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Original Article

Is the preoperative closed reduction irreplaceable for distal radius fracture surgical treatment? - A retrospective clinical study

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Abstract: Patients for all classifications of fresh distal radius fracture (DRF) routinely receive closed reduction combined with plaster immobilization at first. However, among these, some patients with serious communicated fractures asked for being treated surgically directly without prior closed reduction in clinical practice. Currently, the potential effect of preoperative closed reduction on therapeutic effects of surgical treatment has remained unclear. The purpose of the retrospective clinical study was to identify the potential effect of the preoperative closed reduction on therapeutic effects of surgical treatment for fresh (DRF). 128 patients with DRF were divided into two groups, with 70 patients receiving closed reduction combined with plaster immobilization before operation, and the other 58 patients being treated only with plaster or brace immobilization for temporary external fixation. These two groups of DRF cases were compared in operative time, postoperative functional examination results (wrist pain, the range of wrist motion, grip strength and wrist function questionnaire) and radiograph examination results (dorsal radial tilt, radial inclination, radial shortening and articular step off) at different time points as well as the final radiograph examination at 12 months. There were no differences in the demographic characteristics or fracture severity between groups. No significant difference was found between the two groups in the operation time and the rate of complications, but from the means, Closed reduction group (65±7.6) were shorter than the no closed reduction group (77±5.7). There was no significant difference between the two groups for the pain level, the mean ranges of motion, grip strength and DASH score at all time points. The two groups' dorsal radial tilt, radial inclination, radial shortening and articular step off also had no significance at the time of the last follow-up. Preoperative closed reduction and plaster immobilization techniques did not convey improvement of surgical results for the fresh fractures of the distal radius with volar palmar plates. But operation may cost the patients less time in the closed reduction and plaster immobilization group.

Keywords: Distal radius fracture, closed reduction, plaster immobilization, retrospective, trial

Introduction

Distal radius fracture (DRF) is one of the most common types of emergency fractures and accounts for approximately 17% of all skeletal fractures [1]. Although the principle for the management for DRFs seems simple (to move and maintain the broken pieces into positions to restore function), the treatment strategies are actually quite variable. Depending on the classification of the fracture, individual condition of the patient and personal preference of the doctor, they include non-surgical treatment (e.g. closed reduction, casting, and so on) and surgical treatment (open reduction, internal fixation, and so on). Basically, for the patients with fresh DRF, closed reduction and plaster immobilization are usually performed in the emergency departments. Following a radiograph examination, the patients who are observed to fail to achieve the reduction standard (as guided by 2011 American Academy of Orthopedic Surgeons (AAOS) and/or meet the operation criteria are admitted to in-patient services for subsequent surgical treatments [2]. However, in recent years, the percentage of DRF patients

Table 1. General characteristics of the patients between the two groups

	Close reduction group	Non-close reduction group	*P* value
Number of patients	70	58	-
Average age (years)	46.1	43.3	0.15
Male/female	46/24	38/20	0.79
Injured side (right/left)	24/46	18/40	0.77
Fracture classification (A/B/C)	18/26/26	16/18/24	0.31
Average time from injury to surgery (days)	3.3	2.9	0.84
Operative time (minutes)	65±7.6	77±5.7	0.09
Follow-up time points	1, 2, 6 weeks; 6 and 12 months	1, 2, 6 weeks; 6 and 12 months	-

who are treated surgically has significantly increased due to the introduction of volar locking plates which have been confirmed to have benefits and have rapidly gained an increased popularity, and non-surgical treatments have been shown to frequently delay the patient's rehabilitation and functional recovery [3, 4]. Meanwhile, due to the common risk of failed induction and the patient's unwillingness for early weight-bearing exercises, surgical treatment is required to be conducted directly to some of these patients.

Past and present research has demonstrated that a number of factors determine the healing outcome of the surgical treatment for DRFs, such as patient age, fracture classification, osteoporosis, method of treatment, exercise and so on [5-7]. Simultaneously, past work has also analyzed possible relevant factors for potential complications in managing DFRs including soft-tissue complications, neurovascular complications, osseous complications, complex regional pain syndrome and infection [8, 9]. However, as another potential factor that may influence the surgical therapeutic outcome, closed reduction has so far not been considered as the primary preoperative treatment under the circumstances and some patients are only treated by external fixation with casting or other plaster immobilization as a temporary fixation before the operation. Currently, there is not sufficient evidence to conclude whether closed reduction is irreplaceable or not in preoperative therapy and whether closed reduction combined with plaster immobilization technique is superior to plaster immobilization alone for fresh DRFs. The current retrospective clinical study to compare efficacy and safety between preoperative plaster immobilization with/without closed reduction for DRFs.

Materials and methods

Patients

128 DRF patients (84 males and 44 females; 21-76 years old with the average age of 44.7 years old) (**Table 1**), who received surgical treatment at Tong Ji Hospital affiliated Tong Ji University (Shanghai, China) during September 2011 to April 2013, were screened for entry into the current study. Patients were excluded from the study when they had multiple injuries such as skin wound, shin bumps, nerve and vascular injuries. According to the Orthopedic Trauma Association (AO/OTA) fracture classification scheme, these DRF patients were classified from 23A-2 to 23C-3. Each patient had a computer tomography (CT) scan for evaluation and was found to meet operation indications: articular step-off >1-2 mm, instability due to the presence of dorsal angulation >20°, radial inclination angle <15°, longitude of distal radius shortening >5 mm, or dorsal comminution >50% [10].

Measurement

For each patient, open reduction and internal fixation (ORIF) with the volar locking palmar plates (Deputy company) was performed by the same surgical team. During the waiting period for operation, the feeling and blood supply of fingers were observed carefully. The mean time from injury to surgery was 3.1 days (range 0.6-19 days). All the patients underwent supervised physiotherapy. Following the removal of plaster splint at week 2 postoperatively, the patients were encouraged to recover their forearm rotation and finger motion with physiotherapy guidance. By 6 weeks postoperatively when activity levels fully recovered to pre-injury stage levels, maximum range of movement was permitted.

Table 2. Functional examination outcomes during the fellow-up periods

Outcome	Time point	Close reduction group	Non-close reduction group	*P* value
Wrist pain level (VAS)	1 week	6.3±1.4	6.6±0.5	0.43
	2 week	5.4±0.9	5.7±0.7	0.84
	6 week	3.3±0.4	3.1±1.1	0.87
	3 month	2.3±1.6	1.9±0.8	0.57
	12 month	1.1±1.4	0.9±1.2	0.62
Forearm range of motion [^{0} for extension/ flexion (% opposite uninjured side)]	1 week	46±8.0 (40.1)	46±18 (38.9)	0.92
	2 week	55±11 (47.2)	59±13 (49.3)	0.30
	6 week	85±15 (73.3)	89±12 (74.6)	0.57
	3 month	98±12 (84.9)	101±10 (85.1)	0.46
	12 month	106±13 (92.1)	108±17 (90.8)	0.59
Forearm range of motion [^{0} for pronation/ supination (% opposite uninjured side)]	1 week	109±15 (65.1)	106±7.0 (63.7)	0.57
	2 week	141±12 (84.2)	145±16 (86,7)	0.49
	6 week	152±9.0 (91.0)	153±14 (91.7)	0.87
	3 month	158±13 (94.6)	155±18 (93.7)	0.69
	12 month	166±7.0 (99.4)	165±1.8 (98.9)	0.96
Grip strength [kg (% opposite uninjured side)]	1 week	7.83±4.9 (36.6)	8.0±3.6 (37.5)	0.64
	2 week	9.0±5.5 (42.1)	9.3±5.2 (43.7)	0.57
	6 week	13.1±5.6 (61.4)	12.7±5.7 (59.7)	0.80
	3 month	16.8±3.8 (78.5)	17.1±3.9 (80.2)	0.78
	12 month	20.9±4.3 (97.8)	21.1±4.4 (98.9)	0.85
Wrist functional (DASH score)	1 week	-	-	-
	2 week	-	-	-
	6 week	26.3±11.1	28.4±8.8	0.24
	3 month	15.6±10.5	14.5±8.9	0.37
	12 month	9.5±9.6	8.9±11.6	0.65

However, based on the preoperative treatment received, these patients were separated into two groups, which were the closed reduction group and the non-closed reduction group, respectively (**Table 1**). For the closed reduction group patients (n=70), closed reduction combined with plaster immobilization was performed initially under local anesthesia with 1% lidocaine. The non-closed reduction group patients (n=58) were only treated with plaster or brace immobilization for temporary external fixation before operation.

The two groups were compared for operative time, complications as well as postoperative examination outcomes. A number of functional examinations and measurements were conducted and compared at 1, 2, 6 weeks, 3 and 12 months postoperatively, including wrist pain, the range of wrist motion, grip strength and wrist function (using the disability of arm-shoulder-hand or DASH questionnaire) [11]. In addition, fracture reduction was evaluated from radiograph examinations (dorsal tilt, radial inclination, radial shortening and fracture union) at the 12-month-postoperative visit and was compared between the two groups. The average postoperative follow-up period was 14.7 months (range 12.1-29.8 months).

Statistical analysis

All data were reported as mean ± SD. AD' Agostino's test of normality was used to test if the difference between the groups followed a Gaussian distribution. An unpaired t-test was used to assess difference s between two groups for all outcome measures. Significance was set at $P<0.05$.

Results

In total, there were 70 patients eligible in the closed reduction group and 58 patients in the

Table 3. Radiograph examination outcomes at 12-month-fellow-up visit

Radiographs (mean)	Close reduction group	Non-close reduction group	*P* value
Dorsal radial tilt (^{0})	-3.6±6.7	-3.4±5.0	0.78
Radial inclination (^{0})	22.3±5.3	19.8±6.5	0.82
Radial shortening (mm)	0.8±1,4	0.6±2.0	0.23
Articular step off (mm)	0.3±0.4	0.2±0.6	0.21

non-closed reduction group. The average ages of the patients were about 46 and 43 years old, respectively for the two groups, and the general characteristics of the patients were similar between the two groups. While DRFs appeared to be more predominant among the male sex and in the left hand, no statistically significant differences were noted between the two groups in age, sex, cause of injury, injured side and fracture classification (**Table 1**). Although the operative time in closed reduction group (65± 7.6 minutes) were slightly shorter than that in the non-closed reduction group (77±5.7 minutes), this difference was also not statistically significant (P=0.09) (**Table 1**).

All the patients from either group were followed up for functional recovery for at least twelve months. Functional examinations at 1, 2, 6 weeks and 3, 12 months postoperatively (wrist pain, wrist motion, grip strength and DASH questionnaire score) showed no statistically significant differences in these clinical measurements between the two groups (P>0.05) (**Table 2**).

In addition, as a comparison in radiography fracture union outcome, radiograph examinations obtained at 12-month-postoperative follow-up overall did not show significant differences between the two groups with the respects to dorsal radial tilt, radial inclination, radial shortening and articular step off (**Table 3**).

Furthermore, rates of complications after operation were also compared between the two groups. In the closed reduction group, 1 case (1.5%) got delayed wound healing which was healed after 4-week treatment; 1 case (1.5%) had a superficial infection which was cured after 10-day oral antibiotic treatment; and 1 case (1.5%) had a screw found penetrating into the dorsal radius cortex which caused extensor tenosynovitis but resolved when longer screw was removed after 6 months. Some patients in the non-closed reduction group also developed complications. One case (1.7%) got superficial wound dehiscence which was healed after 3.5-week treatment; 1 case (1.7%) was diagnosed to have median nerve neuropathy which recovered after 5-month neurotropic drug treatment; 1 case (1.7%) developed flexor tenosynovitis which was cured following the removal of the implant after 5 months. However, overall, there were no significant differences in the rates of these complications between the group, and in both groups of patients, there were no obvious inter fixations failures found such as loosening and rupture.

Discussion

Fractures of the distal aspect of the radius (DRFs) are common orthopedic injuries, which are prevalent in high-demand (for the young) and low-demand (for the old) trauma groups, respectively [12]. Patients for all classifications of fresh DRF routinely receive closed reduction combined with plaster immobilization at first. Following radiograph examinations, open reduction and internal fixation (ORIF) procedure is usually recommended for those patients who fail to achieve reduction standard and/or meet operation indications. However, in clinical practice some patients are also treated surgically directly without prior closed reduction. Currently, the potential effect of preoperative closed reduction on therapeutic effects of surgical treatment has remained unclear. In current study, through examining postoperative functional measurements and radiographs, we compared the operative time, functional recovery, bone union outcomes and complications between the two groups of DRF patients who were treated surgically with volar plate fixation but with and without prior closed reduction. In general, these comparisons have revealed no statistically significant differences between the two groups of DRF patients.

The results indicated that the average time from injury to surgery of the two groups was 3.3 days and 2.9 days, and the operative time was 65±7.6 minutes and 77±5.7 minutes, respectively, both of which had no significant differ-

ences between the groups. According to the personal experience of the corresponding author (Feng Yuan), the operative time for ORIF would be prolonged if the time from injury to surgery was longer than 12 days. Under such circumstances, the shrinking soft tissues would insert into the fracture gap, which might make the operation process more complicated and the surgeons would have to spend more time in the steps of traction and reduction.

To assess the effect of prior closed reduction on the surgical treatment outcomes in functional recovery and fracture union, a series of time course functional examinations and radiograph examination at 12-month were performed. The results obtained from each follow-up visit showed that all the patients achieved obvious functional recovery and there were no significant differences between the two groups at each visit during the whole period of follow-up. In addition, radiograph examinations (dorsal tilt, radial inclination, radial shortening and fracture union) at 12-month-postoperative follow-up also revealed satisfactory reduction and successful healing of the fracture in all patients (defined as <100 of dorsal tilt, >150 of the radial inclination <2 mm of radial shortening, and <1 mm of articular incongruity), and there were no statistically significant differences observed between the two groups. These results showed that the preoperative closed reduction does not induce a quicker recovery at any postoperative period, which indicates that preoperative reduction combined with plaster immobilization techniques did not confer any improvements in operational effectiveness in treating DRFs. Additionally, all the functional and radiograph examinations indicate that fractures were stable at 12 months postoperatively and thus no further follow ups were not necessary. Furthermore, when considering the functional and radiograph means of examinations, despite the widely-used advanced radiographic techniques, it is worth noting that the traditional and thorough functional examinations should be given more emphasis so that the slight symptoms of nerve/tendon damages or other complications (as discussed below) could be identified at early stage and the patient could achieve a better prognosis.

Although eventual healing of fracture was achieved among all the cases, low rates of complications were observed in both groups. Three minor complications occurred (4.3%) in the closed reduction group, including one case (1.5%) requiring secondary surgical procedures. In that case, ruptured extensor pollicis longus tendon was found caused by a longer distal screw which penetrated the dorsal cortex and was confirmed to have no relation with the closed reduction before operation [13]. In the non-reduction group, there were also three complications (5.2%), including one case (1.7%) which developed superficial wound dehiscence, that was similar with that in the reduction group. The second case (1.7%) received secondary surgical procedures, which was due to flexor tenosynovitis aggravated by the position of the plate on the palmar rim of the distal radius surface distal to the watershed line, which is again unrelated to the closed reduction performed preoperatively [14]. The third case (1.7%) was diagnosed with median nerve neuropathy and was cured after 5-month neurotropic drug treatment. Actually, the fracture classification in this case was 23B2 by AO/ATO classification and medial nerve was observed to be extruded to a certain extent by the proximal fracture during the operation. Thus, this medial nerve injury is also irrelevant to the prior closed reduction. Taken together, the observed complications from DRF surgical treatment are not due to the performance of closed reduction preoperatively.

In addition, from the current work and previous studies, there is also no sufficient evidence to support that the preoperative closed reduction combined with plaster immobilization technique provides better therapeutic effects for surgical treatment of DRFs. However, closed reduction is still regarded as an effective treatment for the fresh fractures of the distal radius. It is noteworthy to mention that the preoperative closed reduction must be conducted as soon as possible for the DRF patients with shin wound, skin bump and/or obvious deformity, nerve and vascular injuries caused by fracture fragments.

As for potential study limitations, while the sample size of approximately 60 patients per group was calculated with a confidence level of 95% and a margin of error of 5%, the current sample size is considered as the primary limitation in current study. Prospective clinical studies with larger sample sizes should be performed in the future to provide more definitive conclusions.

In summary, it is suggested that preoperative closed reduction for the fresh DRFs could not significantly affect their eventual recoveries following standard surgical treatment. The results from current study will be useful for further understanding of the therapeutic effects or usefulness of preoperative closed reduction and for potential development of therapeutic strategies for fresh fractures of distal radius in clinical practice.

Disclosure of conflict of interest

None.

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