Unstable Distal Radial Fractures Treated with External Fixation, a Radial Column Plate, or a Volar Plate. A Prospective Randomized Trial

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Unstable Distal Radial Fractures Treated with External Fixation, a Radial Column Plate, or a Volar Plate
A Prospective Randomized Trial

By David H. Wei, MD, Noah M. Raizman, MD, Clement J. Bottino, MD, Charles M. Jobin, MD, Robert J. Strauch, MD, and Melvin P. Rosenwasser, MD

Investigation performed at Columbia University Medical Center, New York Presbyterian Hospital, New York, NY

Background: Optimal surgical management of unstable distal radial fractures is controversial, and evidence from rigorous comparative trials is rare. We compared the functional outcomes of treatment of unstable distal radial fractures with external fixation, a volar plate, or a radial column plate.

Methods: Forty-six patients with an injury to a single limb were randomized to be treated with augmented external fixation (twenty-two patients), a locked volar plate (twelve), or a locked radial column plate (twelve). The fracture classifications included Orthopaedic Trauma Association (OTA) types A3, C1, C2, and C3. The patients completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire at the time of follow-up. Grip and lateral pinch strength, the ranges of motion of the wrist and forearm, and radiographic parameters were also evaluated.

Results: At six weeks, the mean DASH score for the patients with a volar plate was significantly better than that for the patients treated with external fixation (p = 0.037) but similar to that for the patients with a radial column plate (p = 0.33). At three months, the patients with a volar plate demonstrated a DASH score that was significantly better than that for both the patients treated with external fixation (p = 0.028) and those with a radial column plate (p = 0.027). By six months and one year, all three groups had DASH scores comparable with those for the normal population. At one year, grip strength was similar among the three groups. The lateral pinch strength of the patients with a volar plate was significantly better than that of the patients with a radial column plate at three months (p = 0.042) and one year (p = 0.036), but no other significant differences in lateral pinch strength were found among the three groups at the other follow-up periods. The range of motion of the wrist did not differ significantly among the groups at any time beginning twelve weeks after the surgery. At one year, the patients with a radial column plate had maintained radial inclination and radial length that were significantly better than these measurements in both the patients treated with external fixation and those with a volar plate (all p < 0.05).

Conclusions: Use of a locked volar plate predictably leads to better patient-reported outcomes (DASH scores) in the first three months after fixation. However, at six months and one year, the outcomes of all three techniques evaluated in this study were found to be excellent, with minimal differences among them in terms of strength, motion, and radiographic alignment.

Level of Evidence: Therapeutic Level I. See Instructions to Authors for a complete description of levels of evidence.

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A commentary is available with the electronic versions of this article, on our web site (www.jbjs.org) and on our quarterly CD-ROM/DVD (call our subscription department, at 781-449-9780, to order the CD-ROM or DVD).
The ideal method of surgical management of unstable distal radial fractures is controversial. Excellent clinical results have been achieved with either external fixation or internal fixation. Recently, fixation with a locked volar plate has gained widespread popularity. Although some evidence supporting its use instead of external fixation is available, data from randomized clinical trials in which the investigators employed validated patient-reported outcome measures are only beginning to emerge and have yet to demonstrate clear superiority.

In addition, application of a plate to the radial column as a separate means of fixation, independent of its role as part of a more complex system of fragment-specific fixation, has yet to be explored in the comparative literature, to our knowledge. Use of a radial column plate offers some theoretical advantages over other plate techniques. Dorsal and volar metaphyseal fragments can be indirectly stabilized with minimal disruption of their vascular supply. Furthermore, the adhesion and rupture of the extensor tendons that can be associated with dorsal fixation may be avoided. A biomechanical study conducted at our institution showed the radial column plate to be five times as stiff as the volar plate during wrist flexion and extension, as it is 90° orthogonal to the flexion-extension axis. In addition, the clinical safety and efficacy of fixation with a radial column plate were demonstrated in our retrospective cohort study, which showed minimal surgical morbidity as well as satisfactory reduction and stability until union.

The present prospective randomized study was performed to investigate whether use of a volar plate would accelerate recovery of function as assessed with validated patient-reported outcome measures and also to determine how three surgical modalities—augmented external fixation, use of a locked volar plate, and use of a locked radial column plate—would compare in terms of functional and radiographic outcomes in patients with an unstable distal radial fracture.

**Materials and Methods**

**Study Design**

We conducted a single-center, prospective, randomized clinical trial that was approved by our institutional review board and was in accordance with the Declaration of Helsinki ethical principles for medical research involving human subjects. We report our findings according to the guidelines set forth by the CONSORT group for randomized clinical trials.

**Patient Selection**

All patients who were at least eighteen years of age and had an unstable distal radial fracture were invited to participate in the study. Fractures were deemed unstable if they had displaced after initial treatment with closed reduction and splinting, or

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### Randomization Flow Chart

- **Assessed for eligibility** (n=57)
  - Excluded (n=11)
    - Concomitant ulnar shaft fracture (n=6)
    - OTA class B fracture (n=4)
    - Bilateral injury (n=1)
- **Randomized** (n=46)
  - **Allocated to**
    - External Fixation (n=22)
    - Internal Fixation (n=24)
      - **Allocated to**
        - Radial Column Plating (n=12)
        - Volar Plating (n=12)

---

*Fig. 1* Randomization flow chart.
if three of the following criteria, as described by Lafontaine et al., were met: (1) dorsal angulation of >20°, (2) dorsal comminution, (3) an intra-articular fracture, (4) an associated ulnar styloid fracture, or (5) an age of more than sixty years. The unstable fracture types included Orthopaedic Trauma Association (OTA) class A3 (extra-articular with comminution), C1 (simple intra-articular), C2 (simple intra-articular with a multifragmentary metaphysis), and C3 (multifragmentary with involvement of the intra-articular cortex). Patients with an OTA class-B fracture (partial articular), considerable preexisting arthritis of the hand or wrist that limited grasp, an open or bilateral fracture, a concomitant ulnar shaft fracture, or prior trauma to either hand were excluded. We engaged all patients participating in this study in a thorough discussion of the risks, benefits, and alternatives prior to and following enrollment. Each patient signed and retained a detailed informed consent form.

Randomization
Patients were randomized to three study arms in two phases (Fig. 1). First, the patients were randomly assigned to be treated with either augmented external fixation or internal fixation. During a second randomization, the patients who had been assigned to receive internal fixation were further randomized to be treated with either a volar or a radial column plate. This randomization scheme was designed to balance internal and external fixation arms and allow one surgeon to perform only augmented external fixation while the other surgeon performed only internal fixation. All randomization was done by computer-generated allocation with use of sealed, opaque, numbered envelopes containing the treatment assignments. The research investigator assessing eligibility criteria had no foreknowledge of the assigned treatment until after the patient was enrolled and the envelope was opened. The patients were not made aware of the selected treatment option until after the surgery was performed.

Treatment
Open reduction and internal fixation was performed with a precontoured, locked radial column or volar plate (EBI OptiLock, Parsippany, New Jersey). The patients who were to receive a locked volar plate underwent open reduction of the fracture through a modified Henry approach.

Plate fixation of the radial column was carried out through an incision made on the radial aspect of the forearm over the first dorsal compartment, based from the tip of the volar aspect of the radial styloid and extending proximally by approximately 8 cm. The radial sensory nerve and its branches were identified and were gently retracted with vessel loops. The retinaculum of the first dorsal compartment was incised, and its tendons were retracted dorsally. The brachioradialis tendon was reflected approximately 10 cm proximal to its distal in-
sertion into the radial metaphysis to be utilized for soft-tissue coverage over the plate and to reduce the deforming forces of the brachioradialis on the distal fracture fragment. The fracture was opened through its radial aspect and was reduced by direct manipulation under visual and fluoroscopic guidance. The plate was provisionally fixed both proximally and distally with Kirschner wires before drill-holes were made. To control facet displacement, the distal holes were diverged in the sagittal plane to capture the volar and dorsal lunate facet fragments. Cancellous screws were inserted into the distal holes, the Kirschner wires were removed, and the plate was used as a reduction tool to ensure proper restoration of radial length and tilt. Finally, the proximal holes were filled with cortical screws. Adjunctive use of cancellous bone allograft or the use of a secondary means of fixation, such as a dorsal plate or external fixation, was carried out after assessment of the stability of the primary fixation.

The patients received standardized follow-up care, including a volar splint for comfort, instructions to immediately begin finger motion, and hand therapy including wrist motion and strengthening exercises starting at ten to fourteen days.

The patients in the augmented external fixation group underwent fracture reduction with use of intrafocal fracture pinning under fluoroscopy, followed by stabilization of fracture fragments with placement of percutaneous Kirschner wires, usually subchondral or transradial styloid. Two 3.0-mm pins were then placed in the base of the index metacarpal and two were placed in the distal part of the radial shaft before a bridging external fixator (Hoffmann II Compact; Stryker, Mahwah, New Jersey) was applied. Additional augmentation strategies included filling of a metaphyseal void with cancellous bone allograft and/or the use of additional small buttress plates as deemed appropriate by the orthopaedic surgeon. The patients were instructed regarding appropriate pin care, and all

**TABLE II Scores on the DASH Questionnaire**

<table>
<thead>
<tr>
<th></th>
<th>Internal Fixation†</th>
<th>Volar Plate</th>
<th>P Value</th>
<th>Favoring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Radial Column Plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>76 ± 16</td>
<td>80 ± 14</td>
<td>73 ± 22</td>
<td>a: 0.037</td>
</tr>
<tr>
<td>6 weeks</td>
<td>56 ± 19a</td>
<td>48 ± 19</td>
<td>41 ± 23a</td>
<td>a: 0.028, b: 0.027</td>
</tr>
<tr>
<td>3 months</td>
<td>29 ± 18a</td>
<td>28 ± 17b</td>
<td>7 ± 5ab</td>
<td>a: 0.025, c: 0.056</td>
</tr>
<tr>
<td>6 months</td>
<td>11 ± 10</td>
<td>18 ± 16</td>
<td>6 ± 4</td>
<td></td>
</tr>
<tr>
<td>12 months</td>
<td>18 ± 14c</td>
<td>18 ± 12a</td>
<td>4 ± 5ca</td>
<td>a: 0.025, c: 0.056</td>
</tr>
</tbody>
</table>

*The DASH questionnaire is scored on a 100-point scale, with lower scores being better. †The values are given as the mean and standard deviation. Values that share a letter in each row were significantly (a and b) or nearly significantly (c) different from one another.

**TABLE III Grip and Lateral Pinch Strength**

<table>
<thead>
<tr>
<th></th>
<th>External Fixation</th>
<th>Internal Fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%*</td>
<td>kg</td>
</tr>
<tr>
<td>Grip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 weeks</td>
<td>21 ± 21</td>
<td>2.9</td>
</tr>
<tr>
<td>3 months</td>
<td>49 ± 10</td>
<td>11.2</td>
</tr>
<tr>
<td>6 months</td>
<td>75 ± 21a</td>
<td>19.3</td>
</tr>
<tr>
<td>12 months</td>
<td>69 ± 34</td>
<td>18.0</td>
</tr>
<tr>
<td>Lateral pinch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 weeks</td>
<td>40 ± 27</td>
<td>3.4</td>
</tr>
<tr>
<td>3 months</td>
<td>68 ± 16</td>
<td>4.6</td>
</tr>
<tr>
<td>6 months</td>
<td>86 ± 24</td>
<td>5.8</td>
</tr>
<tr>
<td>12 months</td>
<td>94 ± 12</td>
<td>5.4</td>
</tr>
</tbody>
</table>

*The values represent the percentage of the value on the uninjured side and are given as the mean and standard deviation. Values that share a letter in each row were significantly different from one another.
external fixators were removed between five and six weeks after the surgery. Hand therapy, including wrist range-of-motion and strength-training exercises, was started at that time.

**Clinical Outcomes**

The patients were evaluated at ten to fourteen days; six weeks; and three, six, and twelve months after the surgery. Our primary outcome measure was the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire\(^{13-16}\). The DASH questionnaire is a validated self-reported thirty-item metric of upper-extremity function based on a 100-point scale, with 0 points indicating no disability and 100 points indicating maximum disability. The patients were asked to complete a DASH questionnaire at each follow-up visit, and the score obtained at their first visit served as the postinjury baseline level of function.

Secondary outcomes were measured beginning six weeks after surgery, and they included measurements of wrist and forearm motion as well as grip and lateral pinch strength. Wrist flexion-extension and radioulnar deviation were assessed with a goniometer. Forearm supination and pronation were assessed with the elbow flexed 90° at the patient’s side. Grip strength was measured with use of a calibrated Jamar dynamometer (Sammons Preston Rolyan, Bolingbrook, Illinois) set at level 2, and lateral pinch strength was measured with a hydraulic pinch gauge (Sammons Preston Rolyan). The average of three trials...
for both hands was recorded for all strength measurements. The range of motion and the grip and lateral pinch strengths were also calculated as percentages of the values on the contralateral uninjured side as these ratios have been shown to be more sensitive for detecting clinical changes. We controlled for hand dominance by adjusting values to reflect 10% greater strength of the dominant hand if, and only if, the patient was right-handed. Pain was recorded on a 10-point visual analog scale.

Radiographic Measurements
Standard neutral rotation posteroanterior and lateral radiographs were made at each visit (Fig. 2) for measurement of volar tilt, radial inclination, radial length, ulnar variance, and steps and gaps for intra-articular fractures. Negative values for volar tilt represent dorsal tilt, and negative values for ulnar variance represent an ulna that is shorter than the radius. Two trained clinical investigators independently performed all radiographic measurements on digital radiographs with a digital goniometer and ruler. An interobserver discrepancy of >15% triggered another review of the radiographs and reconciliation of the measurements, sometimes with use of other radiographs made during the same visit that offered superior exposures.

Study Blinding
Because of the obvious nature of the intervention and residual scars, the study was only partially blinded. An independent investigator who collected and analyzed the functional, radiographic, and range-of-motion outcomes data was blinded to the type of treatment. The surgeons were not involved in the collection of the study data.

Sample Size
The DASH questionnaire, our primary outcome measure, was used to perform an a priori power analysis. A meaningful difference in the DASH score was estimated to be 10 points. Recent studies of external fixation and volar plate fixation of the distal part of the radius showing the standard deviation of DASH scores to range from 5 to 10 points allowed for a more accurate power analysis. We estimated that at least ten patients per arm of the study were necessary to detect, with an 80% power, a 10-point difference in DASH scores at one year.

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**TABLE V Pain Scores on Visual Analog Scale**

<table>
<thead>
<tr>
<th></th>
<th>External Fixation</th>
<th>Internal Fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>3.9 ± 2.1</td>
<td>2.8 ± 2.0</td>
</tr>
<tr>
<td>6 weeks</td>
<td>2.3 ± 1.4</td>
<td>1.9 ± 1.1</td>
</tr>
<tr>
<td>3 months</td>
<td>1.9 ± 0.9</td>
<td>1.6 ± 0.8</td>
</tr>
<tr>
<td>6 months</td>
<td>2.2 ± 1.3</td>
<td>1.6 ± 0.9</td>
</tr>
<tr>
<td>12 months</td>
<td>1.8 ± 1.3</td>
<td>2.3 ± 1.8</td>
</tr>
</tbody>
</table>

*Pain was assessed with use of a 10-point visual analog scale. The values are given as the mean and standard deviation.

**TABLE VI Radiographic Measurements**

<table>
<thead>
<tr>
<th></th>
<th>Preoperative</th>
<th>6 weeks</th>
<th>12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>External Fixation*</td>
<td>Internal Fixation*</td>
<td>P Value</td>
</tr>
<tr>
<td>Radial inclination (deg)</td>
<td>15.0 ± 10.4</td>
<td>16.5 ± 9.1</td>
<td>11.6 ± 9.3</td>
</tr>
<tr>
<td>Volar tilt (deg)</td>
<td>−6.7 ± 19.5</td>
<td>−13.9 ± 15.3</td>
<td>−15.2 ± 12.4</td>
</tr>
<tr>
<td>Ulnar variance (mm)</td>
<td>0.2 ± 4.4</td>
<td>2.7 ± 3.0</td>
<td>4.5 ± 3.6</td>
</tr>
<tr>
<td>Radial length (mm)</td>
<td>8.0 ± 5.2</td>
<td>8.1 ± 3.8</td>
<td>5.0 ± 2.7</td>
</tr>
</tbody>
</table>

*The values are given as the mean and standard deviation. Values that share a letter in each row were significantly different from one another.
### Statistical Methods

Single-factor analysis of variance was used to compare continuous outcomes, including the DASH scores, mobility, strength, and radiographic outcomes, among the study groups. If a difference was detected, an independent two-sided Student t test with use of the Bonferroni correction was employed to compare the study groups. Significance was set at p < 0.05. All analyses were performed with use of the intention-to-treat principle. Thus, patients who received adjunctive fixation in addition to their primarily assigned treatment were kept in their originally assigned treatment arm. This intention-to-treat method of analysis is specifically designed to mitigate bias that would result if such patients were removed from the analysis. By keeping them in their treatment group, we measured the effect of allocating an intervention in actual practice.

### Source of Funding

Funding for this work was provided in part by the Doris Duke Clinical Research Fellowship.

### Results

#### Patient Cohort

Fifty-seven patients with a distal radial fracture were screened over eighteen months, and eleven patients were excluded: six because of a concomitant ulnar shaft fracture, four because of an OTA class-B fracture, and one because of a bilateral injury. Thus, forty-six patients with a closed, unilateral, unstable distal radial fracture were randomized to three treatment groups: twenty-two were randomized to be treated with external fixation; twelve, to treatment with a radial column plate; and twelve, to treatment with a volar plate. Of the patients treated with external fixation, all had placement of supplemental Kirschner wires, four had bone-grafting of the fracture, and two received additional plate fixation (with a volar plate in one and a dorsal plate in the other). Within the internal fixation arm, three patients deviated from the randomly assigned treatment: two who had been originally assigned to be treated with a volar plate received additional fixation with a dorsal plate, and one who had been assigned to fixation with a radial column plate received supplemental buttressing of the fracture with a volar plate. Eight wrists in the radial column plate group and four wrists in the volar plate group received supplemental bone-grafting.

The characteristics of the three study groups with respect to sex, age, side injured, handedness, and fracture type are shown in Table I. Thirty-three women (72%) and thirteen men (28%) were enrolled, and their mean age (and standard deviation) was 58 ± 17 years. Fifteen class-A3, four class-C1, fourteen class-C2, and thirteen class-C3 fractures were treated. All of the forty-six randomly assigned patients returned within two weeks after surgery for the first follow-up visit; forty-two (91%) returned for the six-week visit; forty (87%), for the three-month visit; thirty-six (78%), for the six-month visit; and thirty-six (78%), for the one-year visit. The patients who were lost to follow-up did not differ significantly, in terms of treatment assignment, fracture class, or any other baseline characteristic, from the patients who were not.

#### Objective Outcomes

During the first follow-up visit, all patients demonstrated marked impairment of function, with a mean postoperative baseline DASH score of 76 ± 17 points (Table II). There was no significant difference among the groups at this time. By six weeks, the mean DASH score in the volar plate group was significantly better than that in the external fixation group (p = 0.037) but not significantly different from that in the radial column plate group. At three months, the mean DASH score in the volar plate group was significantly better than that in both the external fixation group (p = 0.028) and the radial column plate group (p = 0.027). However, by six months, the DASH score in the volar plate group was not significantly different from that in either the external fixation group (p = 0.26) or the radial column plate group (p = 0.38). At one year, the mean DASH score in the volar plate group (4 ± 5 points) was significantly better than the mean score in the radial column plate group (18 ± 12 points) (p = 0.025) but was not significantly different from the mean score in the external fixation group (18 ± 14 points) (p = 0.056). At the time of final follow-up, all treatment groups showed significant improvement in the DASH scores compared with their original postinjury scores (p < 0.05). The final mean DASH score for all patients was 13 ± 12 points (Table II).

### Table VII Postoperative Step and Gap Deformity of Intra-Articular Fractures

<table>
<thead>
<tr>
<th>Step deformity</th>
<th>Internal Fixation*</th>
<th>Radial Column Plate</th>
<th>Volar Plate</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any step</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0.428</td>
</tr>
<tr>
<td>Step &gt;2.0 mm</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.441</td>
</tr>
<tr>
<td>Gap deformity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any gap</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>0.091</td>
</tr>
<tr>
<td>Gap &gt;2.0 mm</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.582</td>
</tr>
</tbody>
</table>

*The values are given as the number of patients.
as a percentage of that of the uninjured hand increased from 25% ± 16% (6 ± 3 kg) at six weeks to 69% ± 24% (19 ± 9 kg) at one year (Table III).

The lateral pinch strength of the patients with a volar plate was significantly better than that of the patients with a radial column plate at three months (p = 0.042) and at one year (p = 0.036). No other significant differences were found among the groups with regard to lateral pinch strength at any of the follow-up periods, and all groups showed a significant improvement from six weeks to one year postoperatively (p < 0.05). Overall, the average percentage of the lateral pinch strength of the uninjured hand improved from 45% ± 23% (4 ± 2 kg) at six weeks to 89% ± 13% (5 ± 2 kg) at one year (Table III).

Range-of-motion analysis revealed significant improvement from six weeks to one year in all groups (p < 0.05). Although early differences in extension and supination demonstrating less motion in the external fixation group (all p < 0.05) were found at six weeks, no significant differences were found at any follow-up period thereafter (Table IV). At the final evaluation, wrist flexion-extension averaged 117° ± 20° (86% ± 17% of the value on the contralateral side), forearm pronation-supination averaged 158° ± 25° (94% ± 12% of the value on the contralateral side), and wrist radioulnar deviation averaged 48° ± 9° (98% ± 21% of the value on the contralateral side). An analysis of the pain scores recorded on the visual analog scale did not reveal significant differences among the groups during any follow-up period (p > 0.05) (Table V).

**Radiographic Outcomes**

An analysis of radiographs at six weeks showed that the radial column plate maintained significantly greater radial inclination than did the volar plate (p = 0.003) and significantly greater radial length than did external fixation (p = 0.038) (Table VI). At one year, the degree of radial inclination and the radial length in the patients with a radial column plate were significantly greater than those in both the patients treated with external fixation (p = 0.007 and p = 0.002, respectively) and the patients treated with a volar plate (p = 0.003 and p = 0.027). Final measurement showed a mean of 8° of dorsal radial tilt in the patients with a radial column plate, 4° of volar tilt in those with a volar plate, and 2° of dorsal tilt in those treated with external fixation. However, there were no significant differences among the groups with regard to volar tilt or ulnar variance at any follow-up period.

An analysis of the intra-articular fractures for step and gap deformities (Table VII) did not reveal any significant differences among the groups (p > 0.05), but there was a trend toward a higher proportion of patients with a gap deformity of any size in the external fixation group (p = 0.091).

**Complications**

Transient neuropathy in the distribution of the median nerve developed in three patients in the external fixation group, three in the radial column plate group, and two in the volar plate group. None required carpal tunnel release, and all but one case resolved by six months after the operation. One patient who received external fixation experienced pin site irritation and underwent early removal of the fixator at four weeks, but there was no subsequent loss of reduction or additional complications. Thirty-eight (83%) of the patients had no complications. There were no infections, tendon ruptures, loss of digital motion, radial sensory nerve injuries, or secondary procedures (i.e., implant removal).

**Discussion**

Bridging external fixation of distal radial fractures has been part of the surgeon’s armamentarium far longer than have locked plates. External fixation continues to be employed by many surgeons as a familiar technique requiring minimal exposure. External fixation is used to maintain axial length while reduction is attained by manipulation of fracture fragments with supplemental Kirschner wires and ligamentotaxis in intra-articular and extra-articular fracture patterns. However, external fixation alone is limited by the inability to directly reduce intra-articular fracture fragments in complex unstable fracture patterns.

The advantages of open reduction and internal fixation include direct visualization and manipulation of the fracture fragments. Multiple studies have demonstrated good clinical results with various plates, including dorsal, volar, and fragment-specific devices. Of these, locked volar plates have grown in popularity, but there have been few evidence-based trials comparing these techniques.

Several randomized studies comparing external and internal fixation of distal radial fractures have been limited by the use of first-generation implants or by the absence of well-validated outcome measures. Other studies supporting the use of volar plates have largely been observational or retrospective. To our knowledge, this is the first prospective randomized clinical trial of the use of a radial column plate as an independent means of fixation of complex distal radial fractures.

We showed that, compared with both external fixation and use of a radial column plate, fixation with a locked volar plate led to a more rapid improvement in subjective function. This advantage over external fixation was evident at the six-week time point, which may not be relevant because of the delay in initiating therapy when a spanning external fixator is in place. By three months, the patients with a volar plate not only had a higher level of subjective function than the patients treated with the other two techniques, but they also had a mean DASH score comparable with normative values. By six months, all three surgical groups demonstrated excellent subjective functional scores, and at one year, the patients in the volar plate group had significantly better subjective function only when compared with those treated with a radial column plate. Thus, the patients who had been treated with a volar plate had the distinct advantage of achieving normal subjective function three months earlier than the patients who had been managed with either external fixation or a radial column plate.
This study also shows that fixation with a radial column plate is a viable option that produces excellent subjective and objective clinical outcomes that are no different from those obtained with external fixation. At the time of final follow-up, the patients with a radial column plate demonstrated significantly better maintenance of radial inclination and radial length. The change in mean volar tilt demonstrated a slightly increased amount of dorsal collapse at one year, but the values were not significantly different from those in the other groups and all patients demonstrated excellent DASH scores and range-of-motion measurements.

We also found that a significantly better DASH score does not correlate directly with better grip strength. Specifically, at six months, although no difference in the DASH scores was found, the patients who had received external fixation had a significantly higher mean percentage of contralateral grip strength (75% ± 21%) than those with a radial column plate (53% ± 9%) (p = 0.042). Conversely, no significant differences in grip strength were found at one year, despite a significantly better DASH score in the volar plate group. Our results are similar to those of several other comparative studies of distal radial fractures, which demonstrated better grip strength in the external fixation group. For example, Kreder et al. also found a significantly better mean grip strength in the internal fixation group at six months, no difference at one year, and no significant difference in patient-rated outcomes at either time period. Thus, these data suggest that grip strength may not contribute substantially to the patient's perception of function as measured by the DASH questionnaire. Although grip strength after closed treatment of distal radial fractures has been shown to be a significant predictor of the scores on another subjective outcome questionnaire, the Patient-Rated Wrist Evaluation, additional investigations are necessary to delineate the true relationship between grip strength and the scores on the DASH questionnaire in this patient population.

We discovered significant differences in lateral pinch strength that paralleled differences in the DASH scores. Both at three months and at one year, the lateral pinch strength in the volar plate group was significantly higher than that in the radial column plate group (p = 0.042 and p = 0.036, respectively). This finding suggests that lateral pinch strength may be an important predictor of patient perceived function, especially in the setting of internal fixation with a radial column plate. The lower lateral pinch strength in the radial column plate group may reflect the surgical exposure of the first dorsal compartment tendons. However, no patients reported pain over that area. As this is the first comparative trial of radial column and volar plates, to our knowledge, we believe that lateral pinch strength deserves further exploration in future trials as it may serve as a sensitive predictor of perceived function when plate fixation of the radial column is involved.

This study had several limitations. First, we enrolled the number of patients that we believed necessary to detect a difference in our primary outcome measure, the DASH score. Our study was not powered to detect differences in our secondary outcomes, such as mobility or pain. Such differences may exist, and our results should be confirmed by future randomized trials to further identify factors contributing to the differences that we found in functional outcome. Moreover, we randomized patients in two phases, resulting in three treatment groups of unequal numbers of wrists. Randomization in a single phase should be considered to distribute patients equally across treatment groups. Another limitation of this study was our difficulty with maintaining patient follow-up despite vigorous attempts to do so. However, our follow-up rates were comparable with that in another randomized study involving distal radial fractures. Also, our primary objective in conducting this study was to compare functional outcomes using the DASH questionnaire. Multiple authors have noted the durability of function after one year, irrespective of long-term changes such as radiocarpal arthritis, strongly suggesting that longer follow-up is unnecessary in this patient population. Nonetheless, a comparative trial with longer follow-up would allow evaluation of potential long-term sequelae, such as the development of arthritis.

We believe that the subjective short-term advantage of the use of a locked volar plate is robust and applicable to the treatment of unstable distal radial fractures. The selection of implants and their application for any given fracture is based on the surgeon's experience, an assessment of the fracture pattern, the characteristics of the patient, and common sense. We also acknowledge that certain fractures may require both a primary fixation implant and a secondary implant to stabilize a displaced articular facet.

In conclusion, this study provides new evidence supporting the trend toward fixation of distal radial fractures with locked volar plates. Although function was no different at six months, the patients who received a locked volar plate for the treatment of a distal radial fracture recovered more quickly than did the patients in the other two treatment arms. This evidence indicates that locked volar plates may be advantageous for a patient who desires an accelerated return of function; however, all three techniques can provide good subjective and objective functional outcomes at one year.

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