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Treatment of distal radius fracture using external fixator with Kirschner wires augmentation versus locked volar plate

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Abstract--Introduction: Distal radius fractures are considered as the most common fractures among all age groups as these fractures represent approximately one-sixth of all fractures seen in the emergency room. Different methods of treatment were tried for management of these types of fractures. In this study we compared between two of these methods, namely closed reduction and external fixation with Kirschner wire augmentation versus open reduction and internal fixation (ORIF) with a locked volar plate. Aim: The aim of this study is to compare between two groups of patients; ORIF group versus external fixation group as regard patient self-assessed and clinician assessed functional outcomes, radiological outcomes and complications. Patients and methods: 80 patients with displaced intra articular fracture distal radius were included in this study and were treated operatively, between December 2018 and December 2021. Forty patients were treated by Kirschner wire augmented external fixation and the other forty patients by locked volar plate. All patients were followed up and evaluated clinically and radiologically at 2, 4, 6, 12 weeks and thereafter at 6, 12, 18, 24, 30 and 36 months. The patients were assessed clinically through clinician assessed Cooney modification of the Green and O'Brien score and Gartland and Werley score, and patient self-assessed PRWE score, as well as radiologically through Sarmiento score. Results: ORIF had better functional outcomes in Green & O'Brien score, Gartland and Werley score and PRWE score compared to external fixation. In ORIF group 92.5 % of the patients had accepted functional outcomes in Green & O'Brien score compared to 75% in external fixation group and 97.5 % of ORIF group had accepted functional outcomes in Gartland & Werley score

compared to 75% in external fixation group. Total PRWE score was lower in ORIF group with an average value 15.43 ± 2.69 compared to external fixation group which had higher total PRWE score with an average value 16.83 ± 3.71 . The radiographic results in ORIF were more favorable than in external fixation as 95% of ORIF group had acceptable radiological parameters compared to 85% in external fixation group. Conclusion: better functional and radiological outcomes were observed in ORIF group with fewer incidence of complications as compared to K-wire augmented external fixation group.

Keywords---volar, ORIF, Distal, external, radius.

Introduction

Fractures of the distal radius are the most common type of fracture in all age groups as it accounts for approximately one-sixth of all fractures. ^(1, 2) The mechanism of injury varies from to high energy trauma (e.g., road traffic accident, falling from height) to low energy trauma (e.g., simple fall down). ⁽³⁾ Various classification systems are available for distal radius fractures, however, because of the large number of variables to consider and the broad spectrum of injuries, no classification is adequate. ⁽⁴⁾ In this study we used AO/OTA system ⁽⁵⁾ to classify the fracture types as it is comprehensive, reproducible and the most reliable, also it is widely used in researches and can provide a solid foundation for treatment and allows for retrospective outcome assessment.

Different methods of management have been described for treatment of the intra-articular fractures of the distal radius such as cast immobilization, closed reduction and percutaneous pinning (CRPP) external fixation either alone or with Kirschner wire augmentation, and open reduction and internal fixation (ORIF) with plating, however, treatment of distal radius fractures remains controversial with no consensus on the best modality of treatment. ^(6, 7)

In this study, we compared between two methods of surgical treatment of a displaced intra-articular distal radius fracture using Kirschner wire augmented external fixation versus open reduction and internal fixation (ORIF) using a locked volar plate as regard functional outcomes through clinician assessed scores and patient self-assessed scores, radiological outcomes and complications.

Patients and Methods

This randomized prospective study included eighty consecutive patients presented to the emergency room of our tertiary trauma facility with intra-articular distal radius fractures (AO/OTA 23-B and 23-C) and were randomized per Research Randomized, an online free randomization software ⁽⁹⁾, in the period between December 2018 and December 2021. This study was previously approved by the pertinent Ethical Review Board.. We received detailed informed consent from all patients.

In this study, 80 patients with distal radius fractures were managed operatively, 40 patients by ORIF with a locked volar plate, while the other 40 patients were managed by external fixation with K- wire augmentation. All the patients were managed operatively at the same institute by a single surgeon.

Adult patients older than 18 years with recent intra-articular fracture of the distal radius (AO type B and C) with no medical contraindications for surgery were included in this study. Patients with open fractures, pathological fractures, extra-articular fractures, fractures older than 14 days, fractures with active infection, and fractures with severe radiocarpal arthritis were excluded from this study.

Patients aged 18-60 years with average age 36.4 ± 8.7 years in the external fixation group and 43.1 ± 15.4 years in the ORIF-group. Eighty percent (80%) of the patients (32 patients) were males in ORIF group and 85 % (34 patients) were males in the external fixation group. The dominant hand was involved in sixteen patients (40%) in ORIF group and fourteen patients (35%) in the external fixation group. Falling down from a standing height was the most common mode of trauma in both groups and observed in 32 patients (80.0%) in ORIF and 26 patients (65.0%) in the external fixation group,. AO/OTA classification system was used to classify the fractures in this study with 35 patients of ORIF group were type 2R3C (five patients were 2R3C1, fifteen patients were 2R3C2 and fifteen patients were 2R3C3) and five patients were type 2R3B (all these 5 patients were type 2R3B3). In the external fixation group, 36 patients were type 2R3C (two patients were 2R3C1, fourteen patients were 2R3C2, twenty patients were 2R3C3) and four patients were type 2R3B (two patients were 2R3B2 and two patients were 2R3B3). (Table 1)

Patients were evaluated by history taking, physical examination, and imaging (including x-rays which were done routinely in all cases, and CT scan which was done in 14 cases in this study). A detailed informed consent was taken from all patients, the minimum intended follow-up was set to 24 months and averaged 30 months (range 24 to 36 months).

In the external fixation group, a K-wire augmented Orthofix Galaxy external fixator (Orthofix Srl, Verona, Italy) was used. The patient was placed in supine position on simple operating table with the forearm placed on a radiolucent arm-board. General anesthesia was applied in 18 cases (45 %) and regional nerve block (axillary brachial plexus block) in 22 cases (55%). Two small incisions of about 5mm each were made in the middle third of the radial shaft on the dorso-lateral aspect, about 10-12cm from distal end with 2-3cm apart, for insertion of the two proximal fixator Schanz pins (3-4mm in diameter). The Schanz pins were placed in the interval between the extensor carpi radialis brevis and longus after careful Soft tissues dissection to protect the superficial branch of the radial nerve. The two distal Schanz pins (of 2.5-3mm diameter) were inserted through two small skin incisions and applied on the dorso-radial aspect of the second metacarpal with 40-60° inclination regarding the horizontal plane, one near the base and the other proximal to the head of the second metacarpal.

After insertion of shanz pins, connecting rods were applied and attached to the shanz pins by clamps. The clamps were tightened in one side only, allowing the

rods in the other side to move freely in the clamps. Controlled traction and manipulation of the distal fragment was done allowing fracture realignment through the ligamentotaxis, but excessive traction should be avoided as it can increase the dorsal tilt and cause joint stiffness, and this can be achieved through maintaining both intercarpal distance and radiocarpal distance equal to the image intensifier. The traction was followed by tightening of the clamps on the other side to maintain the reduction. External fixator was augmented by application of percutaneous K-wires which were inserted percutaneously under the guide of image intensifier. One or two K-wires of 1.6 mm diameter were used, one from the styloid process and the other K-wires was inserted from the dorso-ulnar aspect of the distal radius. In case of associated distal radioulnar joint dislocation, horizontal K-wires (of 1.6 mm diameter) were applied percutaneously from the distal ulna to the distal radius with the forearm in supination to maintain the stability of the distal radioulnar joint (DRUJ).

Postoperatively, immediate active movements of the fingers were encouraged for all patients. The patients were advised to clean the pin tracts daily with saline. Four weeks postoperatively, traction was released to allow better hand function. The external fixator and K-wires were removed at 6 to 8 weeks according to union. (Fig, 1)

In the ORIF group, sixteen patients (40 %) were received general anesthesia, while a regional nerve block (axillary brachial plexus block) was used in 24 cases (60%). The flexor carpi radialis [FCR] approach as described by Orbay and Fernandez ⁽⁹⁾ was used and fracture site was reached by elevating periosteum around fracture site then fracture was manipulated with reduction clamps and bone holding clamps to achieve the reduction and provisionally fixed by K- wires. Position of Locked anatomical volar distal radius plate (Variax distal radius locking plate system of Stryker) was confirmed under image intensifier and fixation is secured with screws. Tourniquet was then released and haemostasis was achieved followed by Closure of soft tissues and skin. One or two transverse K-wires of 1.6 mm diameter were applied from the distal ulna to the distal radius with the forearm in supination in cases of distal radioulnar joint instability which was assessed clinically and radiologically through an image intensifier These K-wires were again routinely removed at 6 weeks (Fig.2).

All cases were evaluated clinically and radiologically. Clinical evaluation involved assessment of pain, wrist range of motion, grip strength, and regain of patient activity. Radiological evaluation was done by x-ray with P-A & lateral view and involved assessment of radial height, palmar tilt, radial inclination, articular step, ulnar variance, position of the DRUJ as well as fracture healing and position of hardware.

All patients were assessed immediately postoperatively then at second, 4th, 6th, 12th weeks and thereafter at 6th, 12th, 18th, 24th, 30th and 36th month. Both group of patients were evaluated and compared using clinician assessed sores through Cooney modification of the Green and O'Brien score ⁽¹⁰⁾ and Gartland and Werley score ⁽¹¹⁾ and patient self-assessed score though patient rated wrist evaluation (PWRE) score ⁽¹²⁾ for functional assessment, as well as the Sarmiento score ⁽¹³⁾ for radiological assessment. (Fig.3&Fig.4).

The statistical evaluation was conducted by Statistical Package for the Social Sciences: SPSS (IBM, Newark, USA) included the Chi-square test which was used for comparison of qualitative categorical variables, while the Student's-t test was used for comparison of quantitative data in the form of mean and standard deviation. P value was checked at 5% level of significance ($P \leq 0.05$). The Spearman's Rho correlation was used in evaluation of associations in the final grading.

Results

Forty patients were managed by ORIF and 40 patients were managed by external fixation, the mean age of the EF group was 36.4, while that of the ORIF group was 43.7 years. The percentage of males was 82.5% in ORIF group and 85% in EF group. In the ORIF group, 87.5% were Class C (2R3C) and 12.5% were class B (2R3B), while in the EF group 90% were Class C (2R3C) and 10% were class B (2R3B). Falling down was the main cause of injury in both groups, followed by falling from a height (FFH), while road traffic accident (RTA) was the least common cause. 80% of fractures caused by low energy trauma in ORIF group patients and 65% in the EF group patients. The cause or mode of trauma were not significantly different between the groups ($p=0.319$; $p=0.133$ respectively), (Table 1)

The ORIF group showed better functional outcomes in Green & O'Brien score compared to EF group. 92.5% of the ORIF group had accepted functional outcomes in Green & O'Brien score (65% excellent, 27.5% good), while 75% of the EF group had accepted functional outcomes (60% excellent, 15% good), with no significant difference between the groups ($p=0.12$). The 2 groups were comparable in range of motion ($p=0.114$), grip strength ($p=0.305$), and activity ($p=0.07$), while EF group recorded a lower median value for pain ($p=0.046$), (Table 2).

Regarding Gartland & Werley score, 97.5% of patients in the ORIF group had accepted functional outcomes (62.5% excellent, 35% good), while 75% of the EF group had accepted functional outcomes (60% excellent, 15% good), with a statistically significant difference between the groups ($p=0.014$). The two groups recorded comparable results for Subjective evaluation ($p=0.183$), Objective evaluation ($p=0.317$), Residual deformity ($p=0.083$), complications ($p=0.628$) and *Total Score* ($p=0.423$), (Table 3).

PRWE score showed no significant difference in pain score ($p=0.208$), but showed a significantly higher value in external fixation group regarding function specific activities ($p=0.025$), function usual activities ($p=0.042$) and function subscale ($p=0.023$). The difference between groups regarding total PRWE didn't reach the level of statistical significance ($p=0.057$), (Fig. 5), (Table 4). The ORIF group had better radiological outcomes according to Sarmiento score as compared to the external fixation group. 95% of the ORIF group patients had acceptable radiological parameters (85% got excellent and 10% good), in comparison to 85% in the EF group (70% got excellent & 15% got good) in Sarmiento score, with no significant difference between groups ($p=0.225$). The two groups were comparable in palmar tilt ($p=0.531$), whereas EF group recorded significantly higher radial height ($p=0.023$), and radial inclination ($p=0.046$), (Table 5).

Regarding the injury to treatment interval, 70% of ORIF group patients were operated one day after the injury while 30% of patients was operated within the first 24 hours. In external fixation group 35% of the patients were operated in the first 24 hours while 65% of patients were operated 24 hrs. after the injury. In all patients, the amount of blood loss was less than 500 cm³.

Regarding the operation time, external fixation group had less operative time as the mean was 23.25 minutes \pm 5.68 in the external fixation group compared to 45.5 minutes \pm 10.75 in the ORIF group. Student's t test revealed a statistically significant difference between both groups regarding the operation time ($p=0.00$). Regarding the frequency of postoperative complications in the two groups; no cases of tendon injury was reported in the two groups. In the ORIF group the complications was reported in 12.5% of the patients, while 20% of the patients in the external fixation group developed complications. Chi square test revealed no significant difference between the two groups in the total number of patients who developed postoperative complications ($p = 0.363$) (Table 6).

Spearman's test revealed that the Green and O'Brien score had a negative correlation with age and interval between trauma & surgery in the whole group ($n=80$). This correlation was statistically significant ($p=0.00$, $p=0.033$ for age and interval to surgery respectively) (Figure 5). This negative correlation was also statistically significant ($p=0.00$, $p=0.014$ for age and interval to surgery respectively) in the ORIF group (Fig. 6). A significant negative correlation between age and Green and O'Brien score was noted in EF group ($p=0.01$) (Fig.5), however, the correlation with interval to surgery did not reach the level of statistical significance in the EF group ($p=0.451$), (Table 7)

Gartland &Werley score showed no significant correlation with age in EF group ($p=0.067$), but showed a significantly positive correlation with age in ORIF group ($p=0.001$) and in the whole group ($p=0.006$), (Fig. 7), (Table 7) A strong negative correlation was noted between Green and O'Brien and Gartland &Werley scores in each group and overall ($p=0.00$), (Table 7)

Discussion

Fractures of the distal radius are the commonest fractures encountered in the emergency department with an increasing incidence across all age groups worldwide. This type of fracture can occur as a result of different mechanisms either high-energy trauma, especially in young individuals, or low-energy trauma, especially in elderly. Different methods of treatment are used for the management of these fractures, among them two methods were discussed in this study⁽¹⁴⁾ In this study, ORIF group and external fixation group were evaluated and compared using radiological Sarmiento score, functional clinician assessed Gartland and Werley and Green and O'Brien scores, functional patient rated wrist score (PRWE) as well as the incidence of complications.

In the current study, the radiographic outcomes were more favorable in the ORIF group compared to the external fixation group. Ninety five percent (95%) of patients had acceptable radiological parameters in the ORIF group (85% got excellent and 10% good), while in the external fixation group the percentage was

85 % (70% got excellent and 15% got good) according to Sarmiento score. The explanations of these favorable results in ORIF group are mostly because open reduction and internal fixation by volar plate allows direct visualization and better manipulation of the fracture fragments and therefore provides better restoration of the anatomy.

Most of the prior studies support this radiological result as in Mellstrand et al. ⁽¹⁵⁾, Jeudy et al. ⁽¹⁶⁾, Gereli et al. ⁽¹⁷⁾, Zhang et al. ⁽¹⁸⁾, Shu-Peng et al. ⁽¹⁹⁾ Yu X et al. ⁽²⁰⁾, Talmaç et al. ⁽²¹⁾ and Barakat et al. ⁽²²⁾ On the other hand, different results were shown in other studies as in Wei et al. ⁽²³⁾, Saving et al. ⁽²⁴⁾, Kreder et al. ⁽²⁵⁾ and Drobotz et al. ⁽²⁶⁾ studies which revealed that no significant difference in radiological results between the external fixation group and ORIF group. In Gradl et al. ⁽²⁷⁾ study, external fixation group had better radiological outcomes.

In this study, ORIF group had better functional outcomes according to Gartland and Werley score, Green and O'Brien score and patient rated wrist score (PRWE) when compared to the external fixation group; 97.5% of the patients had accepted functional outcomes in Gartland & Werley score (62.5% excellent, 35% good) compared to 75% in the external fixation group (60% excellent, 15% good) and 92.5% of the ORIF group had accepted functional outcome in Green & O'Brien score (65% excellent and 27.5% good) compared to 75% of external fixation group (70% excellent & 5% good). Also, total PRWE score was lower in ORIF group with an average value 15.43 ± 2.69 compared to external fixation group which had higher total PRWE score with an average value 16.83 ± 3.71 .

Most of the prior studies revealed similar results as in Williksen et al. ⁽²⁸⁾, Antonio Abramo et al. ⁽²⁹⁾, Rozental et al. ⁽³⁰⁾, Wei et al. ⁽²³⁾, Egol et al. ⁽³¹⁾ and Sharma et al. ⁽³²⁾, Walenkamp et al. ⁽³³⁾, Schmelzer-Schmied et al. ⁽³⁴⁾, Esposito et al. ⁽³⁵⁾ and Barakat et al. ⁽²²⁾ Other studies showed results different from the results of the current study in which ORIF and external fixation had similar functional outcomes as in Grewal et al. ⁽³⁶⁾, Ludvigsen et al. ⁽³⁷⁾, Hammer et al. ⁽³⁸⁾, Dwyer et al. ⁽³⁹⁾, Bisaccia et al. ⁽⁴⁰⁾, Roh et al. ⁽⁴¹⁾ In Shukla et al. ⁽⁴²⁾ study, External fixation group have better functional outcomes as compared to ORIF group.

In the current study, external fixation had an overall increased incidence of complications compared with ORIF. Complex regional pain syndrome CRPS was observed in four patients (10%) in the external fixation group and in two patients (5%) in the ORIF group. This higher incidence of CRPS in the external fixation group may be related to the severity of injury or excessive distraction and reduction maneuvers associated with external fixation. This can be prevented by avoidance of excessive distraction during external fixator application, encouraging immediate postoperative rehabilitation and postoperative vitamin C supplementation. Stiffness was reported in three patients (7.5%) in the ORIF group compared to five patients (12.5%) in the external fixation group. This probably related to the strength and stability of the volar plate construct which allows early wrist motion. Infection was observed in two patients (5%) of the external fixation group (pin tract infection) while no infection case was reported in ORIF group. Mal-union was observed in two patients (5%) in the ORIF group and in five patients (12.5%) in the external fixation group

These results are in agreement with most of the prior studies, in which fewer complications were reported in patients treated with ORIF as in Karantana et al.⁽⁴³⁾, Wilcke et al.⁽⁴⁴⁾, Xu et al.⁽⁴⁵⁾, Leung et al.⁽⁴⁶⁾, Grewal et al.⁽⁴⁷⁾, McQueen et al.⁽⁴⁸⁾, Satake et al.⁽⁴⁹⁾, Lee et al.⁽⁵⁰⁾, Duramaz et al.⁽⁵¹⁾, Yuan et al.⁽⁵²⁾ Jorge-Mora et al.⁽⁵³⁾ and Barakat et al.⁽²²⁾

Conversely, Mellstrand et al.⁽¹⁵⁾, Egol et al.⁽³¹⁾ Kapoor et al.⁽⁵⁴⁾ and Sha et al.⁽⁵⁵⁾ studies reported that the incidence of complications was higher in ORIF patients than in external fixation patients, which is different than the results of the current study.

Finally, this study revealed that both ORIF and external fixation are good options for the treatment of distal radius fractures. ORIF had better functional outcomes according to Gartland and Werley score, Green and O'Brien score, and PRWE score compared to external fixation. Moreover radiological outcomes according to Sarmiento scoring system were better in ORIF group and the complication rate was higher in external fixation group. Volar plate fixation provides better restoration of the articular surface, anatomical reduction, and fixation of the fracture fragments and so a more stable construct was achieved allowing early postoperative motion compared to external fixation. At 3 month follow up, the grip strength in ORIF group was better in than external fixation group; but after removal of the fixator and starting physiotherapy, it improved gradually in the external fixation group and became comparable to the ORIF group. The increased grip strength in the ORIF group at 3 months follow-up was mostly related to better fracture alignment and reduction at operation and/or a better maintenance of fracture reduction during the healing, leading to a better congruency of the joint. External fixation is a simple, quick, and minimally invasive technique with less blood loss and comparable results to other methods of fixation.

This study was a randomized prospective comparative study which added to its strength while the limitations were the relative small sample size and the short follow-up period. For better evaluation of outcomes of treatment and incidence of complications we recommend further studies with larger number of patients and longer periods of follow-up.

Conclusion

Both ORIF with volar locked plate and external fixation with K- wire augmentation can be used for the treatment of distal radius fractures with good results. However, ORIF is superior to external fixation in functional and radiological outcomes with less incidence of complications. Moreover, open reduction and internal fixation with plating allow early postoperative mobilization and better grip strength. This making ORIF by plating is a preferable method for the treatment of intraarticular distal radius fractures whenever applicable.

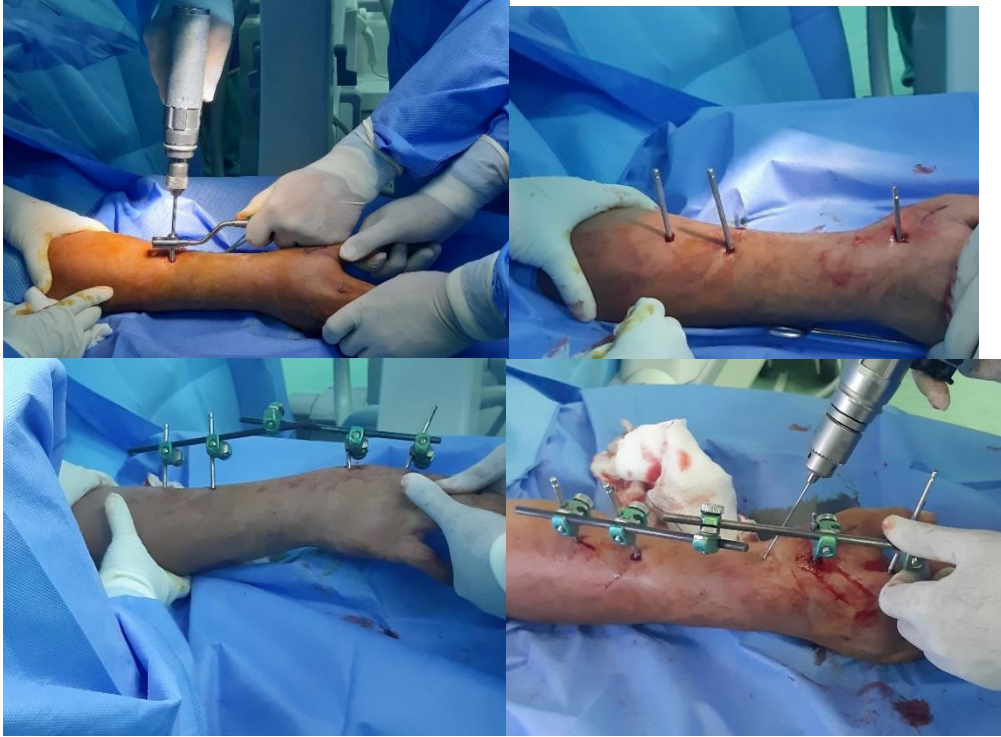


Fig. 1 Application of Schanz pins. Closed reduction through an external fixator. Insertion of percutaneous K-wires

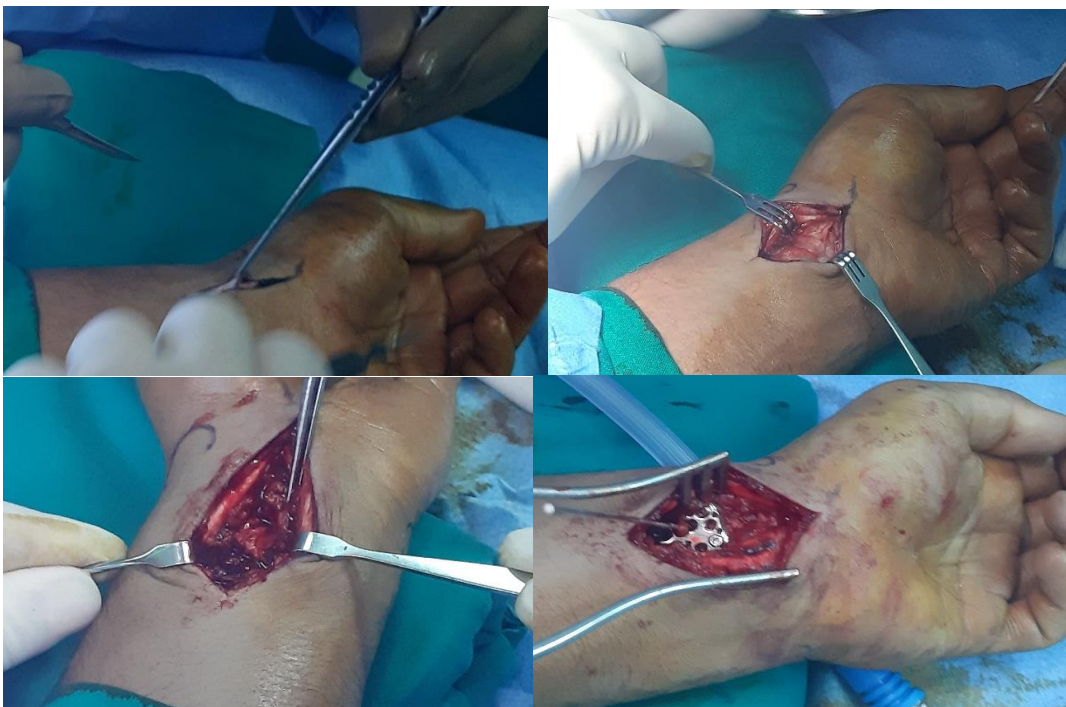


Fig. 2 Skin incision, insertion and fixation of the plate after reduction of fracture.



Fig. 3 A: 35-years-old, right-handed male manual worker, fracture left distal radius, AO/ATO type 2R3C3, Frykman type VIII. Pre-operative radial height was 7 mm, radial inclination 12.8 degrees, intra-articular step-off 1mm, and volar tilt -9.1 degrees (i.e., 9.1 dorsal angulation).



Fig.3 B: 30 months postoperatively, radial height was 12mm, palmar tilt was 0 degrees, radial inclination 25.4 degrees and intra-articular step-off 0 mm. supination 85 degrees, pronation 80 degrees, flexion 75 degrees, dorsiflexion 65 degrees, radial deviation 15 degrees and ulnar deviation 35 degrees. The patient were asymptomatic and grip strength was similar to the normal side. Sarmiento score is excellent, Green O'Brien score is excellent (100%), and Gartland & Werley score is excellent (0).



Fig.4 A: a 46 years old right-handed male patient, manual worker, with fracture left distal radius, AO/ATO type 2R3C2, Frykman type VIII. Preoperative radial height was 10 mm, radial inclination 21.5 degrees, intra-articular step-off 2 mm, and volar tilt 9.9 degrees. ORIF was done 1 day after injury.



Fig. 4 B: 36 months postoperatively, radial height was 12 mm, radial inclination 23.9 degrees, intra-articular step-off 0mm, and volar tilt 11.2 degrees. Range of supination was 85, pronation 80, flexion 80, dorsiflexion 85, radial deviation 20, and ulnar deviation 35. The patient was asymptomatic and grip strength was similar to the healthy side. Sarmiento score was excellent, Green & O'Brien score was excellent (100%), and Gartland & Werley score was excellent (0).

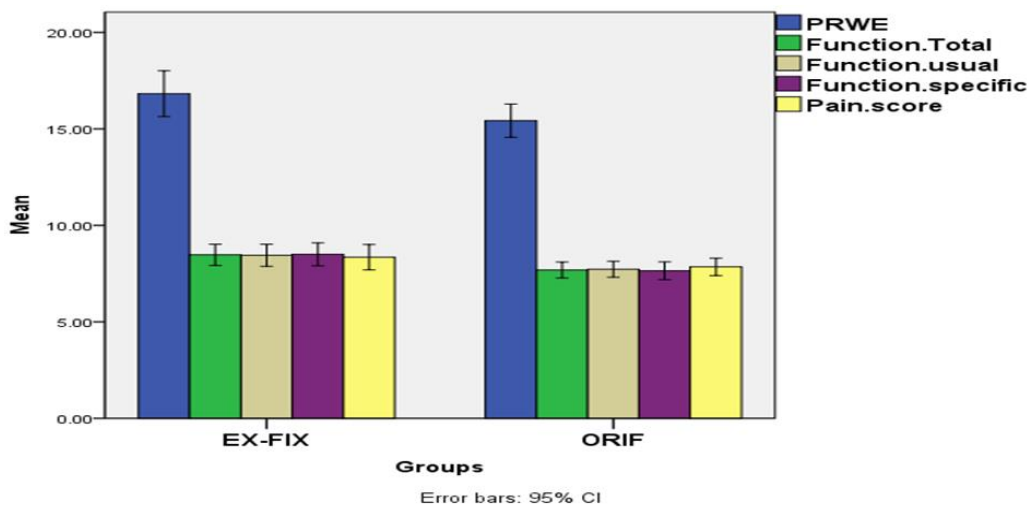


Fig. 5: Bar chart illustrating mean value of PRWE score

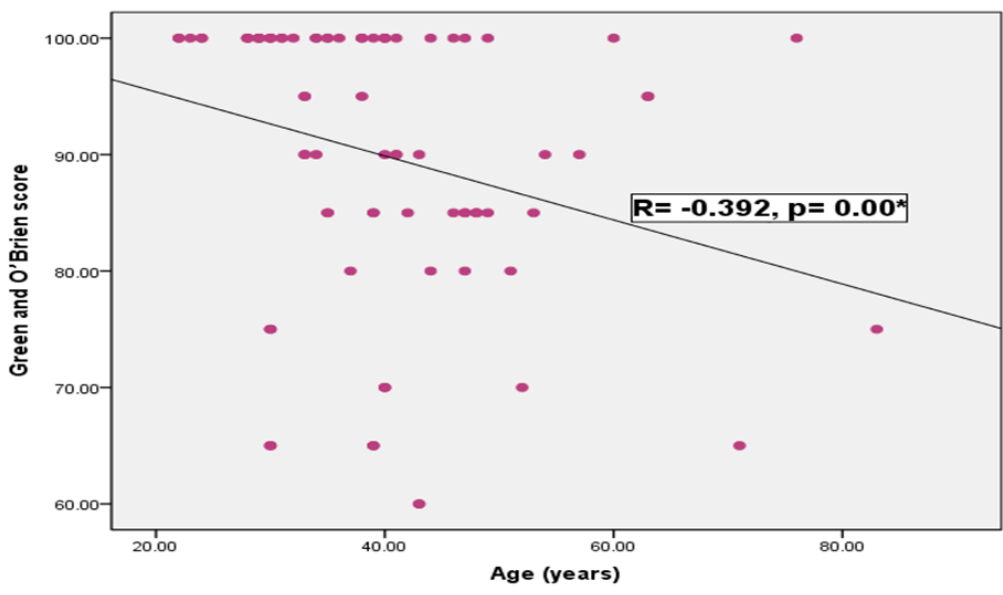


Fig. 6 A: Scatter plot illustrating the correlation between Green and O'Brien scores and age in the whole studied group (n=80).

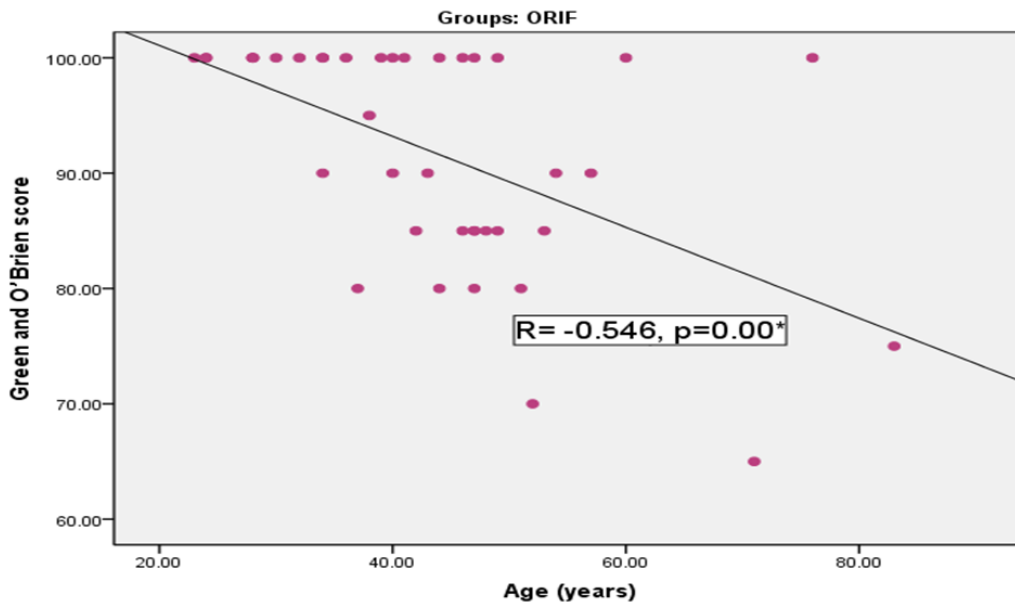


Fig. 6 B: Scatter plot illustrating the correlation between Green and O'Brien score and age in ORIF group (n=40).

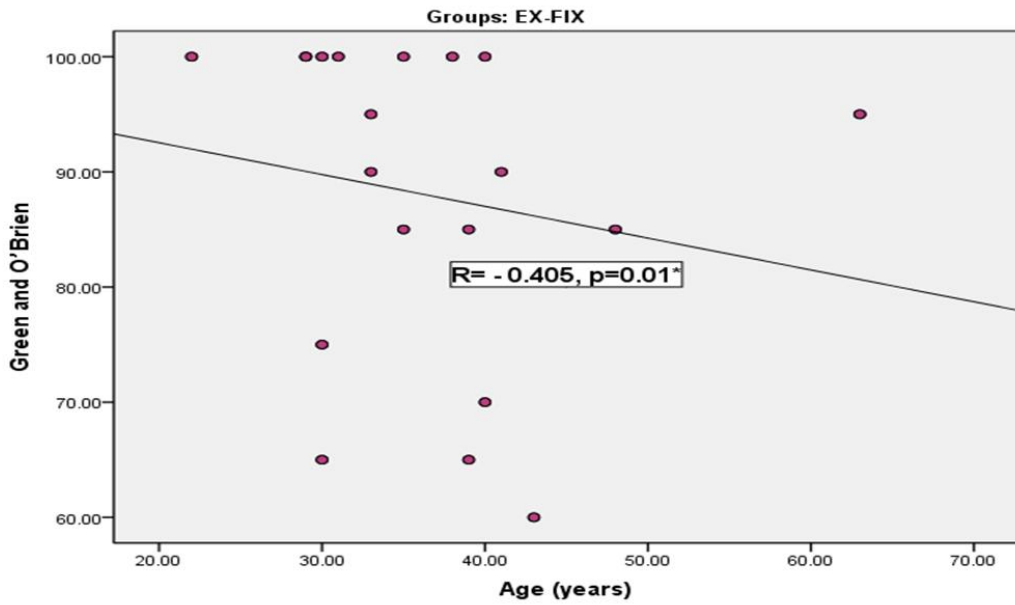


Fig. 6 C: Scatter plot illustrating the correlation between Green and O'Brien score and age in EF group (n=40).

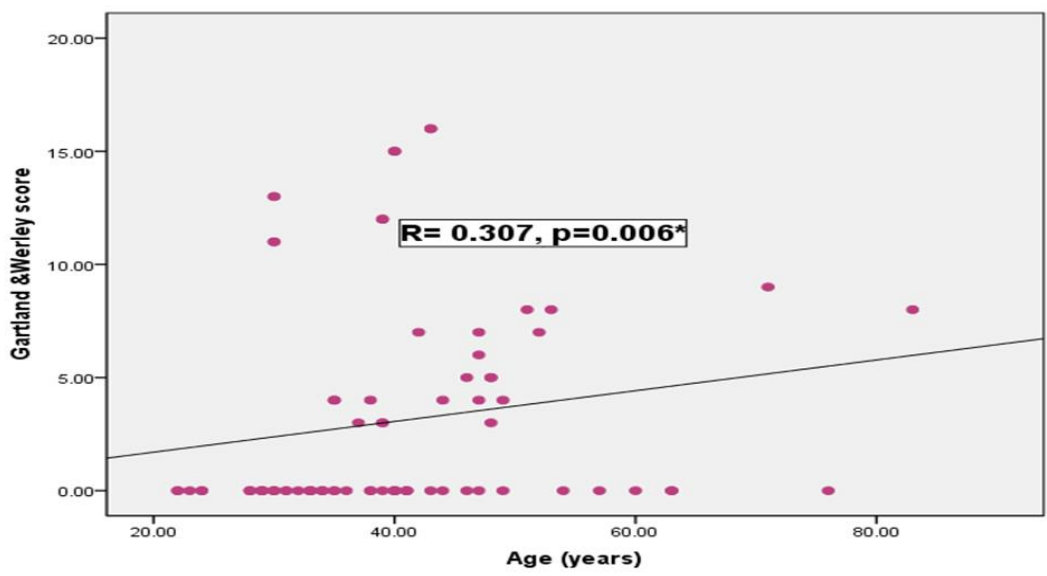


Fig. 7 A: Line chart illustrating the correlation between Gartland & Werley score and age in the whole studied group (n=80).

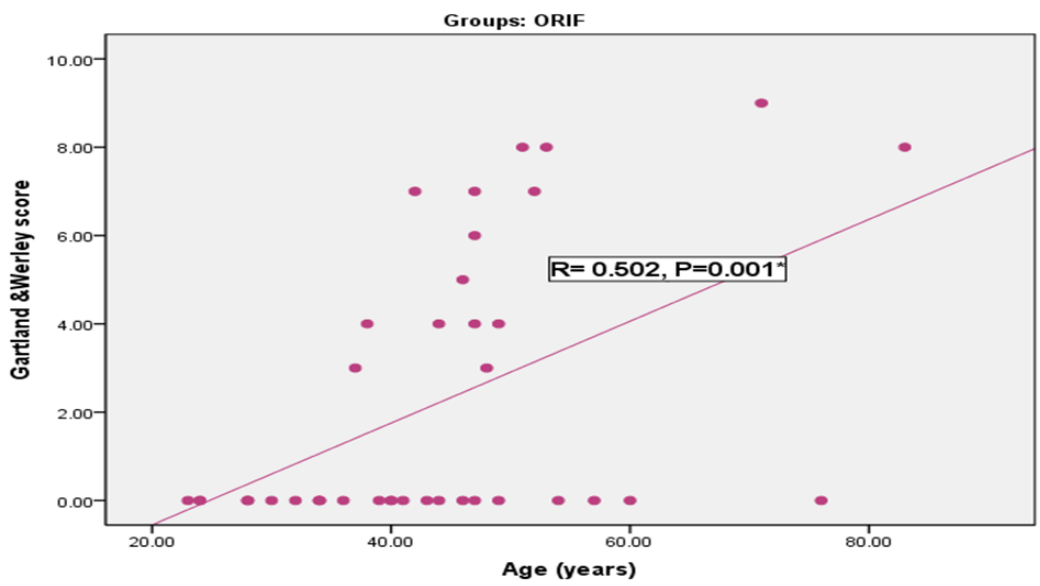


Fig. 7 B: Scatter plot illustrating the correlation between Gartland & Werley score and age in ORIF group (n=40).

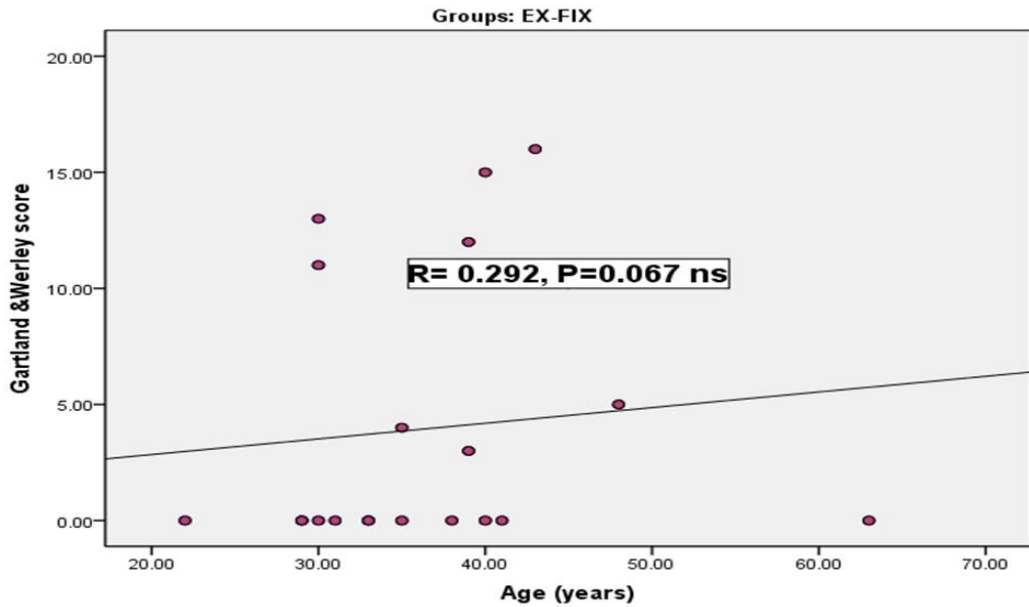


Fig. 7 C: Scatter plot illustrating the correlation between Gartland & Werley score and age in EF group (n=40)

Table 1: pre-operative data

	ORIF Group n=40	EF Group n=40	p value
Age (years)	43.7±13.4	36.4±8.6	0.005*
<u>Age group</u>			
< 50 years	31 (77.5%)	38 (95%)	0.023*
≥ 50 years	9 (22.5%)	2 (5%)	
<u>Sex</u>			
Male	33 (82.5%)	34 (85%)	0.762ns
Female	7 (17.5%)	6 (15%)	
<u>Hand dominance</u>			
Right	16 (40%)	14 (35%)	0.644 ns
Left	24 (60%)	26 (65%)	
<u>Occupation</u>			
Manual worker	26 (65%)	24 (60%)	0.644 ns
Other Jobs	14 (35%)	16 (40%)	
<u>Cause of trauma</u>			
Falling down	32 (80.0%)	26 (65.0%)	0.319 ns
Falling from height	6 (15.0%)	10 (25.0%)	
RTA	2 (5.0%)	4 (10.0%)	
<u>Trauma mode</u>			
Low energy	32 (80.0%)	26 (65.0%)	0.133 ns

High energy	8 (20.0%)	14 (35.0%)	
<u>Injury to treatment Interval</u>			
Within first day	12 (30.0%)	14 (35.0%)	0.633ns
(1-3 days)	28 (70.0%)	26 (65.0%)	
<u>AO/OTA Classification</u>			
2R3-B2	0 (0%)	2 (5%)	0.256 ^{ns}
2R3-B3	5 (12.50%)	2 (5%)	
2R3-C1	5 (12.50%)	2 (5%)	
2R3-C2	15 (37.5%)	14 (35%)	
2R3-C3	15 (37.5%)	20 (50%)	

Significance level $p < 0.05$, *significant, ns=non-significant

Table 2: Comparison of Treatment Outcomes of both groups according to Green and O'Brien scores

	ORIF Group n=40	EF Group n=40	p value
<u>Total Score</u>	97.5 (65-100)	92.5 (60-100)	0.297ns
Pain	25 (15-25)	22.5 (15-25)	0.046*
ROM	25 (15-25)	20 (15-25)	0.114 ns
Grip strength	25 (15-25)	25 (15-25)	0.305 ns
Activities	25 (20-25)	25 (15-25)	0.070 ns
<u>Classification</u>			
Poor	0 (0.0%)	2 (5.0%)	
Fair	3 (7.50%)	8 (20.0%)	0.12 ns
Good	11 (27.5%)	6 (15.0%)	
Excellent	26 (65.0%)	24 (60.0%)	

Significance level $p < 0.05$, *significant, ns=non-significant

Table 3: Comparison of Treatment Outcomes of both groups according to Gartland & Werley score

	ORIF Group n=40	EF Group n=40	p value
<u>Total Score</u>	0 (0-9)	0 (0-16)	0.423 ns
Subjective evaluation	0 (0-4)	0 (0-6)	0.183 ns
Objective evaluation	0 (0-3)	0 (0-5)	0.317 ns
Residual deformity	0 (0-3)	0 (0-2)	0.083 ns
complications	0 (0-3)	0 (0-4)	0.628 ns
<u>Classification</u>			
Poor	0 (0.0%)	0 (0.0%)	
Fair	1 (2.5%)	10 (25.0%)	0.014*
Good	14 (35.0%)	6 (15.0%)	
Excellent	25 (62.5%)	24 (60.0%)	

Significance level $p < 0.05$, *significant, ns=non-significant

Table 4: Comparison of Patient rated wrist evaluation (PRWE) in the two studied groups

	ORIF Group n=40	EF Group n=40	p value
Pain	7.85±1.41	8.35±2.06	0.208 ns
Function specific activities	7.65±1.44	8.5±1.85	0.025*
Function usual activities	7.73±1.3	8.45±1.8	0.042*
Functional subscale (total/2)	7.69±1.3	8.48±1.71	0.023*
Total PRWE score	15.43±2.69	16.83±3.71	0.057ns

Significance level $p < 0.05$, *significant, ns=non-significant

Table 5: Treatment outcome according to Sarmiento radiological score

	ORIF Group n=40	EF Group n=40	p value
Palmar tilt	7.45 (-13.4 - 23.0)	5.7 (-9.4 - 17.0)	0.531 ns
Radial height	10.0 (6.0 - 14.0)	12.0 (0.0 - 22.0)	0.023*
Radial inclination	19.9 (11.7 - 30.1)	21.8 (9.5 - 31.2)	0.046*
<u>Classification</u>			
Fair	2 (5.0%)	6 (15.0%)	0.225 ns
Good	4 (10.0%)	6 (15.0%)	
Excellent	34 (85.0%)	28 (70.0%)	

Significance level $p < 0.05$, *significant, ns=non-significant

Table 6: Comparison of treatment complications in the two studied groups

	ORIF Group n=40	EF Group n=40	p value
Number of patients with complications	5 (12.5%)	8 (20.0%)	0.363ns
Malunion	2 (5.0%)	5 (12.5%)	0.235ns
Complex regional pain syndrome	2 (5.0%)	4(10.0%)	0.396ns
Nerve injury	1 (5.0%)	0 (0.0%)	0.314ns
Stiffness	3 (7.5%)	5 (12.5%)	0.456ns
Pin tract infection	0 (0.0%)	2 (5.0%)	0.152ns

Significance level $p < 0.05$, *significant, ns=non-significant

Table 7: Correlation between age and Green and O'Brien score and Gartland & Werley score (Spearman's rho test)

Groups			Green and O'Brien score	Gartland & Werley score	Age
EX-FIX	Green and O'Brien score	R P value		-.908- ^{**} .000	-.405- ^{**} .010
	Gartland & Werley score	R P value	-.908- ^{**} .000		.292 .067ns
ORIF	Green and O'Brien score	R P value		-.880- ^{**} .000	-.546- ^{**} .000
	Gartland & Werley score	R P value	-.880- ^{**} .000		.502 ^{**} .001
Both groups	Green and O'Brien score	R P value		-.899- ^{**} .000	-.392- ^{**} .000
	Gartland & Werley score	R P value	-.899- ^{**} .000		.307 ^{**} .006

Significance level $p < 0.05$, *significant, ns=non-significant

Declarations:

Ethics approval and consent to participate

Ethics committee approval is attached in the submission Faculty of medicine, Cairo University, Cairo, Egypt

Consent to publish:

Written consent has been taken from all patients to participate in the study without sharing their personal information, signed in the Arabic language, and inserted in their medical files.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on request.

Competing interests

The authors declare that they have no conflict of interest.

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