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Functional outcome of closed diaphyseal fractures of both bone forearm in adults treated by small dynamic compression plate fixation in radius & intramedullary nail fixation in ulna

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Abstract

Introduction: Both bone forearm fractures represent approximately 10-14% of all fractures. It is advocated that these type of fracture should be treated surgically, Fixation of fracture is done by either plate or nail or both.

Aims and objectives: To study and evaluate functional outcome by GE (Grace & Eversmann Rating) rating & Anderson *et al.* score in closed diaphyseal fractures of both bone forearm in adults treated by SDCP (Small Dynamic Compression Plate) in radius & intramedullary nail in ulna.

Method and Materials: Present study included 60 patients aged 18-45yrs having fracture both bone forearm admitted in OPD and emergency at MBGH Udaipur from 1st January 2017 to 31st July 2018 & divided in 4 groups on the basis of location of fracture site of both bones, A (both upper third), B (Both Middle Third), C (both lower third) & D (Both At Different Site). All patients were operated with intramedullary Talwalkar's square nail in ulna & SDCP in radius. Functional outcome using GE rating and Anderson *et al.* score and complications were observed with 9 months clinic radiological follow up.

Result: Maximum no. of patients were in group B which is 36(60%). Mean union time for was minimum for B (15.41 Wks.), maximum in A (20wks) with overall 16.25wks. Average roation arc was 140.51 (90.32% of the reference mean). In GE patients showing excellent result were overall 56.6% & maximum 70% in D, while unacceptable in 6.67%. In Anderson *et al.* score patients showing excellent result were 63.33% overall with maximum 80% in D, while failure in 5%.

Conclusion: Fracture union time was minimum in group-B & maximum in group A (because of prolong immobilization and delayed physiotherapy). Both scoring system showed best results with variable site involvement (D) because of better stability, early mobilization & good rotation arc. Considering GE & Anderson *et al.* scores with overall union rates & rotation arc, SDCP in radius and square nail in ulna is a good fixation modality for fracture forearms especially in group D.

Keywords: GE, SDCP, talwalkar's square nail

Introduction

The forearm functions as clinical & anatomical unit of the upper limb, permitting the effector organ of the upper limb, the hand to be placed in any position to grasp or to give support to an object. Diaphyseal fractures of forearm bones in adults are difficult to treat conservatively. There is a high incidence of malunion and non-union because it is difficult to reduce and maintain reduction of two mobile bones in presence of pronating and supinating muscles which exerts rotator as well as angulatory forces. Maintenance of normal configuration of radius especially the lateral bow is important if full pronation and supination are to be achieved after fracture¹⁻⁴. It is recommended that the displaced Both Forearm Bone Fracture (BFBF) in adults should be treated surgically because of unsatisfactory outcomes of conservative management; however, most of the cases in children can be treated with closed reduction and immobilization⁵. The gold standard of operative treatment is open reduction internal fixation using the dynamic compression plate (DCP). However, the disadvantages of plate fixation include a relatively large skin incision, interruption of bloody supply due to wide periosteal dissection of the forearm bone, or re fracture following plate removal⁵⁻⁶.

Additionally, this method has some limitations in BFBFs with extensive soft tissue damage, severe swelling, open fracture, segmental fracture, or a limited operation time due to associated injuries.

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In order to overcome these problems, intramedullary (IM) nail fixation can be used as an alternative method for treating BFBFs in either of the bones [1].

Aims and objectives

This study is conducted to study and evaluate functional outcomes, union & complications in closed diaphyseal fractures of both bone forearm in adults fixed by SDCP in radius & intramedullary nail in ulna using Grace & Eversman [7] and Anderson *et al.* [8] scores. Union time of fractures also studied and complication after operative procedures managed with appropriate method.

Method and Materials

Present study included 60 patients aged 18-45yrs having fracture both bone forearm admitted in OPD and emergency at RNT Medical college and attached MB Govt. Hospital Udaipur from 1stjanuary 2017 to 31stjuly 2018 & divided in 4 groups on the basis of location of fracture site of both bones, A (both upper third), B (both middle third), C (both lower third) & D (both at different site). All patients were operated with intramedullary Talwalkar’s square nail in ulna & SDCP in radius. It is a prospective time bound study and sample size is 60.

Inclusion criteria

1. Age>17years&< 45 years of age
2. Fractures of diaphysis both bone forearm < 3weeks durations

Exclusion criteria

1. Fractures>3 weeks old.
2. Open fractures.
3. Age of patients <17 &> 45 years
4. Patients with underlying neuromuscular disease.
5. Metabolic bone disorders.
6. Pathological fractures.
7. Associated epiphyseal radius and ulna injury.

Examination of patient

On admission a history was taken from patient and/or attendant to reveal mode and duration of injury. Then all patients were examined clinically and the following points were noted: Side involved, Amount of swelling, Deformity, Site of fracture, Any wound communicating with fracture, Any neurovascular involvement, Presence of any associated injury, Condition of skin and wound.

Preoperative planning

All the cases were subjected to radiological examination (antero-posterior and lateral view of affected forearm with wrist and elbow joint). Other different part of body in which fracture was suspected was also radiologically examined.

Every patient was subjected to necessary pathological investigations, ECG, chest x ray and pre anesthetic evaluation was done. As soon as the patient was medically fit for operation, the operation was done. Consent was taken for surgery and anesthesia. Prophylactic antibiotic (3rd gen. cephalosporin) was given one hour preoperatively.

Position

Patient is supine on the operating table with the arm is placed on arm board with elbow straight and forearm in supination.

Operative procedure

After giving suitable anaesthesia (general anaesthesia or brachial block anaesthesia) the pneumatic tourniquet was applied in all cases.

Surgical steps for ORIF with SDCP fixation in radius

Anterior Henry's approach was used and plate was applied on the broad, flat volar aspect of radius which is well covered with soft tissues. After 10-15cm longitudinal incision, muscle plane is developed between Brachioradialis and Flexor carpi radialis. Fracture site is identified, periosteum stripped and fracture is reduced using bone holding forceps. SDCP of atleast 6 holes applied on volar aspect with plate holding forceps so that minimum of 6 cortex can be purchase on either side. Appropriate sized 3.5mm hexagonal screw inserted after neutral drill of 2.5 mm and 3.5mm tape. If required a lag screw can be Inserted first for oblique fractures. Once the reduction achieved meticulous closure is done.

Surgical steps for CRIF/ORIF with intramedullary nail fixation in ulna

Appropriate diameter and length of Talwalkar’s square nail is determined by uninjured limb & radiological assessment. Closed reduction is achieved by manual traction and manipulation over the fracture site. In some cases open reduction required. Square nails were inserted in an antegrade fashion with the entry point from the olecranon process. Medullary canal is rimmed and prepared before insertion of nail. Skin closure is done, tourniquet is released and A/E POP slab is applied with compression bandage.

Post operative care

The limb was kept elevated for 24 to 48 hours and the patient was instructed to move their fingers. Postoperatively wound was inspected after 2 to 3 days. IV Antibiotics (3rd generation cephalosporin’s) for first 5 days and converted to orals for next 5 days and analgesics were given to the patient till the time of suture removal. Sutures were removed on 10th postoperative day. In grossly comminuted patients posterior slab was given for 3 weeks unless it is a stable rigid fixation

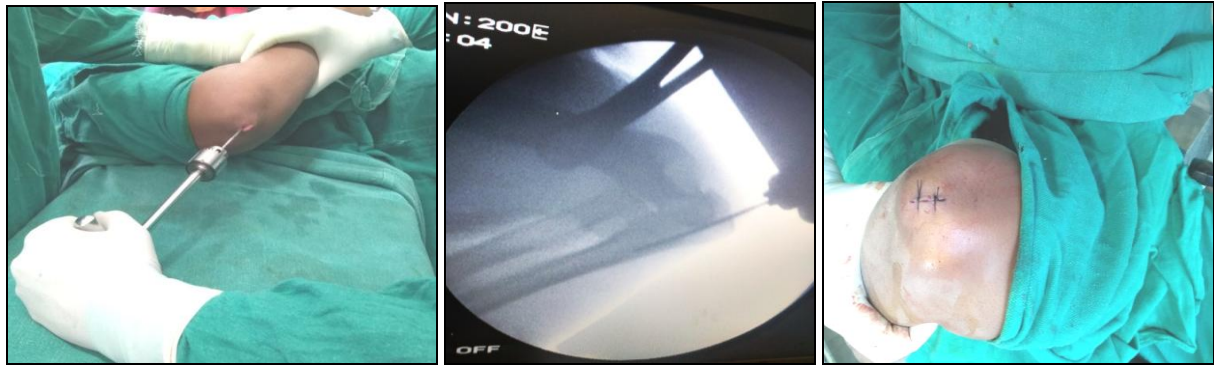
Operative procedure



ORIF with SDCP

Skin incision radius

Closure of radius wound



Square nail insertion from olecranon of ulna C-arm guided insertion of nail in ulna Closure of ulna entry site wound

Case of fracture both bone forearm & its radiological & functional outcome



Preoperative limb attitude Preoperative x ray 9 Month follow up x ray Post-operative x- ray



Flexion (9 Month follow up) Extension (9 Month follow up) Supination (9 Month follow up) Pronation (9 Month follow up)

Post-operative care: The limb was kept elevated for 24 to 48 hours and the patient was instructed to move their fingers. Postoperatively wound was inspected after 2 to 3 days. IV Antibiotics (3rd generation cephalosporin's) for first 5 days and converted to orals for next 5 days and analgesics were given to the patient till the time of suture removal. Sutures were removed on 10th postoperative day. In grossly comminuted patients posterior slab was given for 3 weeks unless it is a stable rigid fixation.

Follow up: Patients were called for follow up at 3weeks, 6 weeks, 3 months, 6 months and 9 month for clinical and radiological evaluation.

Results

Total 60 patients having fractures of both bones of forearm. Patients were treated by open reduction and internal fixation with small DCP for radius and closed reduction and internal fixation with intramedullary Talwalkar's Square Nail in Ulna. Among the both bone forearm diaphyseal fracture those patients having proximal third location of fracture designated as Group A, those patients having middle third location of fracture designated as Group B and those patients having

distal third location of fracture designated as Group C & patients with fractures at variable site in radius-ulna designated as group D.

Important results are as below

1. Younger age (68.33% patients) & male sex (78.33% patients) had more incidence of forearm fractures because of more hard work & outdoor activities in younger males. Average age of patients came out to be 31.78 years.
2. RTA (48.33%) was most common and work accident (28.33%) was the second most common injury mode for forearm fractures.
3. Most vulnerable portion of forearm to get fractured was middle one third (60%) and the right forearm (53.33%) more commonly involved than the left one.
4. Most common fracture pattern in both radius (51.6%) & ulna (66.67%) was transverse.
5. Out of 60 patients maximum 29 (48.33%) patient had RTA and 17 (28.33%) patient had work accident.
6. 33 (53.33%) cases had fractures of right forearm and 27 (45%) cases had fractures of left forearm. One case had bilateral forearm fracture.
7. Most common fracture type is transverse in both radius

(66.67%) and ulna (51.6%).

Only 22 (36.67%) cases had associated fractures of other bones.

8. Out of total of 60 cases maximum 36 cases (60%) had fractures through middle third of radius and ulna (grp B), 8 (13.33 %) cases had fracture through upper one third designated as (grp A), 6 (10%) cases had fracture through lower third of both bones forearm (grp C). While 10 (16.66%) cases had variable involvement of radius & ulna, that means both fractures are not at the same level designated as Group D. See Table 1.
9. Non-union more commonly seen in Grp A and B while infection were mostly found in Grp B. See Table 2.
10. In our study average union time was 16.25 weeks and 5% cases went into non-union. See Table 3.
11. In functional outcome according to the Grace and Eversmann rating system⁷ we found overall 56.6% excellent rating, 21 % good rating, 1.67% acceptable rating and 6.67% unacceptable rating in total 60 patients. Group D (variable fracture site of both bones) gave best results (70% excellent & 0% unacceptable) and Group A (upper one third fracture) gave worst outcome (50% excellent & 12.5% unacceptable). See Table 4 below While according to Anderson *et al.* scoring system⁸ in our study we found total of 63.33% excellent score, 30% satisfactory score, 1.67% unsatisfactory and 5% failure cases. Best result was seen in Group D (variable fracture site of both bones) with 80% excellent and none case of failure while worst result was seen in Group A (upper one third fracture) with total 12.5% failure. See Table 5 below.
12. The average range of supination and pronation in all patients was 75.8° and 64.71°, which was 92.23% and 91.14% of the normal rotation arc value given by

American academy of orthopaedic surgeons(84° and 71°)¹⁰⁴. Mean rotation arc was 140.51° (90.32% of reference value 155°). Group D (variable fracture site of both bones) had best rotation arc while Group A (upper one third fracture) had poor rotation arc.

13. The results of the operative treatment of fractures of both bones of forearm, in four groups, Group A, Group B, Group C and Group D, were graded in our study. The Grace and Eversmann rating system and Anderson score were applied for rating the functional results of operative treatment.

According to Grace- Eversman rating ^[7] Grp D (variable site) has best outcome including 70% excellent and 30% good result with no unacceptable cases.

According to the Anderson *et al.* score ^[8] Grp D (variable site) has again best outcome including 70% excellent and 30% satisfactory results with no failure cases.

Table 1: Site of Fracture

| Site of Fracture | No. of Patients | % of Patients |
|--------------------|-----------------|---------------|
| Upper on third (A) | 8 | 13.33% |
| Middle third (B) | 36 | 60% |
| Lower third (C) | 6 | 10% |
| Variable site (D) | 10 | 16.66% |
| Total | 60 | 100% |

Table 2: Post-Operative Complications

| Post Op. Complication | Group A | Group B | Group C | Group D | Overall |
|------------------------|---------|---------|---------|---------|---------|
| Super facial Infection | - | 2 | - | - | 2 |
| Deep Infection | - | 1 | - | - | 1 |
| Implant Prominence | - | 1 | 1 | - | 2 |
| Non-Union | 1 | 2 | - | - | 3 |

Table 3: Time of Union of Bones

| Grp. | Site of Fracture | No. of Pts. | Time of Union Wks. | | Total Union Time Wks. |
|--------|------------------|-------------|--------------------|-------|-----------------------|
| | | | Radius | Ulna | |
| Grp A | Upper third | 8 | 17.12 | 20 | 20 |
| Grp B | Middle Third | 36 | 14.94 | 15.22 | 15.41 |
| Grp C | Lower Third | 6 | 15.16 | 15.16 | 15.50 |
| Grp. D | Variable site | 10 | 15.10 | 15.70 | 15.70 |

Table 4: Functional Outcome: Grace & Eversmann rating

| Grace & Eversmann Rating | Group A | | Group B | | Group C | | Group D | | Overall | |
|--------------------------|----------|-------|----------|--------|----------|-----|----------|-----|----------|-------|
| | No of Pt | % | No of Pt | % | No of Pt | % | No of Pt | % | No of Pt | % |
| Excellent | 4 | 50% | 20 | 55.56% | 3 | 50% | 7 | 70% | 34 | 56.6% |
| Good | 3 | 37.5% | 12 | 33.33% | 3 | 50% | 3 | 30% | 21 | 35% |
| Acceptable | 0 | 0% | 1 | 2.78% | 0 | 0 | 0 | 0% | 1 | 1.67% |
| Unacceptable | 1 | 12.5% | 3 | 8.33% | 0 | 0 | 0 | 0% | 4 | 6.67% |
| Total | 8 | | 36 | | 6 | | | | 60 | |

Table 5: Functional outcome: Anderson *et al.* Score

| Anderson <i>et al.</i> Score | Group A | | Group B | | Group C | | Group D | | Overall | |
|------------------------------|----------|-------|----------|--------|----------|--------|----------|-----|----------|--------|
| | No of Pt | % | No of Pt | % | No of Pt | % | No of Pt | % | No of Pt | % |
| Excellent | 6 | 75% | 20 | 55.56% | 4 | 66.67% | 8 | 80% | 38 | 63.33% |
| Satisfactory | 1 | 12.5% | 13 | 36.11% | 2 | 33.33% | 2 | 20% | 18 | 30% |
| Un Satisfactory | 0 | 0% | 1 | 2.78% | 0 | 0% | 0 | 0% | 1 | 1.67% |
| Failure | 1 | 12.5% | 2 | 5.55% | 0 | 0% | 0 | 0% | 3 | 5% |
| Total | 8 | | 36 | | 6 | | 10 | | 60 | |

Table 6: Overall Assessment of Fracture Union and Functional Results

| Variable | Group A | Group B | Group C | Group D | Total |
|--|---------|---------|---------|---------|-------|
| Grace & Eversmann Functional evaluation | | | | | |
| Excellent | 4 | 20 | 3 | 7 | 34 |
| Good | 3 | 12 | 3 | 3 | 21 |

| | | | | | |
|--------------------------------------|---------------|---------------|---------------|--------------|---------------|
| Acceptable | 0 | 1 | 0 | 0 | 1 |
| Unacceptable | 1 | 3 | 0 | 0 | 4 |
| Anderson <i>et al.</i> Score | | | | | |
| Excellent | 6 | 20 | 4 | 8 | 38 |
| Satisfactory | 1 | 13 | 2 | 2 | 18 |
| Un Satisfactory | 0 | 1 | 0 | 0 | 1 |
| Failure | 1 | 2 | 0 | 0 | 3 |
| Range of Motion mean, (range) | | | | | |
| Supination | 74.87 (68-81) | 75-47 (65-83) | 77 (70-84) | 77 (70-82) | 75.8 (65-84) |
| Pronation | 63.50 (60-69) | 64.67 (54-72) | 65.33 (59-71) | 65.5 (55-70) | 64.71 (54-72) |
| Union time (wk), mean (range) | 20 (19-37) | 15.4 (19-32) | 15.5 (12-19) | 15.7 (12-19) | |

Discussion

Malecki (1997) ^[10]. treated of forearm with square nail-fixation & reported 4 cases, 12.5%, out of total of 32 cases of square nail fixation with poor anatomical alignment and poor functional results.^[10] Whereas in our study there were 63.33% cases with good, 30% cases with satisfactory and 6.67% case with poor anatomical alignment.

Average union time in Kim's study (2014) ^[11] was 13.1

weeks, in Ravindra gouda (2016) was 15.3 weeks, in Guarav vala (2016) was 14.4 weeks & in our study was 15.93weeks. So our study is comparable to this studies in term of results with less invasive method, because we used SDCP (radius) & square nail (ulna) in place of SDCP in both radius and ulna. Our study has lower complication rates than these three studies. See the table below.

Table 7: Complication Rates

| | No. of patients | Time to union | Range of Motion | | Complications | | | |
|-----------------------|-----------------|---------------|-----------------|-----------|---------------|--------------------|----------------|-----------------|
| | | | Supination | Pronation | Non-union | Implant Prominence | Deep Infection | Implant failure |
| Present Study | 60 | 15.93 week | 75.8 | 64.71 | 3 | 2 | 1 | 0 |
| Sang Kim (2014) | 56 | 13.1 weeks | 82 | 77 | 3 | 2 | 1 | 0 |
| Ravindra Gouda (2016) | 20 | 15.3 weeks | 84 | 78 | 1 | 2 | 2 | 0 |
| Gaurav Vala (2016) | 50 | 14.4 weeks | 81 | 79 | 2 | 3 | 1 | 2 |

Conclusion

Our study concluded forearm fractures with variable site fracture in radius and ulna gave best functional outcome while fracture of both radius & ulna at upper one third gave poor functional outcome because of delayed physiotherapy and prolonged immobilization.

So overall upper one third forearm fractures were difficult to treat, had poor functional outcome and more complication, while fractures at variable site location of forearm bone were satisfactory, have best functional outcome, early mobilization and least complications rates due to its anatomy.

Fixation of ulna by square nail instead of SDCP can reduce the surgical exposure and hence facilitate early healing and early physiotherapy. Because radius is mobile bone so SDCP is good option for anatomical restoration with good functional outcome. Considering Grace & Eversmann rating, Anderson *et al.* score with overall union rates and rotation arc, SDCP in radius And square nail in ulna is a good fixation modality for fractures of both bone forearm especially in Group D (variable site of fractures of both bones).

Functional outcome, union, & complication rates showed that fixation of both bone forearm in by SDCP in radius & square nail in ulna is good surgical method, because functional outcome is comparable to studies in literature with less complication by using less invasive method (square nail in ulna in place of SDCP in ulna).

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