Original Articles

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Differentiated approach to repair of displaced distal radial metaepiphyseal fractures

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Introduction Distal radial metaepiphysis (DRME) with the respecting joints and soft-tissue envelope is responsible for most important motions of orientation and stabilization of radiocarpal joint (RCJ), hand and forearm. **Objective** To assess techniques, terms and results of displaced DRME fractures. **Material and methods** Retrospective study included 85 patients more than 18 years of age who were treated for displaced DRME fractures between 2012 and 2015. Surgical treatment was performed for 36 (42.4 %) patients and 49 (57.6 %) patients were treated conservatively. **Results** Conservative treatment was used 1.8 times more for AO/ASIF type A fractures and 2.2 times less for AO/ASIF type C fractures. Complications rates were significantly 1.7 times less with surgical treatment as compared to conservative methods (χ^2 = 4.14; df = 1; p = 0.041). The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire and Mayo Wrist Score were used to assess long-term outcomes of 2 to 4 years. According to Mayo Wrist Score there were 52 (61.2 %) excellent (90-100 points), 17 (20 %) good (80-90 points) and 14 (16.5 %) fair (60–80 points) results with mean DASH score of 2.7, 11.9 and 26.1, respectively. Two (2.6 %) patients had poor outcomes (with less than 60 points) with mean DASH score of 44.25. **Discussion** Radiological signs of fracture instability and differentiated approach to conservative and surgical treatments are essential to prevent complications in repair of DRME.
Keywords: radius, distal metaepiphysis, displaced fracture, conservative treatment, operative treatment

INTRODUCTION

Distal radial metaepiphysis (DRME) with the respecting joints and soft-tissue envelope is responsible for most important motions of orientation and stabilization of radiocarpal joint (RCJ), hand and forearm. [1, 2]. In fact, the radius is the most commonly broken bone in the arm. Data from the past years has documented a trend towards an overall increase in the prevalence of this injury [3]. Proper anatomical realignment in the distal radio-ulnar joint (DRUJ) comprising the intermediate column is the key to regaining range of motion in radiocarpal joint [4]. Non-osteoporotic patients are known to sustain an intraarticular DRUJ fracture with a high energy injury. Low-energy distal radius fractures in osteoporotic cases normally result in extra- or partially articular injury with dorsal displacement due to forced flexion.

No 'gold standard' has been established in the treatment of different patterns of DRME fractures and associated injuries of soft tissues [5]. The usage of internal fixation reaches 42 % with all types of DRME fractures at some hospitals [6]. In a meta-analysis comparing 46 articles of 1520 patients there was no evidence to support internal fixation [7]. A more advanced meta-analysis by the Cochrane Institute stated that there was insufficient evidence regarding methods of reduction, anaesthesia, conservative interventions, surgical treatment and rehabilitation [3].

Objective The purpose of the study was to assess techniques, terms and results of displaced DRME fractures.

MATERIAL AND METHODS

Retrospective study included 85 patients more than 18 years of age who were treated for displaced DRME fractures between 2012 and 2015. Surgical treatment was performed for 36 (42.4 %) patients and 49 (57.6 %) patients were treated conservatively at FSBEI JSC 'Arkhangel'skaya Regional University Hospital', FSBEI JSC 'Arkhangel'skaya E.E.Volosevich Municipal University Hospital' and trauma department of FSBEI JSC 'Arkhangel'skaya Regional Clinical Outpatient Clinic № 1'. The Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire [8] and Mayo Wrist Score were used to assess long-term outcomes of 2 to 4 years.

Quantitative data are estimated as arithmetic mean and arithmetic mean errors; nominal variables with relative frequency and 95 % confidence interval (95

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% CI). Two-tailed Student's t-test was used to evaluate differences in the mean age of patients treated by conservative or surgical methods. Chi square (χ^2) test was applied to compare application frequency of treatment techniques, patients with a negative volar tilt, dorsal inclination and complication rate. We set the significance threshold at $p < 0.05$. *Epi Info (TM) 3.5.1*software package was applied for statistical analysis. A written informed consent was obtained from all the patients.

RESULTS AND DISCUSSION

The majority of the patients were females (n = 77, 90.5 %). The mean age of patients was 56.6 ± 1.5 years (range, 18 to 86 years). Patients treated with conservative interventions were much older (60.6 ± 1.7 years) (t = 3.1; df = 68; p = 0.002) than patients who received surgical treatment (51.2 ± 2.4 года) with the difference of 9.4 years. Different forces affect the wrist at the time of injury depending on a hand position. Low-energy falls observed in 80 (94.1 %) cases resulted in either flexion or extension injuries depending on the forces applied at injury and position of the hand. High-energy trauma was not common and included falls from height (n = 2; 2.4 %) and road traffic accidents (n = 3; 3.5 %) resulting in extension fractures.

All the patients (n = 85) presented with pain, limited range of motion, swelling and deformity, and 6 (7.1 %) patients developed impaired sensitivity in fingers.

AO/ASIF [9] type A was diagnosed in 31 (36.5 %; 95 % CI: 26.2–46.7) cases, type B, in 28 (32.9 %; 95 % CI: 22.9–42.9) patients, and type C in 26 (30.6 %; 95 % CI: 20.8-40.4) cases. Conservative intervention was used for straightforward cases of DRME type A fractures (n = 22; 44.9 %; 95 % CI: 31.0–58.8), type B injuries (n = 17; 34.7 %; 95 % CI: 21.4–48.0) and type C (n = 10; 20.4 %; 95 % CI: 9.1–31.7). Surgical treatment was mostly applied for type C fractures (n = 16; 44.4 %; 95 % CI: 28.2–60.7), type B injuries (n = 11; 30.6 %; 95 % CI: 15.5–45.6) and type A (n = 9; 25.0 %; 95 % CI: 10.9–39.2). Application of conservative techniques was 1.8 times greater in straightforward cases of type A injury ($\chi^2 = 3.55$; df = 1; p = 0.05) and 2.2 times less in type C fracture ($\chi^2 = 5.65$; df = 1; p = 0.017).

The majority of the patients sustained extension fracture (n = 82; 96.5 %; 95 % CI: 92.6–100.4). Ulnar styloid fracture was observed in 53 (62.4 %; 95 % CI: 52.1–72.6) cases.

Local patients (residents of the city of Archangel'sk) (n = 61; 71.8 %) were treated at specialised trauma departments by trauma surgeons, whereas 22 (91.7 %) residents of Arkhangel'skoy Region underwent primary medical care rendered by a surgeon, and 2 (8.3 %) residents were seen by GP. The time from injury to closed manual reduction was 35 to 60 minutes in 21 (24.7 %) patients, 2 to 6 hours in 32 (37.6 %) cases, 7 to 24 hours in 9 (10.6 %) cases and 2 to 7 days in 6 (7.1 %) patients. No closed manual reduction was performed for 17 (20 %) patients at regional hospitals and the patients were referred to the hospitals of Archangel'sk. Local anaesthesia with Novokain was mostly used for manual DRME fracture reduction. Repeated closed manual reduction was produced for 9 (13.2 %) patients within the first 7 days including 2 cases under conduction anaesthesia and 7 with local anesthetics.

Anteroposterior and lateral views of radiocarpal joint were used for radiological assessment. Check-up radiographs were produced 3 to 7 days of bone reduction in 66 (91.7 %) patients, 6 cases had no radiological evaluation and 13 had no data available.

Results of closed reduction were evaluated in 64 patients. Evaluation of radioulnar angulation prior to bone reduction showed evident impression and radius inclination in 17 (26.6 %) cases, absence of radioulnar angulation in 13 (20.3 %) patients, and the rest 34 (53,1 %) had radial inclination measuring 15.2 ± 1.0º. The mean radioulnar angle measured 18.6 ± 0.5º (less than 4º of the normal angle) following bone reduction, 4 patients had no radial inclination and one patients developed negative radial inclination.

Table 1

Patterns of DRME fractures and techniques used for treatment

Technique of treatment used	AO type of DRME fractures						Total	
	A		B		C			
	abs.	%	abs.	%	abs.	%	abs.	%
Conservative	22	44.9*	17	34.7	10	20.4**	49	100.0
Surgical	9	25.0*	11	30.6	16	44.4**	36	100.0
Total	31		28		26			

Note: *, statistically significant differences at p ≤ 0,05; **, statistically significant differences at p = 0.017.

Evaluation of radiovolar angulation prior to bone reduction showed negative volar tilt and dorsal inclination measuring 28.5 ± 1.8º in 59 (92.2 %) patients, 0º in 2 cases and 23.3 ± 5.3º in 3 patients with Smith fracture. Radiological parameters were shown to considerably improve after bone reduction with radiovolar angle being positive and measuring 10.6 ± 0.7º in 27 (42.2 %) patients and 0º in 30 (46.9 %) cases. Negative volar angle persisted in 7 (10.9 %) cases with dorsal inclination measuring 24.0 ± 7.0º, but the number of the cases was 8.5 times less (χ^2 = 84.6; df = 1; p < 0.0001). Thus, early and adequate manual reduction was binding for stable displaced DRME fractures.

From the patients who underwent manual bone reduction of DRME fractures 49 (76.6 %) continued conservative treatment with plaster cast on up to 6 weeks, and 15 (23.4 %) underwent surgical treatment.

Definitive surgical treatment was produced for 36 (42.4 %) patients including 20 (55.6 %) cases of plating with 10 correcting osteotomy and 2 correcting osteotomy + bone autoplasty, 13 (36.1 %) cases of metal osteosynthesis with Kirschner wires and 3 (8.3 %) cases of extrafocal osteosynthesis. Immobilisation with plaster cast was applied for 24 (66.7 %) patients. An injury-to-surgery interval was 1 to 7 days in 11 (30.6 %) cases, 8 to 21 days in 8 (22.2 %) patients, 22 to 60 days in 12 (33.3 %) cases and more than 60 days in 5 (13.9 %) cases. The mean preoperative period was 27.5 ± 5.2 days.

Results of surgical treatment were reviewed. Preoperative radioulnar angle was negative in 12 (33.3 %) cases with expressed impression, and measured 0º in 10 (27.8 %) cases and 12.9 ± 2.0º in 13 patients. Surgical treatment resulted in reduction of a coarse displacement in all patients, and the meanradila inclination measured 21.0 ± 0.6º, whereas conservative treatment resulted in less recovery of radioulnar angle that measured 18.6 ± 0.5º with the difference of 3 degrees being statistically significant (t = 3.39; df = 69; p = 0.0011).

Preoperative volar tilt was negative and measured 25.1 ± 2.4º in 29 (80.5 %) patients, 0º in 6 (16.7 %) cases and was weak positive (up to 5º) in 1 (2.8 %) case. Surgical treatment resulted in improved radiovolar angle measuring 10.1 ± 0.6º in 27 (75.0 %) patients, 0º in 8 (22.2 %) cases and was weak negative (up to -5º) in 1 (2.8 %) case. The comparison of conservative and surgical treatments showed similar values of volar tilts. The number of patients having volar tilt improved with surgical treatment was significantly (1.8 times) greater than that improved with conservative treatment (χ2 = 9.99; df = 1; p = 0.0015). The number of patients with volar tilt improved up to 0º with surgical treatment was significantly (2.1 times) greater than that improved with conservative treatment (χ2 = 5.94; df = 1; p = 0.014).

The comparison of radiometric characteristics of the radial styloid height and ulna-radial index depending on conservative and surgical treatment is presented in Table 2.

The radial styloid height (radial articular surface height) improved in all patients due to surgical treatment and was significantly (2 times) greater than that with conservative treatment (p = 0.0002). Ulna-radial index was normal (-1.1 mm) with surgical treatment, and the radius settled below ulna to 2.5 mm with conservative treatment with the differences being significant (p = 0.0002).

Thus, radiometric parameters of the radiocarpal joints were shown to improve better after surgical treatment as compared to those achieved with conservative treatment. It is expedient to timely diagnose instability of DRME fracture and identify indications to surgical treatment to reduce malunion rate.

Complications associated with conservative treatment were observed in 41 (50.0 %) patients out of 82 including patients treated conservatively prior to surgery. Twenty (24.4 %) patients developed secondary bone displacement that required repeated closed manual reduction and surgical treatment was indicated for failures with the distal radioulnar anatomy. Stiff fingers and radiocarpal joint were noted in 16 (19.5 %) patients, 5 (6.1 %) developed neuropathy of the radial, median or ulnar nerves, and 2 (2.4 %) had pains. Complications associated with surgical treatment were observed in 10 (29.4 %) out of 34 patients including stiff fingers and radiocarpal joint in 5 (14.7 %) patients, postoperative neuropathy of the radial nerve in 2 (5.9 %) cases, pin tract inflammation in 2 (5.9 %) and metal construct related discomfort in 2 (5.9 %) patients. Complication rate with surgical treatment was significantly (1.7 times) less than that noted with conservative treatment (χ2 = 4.14; df = 1; p = 0.041).

Table 2

Anthropometric parameters of patients measured after conservative and surgical treatment

Radiometric parameters	Preoperatively	Postsurgery	Prior to reduction	Postreduction	p
Radial styloid height (mm)	5.1 ± 1.1	10 ± 0.7**	0.5	5.5 ± 1.0**	= 0.0002
Ulna-radial index	3.64 ± 0.7	-1.1 ± 0.4**	5.9 ± 1.1	2.5 ± 0.8**	= 0.0002

Long-term follow-ups of 2 to 4 years were comprehensively evaluated in 85 patients considering (1) objective findings (biomechanical measurements, range of motion, improvement in sensitivity; (2) patient-reported outcome measures for the wrist and hand using DASH questionnaire and Mayo Wrist Score. Clinical examination was produced for outpatients and objective findings and outcome measures documented. Patients were requested to complete the DASH questionnaire on their own and the score was calculated for each of the scales. Comprehensive exam took about 30 minutes.

Forearm deformity was observed in 19 (22.4 %) patients including 13 (26.5 %) treated conservatively and 6 (16.7 %) treated surgically with insignificant differences ($p < 0.05$). Pain at the fracture site was experienced by 34 (40 %) patients including 28 (32.9 %) persons who had physical activity and weather related pain and 6 (7.1 %) had pain at rest. Pain developed after surgical treatment was significantly (2.2 times) greater in 21 (58.3 %) patients as compared to that observed in 13 (26.5 %) cases treated conservatively ($\chi 2 = 5.77$; df = 1; $p = 0.016$). A Visual Analog Scale (VAS) was used to measure the intensity and frequency of pain. The mean VAS score measured 3.7 points. Patients were equally satisfied with outcomes of surgical (n = 31; 86.1 %) and conservative treatment (n = 40; 81.6 %).

Most patients had full range of motion. Supination of the distal radioulnar joint improved in 75 (88.2 %) patients showing normal values and the majority of the group were contented with outcomes (n = 70). Limited supination was observed in 10 (11.8 %) patients as compared to intact side. Excellent results (Mayo Wrist Score of 90–100 points) were obtained in 52 (61.2 %) patients with the mean DASH score of 2.7. Good results (Mayo Wrist Score of 80-90 points) were observed in 17 (20 %) cases with the mean DASH score of 11.9. Fair results (Mayo Wrist Score of 60–80 points) were noted in 14 (16.5 %) cases with the mean DASH score of 26.1. Two patients (2.6 %) had poor results (Mayo Wrist Score of less than 60 points) with the mean DASH score of 44.25. Most patients could return to their regular activities.

CONCLUSIONS

Distal radial metaepiphysis injuries are accompanied by serious complications including prolonged pain and limited function of the wrist joint and the upper extremity. Radiological signs of fracture instability and differentiated approach to conservative and surgical treatments are essential to prevent complications in fracture repair aimed at elimination of radial shortening, correction of radial inclination, volar tilt, articular surfaces of the wrist joint, stability of the distal radioulnar joint and improvement of supination that is critical to radioulnar functioning.

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