

Original Research Article

Comminuted olecranon fractures: locking compression plate fixation verses conventional plate fixation

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ABSTRACT

Background: A variable consensus exists on the optimal management strategies for olecranon fractures. Though the mechanical properties of the conventional plates and the locking plates used show no difference, pre-contoured locking plates provide a significant advantage over non-locking plates in unstable fractures. The aim of the study was to compare clinical and radiological outcomes in the management of the comminute olecranon fractures by anatomically pre-contoured locking compression plates and the conventional plates.

Methods: The present study was a prospective study of 50 patients with comminuted olecranon fracture, with 25 patients each randomized into two groups, those that underwent fixation of the fracture using a pre-contoured locking compression plate (group LCP) and those fixed using a conventional plate (3.5 mm reconstruction plate) (group CP). Patients were followed up to 1 year with functional outcome assessed at each follow-up with Mayo elbow performance score.

Results: The mean MEPS (LCP vs CP) at 1.5 (47 vs. 43.4) and 3 (67.4 vs 61.6) months follow up showed a statistically significant difference between the two groups, but the difference was not significant at 6 (86.4 vs 85.6) and 12 (88.4 vs 87) months. The time to union (4.3 months vs 5.0 months) was not significantly different between the groups. There were 11 complications in group LCP and 12 complications in group CP.

Conclusions: In the present study, we suggest that the use of a pre-contoured locking compression plate provides better outcomes at earlier periods as compared to the conventional plate; thus, returning the patient to normal function at the earliest.

Keywords: Olecranon fracture, Locking compression plate, Conventional plate

INTRODUCTION

Olecranon fractures are one of the most commonly seen orthopaedic injuries in the emergency room comprising approximately 10-20% of all upper extremity fractures with an incidence of 11.5 per 100000 population per year.¹⁻⁵ Fractures of the olecranon show bimodal age distribution with younger individuals sustaining a fracture due to high energy trauma and older individual as a result of a simple fall due to osteoporosis.^{1,6,7} Fractures of the olecranon process of the ulna typically occur as a result of direct trauma such as falling on the tip of the elbow or by indirect trauma such as falling on a partially flexed elbow with

indirect forces generated by a strong sudden eccentric contraction of the triceps avulsing the olecranon.^{8,9}

A variable consensus exists on the optimal management strategies for these patients, with surgeon experience dictating the choice of management in some cases. Un-displaced fractures can be treated with a short period of immobilization followed by gradual mobilization. When displaced, open reduction and internal fixation are usually required to obtain anatomical realignment of the articular surface and restore normal elbow function. Goals of surgical fixation include restoring both the articular surface and the extensor mechanism of the elbow with

sufficient stability to allow early range of motion.^{4,10} There exists a variety of surgical techniques of which some are indicated for specific types of fractures including K-wire fixation with tension band wiring, and plating. The fixation should be stable to allow active elbow flexion and extension and promote union of the fracture. The active early mobilisation after surgery restores the patient to normal function as early as possible. The early and active movement not only prevents the tissue from disuse atrophy post fracture but greatly influences the quality and rapidity of fracture union.

Displaced fractures that are comminuted show evidence of ulno-humeral incongruence. Comminuted fractures, fractures involving the coronoid process, oblique fractures that extends distal to the midpoint of the sigmoid notch are regarded as unstable and unsuitable for tension band wire fixation.¹¹ Fixation using plating is considered the most appropriate mode of treatment for such fractures.¹²⁻¹⁵ Comminuted olecranon fractures are fixed using plating because subchondral bony comminution opposite the tension band will cause failure in compression.

The mechanical properties of the conventional plates and the locking plates show no significant difference.¹⁶ Despite the above and the increasing cost, pre-contoured fixed angle locking plates provide a significant advantage over non-locking plates in unstable fractures. The use of a non-locking plate in the fixation of the comminuted olecranon fractures may tend to decrease the radius of the greater sigmoid notch as a consequence of over reduction leading to malunion and joint incongruity. This is avoided by using a rigid fixed angle construct, as the pre-contoured nature of the implant aids in optimal placement.^{8,17}

The pre-contoured locking compression plate has the provision of placing a central proximal intramedullary screw. The intramedullary screw considerably increases the mechanical strength of the fixation, producing greater stiffness in flexion compared to a double proximal plate or a posterior construct with no central intra-medullary screw.¹⁸ The locking compression Plate differs substantially from conventional plating in that it allows for the insertion of distal unicortical locking screws. Unlike bicortical screws, unicortical screws do not impede the placement of a long intramedullary screw to augment the construct.

This aim of the study was to evaluate and compare clinical and radiological outcomes in the management of the comminuted olecranon fractures by the means of the anatomically pre-contoured locking compression plates and the 3.5 mm reconstruction plates (conventional plating).

METHODS

The present study was a prospective study, conducted in a tertiary care institute from 2017 to 2019 with prior approval from the institutional ethics committee. The

study population comprised of the patients presenting to the institute with comminuted olecranon fractures and who satisfied the selection criteria for the study.

A total of 50 patients presenting to our tertiary care institute with comminuted olecranon fracture were selected for the study. Written valid informed consent was obtained from the patients at the first presentation. The 50 patients were serially numbered from 1 to 50 as per chronology of presentation and 25 patients each were randomized into two groups, those that underwent fixation of the fracture using pre-contoured locking compression plate and those fixed using a conventional plate (3.5 mm reconstruction plate). Randomization was done using a random number table.

Inclusion criteria

All patients of age of 18 years or above both male and female and closed fracture were included.

Exclusion criteria

Patients with comorbidity, pathological fracture, patients with vascular injury, and open wound fracture or fracture-dislocations were excluded.

Protocol

On admission, a detailed examination of the patients was carried out after hemodynamic stabilisation. Patients underwent routine preoperative investigations. Standard X-ray of the affected elbow in anteroposterior and lateral views were taken for confirmation of diagnosis and also to know the type of fracture. The elbow was immobilized in an above elbow plaster of paris posterior slab. The affected limb was kept elevated. Analgesics and antibiotics were given if necessary.

All patients were operated in a lateral decubitus position using the posterior approach to the elbow. The forearm was kept free to allow flexion/extension of the elbow intraoperatively. Under direct visualization, the fractured articular fragments were manipulated and reduced anatomically and provisionally fixed using K-wires. To achieve close bone plate contact, the triceps attachment was split. In the case of the 3.5 mm recon plate, anatomic contouring of the plate was done to fit the proximal ulna.

Post-operative

All the patients were treated with intravenous antibiotics for 48 hours followed by oral antibiotics till suture removal. Anti-inflammatory and analgesics were started post-operatively. The operated limb was kept elevated to reduce swelling and the patient was asked to perform active finger movements on postoperative day 1. Post-operative first wound check dress was done on day 3. Post-operative mobilization was begun in the patients with a stable fixation on postoperative day 3 as a single arc of the

motion per day. For unstable fixations, the limb was immobilized in an above elbow posterior slab with the elbow in 70 flexion for 3 weeks. Suture removal was done on post-operative days 10-14.

Follow up

Patients were discharged after the suture removal and after the initiation of elbow range of movements. The first follow-up was at 6 weeks (patients were informed to follow up immediately if any problem related to the elbow surgery) and subsequent follow-ups were done at 3 months, 6 months, and at 1 year. At every follow-up visit of the patient, the functional mayo elbow performance score was assessed and compared for any improvement or deterioration in the outcome. At every follow-up, X-rays were repeated to assess the union of the fracture, or the presence of any delayed union, non-union, and implant failure. The range of movements at the operated elbow were assessed in each follow-up. The patients were counselled and explained the use of physiotherapy in getting a full range of elbow movements. In the case of non-cooperative patients, the use of continuous passive motion exercises after checking for union and stability was done to improve the range of motion at the elbow.

RESULTS

The study was a single-centric study conducted in a tertiary care hospital after obtaining permission from the Institutional Ethics Committee. A total of 50 cases of comminuted olecranon fracture were included in the present study. The patients were divided into 2 groups, i.e.; group LCP- patients with fractures fixed using the pre-contoured locking compression plate, and group CP- patients with fracture fixed using the 3.5 mm reconstruction plate.

The average age of the patients in the LCP group was 38.3 years and of the patients in the CP group was 42.9 years in the range of 18-70 years. There were 10 males and 15 females in group LCP and 11 males and 14 females in group CP. In group LCP, the right elbow was involved in 16 patients, and the left elbow in 9 patients. In group CP, the right elbow was involved in 15 patients and the left elbow in 10 patients. In the group LCP, 17 patients reported a history of fall, 7 patients had a road traffic accident and 1 patient had a history of assault. In the group CP 15 patients had a history of fall, 8 patients met with a road traffic accident and 2 patients had a history of assault.

The mean interval in days between the day of trauma and the day of surgery in the case of the LCP group was 6.44 ± 2.67 days, and the for the CP group was 7.52 ± 1.71 days. The average duration of surgery of the patients in the LCP group was 75.12 ± 20.67 minutes and of the patients in the CP group was 90.68 ± 10.33 minutes in the range of 30-120 min (Figure 1). There was a significant difference in the duration for surgery between the two groups ($p < 0.05$) The average blood loss during surgery of the patients in

the LCP group was 60.92 ± 20.38 ml and of the patients in the CP group was 69.72 ± 12.72 ml in the range of 25-125 ml. There was no significant difference seen between the two groups ($p > 0.05$).

The average time to union in the LCP group was 4.4 ± 1.5 months and in the CP group was 5 ± 1.5 months (Table 2). The difference was not found to be statistically significant ($p > 0.05$). The fracture was considered united on the healing of the 3 of the four cortices as visualised on the X-rays taken in orthogonal views.

The average Mayo elbow performance score (MEPS) at each follow up is as presented in Table 3 and Figure 2. The difference between the two groups was statistically significant ($p < 0.05$) at the 1.5 months and 3 months follow up but the difference was not significant ($p > 0.05$) at the 6 and 9 months follow up. In the LCP group, at 12 months, the functional outcome according to the MEPS showed 68% of patients had excellent outcome, 24% patients had a good outcome and 4% patients had a fair and 4% patients had a poor outcome. In the CP group, at 12 months, the functional outcome according to the MEPS showed 68% of patients had excellent outcome, 20% patients had a good outcome and 4% patients had a fair and 8% patients had a poor outcome (Figure 3). The average range of motion achieved at the end of 12 months is as follows (Table 4).

The complications encountered (Figure 4) were seen in 11 patients in the LCP group and among 12 patients in the CP group. The intra-operative complications were higher in the CP group as compared to the LCP group. Difficulty in reduction was observed among 3 patients in the LCP group and 2 patients in the CP group. Among the patients of the CP group, 3 had unstable fixation as seen intraoperatively in the OT under the image intensifier.

The early complications observed were Superficial skin infections (SSI), wound dehiscence, and ulnar nerve neurapraxia. Superficial surgical site infection was seen in 1 participant in the LCP group which required debridement and subsequent flap coverage for the closure of the wound. SSI occurred in 1 patient in the CP group which was managed by antibiotics and debridement. Wound dehiscence was encountered in 2 patients each from the LCP and the CP group. These were managed with daily dressings and secondary suturing was required in 1 patient in the CP group. In the CP group, a patient had developed postoperative ulnar nerve neurapraxia which was managed conservatively which full function returning by 3 weeks post-operatively.

The late complications observed were stiffness, non-union, implant failure, screw back out, and implant prominence. Stiffness occurred in 2 patients in the LCP group and was seen due to non-compliance of the patients to the post-operative physiotherapy advised. Non-union was observed in 1 patient each from the 2 groups. Screw backout was seen in 2 patients of the CP group. Implant failure was seen in 2 patients of the CP group. Implant prominence was

encountered in 2 patients in the LCP and 1 patient in the CP group.

Table 1: Demographic data of the patients.

Variables	Group LCP (N=25)	Group CP (N=25)
Age (years) average	38.3	42.9
Male/female	10/15	11/14
Right/left	16/9	15/10

Table 2: Time to union of the fracture in either groups.

Time to union	LCP	CP
Time to union	4.375	5.045
Mean time to union (months)	1.52	1.43
SD	03-06	03-06
Range (months)	4.375	5.045
P value	0.13 (NS)	

Note: NS- Non-significant (p value>0.05).

Table 3: Mean MEPS at each follow-up.

Time (months)	LCP	CP	P value
1.5	47±6.45	43.40±4.26	0.024 (S)
3	67.4±6.94	61.6±7.73	0.007 (S)
6	86.40±9.84	85.60±12.52	0.8 (NS)
12	88.40±10.87	87±12.90	0.68 (NS)
P value	0.001 (S)*		0.001 (S)*

Note: S- significant (p value<0.05); NS- non-significant (p value>0.05); and*- ANOVA test applied.

Table 4: Mean range of motion at the end of 12 months in degrees

Mean range	LCP	CP
Flexion	131.5 (90-153)	116.52 (85-139)
Extension deficit	12.52 (5-19)	14.6 (10-21)
Pronation	64.76 (51-82)	59.6 (12.35)
Supination	66.84 (57-86)	61.84 (33-86)

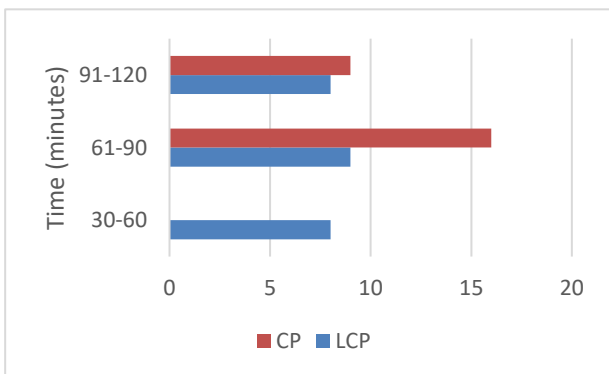


Figure 1: Duration of surgery (in min) in either groups.

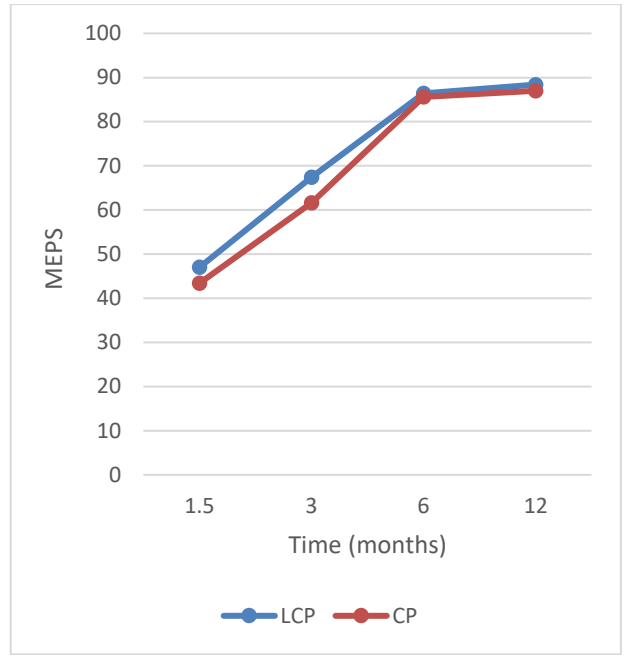


Figure 2: Mean MEPS at each follow up in either groups.

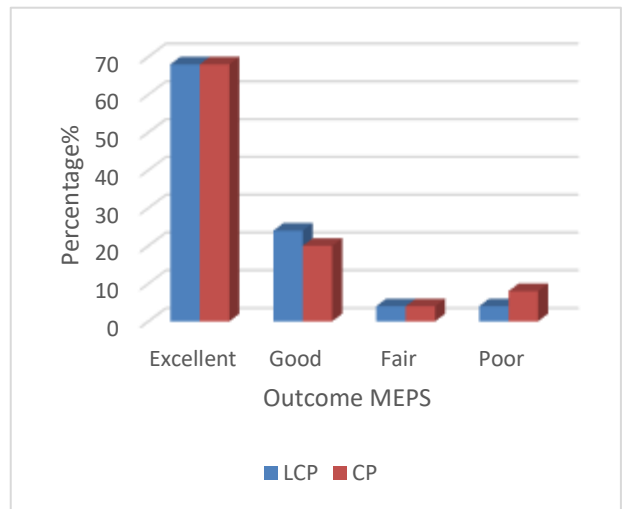


Figure 3: Outcome at end of 12 months.

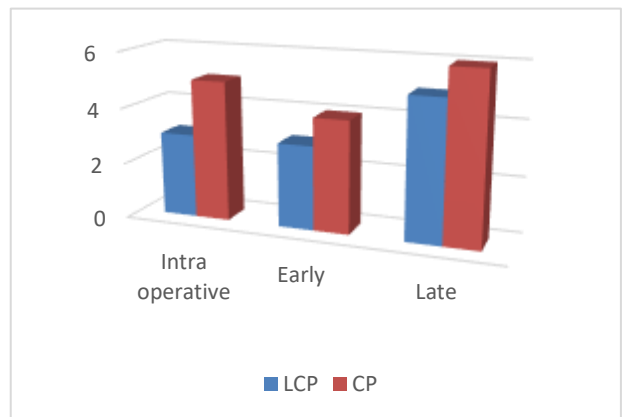


Figure 4: Complications encountered in either groups.



Figure 5: Pre-operative X-ray and immediate post-operative X-ray.



Figure 8: Pre-operative X-rays.



Figure 6: Follow up X-ray at 6 months.



Figure 9: Follow up X-ray at 6 months.



Figure 7: Clinical photos.



Figure 10: Clinical photos.

DISCUSSION

The aim of surgical management of comminuted intraarticular olecranon fractures is to achieve the alignment of the longitudinal axis, restoration of joint stability, articular congruity, normal strength, and a pain-free functional arc of motion at the elbow. The early functional rehabilitation of the elbow in the postoperative period is necessary as the immobilization of the elbow joint after an injury, even for a short period, adversely affects the range of motion of the elbow and the functional outcome. Therefore, stable fixation of the fracture is important. Furthermore, the long-term reliability of plate fixation is crucial because extreme bending stresses at the proximal part of the ulna occasionally can lead to fatigue failure of internal fixation devices.

Age distribution

In the present study, the mean age of the patients in the LCP group was 38.36 ± 15.45 years with the youngest being 19 years and the oldest being 69 years. The majority of the patients, 11, were in the age group of 21 to 40 years. The mean age of the patients in the CP group was 42.92 ± 12.42 years with the youngest being 19 years and the oldest being 65 years. The majority of the patients, 14, were in the age group of 41 to 60 years.

The study by Lan et al showed the mean age of 36.50 years in the group of patients managed with nonlocking plates and 43.4 years in the patients managed with locking plates.¹⁹ The study by Bailey et al showed the mean age of 54 years, range between 14 to 81 years.²⁰ The study by Buijze et al showed the mean age of 56 years, range between 19 to 87 years.²¹ Increased cases of fracture in the middle age group seen may be due to the higher mobility of the patients in the age group with outdoor activities at a greater rate.

Sex distribution

In the present study, the majority of the patients were female in the total study population comprising 58% of the total population studied and the rest were males (42%). The LCP group had 60% females and 40% males while in the CP group there were 56% females and 44% males. In the present study female patients were more, similar to studies by Bailey et al, Lan et al and Niglis et al which are 56%, 56.52%, and 54.54% respectively.¹⁸⁻²⁰ Increased female sex distribution may be due to increased carrying angle of the elbow in females, bimodal age distribution, and osteoporosis.

Side of involvement

31 patients comprising 62% of the total population studied were found to have right-sided fracture whereas the rest of the 38% (19 patients) had a left-sided fracture. The LCP group had 64% (16 patients) right-sided involvement and 36% (9 patients) left-sided involvement. The CP group had

60% (15 patients) right-sided involvement and 40% (10 patients) left-sided involvement. None of the patients in the current study presented with a bilateral olecranon fracture. The present study is similar to the study by Lan et al in which right-sided fractures were more.¹⁹ The side of involvement may be due to differences in genetic susceptibility, the prevalence of other risk factors such as the mechanism of injury and osteoporosis.

Mechanism of injury

In the present study the mechanism of injury in the majority of cases was found to be fall in 64% (32 patients) of the cases while amongst the rest of the cases, 30% cases (15 patients) reported road traffic accident and 6% (3 patients) reported injury due to assault. This is comparable to most of the related studies of Buijze et al and Bailey et al.^{20,21}

Operative time

In the present study, the mean operative time in the LCP group was 75.12 min ranging from 44-112 min while the mean operative time in the CP group was 90.68 min ranging from 71-116 min. The use of conventional plate required more time because of difficulty in reduction, difficulty in maintaining a reduction in osteoporotic bones, and time consumption in bending and contouring of conventional plates respectively. This is similar to the study by Mahamud et al with a mean operating time of 75 min.²²

Time to union of the fracture

In the present study, the radiological union was seen at a mean of 4.375 months in the patients with fracture fixed using the pre-contoured locking plate and 5.045 months in patients with fracture fixed using the conventional plate. This is similar to the study conducted by Buijze et al (average union time of 4.4 months).²¹

Range of motion of the elbow

In the present study, the mean range of motion achieved at the end of 12 months in the patients with fracture fixed using the pre-contoured locking plate was 131° of flexion (90°-153°), mean extension deficit of 12.5° (5°-19°), mean pronation 64° (51°-82°) and mean supination 66.8° (57°-86°).

The mean range of motion achieved at the end of 12 months in the patients with fracture fixed using the conventional plate was 116° of flexion (85°-139°), mean extension deficit of 14.6° (10°-21°), mean pronation 59.6° (34°-75°) and mean supination 61.8° (33°-86°). The mean range of motion achieved in the present study is similar to Buijze et al [flexion: 136° (120°-150°); extension deficit: 13° (0°-10°); pronation: 74° (10°-80°); supination: 71° (10°-80°)]; Mahamud et al [flexion: 121° (80°-140°); extension deficit: 27° (0°-70°); pronation: 64° (5°-90°); supination:

74°(10°-90°)] and Siebenlist et al [flexion: 136° (120°-150°); extension deficit: 13° (0°-10°); pronation: 74° (10°-80°); supination: 71° (10°-80°)].²¹⁻²³ Thus the studies suggest that the early mobilization of the elbow in the post-operative period is essential to get better range of motion.

The alignment of the longitudinal axis in the intraoperative period was achieved due to the contour of the plate on application to the fractured fragments and the fixation using screws post the reduction of fracture fragments. The articular surface was reduced according to the contour of the trochlea as a reference template ensuring proper articular congruity. Thus, we suggest that appropriate alignment of the longitudinal axis along with maintenance of joint congruity ensures a good range of motion arc in the postoperative period.

Complications

In the present study, total intra-operative complications encountered in both the groups were difficulty in reduction (10%) and unstable fixation (6%). The average amount of blood loss was 65.32 ml with a range from 30-110 ml. The total early postoperative complications observed were superficial skin infection (4%), wound dehiscence (8%), and ulnar neuropraxia (2%). The total late postoperative complications were screw back out (4%), implant failure (4%), stiffness (4%), non-union (4%), and implant prominence (6%).

In the group with patients managed using a conventional plate, the intraoperative complications observed were 12% of unstable fixation, 8% difficult reduction, and those in the group with patients managed using pre-contoured locking plate were 12% difficult reduction. There was no patient with unstable fixation. The average blood loss with the pre-contoured locking plate was 60.92 ml and that with the conventional plate was 69.72 ml.

In the group with patients managed using a conventional plate, the early post-operative complications observed were 4% of a superficial skin infection, 8% wound dehiscence, 4% ulnar nerve neuropraxia and those in the group with patients managed using pre-contoured locking plate were, 8% wound dehiscence and 4% superficial skin infection.

In the group with patients managed using a conventional plate, the late post-operative complications observed were 4% non-union, 8% implant failure, 8% screw back out, 4% implant prominence, and those in the group with patients managed using pre-contoured locking plate were, 8% implant prominence, 8% stiffness, 4% non-union. There was no implant failure observed with the pre-contoured locking plate.

The above-mentioned complications are similar to studies by Buijze et al and Lan et al.^{19,21}

Non-union was managed with bone grafting, stiffness was managed with CPM exercises, superficial skin infection treated with appropriate antibiotics and dressing, deep infections were managed with debridement and wound wash, implant prominence was managed with implant removal after the fracture union.

In the present study, the complication of myositis ossificans was not encountered mostly because of early mobilisation of the elbow. We observed most of the complications (unstable fixation, non-union, screw back out, implant failure) with the conventional plating. The pre-contoured locking plates showed fewer complications (screw back out, unstable fixation, and non-union) because locking plates provide more stability during the fixation and hold the fracture fragments better till union occurs as it is a fixed angle implant.

Outcome

In the present study, the outcome after surgery was calculated by using MEPS at every follow-up. According to the MEPS scores, outcome at the end of 12 months showed in the LCP group 17 patients (68%) had excellent, 6 patients (24%) had good, 1 patient (4%) had fair and 1 patient (4%) had a poor result. In the CP group, 17 patients (68%) had excellent, 5 patients (20%) good, 1 patient (4%) fair and 2 patients (8%) poor outcomes.

This was similar to the studies conducted by Buijze et al [mean MEPS: 93; excellent :12 (75%); good: 3 (18.75%); fair: 1 (6.25%)]; Lan et al [non-locking plate group- mean MEPS: 95, excellent: 8 (80%), good: 2 (20%); locking plate group- mean MEPS: 94, excellent: 10 (76.9%), good: 2 (15.3%), fair: 1 (7.69%)]; Mahamud et. al [mean MEPS: 84; excellent: 5 (55.55%); good: 1 (11.11%); fair: 1 (11.11%); poor: 2 (22.22%)].^{19,21,22}

In the present study, the difference in the mean MEPS scores between the 2 groups was significant at 1.5- and 3-months follow-up was found to be significant. However, the difference between the mean MEPS score at the 6- and 12-months follow-up was statistically not significant which was in concordance with the previous studies. Thus, we suggest though the outcome in the patients of both groups is the same, in the short term the pre-contoured locking compression plate provides better results than the conventional plate and thus ensures faster functional recovery of the patient.

The limitations in this study were the small number of cases and the shorter time of follow-up. Future large multicentric studies are required to confirm these findings. Further, long-term results should be monitored and compared to better evaluate the outcomes in either of the fixation methods.

CONCLUSION

Open reduction and internal fixation is the treatment of choice for comminuted olecranon fracture in osteoporotic fractures unless contraindicated. Early surgery is recommended to get a better elbow range of motion and a good functional outcome.

Anatomical reduction, stable fixation, and early elbow mobilization form the prerequisites for a better functional outcome with the restoration of the intra-articular arch of olecranon found to have a major role in the recovery of elbow function. The pre-contoured locking compression plate, a fixed angle device, provides better stability which in turn helps in maintaining apposition of reduced fragment allowing creeping substitution, ultimately micro-motion of fracture fragments leading cancellous union. Proper dissection, the release of soft tissues, and meticulous handling of ulnar nerve prevent post-operative ulnar nerve injury. The above complication is more frequent with the conventional plates as compared to the locking plate as greater soft tissue dissection is required to ensure proper placement of the plate.

In the present study, we suggest that the locking compression plate is the better option to treat comminuted olecranon fractures with good functional outcomes and fewer complications as compared to conventional plates. The functional outcome achieved by both methods of plating is the same. However, the use of a pre-contoured locking compression plate provides better outcomes at earlier periods as compared to the conventional plate; thus, returning the patient to normal function at the earliest.

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