Decoding a Decade: Evolution in Distal Radius Fracture Techniques from Past to Present, Embracing the EFCR Method

Natasha G. Dark, BS[1*], Ahmed Sami Raihane, BS[1*], Laurie G. Wells, PhD[2]; Deana Mercer, MD[2]

[1]The University of New Mexico School of Medicine, Albuquerque, New Mexico
[2]The University of New Mexico Department of Orthopaedics & Rehabilitation, Albuquerque, New Mexico
*Co-First Authors

Corresponding Author Natasha G. Dark, BS. The University of New Mexico School of Medicine. 1 University New Mexico, MSC10 5600, Albuquerque, NM 87131 (email: ngdark@salud.unm.edu).

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ABSTRACT

Background: Commonly occurring in daily activities, distal radius fractures (DRF) traditionally involve immobilization. With an increasing risk in elderly populations, surgical advancements like volar-locking plates challenge conventional methods. Distinguished orthopaedic surgeon, Dr. Deana Mercer, demonstrates expertise in the extended flexor carpi radialis (ECFR) approach, aiming to mitigate surgical complications and improve DRF treatment outcomes.

Methods: Institutional Review Board approval permitted a retrospective chart review of 815 adult patients aged 18 to 58 who underwent open reduction and internal fixation for DRF by Dr. Deana Mercer between November 2011 and November 2023. Patients were identified using current procedural terminology codes, with exclusions for children, incarcerated individuals, patients who were pregnant at the time of injury, and those lacking suitable radiographs or presenting with excluded injuries (eg, Type III fractures). Picture archiving and communication system medical imaging software measured parameters on injury and surgery dates, while operative details were extracted from records.

Medical students underwent training in medical techniques to ensure consistency for intra-rater and inter-rater reliability analyses. Measurements were compared to standard values, and a paired t-test assessed differences in radiographic measurements.

Results: Comparison of EFCR and non-EFCR groups (n=593) revealed no significant preoperative differences in radial incline (P = 0.39), radial height (P = 0.60), or volar tilt (P = 0.67). Postoperative surgical intervention analysis showed a statistically significant improvement in volar tilt in the EFCR group (P = 0.01), with a mean increase to 8.69° (SD = 8.11). In contrast, the non-EFCR group showed an increase of 6.35° (SD = 8.67).

Conclusion: These results demonstrate the efficacy of the EFCR approach in addressing volar tilt postoperatively, suggesting potential superiority over conventional methods in optimizing radiographic outcomes for patients with DRF.

Keywords: Distal Radius Fracture; Forearm; Trauma

INTRODUCTION

Humans are vulnerable to various injuries and fractures in daily activities, with distal radial fractures (DRF) being particularly prevalent. Regardless of the cause—trauma, accidents, or other circumstances—prompt treatment is crucial. Traditionally, immobilization is the primary orthopaedic intervention before further treatment.[1]

Research traces distal radius fractures back 5,000 years to ancient Egypt, documented in the "Edwin Smith Papyrus."[2] Studies suggest that the shift to ambulation without assistance has increased the risk of DRF, particularly in the older population, which has an elevated susceptibility to falls and injuries in athletics. Surgical approaches have significantly altered the landscape, challenging the traditional use of splinting for fractures.[3]

In the past few decades, operative techniques have become pivotal in treating DRF injuries. In the 1970s, Kapandji introduced percutaneous pinning with intrafocal pinning, eliminating the need for surgical incisions.[4] In the 1980s, external fixators and internal fixation emerged, marking a historical shift in steel types from stainless steel to lighter titanium alloys.[5-8] It is well established that while external fixators are commonly used for temporary fixation, internal fixators are generally preferred for long-term treatment.

Rapid advancements in treatment have raised questions about the best approach for DRF injuries. Some advocate for nonoperative treatment, including reduction and cast immobilization, due to complication rates as high as 27.0%.[9] Research suggests that DRF may lead to a loss of volar tilt, with a normal tilt ranging from 7° to 15°. A tilt of 20° or more indicates unstable fractures, while a tilt of 25° or more is associated with dorsal intercalated segment instability (DISI).[10]

Unfortunately, few studies explore surgeons' skill sets, reflecting the rapid progression in this field. Thus, this article examines advancements in volar-locking plates, which are commonly used for open reduction and internal fixation of DRF. One notable advancement is the use of the extended flexor carpi radialis (EFCR) approach in treating DRF. A 2023 study by Orbay et al[11] presented compelling evidence that the EFCR approach not only facilitates effective management of DRF injuries, but also enhances surgical access for reduction and implant application.[12]

To highlight experts in this rapidly developing field, the authors introduce Dr. Deana Mercer, a distinguished orthopaedic surgeon specializing in shoulder, elbow, and hand microvascular surgery. With over a decade of experience, Dr. Deana Mercer is notable among women orthopaedic surgeons and is certified as an expert in orthopaedic surgery. Her impressive track record includes over 10,000 surgical hours, with more than 800 cases involving the treatment of DRF in adults.

Through a retrospective analysis of radiographs depicting DRF injuries in patients operated on by Dr. Mercer, the authors aim to highlight the potential impact of an expert surgeon's work. Additionally, the authors intend to align her findings with existing literature, emphasizing that surgical treatment of DRF using the EFCR approach may ultimately reduce the incidence of complications, ultimately benefitting the at-risk population more effectively.

METHODS

Selection of Radiographs

Institutional Review Board approval was obtained (HRP #21-477) to conduct a retrospective chart review. Using current procedural terminology codes, the authors identified patients who underwent open reduction and internal fixation for DRF performed by Dr. Deana Mercer between November 2011 and November 2023. A total of 815 adult patients, aged 18 to 58, were included in the study. Exclusion criteria included children, incarcerated individuals, and patients who were pregnant at the time of injury. Patients were also excluded if they lacked appropriate preoperative or postoperative radiographic films for measurement. Additionally, patients with injuries too severe for accurate measurement, such as complete fractures (commonly referred to as Type III fractures) or moderate-to-severe Type II fractures based on the Mason Classification, were excluded.

Medical records were reviewed to analyze the dates of injury and surgery. Picture archiving and communication system medical imaging software was then used to measure radial inclination, radial height, and palmar/volar tilt on radiographic images from both the date of injury and the date of surgery.[13] Furthermore, information on specific parameters, including patient age, tourniquet time, follow-up duration, operative time, and operative side (left or right), was extracted from the operative reports using the institution's clinical record software, PowerChart.

Observer Training

Ten medical students from The University of New Mexico School of Medicine received training in measuring radiographic parameters, either as their primary or secondary role, and were responsible for conducting all measurements. Consistency was assessed through intra-rater and inter-rater reliability analyses. Measurements obtained by medical students primarily trained by Dr. Deana Mercer were compared with those of students who were secondarily trained during the initial inter-rater agreement assessment.

Following a methodology similar to that described by Watson et al,[14] medical students repeated their measurements, which were then compared against those of both primary and secondary trainers. Any improper measurement techniques identified during this process were addressed through feedback from the principal investigator. If errors were identified during the training period prior to the study, students were required to remeasure and undergo further evaluation to ensure proper technique. This rigorous process aimed to minimize variability in image interpretation caused by both systemic and random factors.

Measurement Guidance

Medical students were responsible for measuring a total of 815 radiographs. After a detailed evaluation of each radiographic film, 593 patient radiographs were deemed suitable for further analysis. Measurements included parameters such as radial inclination (degrees), radial height (millimeters), volar tilt (degrees), and radial shift (millimeters), following the observer training protocol.

Statistics

A paired t-test was used to evaluate the statistical significance of differences between the radiographic measurements obtained in the study and the standard measurements described by O'Malley et al,[15] which represent expected outcomes during the surgical treatment of DRF. Additionally, the means of the data collected before and after the implementation of the EFCR approach were compared to identify any statistically significant differences in achieving the desired radiographic measurements.

Additional Considerations

In every operative report, the type of approach—EFCR versus non-EFCR—was explicitly stated. EFCR cases were labeled as "EFCR approach," while non-EFCR cases were described as "Henry approach, a volar approach; an incision was made over the flexor carpi radialis (FCR) tendon…through the FCR sheath," allowing for consistent classification based solely on operative documentation. In EFCR cases, the Skeletal Dynamics Geminus distal radius volar locking plate with distal locking screws and non-locking shaft screws was used uniformly. In non-EFCR cases, implant selection varied by year: Hand Innovations plates were used in 2011, Acumed plates in 2012, and Geminus plates from 2013 onward. All implants were volar locking plates. Operative time was extracted from the operative reports and reflected total surgical duration from incision to closure. Average operative time for EFCR cases was 77.07 ± 42.04 minutes, and for non-EFCR cases, 74.03 ± 36.60 minutes. A Welch's t-test comparing operative times showed no significant difference between the groups (P = 0.188).

RESULTS

A total of 123 subjects who underwent the non-EFCR approach and 468 subjects who underwent the EFCR approach were identified through chart review. In the non-EFCR group, average age was 48.13 ± 16.26. The average operative time was 74.03 ± 36.60 minutes with average tourniquet time at 250 mmHg being 47.03 ± 21.38 minutes. Average follow-up duration was 3.9 ± 6 months. In the EFCR group, average age was 52.56 ± 17.95. Average operative time was 77.07 ± 42.04 minutes with average tourniquet time at 250 mmHg being 46.07 ± 16.54 minutes. Average follow-up duration was 3.5 ± 3.6 months.

Pre-surgical measurements of the non-EFCR approach showed mean values of radial inclination (17.25 ± 6.90°), radial height (8.89 ± 3.47°), and volar tilt (-4.48 ± 16.28°), while the pre-surgical EFCR approach measurements were 16.56 ± 8.13° for radial inclination, 8.67 ± 4.37° for radial height, and -5.23 ±18.08° for volar tilt (Figure 1). Post-surgical measurements for the non-EFCR approach indicated mean values of 23.18° ± 4.33° for radial inclination, 11.76° ± 2.54° for radial height, and 6.38° ± 8.67° for volar tilt. For the EFCR approach, post-surgical mean values were 23.41° ± 4.66° for radial inclination, 11.84° ± 2.80° for radial height, and 8.69° ± 8.11° for volar tilt (Figure 2).

Statistical analysis was performed using paired t-tests to compare pre-surgical and post-surgical measurements between the EFCR and non-EFCR groups. The pre-surgical comparisons showed no statistically significant differences for radial inclination (P = 0.39), radial height (P = 0.60), or volar tilt (P = 0.67). Post-surgical comparisons revealed no significant differences for radial inclination (P = 0.62) or radial height (P = 0.79), but a significant difference was observed for volar tilt (P = 0.01).

Regarding intra-rater reliability, the intraclass correlation coefficient (ICC) for postoperative radial inclination, radial height, and volar tilt was 0.83, 0.70, and 0.83 respectively (95.0% confidence interval (CI) 0.81 – 0.86, P = 4.2e-156; 95.0% CI 0.66 – 0.74, P = 2.9e-89; 95.0% CI 0.80 – 0.85, P = 2.4e-150, respectively), indicating good to excellent reliability. Ratings of preoperative radial inclination, radial height, and volar tilt demonstrated excellent agreement with ICCs of 0.89, 0.83, and 0.87, respectively (95.0% CI 0.87 – 0.90, P = 1.6e-200; 95.0% CI 0.80 – 0.85, P = 2.4e-150; 95.0% CI 0.85 – 0.89, P = 6.5e-184, respectively).

Regarding inter-rater reliability, the ICC for post-operative radial inclination, radial height, and volar tilt was 0.505, 0.666, and 0.528 respectively (95.0% CI 0.369–0.644, P = 3.69e-23; 95.0% CI 0.562 – 0.768, P = 5.16e-64; 95.0% CI 0.411–0.657, P = 1.76e-42,

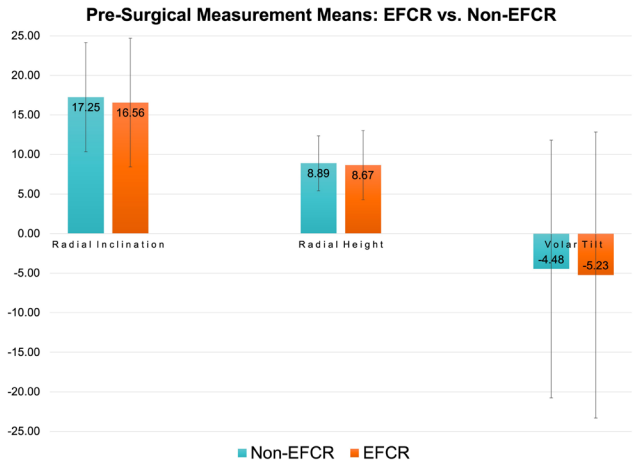

Figure 1. *Pre-surgical measurements for radial inclination, radial height, and volar tilt in the Henry and EFCR groups.*

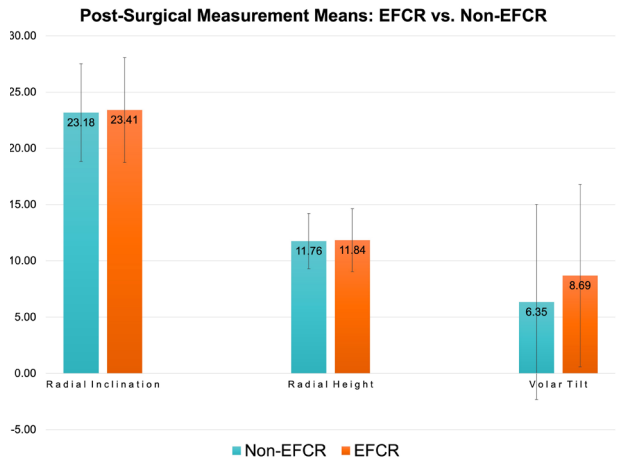

Figure 2. *Post-surgical measurements showing improvements in radial inclination, radial height, and volar tilt for both approaches, with EFCR showing greater improvement in volar tilt.*

respectively), indicating moderate reliability. Raters of preoperative volar tilt also demonstrated moderate agreement (ICC 0.610, 95.0% CI 0.501 – 0.723 *P* = 8.72e-57). Raters of preoperative radial inclination and radial height demonstrated poor agreement with ICC 0.395 and 0.396, respectively (95.0% CI 0.285 – 0.529 *P* = 4.62e-28; 95.0% CI 0.286 –0.53 *P* = 3.62e-28, respectively).

These findings suggest that both intra-rater and inter-rater reliability demonstrated moderate to excellent agreement in values of interest (ie, volar tilt), thus supporting the outcomes of this study. The ICC values were interpreted based on Koo & Li and Shrout & Fleiss, where values below 0.50 indicate poor reliability, 0.50 to 0.75 indicate moderate reliability, 0.75 to 0.90 indicate good reliability, and values above 0.90 indicate excellent reliability.[16,17]

DISCUSSION

This study provides compelling evidence to support the efficacy of the EFCR approach for surgical management of DRF. The results demonstrate a significant improvement in volar tilt in the EFCR group with a mean increase in fixation of 8.69°, compared to 6.35° in the non-EFCR group, which is closer to measurement in what is considered normal anatomy. This suggests that the EFCR approach may be more effective in restoring volar tilt postoperatively, a parameter important for ensuring optimal functional recovery and reducing the risk of long-term complications (ie, DISI). Furthermore, studies have shown that the EFCR approach significantly improves mobility compared to the traditional volar henry approach, while also being safe and effective, backing the authors' findings.[18,19]

The improvements observed in the EFCR group align with the growing body of literature suggesting that this technique offers advantages over traditional approaches.[20,21] Previous studies have shown that the EFCR approach provides better surgical access, particularly when performing carpal tunnel release, which is crucial for accurate implant placement and precise fracture reduction, especially in the absence of an assistant for manual retraction.[22] Additionally, enhanced visualization and control during the procurement may reduce risk of complications such as malunion or fixation failure, which are more common with other advanced surgical techniques.[23]

On the topic of visualization, a study by Ilyas found that volar-extensile approaches allow for carpal tunnel release and provide direct visualization and fracture reduction of the volar-ulnar corner of the distal radius, the radioulnar joint, and other areas of the joint.[24] A Brazilian study also indicated that functional assessments using the Disability Arm, Shoulder, and Hand questionnaire showed better results for radial styloid access compared to the Henry approach for daily function, although the difference was not statistically significant.[25] The literature on other metrics used to assess visualization in the EFCR approach remains sparse, which should be considered in future studies on this topic.

This study reiterates the need for further exploration of the comparative effectiveness of different surgical approaches for DRF. While the EFCR approach showed promise in this cohort, future studies with larger sample sizes, more diverse patient populations, and longer follow-up periods are critical to confirm the long-term benefits of this technique and to determine whether the radiographic improvements lead to functional changes for patients.

Finally, the high clarity in operative report language allowed for confident case classification without ambiguity, reducing misclassification bias in the comparative analysis. Although different implant manufacturers were used in early non-EFCR cases, all were volar locking plates with consistent screw configuration. Additionally, despite EFCR's more extensive exposure, operative times were statistically similar between groups, supporting the procedural efficiency of the EFCR and indicating that the choice of approach does not significantly affect operative duration.

Limitations

Several limitations should be considered when interpreting the results of this study. First, the retrospective nature of the chart review inherently limits the ability to control potentially confounding variables, such as patient demographics, fracture severity, and comorbidities, all of which may influence surgical outcomes. Although exclusion criteria were applied to remove extreme cases, unaccounted factors may still have affected the radiographic measurements. Additionally, the involvement of ten student data collectors introduced variability, particularly in the measurement of volar tilt, which is the most challenging parameter to assess using Picture Archiving and Communication Systems, especially for amateur measures at the medical student level.

Second, reliance on radiographic film interpretation introduces the potential for measurement errors, despite comprehensive observer training and reliability analyses. While intra-rater and inter-rater reliability were evaluated, human error in the measuring parameters such as radial inclination, radial height, and volar tilt, remains a possibility. Variability in measurement outcomes among data collectors further emphasizes the need for additional analysis using agreement statistics. To address this, each data collector measured each radiograph twice, with at least 25 hours between measurements to assess intra-rater reliability. Then, inter-rater reliability was evaluated by having the data collectors measure the same 60 subjects again, with the results compared to those of an orthopaedic expert to ensure that the novelty of the experience did not

interfere with the data quality. These analyses will be completed in the coming months to finalize the results.

Third, this study focused on a cohort of patients treated by a single surgeon, Dr. Deana Mercer. As a result, generalizability of these findings to other surgeons or institutions may be limited. Variations in surgical techniques, experience levels, and patient populations could lead to different outcomes. This study also did not assess long-term follow-up to evaluate the clinical significance of the improvements in volar tilt, radial height, and radial inclination achieved post-operatively. Future studies should explore whether these radiographic improvements with the EFCR approach translate into functional benefits or reduced complication rates.

Fourth, there was variability in implant manufacturer used in non-EFCR cases prior to 2013. However, all implants were volar locking plates with consistent screw types, which limits the impact of this variability on outcomes. Another limitation is the broad range of operative times, which likely reflects variation in fracture severity. While average times were similar between groups, this heterogeneity may mask subtle differences in operative complexity.

Lastly, the sample size for the Henry approach (n = 123) was smaller compared to the EFCR approach group (n = 468), which may limit the statistical power to detect differences between the two groups. Larger, multicenter studies are needed to draw more robust conclusions regarding the comparative effectiveness of these surgical approaches.

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