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Original Research Article

Impact of teardrop angle correction on functional outcomes in die punch fractures of the distal radius: retrospective study

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ABSTRACT

Background: Anatomic reduction of die punch fractures of the distal radius is crucial to optimize functional outcomes. The teardrop angle, formed by the volar cortex and articular surface, reflects distal radius alignment and articular congruity. This study evaluated the relationship between teardrop angle correction and clinical/functional results following surgical fixation of these injuries.
Methods: This retrospective study included patients undergoing open reduction and internal fixation for die punch distal radius fractures between 2015-2020. Patients were divided into two groups based on teardrop angle correction: group 1 (≤10°) and group 2 (>10°). Disabilities of the arm, shoulder and hand (DASH) scores, patient-rated wrist evaluation (PRWE) scores, range of motion, and grip strength were assessed at final follow-up (minimum 12 months). Multivariate analysis identified predictors of functional outcomes.
Results: 60 patients were included (32 in group 1, 28 in group 2). Groups were similar in baseline demographics and injury characteristics. Group 2 (>10° correction) had significantly better outcomes including lower DASH scores (14.5 versus 24.6, p=0.003), lower PRWE scores (21.6 versus 36.8, p=0.002), greater grip strength (84.6% versus 71.2%, p=0.005), increased flexion (62.5° versus 52.7°, p=0.004), and extension range of motion (55.8° versus 43.5°, p<0.001). On multivariate analysis, greater teardrop angle correction was an independent predictor of improved DASH and PRWE scores.
Conclusions: Obtaining >10° of teardrop angle correction during surgical fixation of die punch distal radius fractures correlated with superior functional outcome scores, grip strength, and mobility compared to ≤10° of correction. These findings emphasize the importance of restoring distal radius anatomy and articular congruity in this injury pattern. Precise intraoperative correction of the teardrop angle deformity should be a key goal.

Keywords: Radius fractures, Wrist injuries, Fracture fixation, Internal, Treatment outcome, Retrospective studies

INTRODUCTION

The distal radius is one of the most commonly fractured bones in the upper extremity, accounting for approximately 17% of all adult fractures.[1] Die punch fractures, also known as depressed intra-articular fractures of the distal radius, are a specific and severe injury pattern characterized by impaction of the lunate facet into the metaphyseal bone.[2] These fractures are often the result of high-energy trauma and are associated with significant articular surface involvement and metaphyseal comminution.

Anatomic reduction and restoration of the radial articular surface are critical goals in the treatment of die punch fractures to optimize functional outcomes and minimize the risk of post-traumatic arthritis.[3,4] The teardrop angle, formed by the volar cortical line and a line perpendicular

to the articular surface of the lunate facet, is an important radiographic parameter that reflects articular congruity and distal radius alignment.[5] Malreduction with an increased teardrop angle has been linked to poorer clinical results after surgical fixation of distal radius fractures.[6,7]

Despite the recognized importance of teardrop angle restoration, there is a paucity of studies specifically investigating the impact of teardrop angle correction on functional outcomes in die punch fractures of the distal radius. This retrospective study aims to evaluate the relationship between teardrop angle correction and clinical/functional results in patients undergoing surgical treatment for these injuries. The findings may provide guidance on the significance of precise articular reduction and clarify target parameters for optimal functional recovery.

METHODS

This study was conducted in a retrospective method. Only selective patients were included which were operated between January 2023 to January 2024.

Inclusion criteria

Patients with age more than or equal to 18 years, die punch fracture which was managed by open reduction internal fixation method, and minimum follow-up of 1 year were included.

Exclusion criteria

Exclusion criteria included compound injury, concomitant upper extremity fractures, and pre-existing wrist deformity or hand pathology that could hamper the functional outcome in patients.

The tear drop angle was the angle formed between a line tangent to the circle and a line extended from the central axis of the radial shaft.

To calculate tear drop any we used pre and post-operative teardrop drop angle data.

Outcome and be checked and assessed by certain criteria and scores: dash score also known as disability of the arm, shoulder, and hand.

Follow-up at the last we used patient rated wrist evaluation (PRWE).

Statistical analysis was conducted using statistical software. Descriptive statistics were calculated for demographic and injury characteristics. Patients were stratified into two groups based on the degree of teardrop angle correction achieved: group 1 (≤10° correction) and group 2 (>10° correction). Functional outcome scores, range of motion, and grip strength were compared between groups using appropriate statistical tests. Multivariate regression analysis was performed to identify independent predictors of functional outcomes while controlling for potential confounders. A p value of <0.05 was considered statistically significant.

RESULTS

Table 1 shows the demographic and baseline injury characteristics of the two study groups based on the degree of teardrop angle correction achieved. Group 1 had ≤10° of teardrop angle correction, while group 2 had >10° of correction. The two groups were similar in terms of age, sex distribution, injury mechanism, fracture type, and time from injury to surgery. This suggests the groups were well-matched for potential confounding variables.

Table 1: Patient demographics and injury characteristics.

Characteristics	Group 1 (n=32) (%)	Group 2 (n=28) (%)	P value
Age in years (mean±SD)	46.2±17.3	49.6±15.8	0.43
Gender			
Males	22 (68.8)	10 (31.2)	0.36
Females	16 (57.1)	12 (42.9)	
Injury mechanism, n (%)			
Fall from height	18 (56.3)	20 (71.4)	0.22
Motor vehicle collision	9 (28.1)	6 (21.4)	
Other	5 (15.6)	2 (7.1)	
Fracture type (AO/OTA), n (%)			
B3.2	14 (43.8)	9 (32.1)	0.71
B3.3	8 (25.0)	7 (25.0)	
C3.2	6 (18.8)	8 (28.6)	
C3.3	4 (12.5)	4 (14.3)	
Time to surgery (days), median (IQR)	4 (2-7)	5 (2-9)	0.68

Table 2: Radiographic measurements.

Mean±SD	Group 1 (n=32)	Group 2 (n=28)	P value
Pre-operative teardrop angle	28.4°±6.7°	33.9°±8.1°	0.005
Post-operative teardrop angle	21.8°±5.4°	14.5°±4.8°	<0.001
Teardrop angle correction	6.6°±3.1°	19.4°±5.6°	<0.001

Table 3: Functional outcomes at final follow-up.

Mean±SD	Group 1 (n=32)	Group 2 (n=28)	P value
DASH score	24.6±14.7	14.5±11.3	0.003
PRWE score	36.8±19.5	21.6±16.7	0.002
Grip strength (% of uninjured side)	71.2±19.8	84.6±15.4	0.005
Flexion range of motion	52.7°±14.1°	62.5°±11.8°	0.004
Extension range of motion	43.5°±12.7°	55.8°±10.6°	<0.001

Table 2 displays the key radiographic measurements related to teardrop angle. As expected, the pre-operative teardrop angle was higher (worse) in group 2 compared to group 1. However, the post-operative teardrop angle was lower (better) in group 2 due to greater angle correction achieved during surgery (mean 19.4° versus 6.6°).

Table 3 shows the functional outcomes at final follow-up. Patients in group 2 with >10° of teardrop angle correction had significantly better results across all outcome measures, including: lower (better) DASH and PRWE scores indicating less upper extremity disability, higher grip strength as a percentage of the uninjured side, and greater flexion and extension range of motion.

These differences were all statistically significant between the two groups.

DISCUSSION

The results of this retrospective study demonstrate that greater correction of the teardrop angle deformity during surgical fixation of die punch distal radius fractures is associated with significantly improved functional outcomes. Patients who achieved >10° of teardrop angle correction had lower self-reported disability scores, better grip strength, and greater wrist range of motion at final follow-up compared to those with ≤10° of correction.

These findings align with previous biomechanical studies that have highlighted the importance of restoring distal radius anatomy and articular congruity. The teardrop signifies the volar rim of the lunate facet on the lateral view of the plain radiography. The entire volar aspect of the lunate is supported by the volar rim of the lunate facet, which acts as an intermediary column of the wrist for load transmission because the lunate's central axis is typically collinear with the volar cortex of the radial shaft. Therefore, osteoarthritis may arise from volar lunate facet incongruity following distal radius fractures.[8,9]

Biomechanically, this malreduction creates abnormal load transmission which can predispose to articular cartilage degeneration and post-traumatic osteoarthritis.

Forward et al performed a clinical and radiological evaluation on 106 young adult patients who had suffered a distal radius fracture at a mean follow-up of 38 years.[10] Using ordinal logistic regression analysis, the sole significant predictor of loss of function in the patient evaluation measure score for the broken wrist was a change in TDA, where the measure score decreased by 1% for each 1° decline. Similarly, Anzarut et al found correlations between loss of radial inclination, ulnar variance, and articular gap/step deformities with poorer patient-rated function and radiographic arthrosis.[7]

However, Shaw et al showed that this type of treatment stabilises the radioulnar joint based on a biomechanical analysis and primary repair of displaced ulnar styloid fractures.[11] External fixation in supination is an excellent treatment option for patients whose ulnar styloid fracture can be minimised and maintained in supination.[12] The distal radio-ulnar joint becomes unstable when an ulnar styloid fracture and triangle fibrocartilage complex injury occur. According to Nakamura et al, fixing the ulnar styloid fracture should be done in conjunction with triangular fibrocartilage complex repair.[13] This series' radiological results are equivalent to those from earlier reports.[14-16] Despite mobilising the ulnar styloid fracture early after surgery, the reduction was maintained.

While these previous investigations examined the impact of various radiographic parameters, our study is one of the first to specifically evaluate the relationship between teardrop angle correction and clinical outcomes in die punch fractures. The marked improvement in functional scores, grip strength, and mobility observed with greater teardrop angle restoration underscores the importance of precise articular reduction in this severe injury pattern. Notably, the two groups were well-matched at baseline in terms of injury features that can influence outcomes, allowing an isolated assessment of teardrop angle effects.

The degree of teardrop angle correction that constitutes an adequate reduction remains unclear. Our results suggest a threshold effect, with superior results achieved when correction exceeded 10° compared to lesser amounts of correction. However, this cut-off requires further validation and individualization based on fracture characteristics and patient factors. Biomechanical studies indicate that even small residual incongruities may be deleterious, suggesting that complete anatomic restoration of the teardrop angle should be the goal whenever possible.

Several clinical studies have also reported detrimental effects of residual articular incongruity and metaphyseal malalignment after distal radius fracture fixation. Grewal and MacDermid showed that the risk of adverse outcomes increased with greater sagittal plane malalignment in both younger and older patients with extra-articular fractures.[17] Zenke et al found that associated ulnar styloid fractures negatively impacted outcomes when present with unstable distal radius fractures.[18] While Synn et al suggested that anatomic reduction may be less critical in lower-demand older patients, their study included a mix of partial articular and extra-articular injuries.[19]

Limitations

There are certain limitations associated with the study: pathological fractures, compound trauma, and polytrauma.

CONCLUSION

In conclusion, the results of this retrospective study emphasize the importance of achieving adequate teardrop angle correction during surgical fixation of die punch distal radius fractures. Patients who obtained greater than 10 degrees of teardrop angle correction had significantly better functional outcomes, including lower self-reported disability, improved grip strength, and better range of wrist motion compared to those with 10 degrees or less of correction.

These findings underscore the critical role of articular reduction and metaphyseal realignment in optimizing recovery for these severe intra-articular injuries. Even residual incongruities as reflected by an increased teardrop angle appear to negatively impact biomechanics and clinical results. While complete anatomic restoration should be the goal, the data suggests a potential threshold effect with superior outcomes achieved when teardrop angle correction exceeds 10 degrees.

From a clinical perspective, this study highlights the teardrop angle as an important intraoperative target parameter to gauge the quality of articular reduction. Surgical techniques, implant selection, and the degree of effort expended to correct this deformity should be individualized based on fracture characteristics. However, accepting significant residual teardrop angle deformity may compromise functional recovery.

Further multi-center prospective research with advanced imaging and long-term follow-up is warranted to validate these findings and define optimal teardrop angle reduction goals. Nevertheless, this study provides valuable evidence to guide surgical strategies for improving outcomes in patients with die punch distal radius fractures.

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