients treated with antegrade intramedullary pinning showed better grip strength, fifth digit ROM, lower pain scores, and fewer complications than patients treated with percutaneous transverse pinning or miniplate.

In our study, fracture reduction by percutaneous retrograde intramedullary pinning at 6 months postoperatively was similar to that of antegrade intramedullary pinning. This finding is in line with those of previous studies regarding fracture reductions (assessed by apex dorsal angulation and shortening) achieved by antegrade intramedullary pinning and other surgical methods, such as percutaneous transverse pinning [19, 20], miniplate [4, 6], and percutaneous retrograde crossed pinning [16].

Our study results show that treatment of a displaced fifth metacarpal neck fracture by antegrade intramedullary pinning produces better clinical outcomes at 3 months postoperatively in terms of ROM, VAS, grip strength, and DASH score of the fifth metacarpophalangeal joint than percutaneous retrograde intramedullary pinning, but that the differences in clinical parameters are not sustained at 6 months postoperatively. In addition, our study showed that the radiographic outcomes of these two techniques are not different, with the numbers available. For patients who require an early return of hand function, such as athletes, antegrade intramedullary pinning can be recommended. Otherwise, treatment could be decided according to the surgeon's preference and patient status, and based on consideration of the need for an accessory procedure for pin removal after antegrade intramedullary pinning.

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