MATERIAL AND METHODS
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This study was conducted in the department of orthopaedic surgery M.L.B. Medical college and Hospital Jhansi. The cases for present study were selected from the patients attending emergency as well as the outpatients department of orthopaedics from March 98 to January 2000. A total of eighteen cases are being included in this study.

Patients were selected for this study based on the following criteria:

1. Fractures of both bones of forearm.
2. Age more than 17 years or past the age of skeletal maturity.

Following types of cases were not considered suitable for the study:

1. Unsuitable condition of neighbouring skin, like presence of infection, burns, abrasions or blebs.
2. Poor anesthetic and surgical risk.

Each patient after admission in this hospital was subjected to careful and detailed history with special reference to the following:

* Name
* Age
* Sex

* Occupation

* Mode of injury

* Date and time of injury

* Associated injuries

* Treatment, if any, taken before coming to this hospital and their results.

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

* Local examination of the forearm skin with special reference to the condition of skin.

* Condition of wound

In addition, general examination, relevant systemic examination was also done in every case. All the cases were subjected
to radiological examination (antero posterior and lateral view of affected forearm with wrist and elbow joint). Other different parts of body in which fracture was suspected was also radiologically examined. Every patient was subjected to necessary pathological investigations and preanesthetic check up was done. As soon as the patient was medically fit for operation, the operation was done.

Either of the two appliances were used for internal fixation after open reduction:

(a) Dynamic compression plate.

(b) Talwalkar's square nail for radius and ulna.

Instruments and implants required specially for carrying out the procedure other than the general orthopaedic surgery instruments were:

1. Small fragment Dynamic compression plate of six, seven or eight holes.

2. 3.5mm cortical screws of different lengths from 8 to 24mm.

3. A.O. type bone holding clamps.

4. 2.5mm & 3.2mm drill bits and hand drill machine.

5. 3.5mm drill guide, bone tap, tap sleeve and hexagonal screw driver.

6. Complete set of radial and ulnar square nails of width varying from 1.5mm to 4mm with 0.5mm increments and lengths
varying from 16cm to 30cm with 1cm increments.

7. A set of forearm reamers, extractor hooks and a small size bone awl.

The implants used were the same for both bones. Autogenous iliac bone grafts were used when comminution was significant or where fracture was more than three weeks old and they were applied away from interosseous border.

**OPERATIVE PROCEDURE**

After giving suitable anesthesia (general anesthesia or brachial block anesthesia) the pneumatic tourniquet was applied. In certain cases where operation was prolonged for more than 90min the tourniquet was released and was not applied again. Then, after painting and draping with patient in supine position, the fracture sites of radius and ulna were exposed by their respective operative approaches.

**Radius**

When fracture was in the distal 2/3rd of the bone Anterior or Henry's approach was used and plate was applied on the broad, flat volar aspect of radius which is well covered with soft tissues.

In this approach, with forearm in supination a 10-15cm longitudinal incision was made over the interval between brachioradialis and flexor calpi radialis muscles. The sensory branch of radial nerve lying beneath brachioradialis was identified
and retracted laterally with it. The flexor calpi radialis tendon and radial vessels were retracted medially. Beneath this flexor pollicis longus and prorator quadratus muscles were retracted medially by subperiosteal dissection along with overlying flexor digitorum superficialis muscle and thus the fracture site was exposed.

In fractures through proximal 1/3rd of radius, Thompson's dorsal approach was used and plate was applied on the dorsal surface. In this approach, with forearm in pronation a skin incision was made over proximal radius along a line joining centre of dorsum of wrist to a point 1.5cm anterior to the lateral epicondyle of humerus. Deep dissection was done to create space between extensor carpi radialis longus and brevis and branchioradialis on lateral side and extensor digitorum communis muscle on ulnar side. Supinator muscle being exposed was reflected subperiosteally proximally while protecting the deep branch of radial nerve thus exposing the fracture site.

Periosteum was stripped sparingly and all soft tissue attachments to commnunitied fragments were preserved. Clotted blood or fibrous tissue was cleared away from fracture fragments edges and medullary canal. With the help of bone holding forcep the fracture was reduced by carefully matching the interdigitations.

_Ulna_

Ulna was exposed by posterior subcutaneous approach. In this approach a 10cm longitudinal incision was made over the sub-
cutaneous posterior border of ulna centered over the underlying fracture. Interval between flexor and extensor carpi ulnaris was identified. Fracture site was exposed with minimum periosteal stripping. It was cleared of clotted blood and fibrous tissue and reduced.

After trial reduction of both bones of forearm, either of the internal fixation devices were used.

**Surgical Technique For Talwalkar's square nailing**

**Selection of nail:**

*Diameter of nail:* This was assessed by measuring the narrowest diameter of medullary canal by anteroposterior radiological views of forearm.

*Length of Nail:* It was measured approximately preoperatively from tip of olecranon to within 2 cm of the ulnar styloid from the radiograph which was confirmed peroperatively. Similarly for radius, it was from radial styloid process to within 1.3 cm of the radial head in the radiograph which was confirmed peroperatively.

Fixation of the bone which was less comminuted and easier was done first. Usually ulna was exposed and fracture was reduced with the help of manual traction and manipulation with bone clamps, carefully matching the interdigitations, taking special care to maintain the rotatory alignment.

**Steps of Nail Fixation in Ulna:**

Proximal fragment was delivered through the wound. The canal
was reamed till the tip of reamer was felt beneath the skin at tip of olecrenon after testing the ulnar nail for fitting in medullary cavity.

Distal fragment was also reamed and length of nail measured with the help of guide wire in proximal and distal fragments respectively. Nail driver being applied on the tip of nail, the nail was pushed retrograde into canal of proximal fragment so that its proximal end protruded from the tip of olecrenon.

The fracture was carefully reduced, held with the bone holding forceps and the nail was driven through the distal fragment till three or four threads of proximal tip of nail remained outside the surface of olecrenon tip.

**Steps of Nail Fixation in Radius:**

Proximal and distal fragments were delivered and reamed in similar manner after measuring the fitting of radial nail in medullary canal, the length being measured in similar manner as above.

Nail was introduced in an antegrade manner. Portal tract for radial nail was made with help of small curved bone awl just above the tip of radial styloid between tendons of extensor carpi radialis longus and extensor carpi radialis brevis. Proper size radial nail was introduced through the portal, keeping the bevelled edge towards opposite cortex, the fracture being reduced and held with bone holding forceps. The nail was driven through fracture site into proximal fragment. Autogenous iliac bone grafts were applied if required.
Surgical Technique for DCP Plate Fixation

Radius

Fracture site being exposed and perfectly reduced plate was applied across fracture site and held with A.O. bone clamps. At least six hole plate was used so that at least five cortex purchase would be made on either side of the fracture. More comminuted or oblique fractures were fixed with longer seven or eight hole plates. Plate was applied on dorsal surface in proximal half and volar surface in distal half. In order to accommodate radial and dorsal bows, the plate was contoured with plate bending foerecups. With the neutral drill guide and 2.5 mm drill bit the plate hole nearest to the fracture site (at least from 1 cm from the fracture site), a hole was drilled.

Depth guage was used to ensure the screw length and 3.5 mm bone tap was used for tapping the screw hole. With hexgonal 3.5 mm screw driver, the screw of appropriate length was inserted but not seated completely. Next, the plate hole on other side of fracture nearest to fracture site was drilled, using eccentric drill guide with arrow of guide pointing towards fracture site. After measuring and tapping, screw was inserted. Now both the screws were tightened and seated completely. Rest of the screws were inserted using neutral drill guide. If the fracture was oblique screw were inserted obliquely after overdrilling the proximal cortex to give lag screw effect.

Eccentric screw in oblique fractures was inserted on the side
where fracture line made acute angle with the plate surface so that the fragments impacted beneath the plate surface rather than sliding over the fragment and disimpacting.

**Ulna**

Similarly plate was fixed on ulna on anterior or posterior aspect according to ease and the side of comminution.

**Closure**

After fixing the fractured bones with either of the two devices, the muscles allowed to fall into place, suction drain tube was put, deep fascia sutured loosely, and then skin was sutured. C & D was done and A/E POP slab was applied.

**Post Operative Regimen**

Prophylactic antibiotics were given for 7 days or more depending on condition of operative wound. Active exercise of fingers and shoulder were started post operatively. Sutures were removed on 7th to 12th day.

**Follow up**: Patient was discharged if the operative wound was healthy and no other post operative complication was there to be managed. Plaster cast immobilization was continued for at least 3 weeks or more according to rigidity of fixation.

Patients were called for follow up at 3, 6, 12 and 20 weeks for clinical and radiological evaluation.

All relevant data were filled and tabulated so as to reach final
results:

1. Swelling of part.
2. Condition surgical wound.
3. Neurovascular status.
4. Type and duration of immobilization.
5. Functional status i.e. movements at various adjoining joints.
7. Return to employment.

Anderson (1975) criteria for union were modified and applied as under:

1. Fracture healing in less than 4 months was considered as - Normal union.
2. Fracture healing requiring more than 4 months, upto 6 months, but no additional operative procedure was considered as - Delayed union.
3. Those which failed to unite even after 6 months and required another operative procedure, like bone grafting, were considered as - Non union.

Anderson et al (1973) criteria for rating functional results were applied:
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<tr>
<th>Category</th>
<th>Description</th>
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<tr>
<td><strong>Excellent</strong></td>
<td>Union of fractures with Normal (100%) rotational arc of supination and pronation of forearm and Normal (100%) flexion and extension range present at wrist &amp; elbow.</td>
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<tr>
<td><strong>Good</strong></td>
<td>Union of fracture with &gt;80% of rotational arc of supination and pronation of forearm and &gt;90% of flexion and extension range present at wrist and elbow.</td>
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<tr>
<td><strong>Acceptable</strong></td>
<td>Union of fracture with &gt;60% of rotational arc present and &gt;80% of flexion and extension range present at wrist and elbow.</td>
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<tr>
<td><strong>Poor</strong></td>
<td>Non union and or less than 60% rotational arc and &lt;80% of the forearm extension range present at wrist and elbow.</td>
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Photograph showing instruments and implants for DCP fixation of forearm fractures.

Fracture site at ulna being exposed by Posterior subcutaneous approach.

Peroperative photograph showing excellent reduction of fractured fragments and good position of implant.
Radius fracture site being exposed by Anterior Henry's approach

Per operative photograph showing excellent reduction of fractured fragments and good position of implant.
Photograph showing instruments and implants for square nail fixation

Fracture site at ulna being exposed by Posterior subcutaneous approach.

Ulnar square nail being post into the marrow canal after open reduction of fractured fragments.
Excellent reduction being achieved at ulnar fracture site.

Radius fracture being exposed by Anterior Henry's approach.

Portal being made for introduction of Radial square nail.
Radial square nail being pushed halfway into the marrow canal of the radius

Appearance of forearm immediately after closure of both the surgical wounds (slight swelling of the forearm subsided on the second post operative day).