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*Original Article*

# A comparative study of CREF and ORIF with steel plates in treating unstable distal radius fracture

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**Abstract:** Objective: This study was designed to compare the efficacies of closed reduction & external fixation (CREF) and open reduction & internal fixation (ORIF) with steel plates in treating unstable distal radius fracture. Methods: In total, 107 patients with unstable distal radius fracture were retrospectively analyzed and divided into Group A (GA, n=53, ORIF with steel plates) and Group B (GB, n=54, CREF). The perioperative indices, RI, PTA and UV in postoperative periods, fracture healing time, medical expenses, wrist joint function, incidence of complications and patient satisfaction were compared between the two groups. Results: When compared with GA, GB had less intraoperative blood loss ($P<0.05$), better UV, RI and PTA at 3 months after surgery ($P<0.05$), lower medical expenses ($P<0.05$), shorter surgery time ($P<0.05$) and fracture healing time ($P<0.05$), as well as larger UV, RI and PTA at 3 d after the surgery ($P<0.05$). Significant intergroup difference was not found in the rate of wrist joint function, and the incidence of complications, which were 84.91% and 22.64% in GA, 81.48% and 22.22% in GB; nor were they found in the patient satisfaction ($P>0.05$). Conclusion: Both CREF and ORIF with steel plates are effective with unstable distal radius fracture, each having its benefits, including short surgery time and postoperative fracture healing time, small intraoperative blood loss and low medical expenses in the first case, high reduction degree and little loss of UV, RI and PTA in the second case. Whichever method is chosen can be based on the individual patients' conditions.

**Keywords:** Unstable distal radius fracture, CREF, ORIF with steel plates, efficacy comparison

## Introduction

As a common fracture type, distal radius fracture has a fracture line within 3 cm of the wrist joint, and is accompanied by injury of distal radioulnar joint and radiocarpal joint [1]. At present, the primary purpose of clinical treatment for unstable distal radius fracture is to effectively recover RI, PTA and UV [2, 3].

Previously, manual reduction & plaster fixation was usually used to treat stable distal radius fracture, and CREF or ORIF with steel plates was used for unstable distal radius fracture, although their efficacies are disputed in the clinic [4, 5]. Some scholars believe that ORIF with steel plates is ideal for unstable distal radius fracture, being characterized by firm fixation and low incidence of reduction loss [6]; while others consider that, regardless of its inferior reduction effects and incidence of reduction loss after the surgery, CREF is more advantageous than ORIF with steel plates because it is minimally invasive and destructive to the periost at the fracture site, and more effective in promoting the postoperative fracture healing [7, 8]. Therefore, this study compared the efficacies of CREF and ORIF with steel plates in treating unstable distal radius fracture, and explored their advantages and disadvantages for efficacy enhancement.

## Materials and methods

### *Materials*

In total, 107 patients with unstable distal radius fracture were retrospectively analyzed and divided into GA (n=53) treated by ORIF with steel plates, and GB (n=54) treated by CREF. (1) Inclusion criteria: informed consent was given from patients; diagnosed with unstable distal radius fracture by X-ray examination; good adherence; no other severe systematic basic diseases or skeletal deformity; fresh closed fracture; approval from the Medical Ethics Committee. (2) Exclusion criteria: low adherence; surgical contradictions; severe skin infection at the affected site; open fracture; severe combined injury or multiple injuries; bilateral distal radius fracture; pathologic fracture; or neurovascular damage.

*Methods*

Preoperative preparation: all patients were assessed for breathing rate, HR and blood pressure, as well as a basic examination; patients with abnormalities were treated symptomatically; other measures were adopted to stop pain and swelling. Surgeries were performed when patients were in good condition.

Surgical process: brachial plexus anesthesia was performed in both groups, and patients who were sensitive to pain or overstrained were given combined intravenous anesthesia. Dur ing the surgery, patients were laid horizontally with the affected limb extended. A C-arm X-ray machine was provided in advance. For patients in GA, ORIF with steel plates was performed by the palmar approach. The skin of all patients except those with obvious dorsal displacement, had a 6-8 cm palmar Henry surgical incision to separate the subcutaneous tissue and anadesma, in that order. The flexor carpi radialis was opened up to fully expose the pronator quadratus at 0.5 cm to the radial endpoint. This process was to expose the fracture line; with soft tissues and clots thoroughly cleaned, the fracture block was pried, drawn and reduced to recover the planeness of articular surface, radial length, UV, RI and PTA as far as possible. The surgical site was then properly fixed with T steel plates. During the surgery, the wrist joint was passively moved to recover its plane; in case of severe articular surface collapse, grating was performed as needed, and the articular surface was observed under a C-arm X-ray machine for recovery and the surgical site was rinsed if the articular surface recovered well. The surgical incision was sutured at the last step.

For patients in GB, CREF was performed, before which, the needle-inserting point was marked out, and the external fixation frame was selected. Surgical incisions of 1 cm were made at the dorsal distal radius, 8 cm and 3 cm to the fracture line, in order to separate the tendons thereunder and reach the bone surface where two fixation needles were inserted into the surgical incisions; another surgical incision was formed on the middle section and fundus of the dorsal radius of the second metacarpal bone, through which the extensor tendon was separated and fixation needles were inserted. Based on the injury mechanism and fracture type, the fracture block was pried with a Kirschner wire for closed reduction or manually reduced. The planeness of articular surface, radial length, UV, RI and PTA were observed through a C-arm X-ray machine. With satisfactory results, the external fixation needles were secured with a connecting rod. The surgical site was thoroughly rinsed, the larger surgical wound at the forearm was sutured, and the affected limb was dressed with pressure.

Postoperative management: the affected limb was elevated and treated to stop swelling or pain as the case maybe. Skin sensations at the innervation areas, and the pulse in the radial artery were closely monitored to avoid relevant contradictions. For patients in GA, the affected limb was dressed with pressure, and exercise of the interphalangeal joints, metacarpophalangeal joints and wrist joint were carried out according to the doctor's advice. At 3 d and 3 months after the surgery, an X-ray examination was performed to observe the recovery of UV, RI and PTA, and any possibility of early fracture block displacement. Patients in GB were subject to early metacarpophalangeal joint exercise, daily disinfection of the needle passage, X-ray examination at 3 d and 3 months after the surgery to observe the recovery of UV, RI, and PTA. The patients in both groups were followed up regularly for three months to understand the wrist joint range of movement and fracture healing.

*Observation indices*

(1) Surgery time and intraoperative blood loss were compared between the two groups. (2) RI, PTA and UV: at 3 d and 3 months after the surgery, all patients received an imaging examination. Fracture malunion is defined as |UV|>2 mm, PTA beyond 10°-15° and RI beyond 20°-25°. (3) Fracture healing time and medical expenses: Fracture healing time was compared between the two groups according to the following healing criteria [9]: no local tenderness and pain upon vertical percussion; no abnormal local movement; the fracture line is blurred in the X-ray examination, and passed by continuous poroma; with the external fixation removed, the upper extremities could lift an object of 1 kg to the shoulder and maintain this lift for several minutes; and the fracture is not deformed after 2 week observation. On the first day when those conditions are satisfied, this is defined as the clinical fracture healing date. Medical expenses were also compared. (4) Wrist joint function: after treatment, the

**Table 1.** Comparison of general data between two groups [n (%)]/($\bar{x}$±s)

| General materials | | Group A (n=53) | Group B (n=54) | $t/X^2$ | *P* |
|---|---|---|---|---|---|
| Gender(n) | Male | 23 (43.40) | 26 (48.15) | 0243 | 0.622 |
| | Female | 30 (56.60) | 28 (51.85) | | |
| Age (year) | | 49.63±1.22 | 50.02±1.18 | 1.681 | 0.096 |
| AO type fracture | | | | | |
| Type A | | 5 (9.43) | 7 (12.96) | 0.225 | 0.635 |
| Type B | | 22 (41.51) | 24 (44.44) | | |
| Type C | | 26 (49.06) | 23 (42.59) | | |
| Reasons of fracture | | | | | |
| Tumble | | 10 (18.87) | 11 (20.37) | 0.189 | 0.789 |
| Fall from heights | | 21 (39.62) | 23 (42.59) | | |
| Accidents | | 22 (41.51) | 20 (37.04) | | |

**Table 2.** Perioperative index of the two groups was compared ($\bar{x}$±s)

| Group | Intraoperative blood loss (ml) | Time of operation (min) |
|---|---|---|
| GA (n=53) | 56.12±1.28 | 82.19±1.98 |
| GB (n=54) | 30.12±0.25* | 60.12±1.28* |
| *t* | 18.562 | 20.156 |
| *P* | 0.000 | 0.000 |

Note: *P<0.05 vs GA.

Gartland and Werleywaist score [10] was used to evaluate the wrist joint function at grades of "excellent (0-2)", "good (3-8)", "moderate (9-20)" and "poor (>21)". (5) The incidence of complications was compared between the two groups. (6) Patient satisfaction: After treatment, patient satisfaction was evaluated subjectively based on medical expenses, wrist joint function and incidence of complications. With a full score of 10; patients used 8-10 to indicate their satisfaction, 5-7 to indicate their relative satisfaction, and 0-4 to indicate their dissatisfaction with the treatment.

*Statistical analysis*

Statistical analysis was performed with SPSS 22.0. In the case of numerical data expressed as Mean ± Standard Deviation, comparison studies were carried out through *t* test for data which were normally distributed, and Mann-Whitney U test for data which were not normally distributed. In case of nominal data expressed as [n (%)], comparison studies were carried out through chi-squared test for intergroup comparison. For all statistical comparisons, significance was defined as P<0.05.

## Results

*Intergroup comparison of general materials*

There were 23 (43/40%) males and 30 (56.60%) females in GA, aging between 24 and 69 years old, with mean age of (49.63±1.22). Whereas GB consisted of 26 (48.15%) males and 28 (51.85%) females, who age ranged from 25 to 70 years with a mean value of (50.02±1.18) (*P*>0.05). The numbers of patients with AO-A, AO-B and AO-C type fractures were 5, 22 and 26 in GA, 7, 24 and 23 in GB (*P*>0.05). The number of patients with fractures due to tumble, fall from heights, and accidents were 10, 21 and 22 respectively, in GA; and 11, 23, and 20 respectively in GB (*P*>0.05) (**Table 1**).

*Intergroup comparison of perioperative indices*

The intraoperative blood loss and surgery time were (56.12±1.28) ml and (82.19±1.98) min in GA, (30.12±0.25) ml and (60.12±1.28) min in GB (P<0.05) (**Table 2**).

*Intergroup comparison of reduction at 3 d after the surgery*

According to the X-ray examination results at 3 d after the surgery, the UV, RI and PTA were (1.92±0.28) mm, (22.86±1.35)° and (13.68±0.88)° in GA; and (1.12±0.22) mm, (18.12±1.52)° and (10.02±0.22)° in GB (P< 0.05) (**Table 3**).

*Intergroup comparison of loss at 3 months after the surgery*

According to the X-ray examination results at 3 months after the surgery, the values for UV, RI and PT were (0.48±0.12) mm, (1.52±0.25)° and (1.61±0.12)° respectively, for GA; and (0.78±0.28) mm, (1.95±0.68)° and (1.92±0.28)° respectively, for GB (*P*<0.05).

**Table 3.** Intergroup comparison of reduction at 3 d after the surgery ($\bar{x}\pm s$)

| Group | UV (mm) | RI (°) | PTA (°) |
|---|---|---|---|
| GA (n=53) | 1.92±0.28* | 22.86±1.35* | 13.68±0.88* |
| GB (n=54) | 1.12±0.22 | 18.12±1.52 | 10.02±0.22 |
| *t* | 16.450 | 17.044 | 29.636 |
| *P* | 0.000 | 0.000 | 0.000 |

Note: *P<0.05 vs GB.

**Table 4.** Comparison of the perioperative index between the group ($\bar{x}\pm s$)

| Group | Fracture healing time (w) | Treatment expense (10000 yuan) |
|---|---|---|
| GA (n=53) | 11.35±0.96 | 2.15±0.18 |
| GB (n=54) | 8.16±0.18* | 1.61±0.22* |
| *t* | 20.158 | 6.528 |
| *P* | 0.000 | 0.000 |

Note: *P<0.05 vs GA.

**Table 5.** Comparison the excellent and good rate between the group (%)

| Group | *N* | Excellent | Groud | Central | Difference | excellent and good rate (%) |
|---|---|---|---|---|---|---|
| GA | 53 | 25 | 20 | 5 | 3 | 84.91 |
| GB | 54 | 27 | 17 | 6 | 4 | 81.48 |
| *t* | | | | | | 0.528 |
| *P* | | | | | | 0.996 |

*Intergroup comparison of fracture healing time and medical expenses*

The fracture healing time was (11.35±0.96) w for GA and (8.16±0.18) months for GB (*P*<0.05). The medical expenses in the unit of RMB 10,000 were (2.15±0.18) for GA and (1.61±0.22) for GB (*P*<0.05) (**Table 4**).

*Intergroup comparison of wrist joint function*

Patients with excellent, good, moderate and poor wrist joint function were 25, 20, 5 and 3 respectively in GA (excellent and good rate of 84.91%); and 27, 17, 6, and 4 respectively in GB (excellent and good rate of 81.48%) (*P*> 0.05) (**Table 5**).

*Intergroup comparison of complications*

The cases of complex local pain, fracture repositioning, carpal tunnel syndrome, osteoporosis, traumatic arthritis, and malunion reported in GA were 2, 1, 3, 3, 2 and 1 respectively (22.64%); and 3, 1, 2, 3, 1, and 2 respectively in GB (22.22%) (*P*>0.05) (**Table 6**).

*Intergroup comparison of patient satisfaction*

The score reflecting patient satisfaction was (8.15±0.25) for GA; and (8.13±0.29) for GB (*P*>0.05) (**Table 7**).

## Discussion

Distal radius fractures are very common in clinical practice. This type of fracture not only affects the radius, but it also affects about 1/2 of patients with ulnar styloid avulsion fractures [11, 12]. External fixation and internal fixation are two commonly adopted methods to treat unstable distal radius fracture. Internal fixation, also known as ORIF with steel plates, may be performed by either the dorsal approach, or the palmar approach which is more favored [13, 14]. External fixation refers to the use of ligament repair and traction to maintain the fracture stability, and is divided into non-over-articular external fixation and over-articular external fixation [15].

ORIF can be treated with anatomical reduction under direct vision, and the internal fixation is strong and can effectively maintain the reduction effect [16]. The new universal locking double-column compression plate can provide locking screws from different angles, and the ulnar radial screws have a good supporting effect, which can reduce the risk of fracture redisplacement [17, 18]. However, this surgical method also has some drawbacks. The blood supply at the broken end of the fracture is easily damaged, thus affecting the fracture healing effect. The amount of intraoperative blood loss is large, the operation time is long, and it will bring certain surgical trauma to the patient, the risk of infection of the surgical incision is large, and it may be necessary to perform a second operation to remove the internal fixation [19].

The soft tissue around the wrist joint is thin and the potential tissue gap is small. After the inter-

**Table 6.** Comparison of the complications between the two groups

| Group | *N* | C1 | C2 | C3 | C4 | C5 | C6 | The total incidence (%) |
|---|---|---|---|---|---|---|---|---|
| GA | 53 | 2 | 1 | 3 | 3 | 2 | 1 | 22.64 |
| GB | 54 | 3 | 1 | 2 | 3 | 1 | 2 | 22.22 |
| *t* | | | | | | | | 0.118 |
| *P* | | | | | | | | 0.528 |

Note: C1: complex local pain, C2: fracture reposition, C3: carpal tunnel syndrome, C4: osteoporosis, C5: traumatic arthritis, C6: malunion.

**Table 7.** Intergroup comparison of patient satisfaction ($\bar{x}$±s, score)

| Group | Patient satisfaction |
|---|---|
| GA (n=53) | 8.15±0.25 |
| GB (n=54) | 8.13±0.29 |
| *t* | 0.382 |
| *P* | 0.703 |

nal fixation material is put in, it may cause a series of complications such as carpal tunnel syndrome with secondary tendon injury [20, 21]. The advantage of CREF is that it can avoid the periosteum damage and cause less damage to the surrounding tissues [22]. But the surgery has some limitations as well. When the patient is combined with severe soft tissue injury, the skin is prone to necrosis. If edema is present, the difficulty of wound closure will also be increased [23]. The fixed needle is connected outside, and the position of the needle passage may have a high risk of infection. Insufficient soft tissue tension after surgery increases the risk of re-displacement of the fracture [24]. The results of this study show that, the two groups demonstrated no significant difference in the excellent and good rate of wrist joint function, incidence of complications and patient satisfaction ($P$>0.05), indicating their similar efficacy. Compared with GA, GB had less intraoperative blood loss, shorter surgery time and fracture healing time, as well as lower medical expenses, revealing the advantages of CREF. The underlying reason may be that CREF minimized the damage to the blood circulation around the fracture site and soft tissues, and required fewer supplies during the surgery [25]. The larger UV, RI and PTA at 3 d after the surgery with less loss in UV, RI and PTA at 3 months after the surgery in GB indicated that compared with CREF, ORIF with steel plates was more powerful, and guaranteed higher reduction degree, small loss and low incidence of displacement. In the mode of CREF, an external fixation frame is used to secure the soft tissues around the fracture block rather than to itself. Therefore, as the swelling of soft tissue subsides, the tension of surrounding tissues reduces significantly, resulting in a high possibility of loss of radial height, RI and PTA [26].

In conclusion, both CREF and ORIF can effectively treat unstable distal radius fractures, with their respective advantages and disadvantages. CREF features short surgery time and postoperative fracture healing time, small intraoperative blood loss, and low medical expenses; while the advantages of ORIF with steel plates are high reduction degree and small loss. The choice can be made according to the individual patients' conditions.

However, this study is limited in the number of samples and representativeness of results. Future studies shall be based on larger sample scale and coverage, and longer duration.

## Disclosure of conflict of interest

None.

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