

RESULTS OF OPEN REDUCTION INTERNAL FIXATION OF INTRA-ARTICULAR DISTAL HUMERUS FRACTURES USING NON-LOCKING PLATES: ARE THEY REALLY OBSOLETE?

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Abstract

Background: Intra-articular distal humerus fractures are challenging to manage successfully, even for the most experienced surgeon because of the complex anatomy. These fractures are often associated with comminution, displacement, and osteopenia. **Objective:** To assess the functional results of open reduction internal fixation of intra-articular distal humerus fracture using non-locking plates. **Materials and Methods:** This was a retrospective study conducted over the span of 4-years (April 2016– April 2020). The functional outcome was assessed using the Mayo Elbow Performance Score. 40 patients were included in this study. Data was entered and analysed using SPSS version 22. **Results:** In this study, the majority were males as 28 (70%) and 12 (30%) were females with an average age of 36.37 years ranged from 18-70 years. The minimum follow up time was 8-months; the mechanism of injury was RTA in the majority of cases. Mean union time was 13-weeks. The mean MEPS score was 91.40 ranged from (50-100) poor to excellent. The results indicated that more than half of the patients reported excellent outcome (62.5%) as compared to that group of patients with good outcome identified as 35%, 1 patient reported the poor outcome. **Conclusion:** The study concluded that in carefully selected cases the use of elbow reconstruction using non-locking plates for the fixation of complex intra-articular fracture is a safe and effective surgical procedure for early recovery and early mobilization.

INTRODUCTION

Distal humerus fracture constitutes 2 to 6% (5.7 per 100,000) of all fractures and 30% of elbow fractures in adult population. Intra-articular distal humerus fractures are challenging to manage successfully, even for the most experienced surgeon because of the complex anatomy, distal location, small size of fragment, limited amount of subchondral bone and limited option for internal fixation.^[1-3] These fractures are often associated with comminution, displacement, and osteopenia which when treated poorly may lead to devastating outcomes with suboptimal salvage options during complications. Injury leading to distal humerus fractures often leads to decrease in elbow movement with severe stiffness and prolonged immobilization.^[4] Mechanism of injury include high energy trauma in young and low energy trauma in old osteoporotic patients. Intra-articular and partial articular fracture pattern reported in one third of cases. Incidence of

distal humerus fracture is rising especially in older age group due to reduced soft tissue envelop and poor rehabilitation capacity. It is estimated that the incidence of distal humerus fractures will trend to three times higher similar to spine and hip by 2030.^[5] Most of the fractures are now being treated with surgical modalities as opposed to conservative management which have poor functional outcomes.^[6] Optimal treatment of humerus fractures still remains a topic to be explored.

The recent trend to treat distal humerus fractures is open reduction and internal fixation with early mobilization.^[7,8] Adequate exposure is the mainstay for the visualization of the fracture fragments. Complications include malunion, non-union, contracture, avascular necrosis, heterotopic ossification, implant failure and ulnar neuropathy.^[9] Primary total elbow arthroplasty, also hemiarthroplasty for fracture of trochlea and capitellum can be considered in very old age low-demanding patients due to severe osteoporosis,

comminution and complications associated with fixation methods.^[10-12]

The articular block of the distal humerus along with medial and lateral columns forms an asymmetric triangle, which is the base for the stability of the distal humerus. In most intra-articular distal humerus fractures, all three sides of the triangle of stability are broken. The lateral column gets fractured in coronal plane in most of the cases while the medial column has a sagittal shearing fracture pattern in most cases. Considering this, the lateral column requires antgliding plating while the medial column requires a buttress plate.

In most Indian scenarios, all intra-articular distal humerus fractures are treated by open reduction and internal fixation using the pre-contoured locking plates which are locally made. These implants cost around ₹ 12,000/- to 13,000/-. The other disadvantages include its usage like availability of fixed angle screws and cross threading of screws. Moreover, many a times anatomical plate fails to have exact contour as per the bone so bending is also difficult.

While the non-locking plates comparatively are less expensive which cost around ₹ 5000/- to 6000/- and are associated with other advantages as can be contoured easily in anatomical shape becoming patient-specific and they provide freedom to insert screws in any direction. They can be a cheap alternative to locking plates if used properly.^[13,14]

MATERIALS AND METHODS

This was a retrospective study conducted for the patients treated for intra-articular and peri-articular fractures involving the distal humerus over 4-years (April 2016– April 2020) to measure the outcome. The study was approved by institutional ethics committee and written informed consent was obtained from all patients.

Selection Criteria

1. All patients with age \geq 18 years
2. Patients with AO type 13B1, 13B2, 13C1 and 13C2 having large articular fragment.
3. Patients having good bone stock.

Exclusion Criteria

1. Patients with AO type 13A as it is an extra-articular distal humerus fracture.
2. Patients with AO type 13B3 and 13C3 having frontal/coronal articular fragments which require fixed angular stability that is provided by locking plates only.
3. Patients who were treated primarily in other setup.
4. Patients who were managed conservatively.
5. Patients who were treated with K-wires or using locking plates.

Data of 40-patients were collected through informed consent for a minimum follow up duration of 1 year. The study included the demographic and study variables as age, gender, side, pain, stability, motion and functional scores based on which outcome was

assessed using Mayo Elbow Score classified as Excellent \geq 90 scores, Good 75-89 scores, Fair 60-74 scores and Poor $<$ 60 scores.^[15] After the collection of data from respondents, data were entered and analysed using SPSS version 22. Descriptive and Inferential statistics were applied to describe the summary of data and draw an inference based on the data. For categorical variables like gender, side, pain, stability, motion and function frequency and percentages were constructed and mean as well as standard deviation was also evaluated for continuous variables (age, functional score). A chi-square test was also applied to find the association between variables. A p-value was considered to be significant at 5% level of significance.

After the anaesthesia all patients were then placed in lateral decubitus position with arm supported by pad and elbow can be flexed upto 100°. The tourniquet was used in all patients. After the aseptic preparation of surgical part the standard incision was kept. The ulnar nerve was then identified and released from cubital tunnel which was protected by vessel loop around it during whole procedure. Based on the fracture configuration, the appropriate surgical exposure in form of Chevron olecranon osteotomy or Paratricipital approach was selected. The first step in fracture reduction was a reduction of the condyles and reconstruction of joint surface with the help of pointed reduction clamp and provisional K-wires followed by re-attachment of condyles with humeral shaft anatomically. After the provisional fixation, two appropriate sized plates were selected and were contoured anatomically using plate benders. Simple dynamic compression plate, pelvic reconstruction plate, one third tubular plate were used for fixation. Plates were placed in 90-90 perpendicular pattern, one on posterolateral surface of bone and one on medial border of distal humerus. At least one distal screw from medial plate was inserted in such a way that it traverses both medial and lateral condyles and having a good purchase in the opposite cortex. If possible, the construct was made stronger by inserting a second screw in a similar fashion. Articular reduction, plate and screw size were confirmed under IITV in AP and lateral views. At the end of the procedure, if the osteotomy was done, the olecranon was reduced and fixed with two 2 mm K-wires and 18 gauge tension band wire. The anterior transposition of ulnar nerve was not done in any of our patients. Post-operatively active and assisted elbow mobilization was initiated from day 1 in pouch arm sling support. Follow up examination was conducted on monthly basis for initial two months followed by bimonthly basis for next 6 months and later annually. Patient evaluation was done approximately for 12 months. Patients were allowed to resume light duty work after 2 months and heavy strenuous work after union at around 3 to 4 months. At final follow up X-ray examination of every patients' were performed and their functions were evaluated. Elbow range of motion i.e. flexion, extension, supination and pronation were measured

by goniometer. Functional evaluation was done using “Mayo Elbow Performance Score”.

Table 1: Mayo Elbow Performance Score (MEPS)

Characteristics	Points	Definitions
Pain	45	None (45)
		Mild (30)
		Moderate (15)
		Severe (0)
Motion	20	Arc of motion >100° (20)
		Arc of motion between 50°-100° (20)
		Arc of motion <50° (5)
Stability	10	Stable (10)
		Moderate instability (5)
		Gross instability (0)
Function	25	Comb hair (5)
		Feed (5)
		Perform hygiene (5)
		Don shirt (5)
		Don shoe (5)
Total	100	

≥90: Excellent, 75-89: Good, 60-74: Fair, <60: Poor



Figure 1: Preoperative, post-operative and follow-up X-ray of Patient A with AO type 13C2 fracture treated with open reduction and internal fixation.



Figure 2: Preoperative, post-operative and follow-up X-ray of Patient B with AO type 13C2 fracture treated with open reduction and internal fixation.



Figure 3: Preoperative, post-operative and follow-up X-ray of Patient C with AO type 13C1 fracture treated with open reduction and internal fixation.

Table 2: Classification Distribution

AO Classification Type	Number of patients	p Value
B1	10(25%)	>0.05 (NS)
B2	0	
C1	11 (27.5%)	
C2	19 (47.5%)	
C3	0	

Table 3: Complications

Complication	Number of patients	p Value
Superficial wound infection	2	>0.05 (NS)
Ulnar Neuropathy	2	
Non-union	1	
Fixation Failure	1	
Implant Back-out	1	
Implant Impingement	2	
Olecranon Bursitis	2	
Elbow Arthritis	1	
Total	12	

Table 4: Functional Outcome according to Mayo Elbow Performance Score (MEPS)

Mayo Elbow Performance Score (MEPS)	Number of patients	p Value
≥90 (Excellent)	25 (62.5%)	>0.05 (NS)
75-80 (Good)	14 (35%)	
60-74 (Fair)	0	
<60	1 (2.5%)	

RESULTS

In present study, 40-patients diagnosed with distal humerus intra-articular fracture were selected among these majority were males 28 (70%), and minority 12 (30%) were females with an average age of 36.37 years ranging from 18-70 years. The minimum follow up time was 8-months in which the mechanism of injury was RTA in the majority of cases. Mean union time was 13 weeks (Range 10-18 weeks). Table 2 reveals the distribution of patients

according to AO classification. As seen in table 2 type C2 (47.5%) was the most common type. Type A, type B3 and type C3 were excluded from our study In present study, 29 (72.5%) patients were operated using olecranon osteotomy approach whereas 11 (27.5%) patients were operated using triceps on (paratricipital) approach. The reason for this being is, olecranon osteotomy approach offers better visualization of articular surface of elbow. While all simple articular, simple metaphyseal fractures i.e. AO type C distal humerus fracture were initially

operated using triceps on approach to minimize the soft tissue insult, the intra-op conversion of triceps on approach to olecranon osteotomy approach was not hesitated when visualization of intra-articular fragment was not adequate.

Complications were also recorded and are reported in table: 3. Total 12 patients (30%) reported complication after the surgery. Three patients (7.5%) suffered from superficial wound infection which resolved with regular dressing and antibiotics. Two patients (5%) had post-operative ulnar neuropathy which was resolved spontaneously after 1 month. One patient (2.5%) had deep infection with fixation failure following re-trauma due to psychiatric illness which was immediately resolved by debridement and removal of implant but the patient ultimately developed elbow arthritis. One patient (2.5%) suffered from mechanical failure who had screw back out from medial epicondyle after 6 months of surgery which required removal of implant. Implant impingement was complained by two patients (5%) for which, implant removal was done in both the patients. Olecranon bursitis was noted in two patients (5%) for which excision of bursa and removal of tension band wire along with removal of K-wires was done. On analysis of functional outcome during prospective follow up of the patients using the Mayo Elbow Performance Score, the mean MEPS score observed was 91.40 ranging from (50-100) poor to excellent. The results indicated that more than half of the patients reported excellent outcome (62.5%) due to high stability and mobility as compared to those group of patients with good outcome identified as 35% and 1 (2.5%) patient reported the poor outcome because of instability and stiffness of elbow and shoulder unable to perform daily living activities. The results also explored that the majority of the patients were satisfied after surgical intervention because of their excellent and good outcome as compared to a dis-satisfied group of patients with fair and poor results.

DISCUSSION

An intra-articular distal humerus fracture is one of the most difficult fractures to deal with whereby, even the most experienced surgeon faces challenges to deal with these fractures in terms of fixation and reduction as articular fracture demands anatomical reduction, stable fixation, and early mobilization. Both conservative and operative treatment options are found to be promising options but open reduction and internal fixation with anatomical articular congruity is considered as gold standard.^[16]

Various surgical exposures are available to treat these difficult fractures but posterior approach through olecranon osteotomy is the most common and validated approach as olecranon osteotomy provides a better visualization of articular surface. Elbow joint poorly tolerates immobilization, therefore it is highly recommended to mobilize the elbow as early as

possible subjective to bone quality, comminution and stable fixation.^[17]

Korner et al. (2009) performed a biomechanical evaluation in distal humerus fracture using locking compression plate versus conventional reconstructive plates in different configurations. It was demonstrated that primary stiffness in anterior/posterior bending and torsional loading is significantly increased by using locking compression plates in a 90° configuration ($p < 0.05$) as compared with dorsally applied plates. The differences between the different plate types were insignificant if applied in the same configuration. It was stated that biomechanical behaviour of the osteosynthesis depends more on plate configuration rather than plate type. The advantages of locking compression plates are only significant if compared with dorsal plate application techniques.^[11]

R.C. Koonce et al. (2012) did a biomechanical cadaver study in 30 fresh frozen distal humerus models with artificially created metaphyseal gap. They demonstrated that perpendicular conventional reconstruction plates (CRPs) have similar stiffness and load to failure properties compared to perpendicular and parallel precontoured distal humerus locking plates (PDHLPs) regardless of plate configuration.^[14]

Clavert et al. (2013) performed a study on 53 elderly patients with age greater than 65 reporting results of various types of internal fixation for the management of distal humerus fractures with complications of nerve injury. High quality internal fixation with two plates was recommended for intra-articular fractures for reconstruction of both humerus columns as failure rate for a single, nonlocking plate construct was significantly higher. Mayo Elbow Performance Score was employed for evaluation of joint function. It was concluded that age of the patient and fracture types were the important prognostic factor.^[18]

Caravaggi et al (2013) performed a biomechanical study on 28 frozen cadaveric models. They showed significantly higher stiffness to axial load and ultimate failure strength using parallel locking plate configuration when compared with orthogonal locked and non-locked plating.^[19]

Another study performed by Cusik et al aimed towards evaluation of reliability of MEPS score in comparison to American Shoulder and Elbow Surgeons (ASES) score. It was observed that MEPS was completely reliable due to various advantages like completely patient administered with strong test retest agreement when assessed at different times with a difference of approximately 10 points.^[20]

Berkes et al. (2011) was the first to do a clinical comparative study between locking and non-locking constructs in intra-articular distal humerus fractures. They concluded that there is no statistically significant advantage that locking plates provide with regard to adequacy of fixation, clinical outcomes and complications. They achieved similar radiographic and clinical outcomes using locking and non-locking plates.^[13] A similar study was performed earlier by

Amar et al. on 20 patients using pre-counteracted distal humerus locking plates in orthogonal fashion. It was observed that internal fixation with distal humerus locking plates was associated with minimal soft tissue irritation and periosteal stripping and multiple screw slots to provide maximum stability.^[21]

Another study performed by Galal et al. aimed towards evaluation and comparison of MEPS score as a functional outcome among two group of patients with type 13-A fracture treated with locking and non-locking plates respectively. It was concluded from the study that locking plates construct performed significantly better with higher MEPS score at one year 88 ± 10.1 , compared to MEPS score of 75.8 ± 12.8 with nonlocking plates. The results of the study were found to be in agreement with ours.^[22] Another prospective study on 31 patients with distal humerus fractures of type 13-B and 13-C performed by Patel et al. using anatomical locking plates observed an improved mean MEPS of 87.9 (55–100) points and a mean elbow flexion/extension arc of 115.8° (85 – 150°) the results of which were consistent to the results of our study.^[23] Patel S (2020) performed a study on 43 adult patients with a distal humerus fracture underwent open reduction and internal fixation to identify post-operative complications. Post-operative stiffness and ulnar neuropathy were prominent complications observed during the study which was consistent to our results.^[24]

Olga et al also reported complications such as mechanical failure, ulnar neuropathy, stiffness, heterotopic ossification, nonunion, malunion, infection, and complications from olecranon osteotomy which were accordant to the complications in our study as well.^[25]

Various interventions are used to improve impaired range of motion (ROM) in the upper extremities affecting activities of daily living (ADL) which have been reported in literature. Previous findings of necessity of full elbow and shoulder flexion in personal care and feeding tasks is in accordance with our findings where various ROM measurement procedures have been reported in which ROM is the primary outcome parameter. An elbow motion from 0° to 150° is required for ADL with upper limits of 150° and 90° were needed in ADL for shoulder flexion and abduction, respectively.^[26,27]

Ullah et al. (2020) aimed to analyse the functional outcome of open reduction internal fixation of distal humerus intra-articular fracture after using reconstruction plates. They did a retrospective study in 50 patients. The results were studied using Mayo Elbow Performance Score. Excellent outcome was seen in 26 (56%), good in 11 (22%), fair in 7 (14%) and poor in 4 (8%). Among those, 35 (70%) patients had no pain, 33 (66%) had an arc of motion greater than 100° , 82% patients had stable elbow, while 76% performed all activities of daily living using Mayo Elbow Performance Score.^[28]

Lopez et al. (2021) recently published mid-term follow up study comparing the results between primary total elbow arthroplasty and open reduction

and internal fixation in complex fractures of distal humerus in the elderly. They conducted a retrospective study having 24 patients (11 TEA vs 13 ORIF) with a mean age of 82 years and all being females. TEA group vs. ORIF group achieved a mean flexion of $117^\circ \pm 9.6^\circ$ vs. $106^\circ \pm 14^\circ$, extension loss of $38^\circ \pm 17^\circ$ vs. $30.8^\circ \pm 16^\circ$, pronation $75^\circ \pm 5^\circ$ vs. $85^\circ \pm 7^\circ$ and supination $75^\circ \pm 4^\circ$ vs. $70^\circ \pm 5^\circ$. Mean MEPS score was 71.6 vs. 83.6 ($p = .183$) and mean quick-DASH was 44.8 vs. 42.6 ($p = .789$). All 13 patients in the ORIF group demonstrated radiographic signs of bone union and none underwent conversion to TEA. 63% of the patients in the TEA group underwent re-operation at an average of 72 months (62.4–75.2 months), including three for periprosthetic fracture and four for implant loosening. Whereas in the ORIF group, 23% of the patients were re-operated upon excluding olecranon osteotomy hardware, two for stiffness, and one for an olecranon tension band failure. They concluded that there was no difference in mid-term functional outcomes between TEA and ORIF. The results suggested that the recent trends towards the use of TEA instead of ORIF in the elderly should be re-examined due to high rate of complications beyond five years of follow-up with TEA.^[29]

The outcome of our study was found to be excellent in 25 (62.5%), good in 14 (35%), fair in 0 and poor in 1 (2.5%). Mean flexion was found to be 129.5° ranging from 110° to 140° . Mean fixed flexion was found to be 8.3° ranging from 0 – 30° . Mean MEPS was 91.4 ranging from 50–100. Limitation of this study include the retrospective design and the small sample size that prevents from obtaining very solid conclusions, although it allows the interference of trends of using precontoured locking plates only. Another drawback of this study is, not able to get the long-term follow-up of the patients. Also, in patients having osteoporosis, the locking plates are preferred over non-locking plates. This study demonstrates that in partial articular and in simple complete articular distal humerus fractures good to excellent results can be achieved even with non-locking plates. In Indian scenario, where the resources are scarce and the affordability by the patients is an issue, we can reduce the financial burden by more than 50% by using simple non-locking plates whenever feasible with similar results.

CONCLUSION

Present study concludes that the use of elbow reconstruction using non-locking plates for the fixation of complex intra, or extra-articular fracture is a safe and effective surgical procedure for early recovery and early mobilization in carefully selected patients. The implant type do not have a significant impact on the ultimate outcome as far as the fracture fixation principals are being followed correctly and being neutral to the patients and following necessary criteria is the key to better outcome. This study needs a back-up by a randomized control trial with a large sample size which we look forward.

Ethics approval: Institutional Review Board (IRB) “Ethics Committee for Clinical Research” (CEIC) approved the present study.

Informed Consent: Informed consent was obtained from all individual participants included in this study.

REFERENCES

1. Korner J, Diederichs G, Arzdorf M, Lill H. A Biomechanical Evaluation of Methods of Distal Humerus Fracture Fixation Using Locking Compression Plate versus Conventional Reconstruction Plates. *J Orthop Trauma*, 2004;18:286-93.
2. Helfet DL, Hotchkiss RN. Internal fixation of the distal humerus: a biomechanical comparison of methods. *J Orthop Trauma*. 1990;4:260-4.
3. Henley MB, Bone LB, Parker B. Operative management of intra-articular fractures of the distal humerus. *J Orthop Trauma*. 1987;1:24-35.
4. Charissoux J-L, Vergnenegre G, Pelissier M, et al. Epidemiology of distal humerus fractures in the elderly. *Orthop. Traumatol. Surg. Res.* 2013;99:765-9.
5. Palvanen M, Niemi S, Parkkari J, Kannus P. Osteoporotic fractures of the distal humerus in elderly women. *Ann Intern Med*. 2003;139(3):W61.
6. Gosler MW, Testroote M, Morrenhof JW, Janzing HM. Surgical versus non-surgical interventions for treating humeral shaft fractures in adults. *Cochrane Database Syst Rev*. 2012 Jan 18;1:CD008832. doi: 10.1002/14651858.CD008832.pub2.
7. Tejwani N, Murthy A, Park J, McLaurin T, Egol K, Kummer F: Fixation of Extra-Articular Distal Humerus Fractures Using One Locking Plate Versus Two Reconstruction Plates: A Laboratory Study. *J Trauma*, 2009;66:795-9.
8. Galano G, Ahmad C, Levine W: Current Treatment Strategies for Bicolumnar Distal Humerus Fractures. *J Am Acad Orthop Surg*, 2010;18:20-30.
9. Thomas R. Y, Paul J. W, Jeremy S. S, Complications of articular distal humeral fracture fixation: a systematic review and meta-analysis, *J Shoulder Elbow Surg*. 2021 Aug;30(8):1957-1967.
10. Sardelli M, Tashjian R, MacWilliams B: Functional Elbow Range of Motion for Contemporary Tasks. *J Bone Joint Surg Am*. 2011;93:471-7.
11. Huang J, Paczas M, Hoyen H, Vallier H: Functional Outcome after Open Reduction Internal Fixation of Intra-articular Fractures of the Distal Humerus in the Elderly. *J Orthop Trauma* 2011;25:259-65.
12. Andras H, Marc LW, Maarten J, Denise E, Distal humerus prosthetic hemiarthroplasty: midterm results, *Strategies Trauma Limb Reconstr*. 2015 Aug; 10(2): 101-8.
13. Berkes M, Garrigues G, Solic J, Van Zeeland N, Shourbaji N, Brouwer K, Jupiter J, Ruch D, Obrebsky W: Locking and Non-locking Constructs Achieve Similar Radiographic and Clinical Outcomes for Internal Fixation of Intra-articular Distal Humerus Fractures. *HSS J* 2011;7:244-50.
14. Moorey BF, An KN, Chao EYS, Functional Evaluation of Elbow. In: Morrey BF, ed. *The Elbow and its disorders.*, 2nd Ed., Philadelphia, PA: WB Saunders Co; 1993-95.
15. Koonce R, Baldini T, Morgan S: Are conventional reconstruction plates equivalent to precontoured locking plates for distal humerus fracture fixation? A biomechanical cadaver study. *Clinical Biomechanics* 2012;27:697-701.
16. Wang Y, Zhuo Q, Tang P, Yang W: Surgical interventions for treating distal humerus fracture in adults. *Cochrane Database of Systemic Reviews* 2013; Issue 1; Art No: CD009890
17. Duncan C, Ramsey, Austin R, Thompson, Omar F, Nazir, Adam J, Mirarchi, A new technique for olecranon osteotomy in the treatment of distal humeral fractures, *JSES* 2018: 1-4.
18. Clavert P, Ducrot G, Sirveaux F, Fabre T, Mansat P, SOFCOT: Outcomes of distal humerus fractures in patients above 65 years of age treated by plate fixation. *Orthopaedics & Traumatology: Surgery & Research* 2013;99:771-.
19. Caravaggi P, Laratta J, Yoon R, Biasio J, Ingargiola M, Frank M, Capo J, Liporace F: Internal Fixation of the Distal Humerus: A Comprehensive Biomechanical Study Evaluating Current Fixation Techniques. *J Orthop Trauma* 2014;28:222-6.
20. Cusick MC, Bonnaig NS, Azar FM, Mauck BM, Smith RA, Throckmorton TW: Accuracy and Reliability of the Mayo Elbow Performance Score. *J Hand Surg Am*. 2014;39(6):1146-50.
21. Amar, Hussain S: A prospective study: Functional outcome of intra-articular distal humerus fractures treated with bicolunar locking plates in Indian population. *Nat. J of Clin. Orthopaedics* 2020;4(1):122-6.
22. Galal S, Mattar Y, Solyman A, Ezzat M: Locking versus non-locking plates in fixation of extra-articular distal humerus fracture: a randomized controlled study. *Int Orthop*. 2020 Dec;44(12):2761-2767.
23. Patel J, Motwani G, Shah H, Daveswar R: Outcome after internal fixation of intraarticular distal humerus (AO type B & C) fractures: Preliminary results with anatomical distal LCP system. *J Clin Orthop Trauma* 2017;8(1):63-7.
24. Patel S, Mir H, Horowitz E, Smith C, Ahmed A, Downes K, Nydick J: ORIF of Distal Humerus Fractures with Modern Pre-contoured Implants is Still Associated with a High Rate of Complications. *Indian Journal of Orthopaedics Indian J Orthop*. 2020 Apr 24;54(5):570-579.
25. Savvidou O, Zampeli F, Koutsouradis P, Chloros G, Kaspiris A, Sourmelis S, Papagelopoulos P: Complications of open reduction and internal fixation of distal humerus fractures. *EFFORT Open Rev* 2018;3:558-67.
26. Zdravkovic V, Jost B: Rounded data have a high potential for false comparative statistical results as shown with elbow arc of motion. *J Shoulder Elbow Surg* 2018;27:276-81.
27. Oosterwijk A, Nieuwenhuis M, Van der Schans C, Mouton L: Shoulder and elbow range of motion for the performance of activities of daily living: A systemic review. *Physiotherapy Theory and Practice* 2018;34(7):505-28.
28. Ullah R, Iqbal J, Imran A, Ahmed A, JavedMohd, Sadiq S, Ahmed N: Functional outcome of open reduction internal fixation of distal humerus intra articular fracture using recon plates. *Pak J Surg* 2020;36(1):66-70.
29. Lopiz Y, Garriguez-Pérez D, Garcia-Fernández C, Baño L, Galán-Olleros M, Marco F: Complex fractures of the distal humerus in the elderly: primary total elbow arthroplasty or open reduction and internal fixation? Mid-term follow-up. *Int Orthop*. 2021 Aug;45(8):2103-10.