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Introducing and Prospective Efficacy Comparison of an Innovative and Affordable Technique for the Treatment of Distal Radius Fractures

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ABSTRACT

Background: There are different treatments as well as controversies surrounding the adequate treatment for Distal Radius Fractures (DRF). In the absence of enough evidence[HYPHEN]base data regarding clinical effectiveness of available treatments, cost should be considered as an essential factor in selecting the surgical technique for DRF treatment. The goal of this study is introducing an improved and modified pin[HYPHEN]and [HYPHEN]plaster (MP&P) technique as an affordable alternative for treatment of DRF. This study also assesses and compares the outcomes of DRF treatment by using the introduced method versus external fixation (EF) technique.

Methods: In this clinical cohort study, 98 patients presenting with closed DRF Types III or IV, randomly were classified into two modified P&P (50 patients) and EF (48 patients) groups and assessed for functional, clinical, radiographic and overall outcome at the time, 2, 10 and 22 months after surgery. They were also followed [HYPHEN]up for up to 3 years to determine the rate of complications.

Results: Eighty one percent of EF and 86% of MP&P group were female. The average ages in the EF and MP&P groups were 44.9 ± 12.4 and 46.1 ± 5.4, respectively. Around 70% of the patients in each group had a Type III fracture, and 30% had Type IV. The rate of complications was higher among EF group patients (seven major and seven minor complications) compared to the MP&P (only 4 minor complications), however the difference between two groups regarding the complications and treatment outcome were insignificant, except in extension ROM and the quick[HYPHEN]dash score (only in two and four months follow up visits) and also returning to work (only in two month follow up visit).

Conclusion: This study introduces a modified P&P technique that protects the transverse palmar curvature, prevents the collapse of the distal radius, and simplifies casting, thereby obviating a full arm cast and mitigating elbow stiffness in patient outcomes. This modified technique could be considered as a more cost[HYPHEN]conscious alternative to external fixation for patients with distal radius fractures.

1. Introduction

Distal radius fractures (DRF) are the most common orthopedic fractures accounting for more than 16% of all fractures.[1–3] The annual incidence in the U.S. is estimated to be 57–100 out of 10,000 among those older than 65 years of age.[4–6] The incidence of DRFs has a positive correlation with age; however the prevalence of these fractures has increased in younger population as high-energy, sports-related activities have gained popularity.[7]

Despite the high incidence of DRF and the significant time patients with these fractures spend in hand therapy, optimal management of fractures of the distal end of the radius continues to be debated among the orthopedic community.[8–10] Different surgical and non-surgical treatments has been recommended for DRF management, such as

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casting, pin-in-plaster (P&P), percutaneous pining, open-reduction and internal fixation (ORIF), external fixation (EF), and arthroscopy.[2,11,12] Despite this, DRF management remains highly controversial.[3,13–15] The American Academy of Orthopaedic Surgeons (AAOS) guideline for DRF management includes 29 recommendations based on a systematic review; however none of them were graded as "strong". Furthermore, according to the Cochran Database, there is not sufficient evidence supporting the many aspects of the treatment and management of DRF's.[14,16–18]

A major concern regarding DRF treatment is the cost to the health care system. In 2007, United States Medicare expended $170 million on management of DRFs.[15,19] It is anticipated if this rate of using expensive techniques such as internal fixation (averaging $3832 per patient) exceeds 50%, this annual expense will reach $240 million.[19–21] This places a significant economic burden on both the patient and the healthcare system. Because of this consideration, it is essential to improve and employ more affordable surgical techniques especially for developing countries, including pin-in-plaster (averaging $2791 per patient) and/or external fixation (averaging $2890 per patient).[2,13,19]

These two methods have their advantages and disadvantages. Some studies have indicated that the two methods are equally acceptable, however others have shown that EF is more advantageous than P&P.[10,22–24] Since encouraging results have been extensively reported with EF, the rate of using pins and plaster has decreased in comparison with external fixation, which is considered a particularly attractive treatment option in cases of unstable distal radial fractures.[10,22,24] A noteworthy point is EF is associated with a greater number of minor complications including radial neuritis and pin tract infections and it also has higher initial costs (compared to P&P) which is an important concern for treatment of DRF, especially in developing countries.[9,10]

This study aims to introduce a modified P&P technique with greater advantage than standard P&P, as an equally acceptable and more affordable alternative to EF.

2. Methods

2.1. Sample and recruitment

This single-center prospective study; is a randomized comparative trial that was approved by the research ethics committee and institutional review Board (IRB). All subjects were informed and consented to this study before participation. From February 2010 to August 2012, 120 patients with closed DRF Types III or IV under the Fernandez classification system who required surgical fixation were seen and treated in Akhtar hospital. Ninety eight of these patients agreed to participate and were included to this study. Surgical procedures were performed by an attending orthopedic surgeon with subspecialty interest in upper-extremity and trauma surgery. Participants were allocated to the two treatment groups: 50 patients for Modified Pins and Plaster Technique, and 50 patients for treatment by External Fixation. The groups were balanced for age, with no significant difference in age distribution. They were followed-up for 2 years. Patients with synchronic upper limb fractures, torn intercarpal ligaments, chronic disease (such as diabetes), and bilateral DRF were excluded from the study. Patients whose fractures were untreatable with closed reduction were also excluded.

2.2. Surgery techniques

The surgical techniques were used on this study, includes modified Pins and Plaster and External Fixation.

2.2.1. Modified pins and plaster technique

In this study we used a modified version of classic Pins and Plasters (Fig. 1 and Table 1). In this new technique, two pins were inserted at an angle of 20–30° from the dorsal side to the base of proximal third of second metacarpal bone. Also, two pins were inserted in the mid-shaft of radius in opposite directions, attached to both ulnar and radial cortices; one form radial side and one from dorsal to volar side of mid-shaft radius with 1 cm distance longitudinally from each other. The upper limb was hanged on Chinese finger traps (only on second to fifth fingers), by using an IV pole and a broad strap on the distal of arm with 8–10 Lbs in 90° flexion of the elbow. The ratio of length of third metacarpal bone to the length of wrist bones was measures, which had to be more than 1 (or at least 1) to prevent metacarpal and phalangeal bones stiffness in future. Then, a short arm cast was applied with incorporating thin pins (not thicker than 1.5 mm) into the cast, with a five-degree ulnar deviation. Finally, a control X-rays were obtained to verify the adequacy of the reduction. Most patients were admitted to the hospital for overnight evaluation and observation and discharged the following morning.

Fig. 1. Pins and plaster method.

2.2.2. External fixation

In this study, the standard and classic method was employed for External Fixation (Fig. 2). After, close reduction, a pair of Schanz screws were inserted in the second to third metacarpals. Also, a pair of Schanz screws was inserted in the distal to middle radius. Then, these two pairs were connected with two rods. Also, distal radius pin was used to fix the fracture a (if it was required). Finally, a control, X-rays were obtained to verify adequate reduction and pin placement. The patients were normally discharged the following day after being taught their own pin care.

2.3. Follow-up

Follow-up with patient's functional, clinical, radiographic and overall outcome measures was performed at the time, 2, 10 and 22 months after pin removal (approximately 2, 4, 10 and 22 months after the injury). At each follow-up appointment, a full examination of the

Table 1
Comparison between "Modified" Pins and Plaster and "Classis" Pins and Plaster techniques.

Modified Pins and Plaster Technique	Standard Pins and Plaster Technique
Technique Description	
- Hanging the upper limb on Chinese finger (only on second to fifth fingers), using a serum stand by a broad strap on the distal of arm with 8–10 LB in 90° flexion of the elbow; - Inserting **two** 0.75-cm pins at an angle of 20–30° from the dorsal side to the base of proximal third of **second** metacarpal bone; - Inserting **two** 1-cm Steinman pins in the mid-shaft of **radius** in opposite directions, attached to both ulnar and radial cortices**;** one form radial side and one from dorsal to volar side of mid-shaft radius with 1 cm distance longitudinally from each other; - Applying a **short** arm cast with incorporating thin pins (not thicker than 1.5 mm) into the cast: a five-degree ulnar deviation was also applied during casting.	- Reduction and traction on Chinese finger tapps under control radiographs; - Inserting **one** pin horizontally at an angle of 30–40° from the dorsal side to the base of **the second to fourth** (sometimes even the **fifth**) metacarpal bones; - Inserting **one** pin horizontally into the shaft of **ulnar** bone (un-involved bone in fracture); - Applying a **long** arm cast.
Advantage & Disadvantage	
- Inserting two pins in the proximal third of second metacarpal bone allows **protecting transverse palmar curvature;** - Inserting two 1-cm Steinman pins in the mid-shaft of radius in opposite directions allows having **more traction along radius and also mild deviation of wrist to ulnar side;** - By placing the pin in the shaft of the radius, a full arm cast is not required, which leads to **less elbow stiffness in patients;** - Having a five-degree ulnar deviation during the short arm casting allows **preventing the collapse of the radial head;** - Hanging the upper limb on Chinese finger (only on second to fifth fingers) provides **enough time to manipulate the distal radius and by C-Arm control the reduction;** - **8 weeks** casting could **reduce the further chance of late collapse of radial head.**	- Inserting one pine in the base of the second to forth metacarpal bones results in **stiffness and flattening of transverse palmar arch**; - Applying long arm cast results in **immobilization on elbow** which can cause **elbow stiffness**.

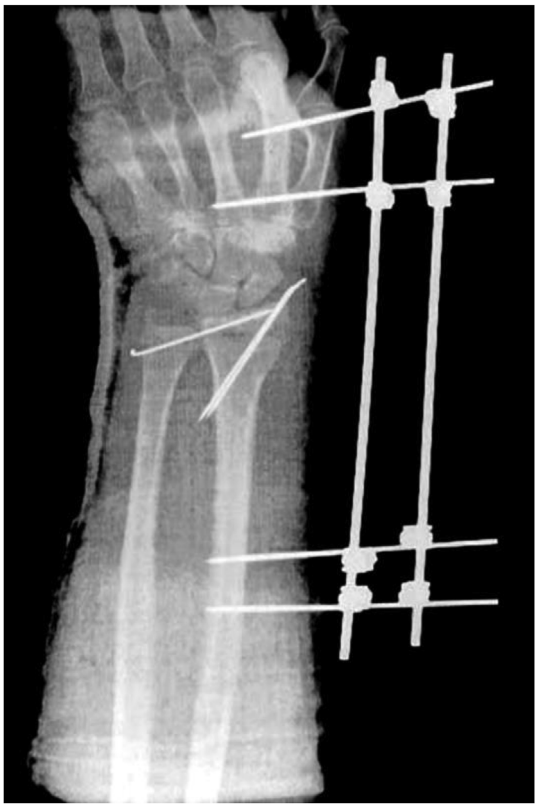

Fig. 2. External fixator method.

arm was done to assess the surgical complications such as swelling and deformity. Additionally, the hospital records were evaluated to determine the rate of complications within the first 3 years after injury.

2.3.1. Functional outcomes

Three functional outcomes were assessed in this study, including QuickDASH, Quality of life (QOL), and Return to the job and driving. The QuickDASH self-administered standardized questionnaires,[25,26] a shortened version of the Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure, was used to measure disability, which is a standardized questionnaire with eleven items to measure physical function and symptoms of the upper limb. The EuroQol-5D (EQ-5D) self-administered questionnaire[27,28] was used to measure the Quality of life, as a standardized measure of health status. The questionnaire consists of the EQ- 5D descriptive system and the EQ visual analogue scale (EQ-VAS) and it includes five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) and three levels for each dimension (no problems, some problems, and severe problems). The EQ-VAS measures the patients' self-rated health on a vertical visual analogue scale. Patients were also asked if and when they had resumed driving and, if employed, resumed working.

2.3.2. Clinical outcomes

At each visit, a complete examination of the arm was done by a surgeon, including documentation of surgical outcome, measurement of arm range of motion (ROM), and grip strength. The ROM and grip strength were measured with use of a standard goniometer and dynamometer (Jamar; Sammons Preston Rolyan, Bolingbrook, Illinois)[27,28] respectively. These values were compared with those for the uninjured, contralateral limb for each participant and expressed as a percentage of those values.

2.3.3. Radiologic outcomes

The radiographic outcomes assessment was performed using X-rays from the original injury, post-reduction, post-pin removal, and two, four, twelve and twenty four months follow-up. Distal radius parameters of palmar angle (PA), radial angle (RA), radial length (RL) were measured.[29,30]

2.3.4. Overall outcomes

Gartland and Werley's demerit point system[31,32] was employed to evaluate the end results in our 2-year follow-up patients. This criterion combines objective, subjective and radiographic results into a score that corresponds to an excellent, good, fair or poor result.

2.4. Statistical analysis

Data Pertinent information was gathered and compared between the two groups. Statistical analysis was performed with the SPSS® program (SPSS 20.0 for Windows, SPSS Inc., Chicago, IL, USA). In addition to a descriptive analysis of all variables, a statistical analysis was conducted to determine the correlates of the independent variables. At the descriptive level, the distribution and frequency of all items were examined. In the bivariate analysis, chi-square and analysis of variance were performed to examine the association between the independent and outcome variables. For evaluation of the discrete variables, the chi-square test was utilized, and for comparison of the continuous variables, a Student's t-test was implemented. P. Value < 0.05 was considered statistically significant, and all continuous variables were expressed as Mean +SD (the average standard deviation from the mean).

2.5. Sample characteristics

During a 2-year period, 98 patients with closed DRF Types III or IV under the Fernandez classification system[33,34] who were treated in Akhtar hospital with one surgeon and agreed to participate in this study. Distribution of age, gender, type and fracture patterns and follow-up duration were similar for the MP&P and EF groups (Table 2). Fifty patients were treated with modified pins and plaster technique and 50 patients with external fixation technique, however two patients from EF group were lost to follow-up, due to illness or death. External fixation treatment consisted of 18.8% men and 81.2% female and modified pins and plaster was 14% men and 86% female. The average ages in the External fixation and pins and plaster groups were 44.9 ± 12.4 and 46.1 ± 5.4, respectively. Around 70% of the patients in each group had a Type III fracture, and 30% had Type IV. The External fixation and pins and plaster groups were followed for 38 ± 8.8 and 35.4 ± 3.4 months, respectively (Table 2). The average time in the device was 7.1 weeks (range 4–11 weeks) including those patients who needed early pin removal due to complication. The randomized groups of pins and plaster treatment and external fixation treatment did not significantly differ regards to the patients' age, sex and fracture (severity, type, mechanism, classification) characteristics. In addition, these groups did not differ in delay time to surgery, time in the hospital, or the use of post-operative physical therapy.

3. Results

3.1. Functional outcomes

The QuickDASH scores were significantly higher in the Modified Pins and Plaster group than External Fixation group at 8 weeks (P. value = 0.037) and 16 weeks (P. value = 0.048) follow-up (Table 3).

Table 2
Comparison of demographic characteristics between "Modified Pins and Plasters" group and "External Fixation" group.

Characteristics		MP&P[b] (n = 50) *f (%)*	EF[a] (n = 48) *f (%)*	P-Value***
Age (years) *mean (± SD)*		46.1 ± 5.4	44.9 ± 12.4	N.S.
Gender *f (%)*	*Male*	7 (14%)	9 (18.8%)	N.S.
	Female	43 (86%)	39 (81.2%)	N.S.
Type of fracture	*III*	35 (70%)	34 (71%)	N.S.
(Fernandez	*IV*	15 (30%)	14 (29%)	N.S.
classification) *f (%)*				
Follow up duration (months) *mean (± SD)*		35.3 ± 3.4	38 ± 8.8	N.S.

***: S: Significant value ($p < 0.05$), N.S.: Not Significant value ($p \geq 0.05$).
[a] Modified Pins & Plaster.
[b] External Fixation.

There were no significant differences between the two groups in terms of the EQ-5D quality-of-life index value or health state score at any assessment time point. Significantly more patients in the MP&P group had resumed driving at the end of eight weeks (P. value = 0.041), however this did not translate to a significant difference between the two groups in terms of those returning to work by that time. By eight weeks, there were no significant differences in the proportions.

3.2. Clinical outcomes

The mean values for range of motion and grip strength are summarized as percentage, in Table 3. Physical examination of range of motion improved rapidly in the first 2 and 4 months and improvement continued within the first year with nearly 77% (for EF group) and 75% (for MP&P group) of normal range of motion eventually obtained. Between the MP&P and EF groups, no statistically significant differences were found for rang of motion, except for extension in 2 months (P. value = 0.037) and 4 months (P. value = 0.043) which were significantly higher among EF group. Also, measurements of grip strength revealed no significant differences between the two treatment groups. The improvement in grip strength was dramatic between 4 months and 1 year follow-up. Grip strength was greater in the Modified Pins and Plaster all follow-up assessment, however these differences were not statistically significant.

3.3. Radiographic outcomes

Distal radius parameters of PA, RA, and RL of all 98 participants were measured and the Radiographic parameters were found in this order: means of 11° for PA, 13° for RL and 25° for RA. No significant differences were found when comparing these data between MP&P and EF groups (Table 4).

3.4. Overall outcomes

Gartland and Werley's demerit point system revealed 26 excellent, 21 good, 3 fair and no poor results for Pins and plaster group, while treatment resulted in 28 excellent, 18 good and two fair results. These outcomes were not significantly different between the two treatment groups. The combination of these two groups gave 94% overall good to excellent results.

3.5. Complications and additional procedures

There were no significant differences between two EF and MP&P groups, regarding complications (both major and minor). Seven patients in the EF group have experienced major complications (six pin infections and one Reflex Sympathetic Dystrophy Syndrome) and also seven participants have had minor complications (six infections and one radial neuritis). The MP&P group record showed that only four patients have had complications which all were minor (two buried wires and two nonspecific wrist pain). The percutaneous wires became inadvertently buried in two patients who had MP&P surgery, requiring removal with use of a local anesthetic (Table 5).

4. Discussion

Fracture of the distal radius is one of the most common injuries in orthopedics. There are a number of surgical options for management of distal radial fractures, including the use of percutaneous wire fixation, external fixation and open reduction internal fixation with volar and dorsal plates.[35,36] This reflects both the variety of the fracture and the fact that uniformly good results have not been obtained with any treatment method. In the absence of data guiding management with regard to clinical effectiveness, cost must play a major factor in determining the type of operation offered.[35,37,38]

Table 3
Comparison of surgery outcomes between "Modified Pins and Plasters" group and. "External Fixation" group.

Surgery Outcomes		Follow up (months)	External Fixation Group	Modified Pins & Plaster Group	P. Value*****
Range of Motion (ROM)[a]	*Flexion*	2	45 ± 18	43 ± 15	N.S.
	Extension		**24 ± 25**	**10 ± 24**	**S**
	Pronation		63 ± 22	62 ± 18	N.S.
	Supination		32 ± 21	34 ± 21	N.S.
	Flexion	4	70 ± 19	68 ± 16	N.S.
	Extension		**75 ± 17**	**54 ± 20**	**S**
	Pronation		88 ± 12	86 ± 10	N.S.
	Supination		82 ± 14	86 ± 15	N.S.
	Flexion	12	86 ± 11	85 ± 13	N.S.
	Extension		90 ± 7	83 ± 6	N.S.
	Pronation		97 ± 9	94 ± 8	N.S.
	Supination		90 ± 7	92 ± 9	N.S.
	Flexion	24	95 ± 12	93 ± 15	N.S.
	Extension		98 ± 6	94 ± 9	N.S.
	Pronation		106 ± 7	103 ± 8	N.S.
	Supination		97.7 ± 4	99 ± 6	N.S.
Grip Strength[b]		2	11 ± 13	16 ± 10	N.S.
		4	42 ± 19	48 ± 18	N.S.
		12	76 ± 17	82 ± 11	N.S.
		24	83 ± 14	89 ± 15	N.S.
QuickDASH score[c]		2	**39 ± 22**	**55 ± 21**	**S**
		4	**16 ± 15**	**28 ± 17**	**S**
		12	8 ± 19	11 ± 16	N.S.
		24	3 ± 9	5 ± 7	N.S.
EQ-5D questionnaire[d]	*Index value*	2	0.62 ± 0.21	0.59 ± 0.24	N.S.
	Health state		73 ± 15	76 ± 14	N.S.
	Index value	4	0.74 ± 0.21	0.71 ± 0.19	N.S.
	Health state		77 ± 18	79 ± 16	N.S.
	Index value	12	0.86 ± 0.13	0.90 ± 0.15	N.S.
	Health state		82 ± 10	83 ± 8	N.S.
	Index value	24	0.95 ± 0.11	0.98 ± 0.8	N.s.
	Health state		92 ± 7	94 ± 2	N.s.

*****: S: Significant value ($p < 0.05$), N.S.: Not Significant value ($p \geq 0.05$).
[a] Range of motion (ROM): % of range of motion of uninjured, contralateral limb.
[b] Grip strength: (% of range of motion of uninjured, contralateral limb).
[c] QuickDASH = Disabilities of the Arm, Shoulder and Hand.
[d] EQ-5D = EuroQol-5D.

One the most popular technique to treat the DRF is internal fixation with locking plates. This treatment option affords improved fixation in osteoporotic bone. The enthusiasm to use this technique has increased and resulted in the development of a variety of specific locking devices, however there is limited study to guide the use of these devices.[36,39] In 2009, a study analyzed and compared the cost of locked volar plate fixation and percutaneous Kirschner wire (K-wire) fixation and it showed that the mean time taken to perform percutaneous K-wire fixation with an average of two K-wires was 56 min (costs £662), while for volar locked plate was 121 min (costs £2212). Also, this study reported that the cost of a pack of 10 K-wires was £3, significantly lower than the cost for standard volar locking plate (£787). There was a calculated difference of £1549 and 65 min between these two techniques.[36] Also, Tubeuf's study (2015) compared the relative cost

Table 4
Comparison of radiographic parameters between "Modified Pins and Plasters" group and "External Fixation" group.

Radiographic parameters	Surgical Techniques	Follow-up						P. Value***
		Pre-op	*post-op*	*2 Months*	*4 Months*	*12 Months*	*24 Months*	
Palmar Tilt	*MP&P Group*[a]	−13.9°	4°	3.5°	2.7°	3.7°	2.4°	N.S.
	EF Group[b]	−15.1°	3.3°	2.6°	1.4°	3°	3.3°	N.S.
Radial Angle	*MP&P Group*	11.9°	22.4°	22.2°	22.1°	20.4°	21.1°	N.S.
	EF Group	10.4°	21.7°	21.9°	22.4°	22.6°	24.3°	N.S.
Radial Length	*MP&P Group*	4.3°	12.3°	10.7°	9.6°	8.6°	8.3°	N.S.
	EF Group	3.6°	11.8°	11.1°	10.3°	10.5°	9.8°	N.S.

***: S: Significant value ($p < 0.05$), N.S.: Not Significant value ($p \geq 0.05$).
[a] Modified Pins & Plaster.
[b] External Fixation.

Table 5
Comparison of complications and additional Procedures between "Modified Pins and Plasters" group and "External Fixation" group.

Complications	MP&P group[a](n = 50)		EF group[b](n = 48)		P. Value***
	Minor	*Major*	*Minor*	*Major*	
Buried wires	2	0	0	0	N.S
Carpal tunnel syndrome	0	0	0	0	N.S
Extensor pollicis longus rupture	0	0	0	0	N.S
Infection (Superficial)	0	0	1	0	N.S
Infection (Pin tract)	0	0	5	6	N.S
Loss of reduction	0	0	0	0	N.S
Miscellaneous	0	0	0	0	N.S
Nonspecific wrist pain	2	0	0	0	N.S
RDS	0	0	0	1	N.S
Radial neuritis	0	0	1	0	N.S
Transient nerve palsy	0	0	0	0	N.S
Ulnar styloid pain	0	0	0	0	N.S
Total	4	0	7	7	N.S
Additional Procedures					
Carpal tunnel decompression	0		0		N.S
Extensor pollicis longus reconstruction	0		0		N.S
Removal of buried wires	2		0		N.S
Total	2		0		N.S

***: S: Significant value ($p < 0.05$), N.S.: Not Significant value ($p \geq 0.05$).
[a] Modified Pins & Plaster.
[b] External Fixation.

effectiveness of volar locking-plate and percutaneous wire fixation and showed that K-wire fixation is a 'cost saving' intervention, with similar health benefits.[40] Since there is an increasing emphasis on the need to make the best possible use of available resources in the health care system,[36,41] it seems necessary to reconsider using more affordable techniques including Pins and Plaster and External Fixation, especially in the developing countries.

The Pins and Plaster and External Fixation are two acceptable techniques to maintain alignment and prevent repeat displacement, after achieving the accurate anatomic reduction in the DRF fracture. Each of these methods has its own limitations, however the advantages in end results obtained with either type of these treatments warrant their use.[10,20–22] Some studies compared these two treatments and concluded that the two methods provide roughly the same results, however these are some especial concerns still remained for each technique.[2,10] External fixation did prove to be slightly more stable than pins and plaster technique which caused less fracture collapse and more effective radial length maintenance. However, the EF procedure and material cost has been always a significant consideration (20 times more than pins and plaster). Additionally, the pin-in-plaster technique allows treatment of the distal radius fracture with minimal manipulation and revascularization of the bone.[42–44] Therefore, the authors of this study aimed to introduce a modified and improved pins and plaster technique as an equally acceptable and more affordable alternative for DRF treatment.

In the introduced modified pins and plaster technique, two pins were inserted in the proximal third of second metacarpal bone to protect transverse palmar curvature. Also, two 1-cm Steinman pins were inserted in the mid-shaft of radius in opposite directions to make more traction along radius and also mild deviation of wrist to ulnar side. Additionally, one pin was placed in the shaft of the radius to allow using short arm cast for having less elbow stiffness. Furthermore, a five-degree ulnar deviation was applied during the short arm casting to prevent the collapse of the radial head and improve the radial length more efficiently. Therefore, compared to the traditional pins and plaster technique,[2,10,17,18] the modified method is more advantageous, as it leads to fewer complications. The modified technique protects the transverse palmar curvature, prevents the collapse of the radial head, and simplifies casting, thereby obviating a full arm cast and mitigating elbow stiffness in patient outcomes. Compared to the EF technique, interestingly there was no statistically significant difference between the two groups (EF and P&P) except in extension ROM and the quick-dash score (only in two and four month follow up visits) and also returning to work (only in two month follow up visit). Yet, these issues have little impact when evaluating the findings as a whole. It's notable that this new modified Pins and plaster technique can be used in the emergency room, because it's simple to use and straight forward, as oppose to external fixation which usually comes in kits and would probably have to be sterilely processed and used in the operating room. The cost saving of this modified technique over done in the emergency room would be significant (both in regards the use of device and the place where it's done, saving cost of operating room time). The cost saving in the operating room would not only include the operating room itself, it can include the cost of various personnel who are used to help with the surgery including the sterile service that have to process the equipment as it comes through. Additionally, the obvious cost to the patients are much less having done in an emergency room. Also, it's notable that this would be required no significant recovery time if done in emergency room and also the cost saving to the patients and insurance company would be significant. Consequently, the authors would suggest this modified P&P method as a possible, equally comparable and more affordable alternative for cost-conscientious patients who are scheduled for external fixation.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2019.05.007.

Conflict of interest

The authors of this study declare no conflict of interest.

References

1. Tommy l. *Distal Radial Fractures and Effects of Associated Ligament Injury.* lund university thesis; 2000.
2. Chen CE, Juhn RJ, Ko JY. Treatment of distal radius fractures with percutaneous pinning and pin-in-plaster. *HAND.* 2008;3:245–250.

3. Vasenius J. Operative treatment of distal radius fractures. *Scand J Surg.* 2008;97:290–296 discussion 296-297.
4. Singer BR, McLauchlan GJ, Robinson CM, Christie J. Epidemiology of fractures in 15,000 adults: the influence of age and gender. *J. Bone Jt. Surg. Br. Vol.* 1998;80:243–248.
5. Cummings SR, Black DM, Rubin SM. Lifetime risks of hip, Colles', or vertebral fracture and coronary heart disease among white postmenopausal women. *Arch Intern Med.* 1989;149:2445–2448.
6. Vogt MT, Cauley JA, Tomaino MM, Stone K, Williams JR, Herndon JH. Distal radius fractures in older women: a 10-year follow-up study of descriptive characteristics and risk factors. The study of osteoporotic fractures. *J Am Geriatr Soc.* 2002;50:97–103.
7. Ismail AA, Pye SR, Cockerill WC, et al. Incidence of limb fracture across Europe: results from the European prospective osteoporosis study (EPOS). *Osteoporos Int.* 2002;13:565–571.
8. White DM. Distal radius fractures: therapy practice patterns. *J Hand Ther : Off. J. Am. Soc. Hand Ther.* 2003;16:64 author reply 64.
9. Rizzo M, Katt BA, Carothers JT. Comparison of locked volar plating versus pinning and external fixation in the treatment of unstable intraarticular distal radius fractures. *HAND.* 2008;3:111–117.
10. Hutchinson DT, Strenz GO, Cautilli RA. Pins and plaster vs external fixation in the treatment of unstable distal radial fractures. A randomized prospective study. *J Hand Surg.* 1995;20:365–372.
11. Cole DW, Elsaidi GA, Kuzma KR, Kuzma GR, Smith BP, Ruch DS. Distal radioulnar joint instability in distal radius fractures: the role of sigmoid notch and triangular fibrocartilage complex revisited. *Injury.* 2006;37:252–258.
12. Lam NJ F, Karmani S, Jupiter JB. What's new in the treatment of distal radius fractures? *Curr Orthop.* 2006;20:208–211.
13. Yoon A, Grewal R. Management of distal radius fractures from the North American perspective. *Hand Clin.* 2012;28:135–144.
14. Lichtman DM, Bindra RR, Boyer MI, et al. Treatment of distal radius fractures. *J Am Acad Orthop Surg.* 2010;18:180–189.
15. Koval K, Haidukewych GJ, Service B, Zirgibel BJ. Controversies in the management of distal radius fractures. *J Am Acad Orthop Surg.* 2014;22:566–575.
16. Handoll HH, Madhok R, Howe TE. Rehabilitation for distal radial fractures in adults. *Cochrane Database Syst Rev.* 2006 Jul;4(3) CD003324.
17. Handoll HH, Madhok R. WITHDRAWN: surgical interventions for treating distal radial fractures in adults. *Cochrane Database Syst Rev.* 2009 Jul;8(3) CD003209.
18. Handoll HH, Madhok R. Surgical interventions for treating distal radial fractures in adults. *Cochrane Database Syst Rev.* 2003 Jul;4(3) CD003209.
19. Shauver MJ, Yin H, Banerjee M, Chung KC. Current and future national costs to medicare for the treatment of distal radius fracture in the elderly. *J Hand Surg.* 2011;36:1282–1287.
20. Nellans KW, Kowalski E, Chung KC. The epidemiology of distal radius fractures. *Hand Clin.* 2012;28:113–125.
21. Jupiter J. Future treatment and research directions in distal radius fracture. *Hand Clin.* 2012;28:245–248.
22. McQueen MM, Hajducka C, Court-Brown CM. Redisplaced unstable fractures of the distal radius: a prospective randomised comparison of four methods of treatment. *J. Bone Jt Surg Br Vol.* 1996;78:404–409.
23. Moroni A, Vannini F, Faldini C, Pegreffi F, Giannini S. Cast vs external fixation: a comparative study in elderly osteoporotic distal radial fracture patients. *Scand J Surg.* 2004;93:64–67.
24. Weber SC, Szabo RM. Severely comminuted distal radial fracture as an unsolved problem: complications associated with external fixation and pins and plaster techniques. *J Hand Surg.* 1986;11:157–165.
25. Kennedy CA, Beaton DE, Smith P, et al. Measurement properties of the QuickDASH (disabilities of the arm, shoulder and hand) outcome measure and cross-cultural adaptations of the QuickDASH: a systematic review. *Qual Life Res.* 2013;22:2509–2547.
26. Franchignoni F, Vercelli S, Giordano A, Sartorio F, Bravini E, Ferriero G. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). *J Orthop Sport Phys Ther.* 2014;44:30–39.
27. Trampisch US, Franke J, Jedamzik N, Hinrichs T, Platen P. Optimal Jamar dynamometer handle position to assess maximal isometric hand grip strength in epidemiological studies. *J Hand Surg.* 2012;37:2368–2373.
28. Muhldorfer-Fodor M, Ziegler S, Harms C, et al. Grip force monitoring on the hand: manugraphy system versus Jamar dynamometer. *Arch Orthop Trauma Surg.* 2014;134:1179–1188.
29. Chmielnicki M, Prokop A. [New minimally invasive approach for palmar plating in distal radius fractures]. *Zeitschrift fur Orthopadie und Unfallchirurgie.* 2015;153:25–28.
30. Rueger JM, Hartel MJ, Ruecker AH, Hoffmann M. [Fractures of the distal radius: operative technique of fixed-angle palmar plates for extension type fractures]. *Unfallchirurg.* 2014;117:1037–1044.
31. Vargaonkar G. Distal end radius fractures: evaluation of results of various treatments and assessment of treatment choice. *Chinese journal of traumatology = Zhonghua chuang shang za zhi / Chinese Medical Association.* 2014;17:214–219.
32. Chang HC, Poh SY, Seah SC, Chua DT, Cha BK, Low CO. Fragment-specific fracture fixation and double-column plating of unstable distal radial fractures using AO mini-fragment implants and Kirschner wires. *Injury.* 2007;38:1259–1267.
33. Fei JL, Liang B, Jiang CZ, Wang LM. [Minimally invasive treatment for distal radial fracture and dislocation of type IV based on Fernandez classification]. *Zhongguo gu shang = China J Orthop Traumatol.* 2014;27:341–345.
34. Arealis G, Galanopoulos I, Nikolaou VS, Lacon A, Ashwood N, Kitsis C. Does the CT improve inter- and intra-observer agreement for the AO, Fernandez and Universal classification systems for distal radius fractures? *Injury.* 2014;45:1579–1584.
35. Handoll HH, Huntley JS, Madhok R. *Different Methods of External Fixation for Treating Distal Radial Fractures in Adults.* The Cochrane Library; 2008.
36. Shyamalan G, Theokli C, Pearse Y, Tennent D. Volar locking plates versus Kirschner wires for distal radial fractures—a cost analysis study. *Injury.* 2009;40:1279–1281.
37. Mattila VM, Huttunen TT, Sillanpää P, Niemi S, Pihlajamäki H, Kannus P. Significant change in the surgical treatment of distal radius fractures: a nationwide study between 1998 and 2008 in Finland. *J Trauma Acute Care Surg.* 2011;71:939–943.
38. Koval KJ, Harrast JJ, Anglen JO, Weinstein JN. Fractures of the distal part of the radius. *J Bone Jt. Surg.* 2008;90:1855–1861.
39. Downing N, Karantana A. A revolution in the management of fractures of the distal radius? *J Bone Jt Surg.* 2008;90:1271–1275 British Volume.
40. Tubeuf S, Yu G, Achten J, et al. Cost effectiveness of treatment with percutaneous Kirschner wires versus volar locking plate for adult patients with a dorsally displaced fracture of the distal radius analysis from the DRAFFT trial. *Bone Jt J.* 2015;97:1082–1089.
41. Kakarlapudi TK, Santini A, Shahane SA, Douglas D. The cost of treatment of distal radial fractures. *Injury.* 2000;31:229–232.
42. Rogachefsky RA, Lipson SR, Applegate B, Ouellette EA, Savenor AM, McAuliffe JA. Treatment of severely comminuted intra-articular fractures of the distal end of the radius by open reduction and combined internal and external fixation. *J Bone Jt. Surg.* 2001;83:509.
43. Ruch DS, Papadonikolakis A. Volar versus dorsal plating in the management of intra-articular distal radius fractures. *J Hand Surg.* 2006;31:9–16.
44. Werber K-D, Raeder F, Brauer R, Weiss S. External fixation of distal radial fractures: four compared with five pins. *J Bone Jt. Surg.* 2003;85:660–666.