

Comminuted intra-articular distal radius fractures treated by ligamentotaxis external fixation with and without bone marrow injection to prevent late metaphyseal collapse

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Objective: To compare the radiological and functional outcomes of patients of Comminuted intra-articular distal radius fractures treated with or without bone marrow injection along with external fixator ligamentotaxis.

Methodology: This prospective comparative study on 41 patients with comminuted intra-articular lower end radius fractures distributed patients randomly into two groups depending on whether an aspirate of bone marrow was injected at the fracture site two weeks after fracture management with external fixation ligamentotaxis.

Results: The mean age was 35.8 years, with male predominance. The radiological parameters (radial height, radial inclination, and volar tilt) at the 6th month follow up were lower in the group who did not

receive a bone marrow aspirate injection but was not significant statistically. Moderate deformities developed in half of the patients who did not receive bone marrow aspiration according to Lidstrom scores modified by Sarmiento et al. The functional outcome was excellent to good in all patients who received marrow aspiration, according to the demerit system of Gartland and Werley.

Conclusion: The injection of bone marrow aspirate to the fracture site might have a potential role in the management of comminuted intra-articular lower end radius fractures treated by external fixation ligamentotaxis.

Keywords: Bone marrow injection, ligamentotaxis, distal intra-articular radius fractures.

INTRODUCTION

Distal radius fractures (DRF) are among the commonest fractures seen in the emergency department.^{1,2} They are the most common upper extremity fractures and account for 16 – 25% of these fractures.^{3,4} Increase in childhood obesity and the overall potential for individuals to live more years with comorbidities such as osteoporosis may have largely contributed to rise in prevalence.^{5,6} DRF can occur at any age; however, two most common age groups are adolescents and adults older than 50 years.⁷ Most commonly occurs as a result of a fall on the outstretched hand.^{5,8} Radius along with lateral carpus carries 80% of the load and ulna with medial carpus via triangular fibrocartilage complex (TFCC) carry 20% of the axial load.^{9,10}

When treating comminuted intra-articular lower end radius fractures, it may be favorable to consider of these structures inform of three columns: radial, intermediate and ulnar maintained by the shaft or pedestal.⁹ Several classification systems have been proposed for lower end radial fractures, like Gartland and Werley's system, Frykman, Melone, and Fernandez classifications, the

last one is more applicable classification.^{2,11} Radiographic evaluation is important in the diagnosis, classification, treatment and follow-up,^{8,12} including Radial,¹² Radial inclination,^{6,12} Ulnar variance,^{6,12} Volar tilt.⁶ Computed tomography is required when X-rays are equivocal but there is a strong suspicion of a fracture by clinical evaluation.¹³

Several factors are important in decision making in the treatment plan either conservative by cast or surgical fixations by percutaneous pinning with or without external fixation, and open reduction and internal fixation, including the preliminary injury appearances, alignment after reduction, age of the patient, bone quality, patient request and estimated outcome.^{1,2,14} We compared the functional and radiological outcomes of comminuted intra-articular lower end radius fractures treated by ligamentotaxis with and without bone marrow injection two weeks later.

METHODOLOGY

An interventional prospective analytic comparative study was carried out in the orthopedics department of

Al-Kindy Teaching Hospital, Baghdad, Iraq from August 2020 May 2021. Patients with DRF enrolled in the study were divided randomly into two groups depending on whether an aspirate of bone marrow (BM) was injected at the fracture site two weeks after fracture management with external fixation. Approvals on the study protocol were gained from the scientific and ethical committee in AL-Kindy College of Medicine and written informed consent was taken from all patients.

Skeletally mature, age between 20- 50 years, comminuted, intraarticular closed DRF with Frykman's type VII and VIII types were included in the study, while pathological fractures, pre-existing wrist or forearm deformity in the injured side, concomitant injury or deformity in the contralateral wrist, comorbid diseases that render them unfit for surgery, and bone marrow disease (e.g. myelofibrosis) were excluded from the study. A thorough history and physical examination were done on the patients, radiographic imaging in AP and lateral views were taken for the injured wrist. Fractures were reduced and initially stabilized in splints till the time of surgery. Assessment of the neurovascular compromise was carried out on all patients.

Initially, 44 patients had met the eligibility criteria and were enrolled in the study. They were divided randomly into two groups as follows: Group A consisted of patients treated by external fixation ligamentotaxis with the addition of BM aspirate at the fracture site after 2 weeks and Group B consisted of patients treated by external fixation ligamentotaxis without the addition of BM aspirate.

The patients were followed for 6 months postoperatively, unfortunately, three of them didn't show at the final follow-up, so the final study sample consisted of 41 patients, 21 patients in group A and 20 patients in group B. The surgical operation was done on all patients after a range of 1 – 5 days after the injury. A prophylaxis dose of third-generation cephalosporin was given 30 minutes before operation.

Under the effect of general anesthesia, under fluoroscopy, after longitudinal traction and manual molding of the fracture fragments to standard alignment. The external fixation device was tightened and the reduction was carefully assessed clinically and under fluoroscopy. No splint was applied. Radiographs images were taken in both AP and lateral views on postoperative day one.

Active exercises of thumbs and fingers were initiated from the day of operation. For group A patient, 10cc of BM aspirate was injected, two weeks after the operation, into the metaphyseal defect under image control. The BM was aspirated from the anterior iliac crest using a special BM aspiration needle. The procedures were done

under strict aseptic precautions and local infiltration with 2% xylocaine was done to both the aspiration and injection areas.

After 6 weeks, external fixators were removed and radiological and functional evaluations were done on all patients. Patients with no signs of the clinical union were treated with below elbow plaster cast for 2 weeks. All the patients were assessed after 3 and 6 months post-operatively, both radiologically and functionally. Radiological outcome was assessed at the final follow up visit by Lidstorm scores modified by Sarmiento et al,¹⁵ and radiological union was assessed at 3 and 6 months visits, while functional outcome was assessed at the final follow up visit by the Demerit system of Gartland and Werley.¹⁶

Statistical Analysis: The SPSS version 22 was used for the statistical analyses.

RESULTS

Out of 41 patients, 28 (68.3%) were male and 13 (31.7%) females. The ages ranged from 20 – 46 years (mean 35.8). History of falls accounted for 53.8% and motor vehicle accidents for 46.2% patients. Both groups of patients had comparable values of radiological parameters in the post-op day 0 or 1 ($p > 0.05$). However, at the 6th-month radiological assessment, these parameters were lower in the group of patients who did not receive a BM aspirate injection though these differences were not significant statistically (Table 1).

The Lidstorm scores modified by Sarmiento et al showed slight deformities developed in the highest proportion of patients who received an aspirate of BM (57.1%), while moderate deformities were developed in 50% of the patients who did not receive it (Table 2). All patients in both groups had a good range of movements, and no significant statistical differences were found between the two groups, however, slightly higher values were observed in the BM group (Table 3).

The functional outcome evaluation according to the Demerit system of Gartland and Werley at the final follow-up visit showed excellent to good results in all the patients (21/21) who received the BM injection and in 17 of 20 patients who did not (Table 4). Superficial pin tract infection developed in 10 patients, six patients (28.5%) in group A, and 4 patients (20%) in group B; it required antibiotics administration with frequent changes of dressing.

Finger stiffness was encountered in six patients which resolved with physiotherapy, three patients in each groups. Three cases of the delayed union (15%) were found in the patients treated by ligamentotaxis alone. No

cases of pin loosening, bending or breakage, median or radial nerves neuropathies were seen in our patients.

DISCUSSION

DRF is among the commonest fractures treated by orthopedic surgeons and are considered to be the most challenging ones to treat since there is no conclusive evidence for which treatment method should be used for their management.¹⁷ The use of external fixators with the concept of ligamentotaxis in the management of these fractures can offer the advantages of the relative ease of application, less surgical trauma, fracture alignment, and radial length preservation, and achieving acceptable reduction under fluoroscopy. However, with this method, the anatomical reconstruction of the articular surface is not always applicable; since it takes a longer time for the fractures' gaps to be filled by the new bone formation in addition to the event of late metaphyseal collapse.^{17,18}

For this reason, adjunctive cancellous autologous bone grafting (ABG) was used to augment the structural integrity of the bone and aid in the fracture healing process due to its osteogenic, osteoinductive, and osteoconductive properties.¹⁸ However, because of the risks inherent to cancellous autograft harvest, BM aspirate injection at the dorsal defect was proposed. Autologous BM aspiration and injection are less invasive than ABG and it has both osteogenic and osteoinductive characteristics.¹⁹ In our study, the patients' ages ranged from 20 – 46 years with a mean of 35.8 years. The male patients constituted the majority (68.3%) of them. The male predominance was also noticed in other studies whose major participants were below the age of 50 years.^{18,20-22}

Radial inclination and volar tilt are very important for maintaining patients wrist joint function because even

Table 1: Radiological parameters comparison in the two groups.

Variable		With BM	Without BM	P-value
Radial height	Post-op	9.1 ± 0.8	9.1 ± 0.7	0.96
	At 6 months	6.8 ± 1.4	4.6 ± 2.1	0.052
Radial inclination	Post-op	19.5 ± 2.3	19.1 ± 2.1	0.75
	At 6 months	17.0 ± 1.7	14.6 ± 2.1	0.053
Volar tilt	Post-op	11.5 ± 2.2	11.0 ± 2.0	0.64
	At 6 months	8.5 ± 2.2	6.1 ± 2.9	0.12

Table 2: Radiological outcome according to Lidstrom scores modified by Sarmiento et al.

Deformity	With BM	Without BM
No deformity	6 (28.6%)	3 (15.0%)
Slight deformity	12 (57.1%)	7 (35.0%)
Moderate deformity	3 (14.3%)	10 (50.0%)

Table 3: Range of movement.

Movement	With BM		Without BM		P value
	Mean	SD	Mean	SD	
Extension	58.5	8.9	51.6	7.5	0.16
Flexion	63.5	8.5	57.5	6.8	0.19
Radial deviation	16.4	3.6	14.1	3.7	0.30
Ulnar deviation	26.4	5.5	21.6	5.1	0.14
Supination	70.0	10.8	64.1	11.5	0.36
Pronation	71.4	11.8	65.0	11.8	0.34

Table 4: Functional results according to the demerit system of Gartland and Werley.

Result	With BM (n = 21)		Without BM (n = 20)	
	No.	%	No.	%
Excellent	12	57.1	7	35.0
Good	9	42.9	10	50.0
Fair	0	0	3	15.0

slight changes in radial inclination and volar tilt can result in restrictions of wrist flexion and other functions.²³ Preservation of radial height leads to good functional outcome and a height of < 6mm is considered unacceptable.²⁴ In our study, the radial height of ≥ 6 mm was maintained in 85.7% (18 of 21 patients) of the

group with the addition of BM vs. 33.3% (7 of 20 patients) of the patients without. In the study by Raji and Kini, maintaining radial height ≥ 6 mm was found in 95% of patients, which is a higher percentage than that of our study.¹⁸

The median and mean radial height, in the groups of patients treated by bridging external fixators in the studies by Talmac et al and Lui and Bai, were 4.9 mm and 5.6 mm, respectively.^{17,23} Shibu et al²⁰ compared the functional and radiological outcomes after DRF treated by BM injection and ligamentotaxis vs. ligamentotaxis alone and showed that radial height, radial inclination, and volar tilt of both groups were maintained during the period of external fixator application. However, significant reductions in the values of these parameters were observed at the 6th-month follow-up. Significant losses of reduction in the radial height, radial inclination, and volar tilt were also observed, by Lui and Bai, at the 12th-week follow-up in the patients treated by bridging external fixation.²³

Both groups of patients in this study had comparable values of radial inclination in the post-op day 0 or 1 (19.5° and 19.1°), however, at the 6th-month, these values were slightly lower in the group of patients who did not receive a BM aspirate injection (17° vs 14.6°) although it was of no statistical significance. Similar findings were observed by Shibu et al.²⁰

In the current study, volar tilt was restored in all the patients and statistically insignificant higher values were found in the patients for whom the lagamentotaxis was augmented with BM injection (8.5° vs 6.1°). Higher values were also observed in the patients who received BM injection in the study by Shibu et al (9° vs 4.5°).²⁰ The final mean of the volar tilt measurements in the study by Lui and Bai was reported to be 8.3° which is close to the measurement of our study.²³

All of our patients had a good range of wrist and forearm movements and no limitations were encountered. Both groups had comparable results. We had excellent to good functional outcomes according to the Demerit system of Gartland and Werley was found in 83.3% of the patients treated by ligamentotaxis alone, which is comparable with the results of other studies by Gowda (70%),²² Lui and Bai (83.1%),²³ and Chilakarmay et al (88.4%).²⁴

CONCLUSION

In the short-term follow up, the injection of BM aspirate in the metaphyseal defect two weeks after external fixator placement resulted in better anatomical results but statistically insignificant radiological outcomes in terms of radial height, radial inclination and volar tilt.

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