“PROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF CLAVICLE FRACTURES TREATED BY PLATE OSTEOSYNTHESIS”

Dissertation submitted for

M.S. Degree Examination

Branch II – ORTHOPAEDIC surgery

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Chennai – 600 032.

CERTIFICATE

This is to certify that this dissertation entitled **"PROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF CLAVICLE FRACTURES TREATED BY PLATE OSTEOSYNTHESIS"** *is the bonafide work done by* **DR. T. ARUN SAM** *under my direct guidance and supervision in the Department of Orthopaedic Surgery, Madurai Medical College, Madurai-20*

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DECLARATION

I **DR. T.ARUN SAM**, solemnly declare that the dissertation titled "**PROSPECTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF CLAVICLE FRACTURES TREATED BY PLATE OSTEOSYNTHESIS"** has been prepared by me. This is submitted to **"The Tamil Nadu Dr. M.G.R. Medical University, Chennai",** in partial fulfilment of the regulations for the award of M S degree branch II orthopaedics

Place: Madurai

Date : **DR. T. ARUN SAM**

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CONTENTS

INTRODUCTION

Clavicular fractures are common injuries, accounting for 2.6% of all fractures[1]. Fractures of the middle third (or midshaft) account for approximately 80% of all clavicular fractures[1,2] .

The traditional view that the vast majority of clavicular fractures heal with good functional outcomes following non-operative treatment is no longer valid.

Recent studies have identified a higher rate of nonunion and specific deficits of shoulder function in subgroups of patients with this injuries[3,4,5,6,7].

These fractures should therefore be viewed in the spectrum of injuries with diverse functional outcomes, each requiring careful assessment and individualized treatment and when indicated these fractures should be treated by primary operative fixation.

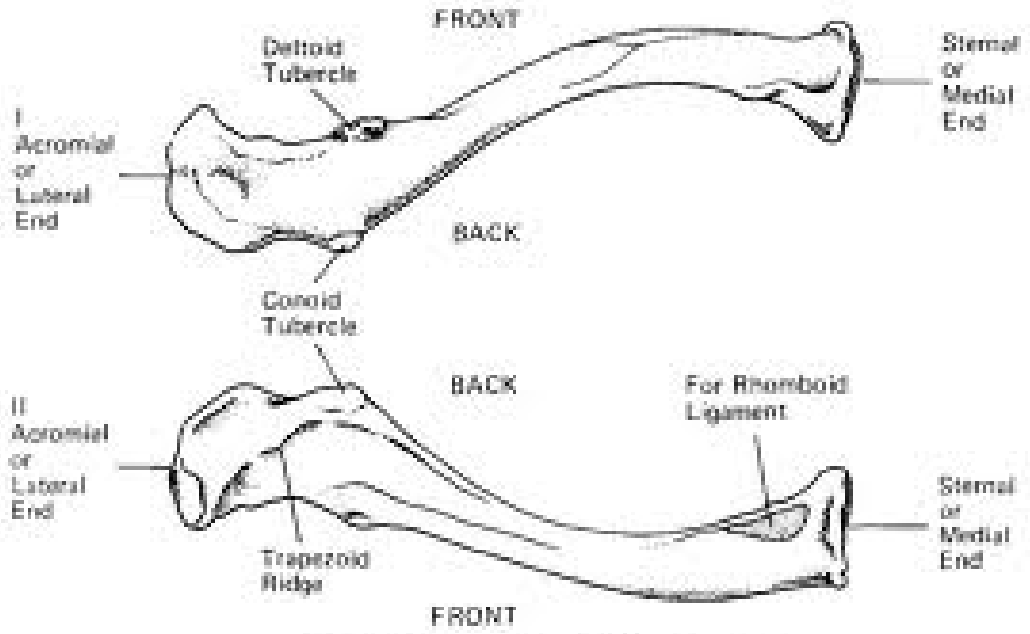
AIM OF THE STUDY

The aim of the study is to "**PROSPECTIVELY ANALYSE THE FUNCTIONAL OUTCOME OF CLAVICLE FRACTURES TREATED BY PLATE OSTEOSYNTHESIS"** in terms of complications and functional outcome in indicated cases.

SURGICAL ANATOMY

The name **"Clavicle"** is derived from the latin word clavis (key), the diminutive of which is clavicula, a reference to musical symbol. The clavicle is the only bony attachment between the trunk and the upper limb. It is palpable along its entire length and has a gentle S-shaped contour, with the forward-facing convex part medial and the forward-facing concave part lateral.

The acromial end of the clavicle is flat, whereas the sternal end is more robust and somewhat quadrangular in shape. Although designated as long bone, the clavicle has no medullary cavity.

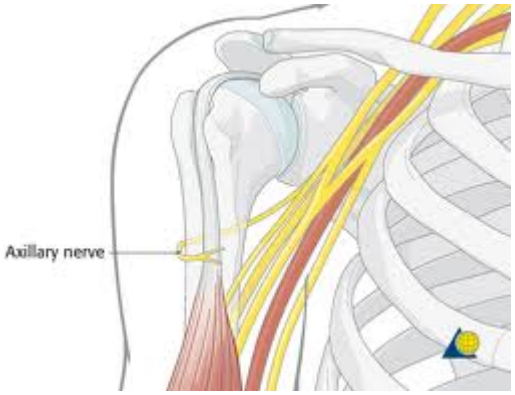


Left clavicle from above (top) and from below.

The inferior surface of the lateral third of the clavicle possesses a distinct tuberosity consisting of a tubercle (the **conoid tubercle**) and lateral roughening (the **trapezoid line**), for attachment of the important coracoclavicular ligament.By the coracoclavicular ligament , the remainder of the upper limb is passively suspended from the clavicle. The costoclavicular ligament limits elevation of the shoulder.

The clavicular head of sternocleidomastoid arises from the medial third of upper surface. Anteriorly, pectoralis major is attached to the medial half and the lateral third gives origin to deltoid. Trapezius is attached to the lateral third posteriorly.

The subclavian vessels and brachial plexus pass posterior/posteroinferior to the clavicle before passing inferior to the coracoid and into the arm.The apex of the lung lies posterior/ posteroinferior to the clavicle. Superficially, cutaneous braches of the intermediate supraclavicular nerve fan out over the anterior-superior region of the middle third of the clavicle.



Clavicle & Neurovascular bundle

EMBRYOLOGY

It is the first bone in the body to ossify. It ossifies from two primary centres and one secondary centre.

Two **primary centres** appear in the shaft between the **fifth** and **sixth weeks** of intrauterine life, and fuse about the 45^{th} day after birth.

The **secondary centre** for medial end appears during **15-17 years,** and fuses with the shaft during **21-22 years.**

PECULIARITIES OF THE CLAVICLE

1. It is the only long bone that lies horizontally.

2. It is subcutaneous throughout.

3. It is the first bone to start ossifying.

4. It is the only long bone which ossifies in membrane.

5. It is the only long bone which has two primary centres of ossification.

6. It is generally said to have no medullary cavity, but this is not always true.

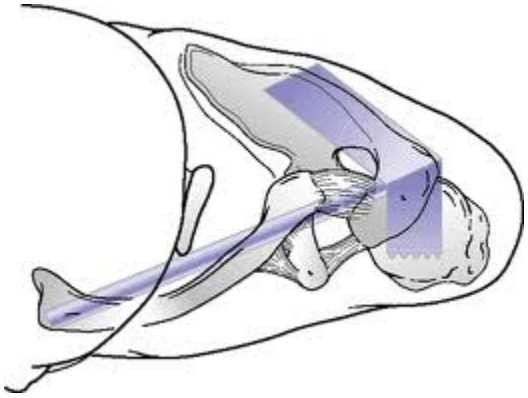
7. It is occasionally pierced by middle supraclavicular nerve.

FUNCTIONS OF CLAVICLE

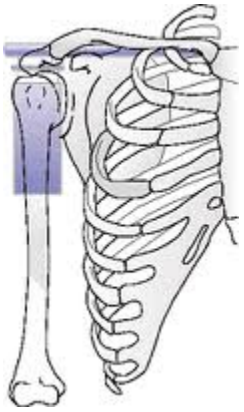
1. Serves as a movable, crane like strut from which the scapula and free limb are suspended, keeping them away from the trunk so that the limb has maximum freedom of motion.

2. The strut is movable and allows the scapula to move on the thoracic wall at the "scapulothoracic joint", increasing the range of motion of the limb.

3. Forms one of the bony boundaries of the cervico-axillary canal, affording protection to the neurovascular bundle supplying the upper limb.



Strut function of the clavicle



Suspension function of the clavicle

CLASSIFICATION OF CLAVICLE FRACTURES

Robinson analyzed 1000 consecutive clavicle fractures seen at the Orthopaedic Trauma Unit of the Royal Infirmary of Edinburgh over a 6-year period and he proposed his own classification. It includes prognostically important variables such as intra-articular extent, degree of displacement, and degree of comminution.

Robinson Classification of Clavicular Fractures:

Type 1 medial	**Type 2** middle	**Type 3** distal
A nondisplaced A1 extraarticular A2 intraarticular B displaced B1 extraarticular B2 intraarticular	A cortical alignment A1 nondisplaced A2 angulated B displaced B1 simple or single butterfly fragment B2 comminuted or segmental	A nondisplaced A1 extraarticular A2 intraarticular B displaced B1 extraarticular B2 intraarticular

Indications for Open Reduction and Internal Fixation of Displaced Midshaft Fractures

Absolute

Shortening of >20 mm

Open injury

Impending skin disruption and irreducible fracture

Vascular compromise

Progressive neurologic loss

Displaced pathologic fracture with associated trapezial paralysis

Scapulothoracic dissociation

Painful non-unions.

Relative

Displacement of >20 mm

Comminution >3 fragments

Neurologic disorder

Parkinson's

Seizures

Head injury

Multitrauma

Expected prolonged recumbency

Floating shoulder

Intolerance to immobilization

Bilateral fractures

Ipsilateral upper extremity fracture

Cosmesis

CLINICAL ASSESSMENT

Abrasions marking the site of application of the traumatic force are present in approximately 10% of patients. Ecchymosis and deformity are usually apparent. Open fractures of the clavicle are extremely rare, but skin tenting is common and should be identified.

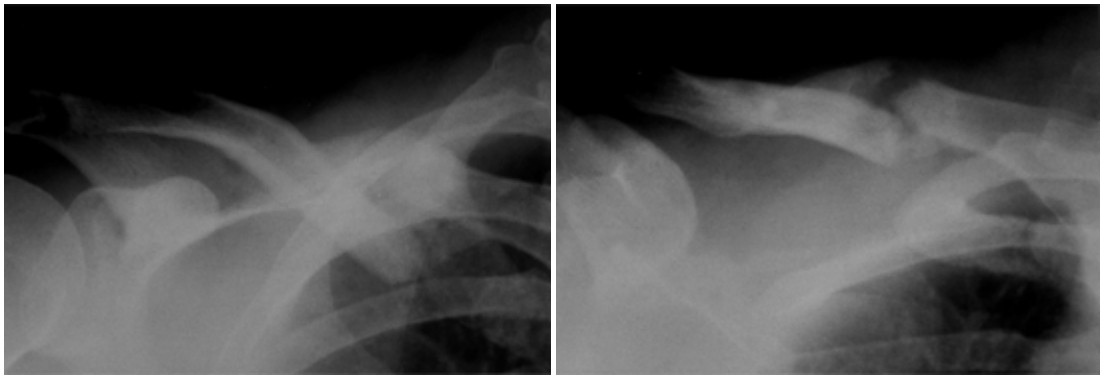
Clavicular fractures typically produce an obvious painful deformity, with tenderness & bony crepitus localized over the site of the fracture. There is often downward displacement of the lateral fragment under the weight of the shoulder and elevation of the medial fragment from the unopposed pull of the sternocleidomastoid muscle. The length of the clavicle is also clinically measured to assess the shortening and overriding.

Examination for associated injuries is a must, particularly in the setting of a high-velocity injury. Associated fracture of the ipsilateral scapula and upper ribs can occur and, in the high-energy setting, a chest radiograph is mandatory. The prevalence of pneumothorax in association with a clavicle fracture is 3%.

The whole arm distal to the fracture should be assessed to exclude brachial plexus or vascular injury.

RADIOGRAPHIC ASSESSMENT

For better visualization of the fracture pattern and displacement, an apical oblique radiograph is taken along with the routine anteroposterior view.



True anteroposterior (AP) Apical oblique view

To obtain this view, a bump or roll is placed under the contralateral scapula, which places the involved scapula flat against the radiographic cassette (a true AP). The beam is then angled 20 degrees cephalad, which brings the clavicular image away from the thoracic cage.

VARIOUS MODALITIES OF TREATMENT

Options for treatment of displaced clavicle fractures:

- For non-operative treatment, a **simple sling** is preferred.

  A figure-of-8 bandage can lead to brachial plexopathy if not applied appropriately, and has little influence on fracture outcome.

- **Plate fixation**: This technique provides immediate rigid stabilization and pain relief and facilitates early mobilization[8,9,10,11]. Most commonly, the plate is implanted on the superior aspect of the clavicle, and biomechanical studies have shown this to be advantageous, especially in the presence of inferior cortical comminution[11,12] .

- **Intramedullary fixation:** A variety of devices, including Knowles pins, Hagie pins, Rockwood pins, and minimally invasive titanium nails, have been used. Two methods of implant insertion have been described: antegrade, through an anteromedial entry point in the medial fragment, and retrograde, through a posterolateral entry portal in the lateral fragment. There is biomechanical evidence to suggest that plate fixation provides a stronger construct than intramedullary fixation[13].

- **External fixators** have been used to treat clavicular fractures, although this technique is most commonly recommended only for open fractures or septic nonunions[14].

Instrumentation for clavicle plate osteosynthesis :

Include 2.7 drill bit, drill, depth gauge, 3.5 bone tap, reduction & bone holding forceps, plate benders and the 3.5 straight reconstruction plates (6-10 holes).

COMPLICATIONS OF CLAVICLE FRACTURES

1. **Painful Non-union:** Adults with a displaced fracture have a higher rate of nonunion (up to 15%; eight of fifty-two) [15,16] .The risk factors for nonunion include increasing age, female sex, fracture displacement, and comminution[15,16]. Shaft nonunions in active individuals are usually symptomatic, causing pain [17,18,19,20,21] and a clicking sensation on movement[17,18]. Restriction of shoulder movement[18,19,21], weakness[17,18,21], cosmetic deformity[17,18,20], neurological symptoms[19,20,22], thoracic outlet syndrome[18,19,20,23], and subclavian vein compression have also been reported. Patients may also report disturbed sleep, an inability to perform manual work, difficulty driving, enforced absence from normal sporting activities, and a reduction in sexual activities due to pain[20].

   Plate fixation permits early mobilization of the shoulder while providing secure fixation, with a predictably high rate of union and a low risk of complications[8,9,24,25] .

2. **Symptomatic malunion:** All displaced fractures that are treated nonoperatively heal with some degree of malunion due to angulation or shortening[26], but often with few or no symptoms[27]. Some authors have reported that shortening of >15 mm is associated with shoulder discomfort and dysfunction[28,29,30], and it has been suggested that the

angular deformity and shortening change the orientation of the glenoid, altering the shoulder dynamics[31].

Corrective osteotomy and plate fixation can improve function in patients in whom symptomatic malunion has produced neurovascular compression, discomfort and weakness with use of the shoulder, or cosmetic deformity[31,32,33,34,35].

3. **Shoulder strength**: Michael D. McKee et al. [36] in their study after comparing the strength of the uninjured shoulder, the strength of the injured shoulder was reduced to 81% for maximum flexion, 75% for endurance of flexion, 82% for maximum abduction, 67% for endurance of abduction, 81% for maximum external rotation, 82% for endurance of external rotation, 85% for maximum internal rotation, and 78% for endurance of internal rotation ($p < 0.05$ for all values).
4. **Shoulder stiffness**: Reported to be high in patients with conservatively treated clavicle fractures, especially in elderly.
5. **Neurological :** Nerve compression can be caused acutely by displacement of the fracture fragments, or it can be caused by chronic malunion or nonunion associated with hypertrophic callus formation, subclavian pseudoaneurysm, or scar constriction (delayed type) [37,38].

Injury to the brachial plexus in conjunction with a clavicle fracture has also been reported. Although a displaced fracture fragment can result in neurologic insult[39], more typically plexus injuries are secondary to traction[40,41] and may occur in the setting of scapulothoracic dissociation. In the awake patient, the diagnosis is made by neurologic examination. Radiographic hints in the comatose or uncooperative patient are associated displaced scapula fracture or a wide separation of the clavicle fracture ends, typically greater than 1 cm [42].

Rowe reported late neurovascular sequelae after 0.3% (two) of 690 fractures[43], although higher rates have been reported in more recent studies, with prevalences of between 20% and 47% in series of between fifteen and fifty-two patients[17,44,45,46].

6. **Vascular :** Vascular injuries associated with clavicle fracture, although rare, have also been reported[47,48,49,50,51,52,53,54]. These lesions may be life or limb threatening. Costa and Robbs treated 167 patients with subclavian artery injury[47]. All lesions involving the third part of the subclavian artery were accompanied by fractures of the clavicle. Natali and colleagues treated 10 cases, all associated with clavicle fracture, by excision of the clavicle and subclavian artery repair[52]. More often,

vascular injury is an intimal tear, and initial clinical findings may be minimal. In these cases, the diagnosis is usually made after late arterial thrombosis[55,56]. If initial vascular examination leaves doubt, comparison of blood pressure in the ipsilateral and contralateral extremity is necessary. If uncertainty still exists, angiography is required.

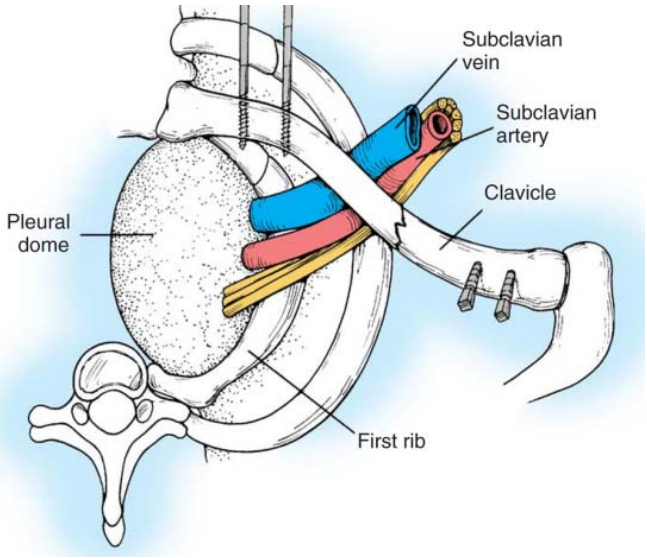
7. **Refracture :** Refracture can occur after nonoperative or operative treatment, with risk factors including epilepsy and alcohol abuse[57] and an early return to contact sports. Reinjury shortly after operative treatment may cause breakage or bending of the fixation device, or fracture around the implant[57,58,59], whereas a reinjury after implant removal may produce further fracture at the site of the previous injury. Nonunion is relatively common after refracture, and internal fixation is often required.

The prevalence of pneumothorax in association with a clavicle fracture is 3%[60] . This incidence, however, depends on the rate of low versus high velocity trauma seen by each individual physician. The finding of ipsilateral rib or scapula fracture on a screening supine chest film mandates an upright chest radiograph to evaluate for pneumothorax.

8. Complications of Operative Treatment

The main potential intraoperative complication is injury to the subclavian artery or vein at the time of fracture mobilization or from drill penetration. The risk of this complication should be very low, but it may necessitate vascular or cardiothoracic surgical intervention.

Brachial plexus palsy may also occur as a complication of operative treatment with use of intramedullary fixation[61].



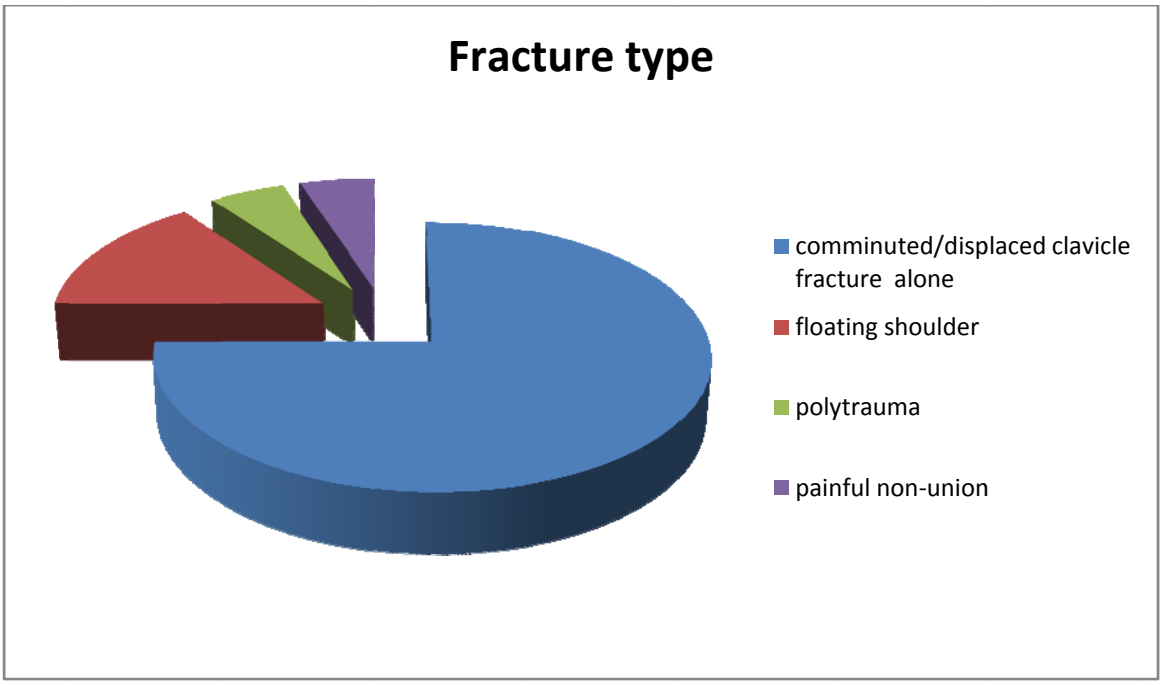
Postoperative wound complications, scar dysesthesia, infection, fixation failure, and nonunion are relatively common and may require revision surgery, as does any other failed osteosynthesis.

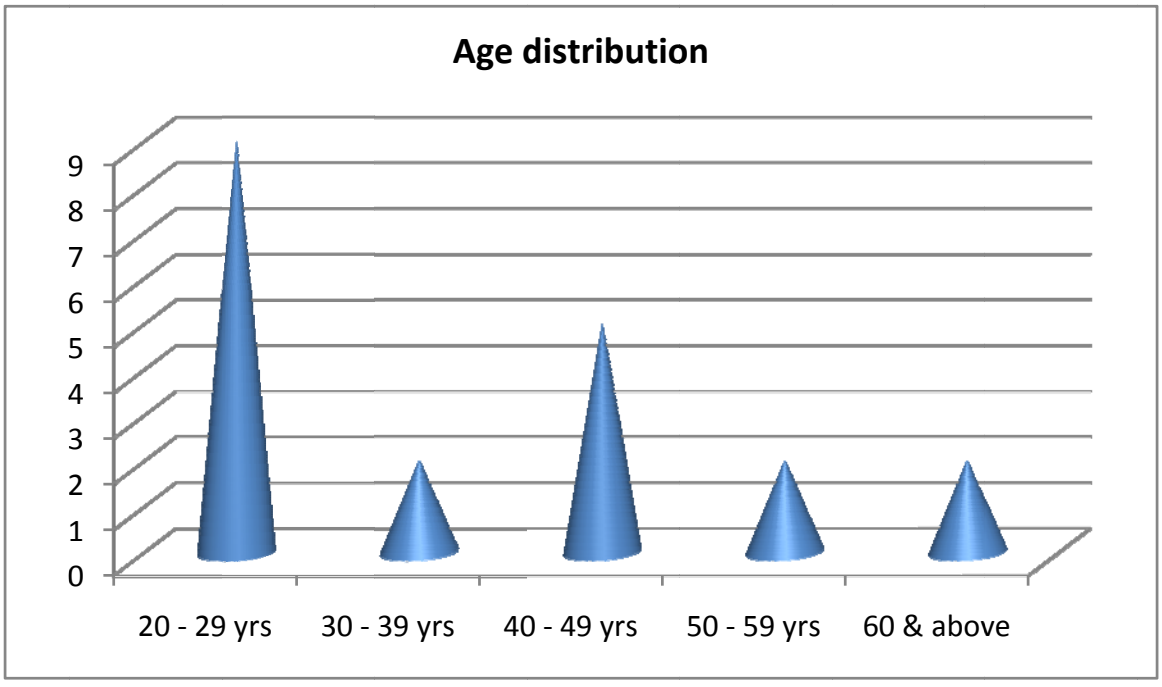
MATERIALS AND METHODS

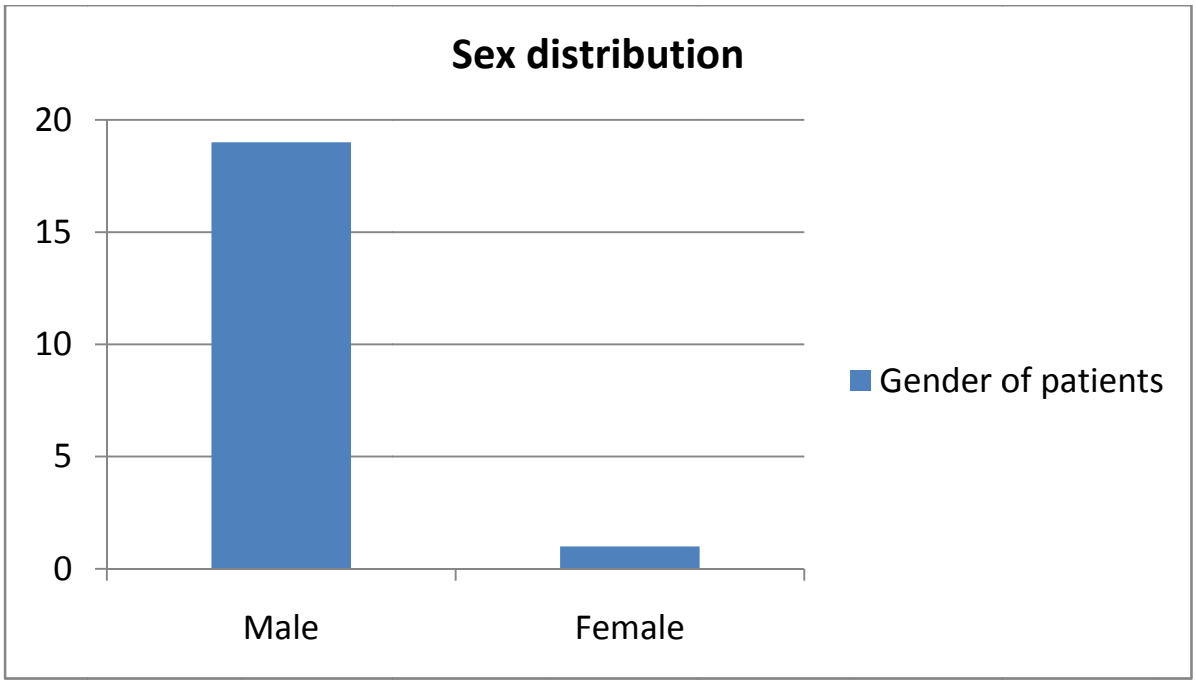
Study is conducted in Madurai Medical College and Government Rajaji Hospital on 20 patients with displaced/comminuted midshaft clavicle fractures from May 2010 to Dec 2011. All the patients were treated by open reduction and internal fixation with 3.5 reconstruction plate and screws.

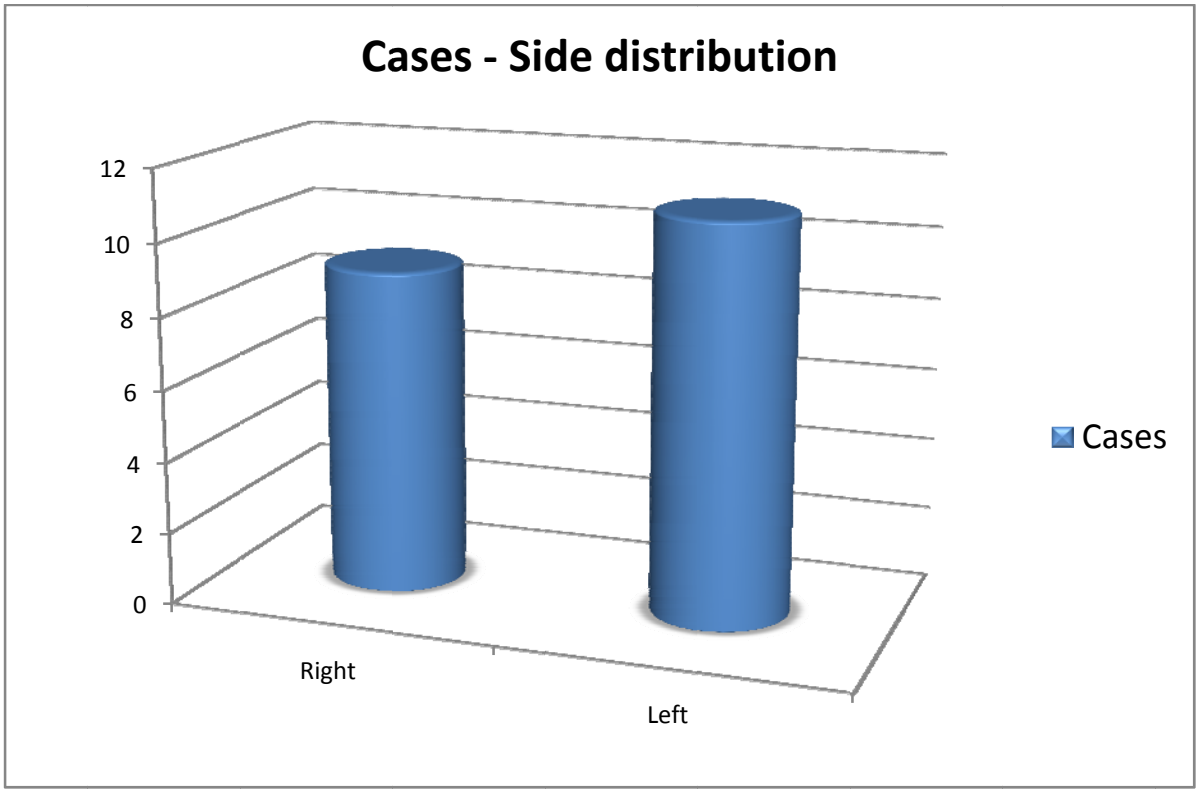
Inclusion Criteria

Patients were included in the study if they had (1) a completely displaced (>2cms) mid shaft fracture of the clavicle (derived by clinical measurement), (2) a comminuted middle third fracture of the clavicle with inferior cortical defect, (3) a clavicle fracture associated with scapular neck fracture (floating shoulder), (4) painful non-union, (5) an age between sixteen and sixty years, (6) no medical contraindications to general anesthesia, and (7) informed consent.


Fracture type
comminuted/displaced clavicle fracture alone
floating shoulder
polytrauma
painful non-union


Age distribution
9
8
7
6
5
4
3
2
1
0
20 - 29 yrs
30 - 39 yrs
40 - 49 yrs
50 - 59 yrs
60 & above


Sex distribution
20
15
10
5
0
Male
Female
Gender of patients


Cases - Side distribution
12
10
8
6
4
2
0
Right
Left
Cases

Exclusion Criteria

Patients were excluded from the study if they had (1) an age of less than sixteen years or greater than sixty years, (2) a fracture in the proximal or distal third of the clavicle, (3) Pathological fractures, (4) Undisplaced or minimally displaced clavicle fractures.

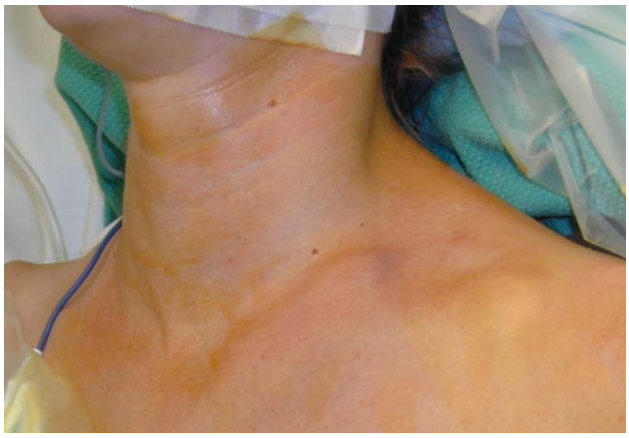
Operative Technique

Under a general or anaesthesia, the patient positioned in supine position with sand bag beneath the ipsilateral scapula. The involved shoulder prepared and draped, and an oblique incision made over superior surface of clavicle centring the fracture site.

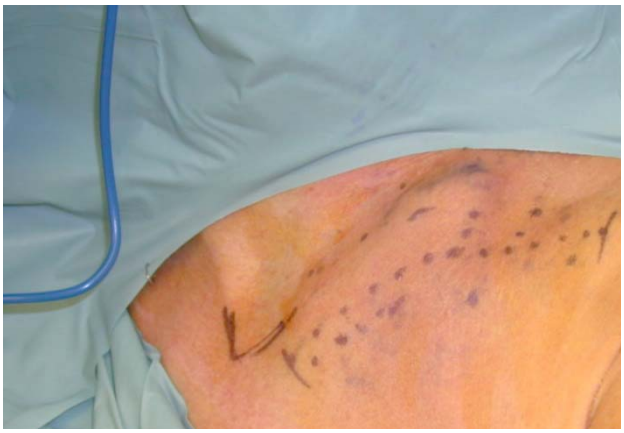
The fracture site identified, and the fracture reduced and fixed with a 3.5 mm reconstruction plate after contouring. Plate is applied to the superior surface of the bone, with the goal being a minimum of three screws in the main proximal and distal fragments in most cases. Comminuted fragments were secured with lag screws if possible, with care being taken to preserve soft-tissue attachments. Bone grafting performed in the case with non-union.

The deltotrapezial fascia was closed with interrupted number-1 absorbable sutures as a distinct layer, followed by skin closure. No drains were used.

A sling was used for comfort for seven to ten days, and then active range-of-motion exercises were allowed. When fracture union (defined as radiographic union with no pain or motion with manual stressing of the fracture) was evident, typically at six weeks, overhead abduction and strengthening were allowed, with a return to full activities at three months.

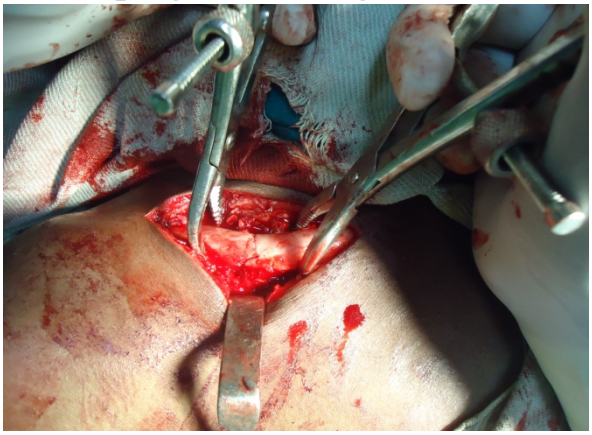


Positioning



Draping & marking of fracture

Fracture exposed



Fracture reduced

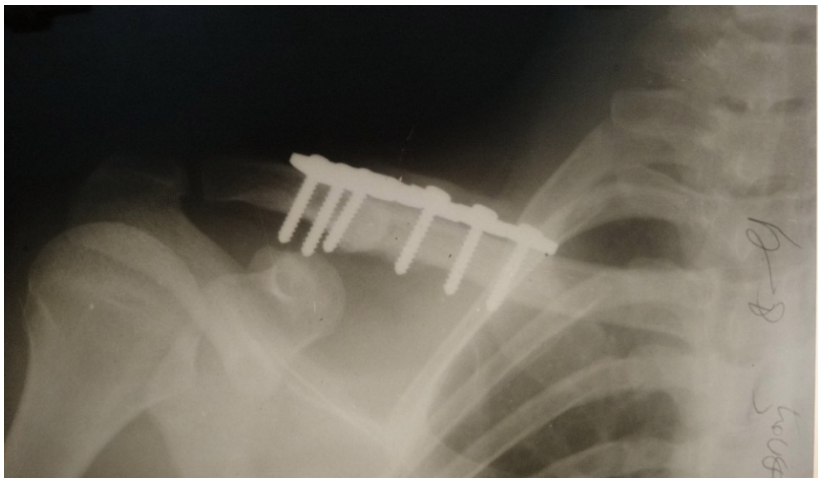
Plate fixation done

Wound closed

Assessment

Patients were seen at six weeks and at three, four, six, and twelve months. Assessment included standardized clinical evaluation and completion of the Constant shoulder score. Both an anteroposterior and a 20° cephalad radiographs were made for each patient.

Anteroposterio (AP) x-ray



20° cephalad x-ray

Constant–Murley Shoulder Score

The Constant–Murley Shoulder Score_ is a 100-point functional shoulder-assessment tool in which higher scores reflect increased function. It combines four separate subscales: subjective pain (15 points), function (20 points), objective clinician assessment of range of motion (40 points), and strength (25 points). The CMS system is used internationally as a means of establishing normal levels of shoulder function appropriate for different age groups and to establish what constitutes disability in normal individuals. It has also been used to establish differential rates of progress after injury or treatment.

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☐ None

2. Activity Level (check all that apply)

☐	yes	Unaffected Sleep
☐	no	
☐	yes	Full Recreation/Sport
☐	no	
☐	yes	Full Work
☐	no	

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☐ Above Head

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☐ 22-24
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☐ 151-180 degrees

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☐ 151-180 degrees

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☐ Full Elevation

8. Internal Rotation

- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☐ Interscapular (T7)

The Constant Shoulder Score is 0

Grading the Constant Shoulder Score

(Difference between normal and Abnormal Side)

>30 Poor 21-30 Fair 11-20 Good <11 Excellent

CASE ILLUSTRATION

CASE - I

Name : A IP No. : 52903

Age : 24 Sex : M

Occupation : Businessman

Date of surgery : 05-08-2010

Diagnosis : Robinson 2B2

Associated injuries : nil

Procedure : ORIF with 3.5mm Rec. Plate

Complications : nil

Secondary procedure : nil

Follow up period : 17 months

FUNCTIONAL OUT COME

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☒ None
  15

2. Activity Level (check all that apply)

- ☒ yes ☐ no Unaffected Sleep
  2
- ☒ yes ☐ no Full Recreation/Sport
  4
- ☒ yes ☐ no Full Work
  4

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☒ Above Head
  10

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☒ 22-24
  23
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☒ 151-180 degrees
  10

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☒ 151-180 degrees
  10

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☉ Full Elevation
  10

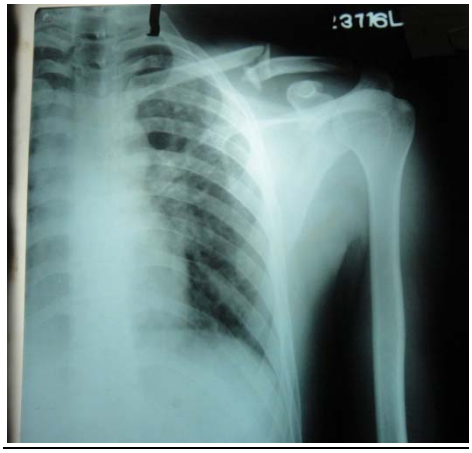
8. Internal Rotation

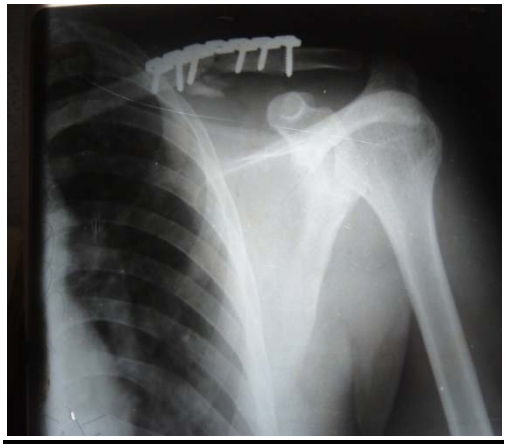
- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☉ Interscapular (T7)
  10

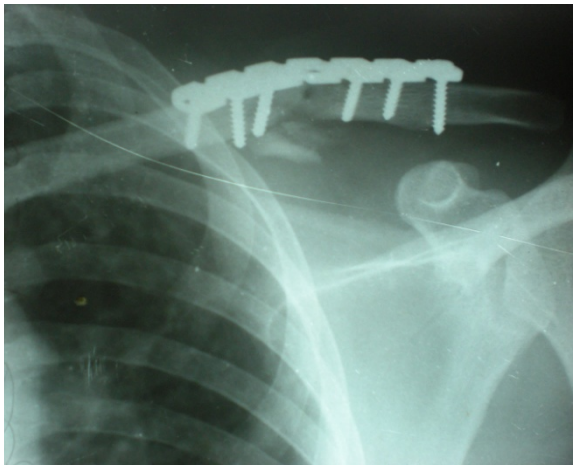
Constant shoulder score: 98

Grade: Excellent

Case I







CASE - II

Name : B IP No. : 61980

Age : 22 Sex : M

Occupation : Student

Date of surgery : 25-08-2010

Diagnosis : Painful non-union Rt. clavicle

Associated injuries : Nil

Procedure : ORIF with 3.5mm Rec. Plate

Complications : Implant prominence

Secondary procedure : Nil

Follow up period: 16 months

FUNCTIONAL OUT COME

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☑ None
  15

2. Activity Level (check all that apply)

- ☑ yes / ☐ no — Unaffected Sleep
  2
- ☑ yes / ☐ no — Full Recreation/Sport
  4
- ☑ yes / ☐ no — Full Work
  4

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☑ Above Head
  10

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☑ 22-24
  23
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☉ Full Elevation
  10

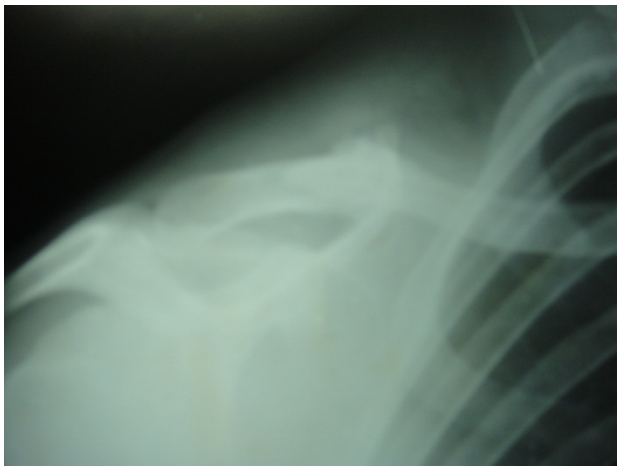
8. Internal Rotation

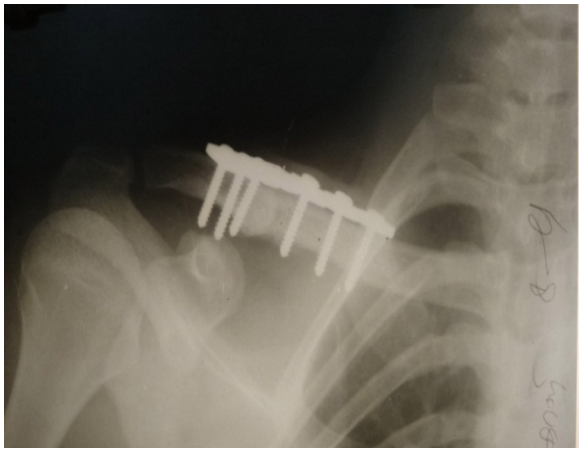
- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☉ Interscapular (T7)
  10

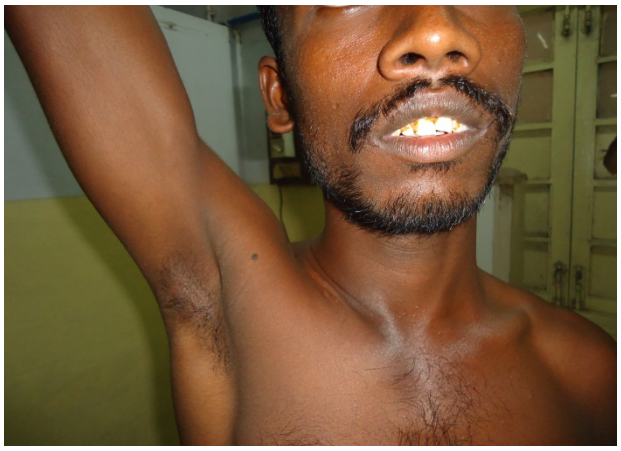
Constant shoulder score: 98

Grade: Excellent

Case II







CASE - III

Name : C IP No. : 79921

Age : 23 Sex : M

Occupation : Student

Date of surgery : 08-11-2010

Diagnosis : Robinson 2B1(L)

Associated injuries : Neck of scapula fracture

Procedure : ORIF with 3.5mm Rec. Plate

Complications : Nil

Secondary procedure : Nil

Follow up period : 14 months

FUNCTIONAL OUT COME

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☑ None
  15

2. Activity Level (check all that apply)

- ☑ yes / ☐ no — Unaffected Sleep
  2
- ☑ yes / ☐ no — Full Recreation/Sport
  4
- ☑ yes / ☐ no — Full Work
  4

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☑ Above Head
  10

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☑ 22-24
  23
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☉ Full Elevation
  10

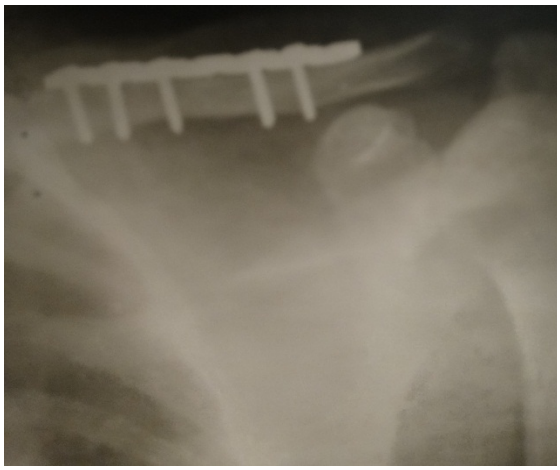
8. Internal Rotation

- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☉ Interscapular (T7)
  10

Constant shoulder score: 98

Grade: Excellent

Case III



CASE - IV

Name : D

Age : 38 Sex : M

Occupation : Clerical

Date of surgery : 04-10-2010

Diagnosis : Robinson IIB1(R)

Associated injuries : Nil

Procedure : ORIF with 3.5mm Rec. Plate

Complications : Nil

Secondary procedure : Nil

Follow up period : 15 months

FUNCTIONAL OUT COME

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☒ None
  15

2. Activity Level (check all that apply)

- ☒ yes ☐ no Unaffected Sleep
  2
- ☒ yes ☐ no Full Recreation/Sport
  4
- ☒ yes ☐ no Full Work
  4

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☒ Up to Top of Head
  8
- ☐ Above Head

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☒ 22-24
  23
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☒ 151-180 degrees
  10

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☒ 151-180 degrees
  10

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☉ Hand to top of Head, Elbow back - 8
- ☐ Full Elevation

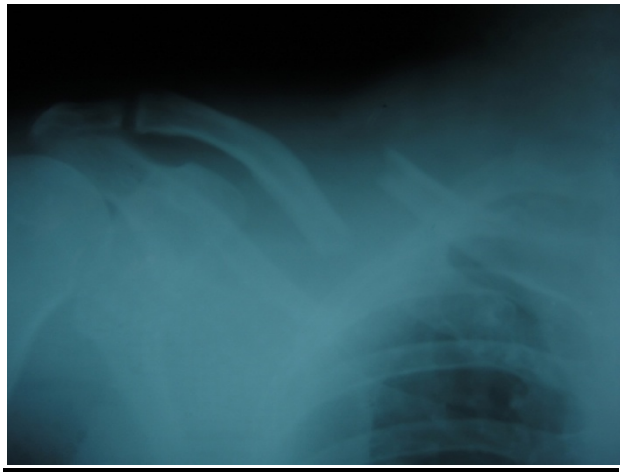
8. Internal Rotation

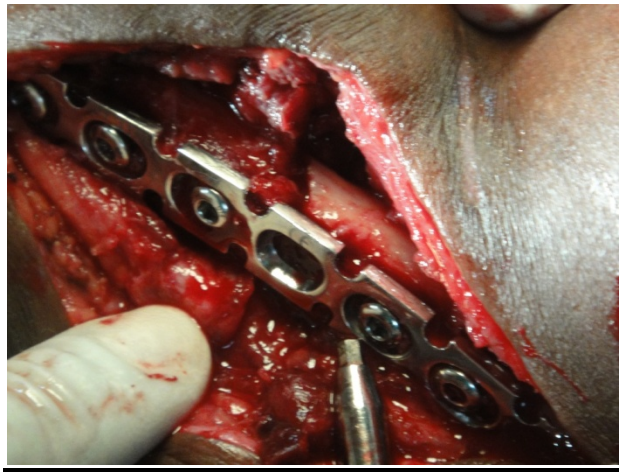
- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☉ T12 Vertebra 8
- ☐ Interscapular (T7)

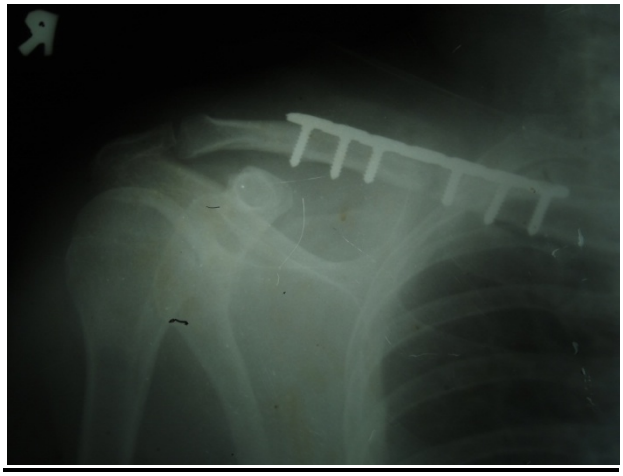
Constant shoulder score: 92

Grade: Excellent

Case IV







CASE - V

Name : E IP No. : 70031

Age : 40 Sex : M

Occupation : Daily wager

Date of surgery : 07-10-2010

Diagnosis : Robinson 2B1(L)

Associated injuries : Nil

Procedure : ORIF with 3.5mm Rec. Plate

Complications : wound infection

Secondary procedure : implant removal

Follow up period : 15 months

FUNCTIONAL OUT COME

1. Pain

- ☐ Severe
- ☐ Moderate
- ☑ Mild
  10
- ☐ None

2. Activity Level (check all that apply)

- ☐ yes / ☑ no — Unaffected Sleep
  0
- ☐ yes / ☑ no — Full Recreation/Sport
  0
- ☐ yes / ☑ no — Full Work
  0

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☑ Above
  10

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☑ 19-21 — 20
- ☐ 22-24
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☉ Full Elevation
  10

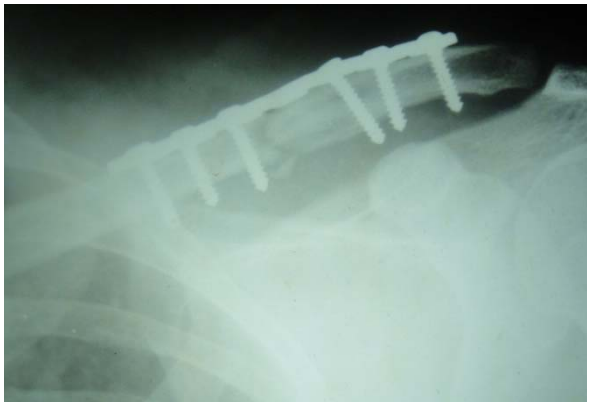
8. Internal Rotation

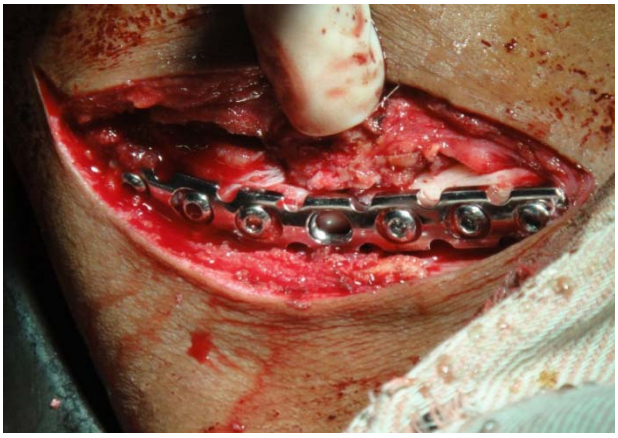
- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☉ Interscapular (T7)
  10

Constant shoulder score: 80

Grade : Good

Case V





Case VI

Name : F

Age : 27 Sex : M

Occupation : Driver

Date of surgery : 02-09-2010

Diagnosis : Robinson 2B2 (L)

Associated injuries : Nil

Procedure : ORIF with 3.5mm Rec. Plate

Complications : Nil

Secondary procedure : Nil

Follow up period : 15 months

FUNCTIONAL OUT COME

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☑ None
  15

2. Activity Level (check all that apply)

- ☑ yes / ☐ no — Unaffected Sleep
  2
- ☑ yes / ☐ no — Full Recreation/Sport
  4
- ☑ yes / ☐ no — Full Work
  4

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☑ Above Head
  10

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☑ 22-24
  23
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☑ 151-180 degrees
  10

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☉ Full Elevation
  10

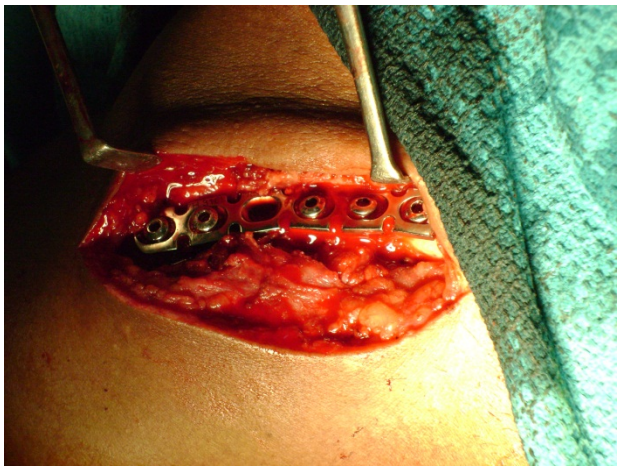
8. Internal Rotation

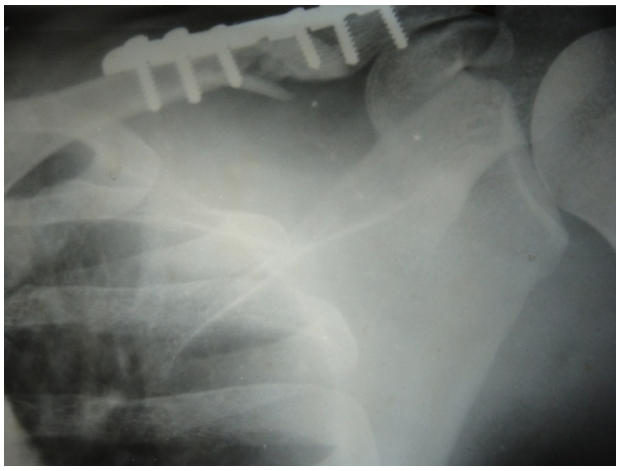
- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☉ Interscapular (T7)
  10

Constant shoulder score: 98

Grade: Excellent

Case VI

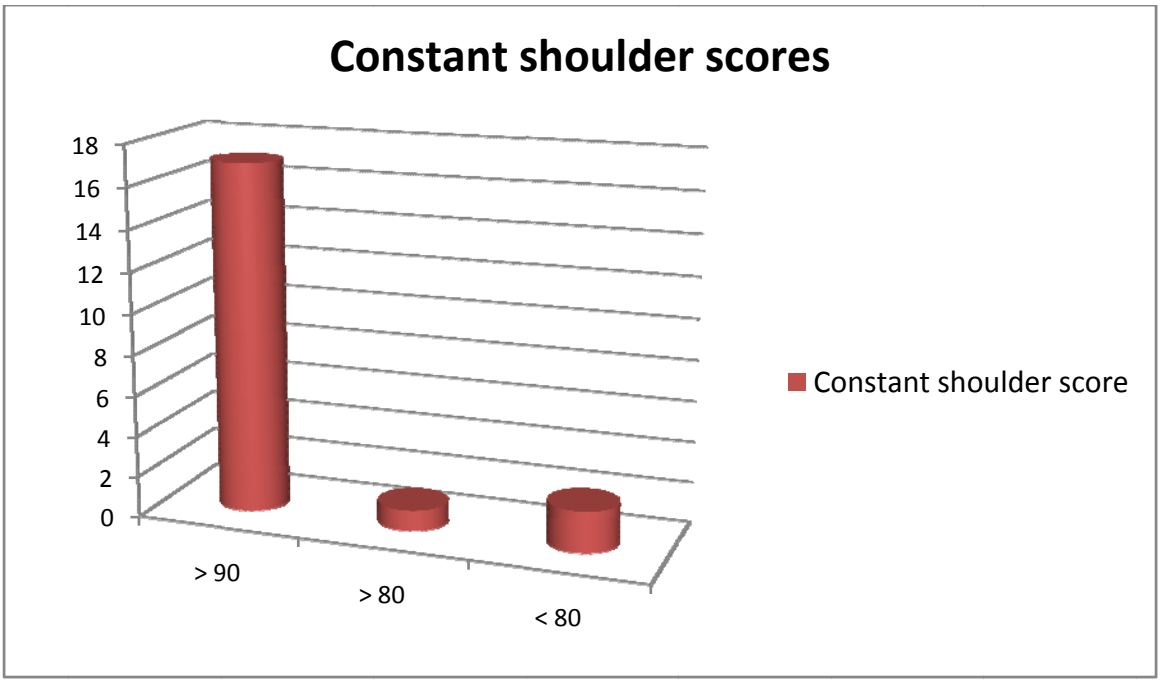


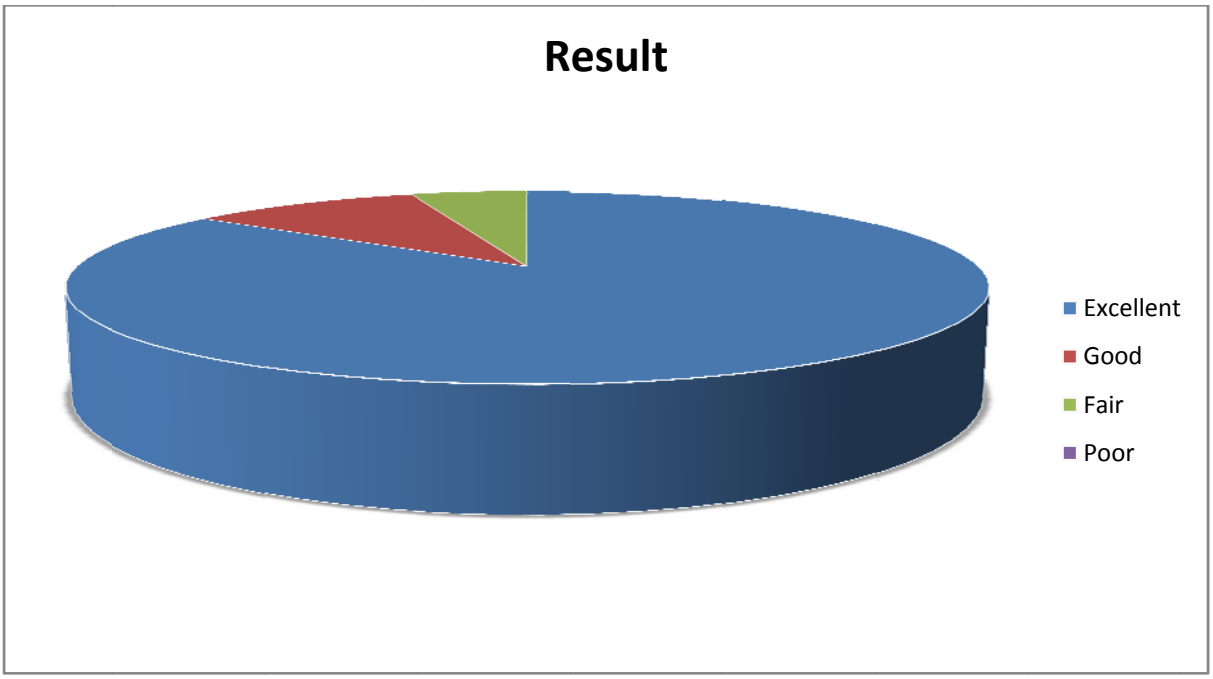


RESULTS

Of the twenty patients (19 male and 1 female and most of them aged below 30 years) studied between May 2010 and Dec 2011, all had primary plate fixation except the one with painful non-union for whom plate osteosynthesis with bone grafting was done. Three patients were lost to follow-up and remaining 17 patients had a mean of 15.5 months follow-up.

All seventeen patients had fracture union in a mean of 16 weeks. Most of the patients (82%) had constant shoulder score above 90 with an excellent grade except for three patients. Of these, two of them had wound infection and function improved after implant removal; and one patient was a 60 year old lady who developed shoulder stiffness due to improper follow-up and physiotherapy.


Constant shoulder scores
18
16
14
12
10
8
6
4
2
0
> 90
> 80
< 80
Constant shoulder score


Result
Excellent
Good
Fair
Poor

Patient Satisfaction

After the surgery, all patients were satisfied with their shoulder except the above mentioned three patients with complications. Between operated and normal clavicle there was mean length difference of 0.4 mm.

Return to Work

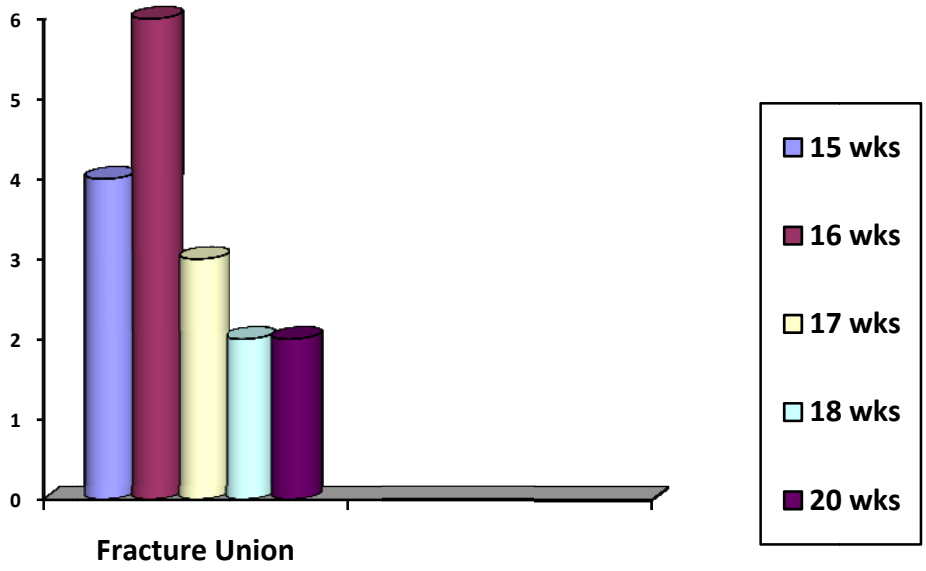
Of the 17 patients in regular follow-up, thirteen patients had returned to their pre-injury levels of work and recreational activity. Two patients with post-op infection didnot go to work. Patient with shoulder stiffness found difficult with her house-hold activities.

Range of Motion

Range of motion was well maintained in all patients except the old lady who developed shoulder stiffness. The values were as of the normal contralateral shoulder, 82% of patients having >90% of the normal function (Excellent grade).

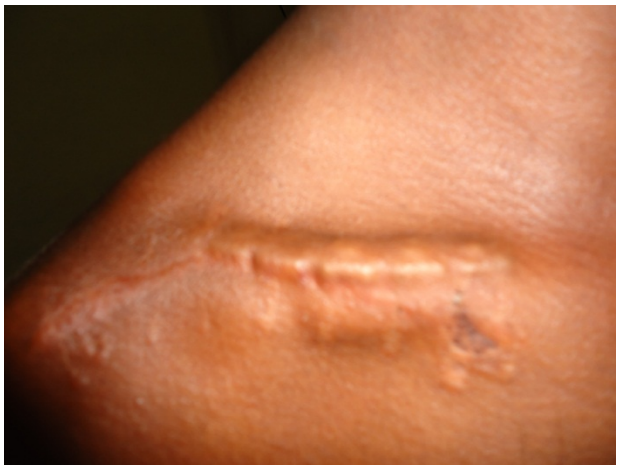
Rate of union

Fracture union was assessed with clinical and radiological means. Fractures united at an average of 16 weeks.



Complications

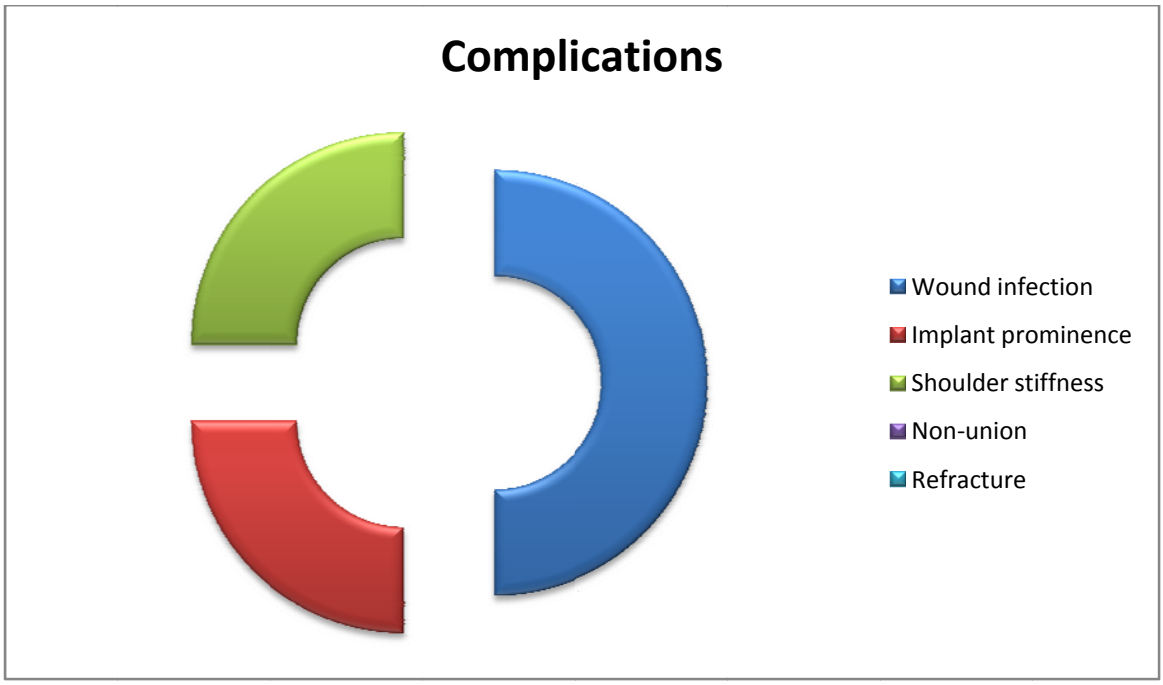
Two patients had wound infection and their plates were removed. One patient except for hardware prominence was doing well. One patient developed shoulder stiffness due to improper follow-up and physiotherapy. There was no non-union/mal-union in our study. There were no neurovascular complications. There were no re-fractures.



Hardware prominence (case 5)

Shoulder stiffness (case 16)

Post-op infection (cases 7, 18)


Complications
Wound infection
Implant prominence
Shoulder stiffness
Non-union
Refracture

DISCUSSION

There is a general consensus that clavicular fractures are best treated nonoperatively. In the 1960s, Neer and Rowe reported on the nonoperative treatment of clavicular fractures[3,4]. However, more recent studies have shown that the union rate for displaced midshaft fractures of the clavicle may not be as favourable as once thought.

There were no non-union in our study. In a prospective, observational cohort study, Robinson et al. described a consecutive series of 868 patients with clavicular fractures, 581 of whom had a midshaft diaphyseal fracture[16]. They found a significantly higher nonunion rate (21%) for the displaced, comminuted midshaft fractures ($p < 0.05$).

Similarly, in a study of fifty-two displaced midshaft clavicular fractures, Hill et al. reported that eight patients had a nonunion and sixteen patients had an unsatisfactory outcome on the basis of patient-oriented measures[6] .They concluded that displacement of the fracture fragments by >2 cm was associated with an unsatisfactory result.

A meta-analysis of recent studies revealed that the rate of nonunion for displaced midshaft clavicular fractures was 2.2% (ten of 460 patients) after plate fixation compared with 15.1% (twenty-four of 159 patients) after nonoperative care, a relative risk reduction for nonunion of 86%[62]. That meta-analysis also

showed that primary plate fixation was, contrary to prevailing opinion, a safe and reliable procedure[62].

Modern studies on primary plate fixation of acute midshaft clavicular fractures have described high rates of successful results with rates of union ranging from 94% to 100% and low rates of infection and surgical complications: a recent meta-analysis of plate fixation for 460 displaced fractures revealed a nonunion rate of only 2.2%[62,63,64]. With improved implants, prophylactic antibiotics, and better soft-tissue handling, plate fixation has been a reliable and reproducible technique.

Late neurovascular compromise upto 6% was seen in patients treated conservatively due to non union and excessive callus formation[65]. In our study we had no transient neurological abnormalities.

The range of motion was good and the mean constant score was above 90 in our study. On reviewing the literature we found patients treated conservatively had substantial residual disability of the affected shoulder with minimal loss of muscle strength[34,36,45,66].

The advantages of internal fixation of clavicle fractures, which includes early pain resolution, early return of shoulder function and potentially early return to work makes it an appealing option for the treatment of displaced fractures in active individuals.

Many different methods of operative fixation of mid-shaft clavicle fractures have been described. Intramedullary pinning techniques have been associated with a high number of complications, such as pin migration and rotational instability and fixation with interfragmentary screws or wire sutures show insufficient immobilization[37,65]. As a result, we prefer rigid fixation with a plate osteosynthesis which provides superior fracture stability and excellent clinical results in the treatment of acute fractures and nonunions.

In our study, the majority of complications were post-operative wound disorder (10%). Literature review shows infection rate upto 10% for plate fixation of displaced mid shaft fracture[63,67]. The other major complication of our study was hardware irritation and prominence in 5% of patients. All cases were followed up regularly we have no refractures till date.

Taking these percentages into account, we believe that operative treatment of acute middle-third clavicle fractures should be reserved for persons who wishes to return early to activity and who accept the risk for potential complications. Especially wound disorders and infection may lead to disasters and the patient should be duly informed before deciding to have the operation.

CONCLUSION

The traditional view that the vast majority of clavicular fractures heal with good functional outcomes following nonoperative treatment is no longer valid. Recent studies have identified a higher rate of non-union, late neurovascular compromise and specific deficits of shoulder function in subgroups of patients with these injuries who are treated by conservative means. Internal fixation by plate osteosynthesis has the advantage of early pain resolution, early return of shoulder function and potentially early return to work. The encountered complications in our study were similar to other recent studies. Clavicle fractures should therefore be viewed as a spectrum of injuries with diverse functional outcomes, each requiring careful assessment and individualized treatment, and plate osteosynthesis should be preferred for the treatment of indicated middle-third clavicle fractures in active individuals.

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PROFORMA

Name : IP No.

Age : Sex

Occupation:

Date of surgery:

Diagnosis :

Associated injuries :

Procedure :

Complications :

Secondary procedure :

Follow up period :

FUNCTIONAL OUTCOME :

1. Pain

- ☐ Severe
- ☐ Moderate
- ☐ Mild
- ☐ None

2. Activity Level (check all that apply)

- ☐ yes ☐ no Unaffected Sleep
- ☐ yes ☐ no Full Recreation/Sport
- ☐ yes ☐ no Full Work

3. Arm Positioning

- ☐ Up to Waist
- ☐ Up to Xiphoid
- ☐ Up to Neck
- ☐ Up to Top of Head
- ☐ Above Head

4. Strength of Abduction [Pounds]

- ☐ 0
- ☐ 1-3
- ☐ 4-6
- ☐ 7-9
- ☐ 10-12
- ☐ 13-15
- ☐ 15-18
- ☐ 19-21
- ☐ 22-24
- ☐ >24

RANGE OF MOTION

5. Forward Flexion

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☐ 151-180 degrees

6. Lateral Elevation

- ☐ 31-60 degrees
- ☐ 61-90 degrees
- ☐ 91-120 degrees
- ☐ 121-150 degrees
- ☐ 151-180 degrees

7. External Rotation

- ☐ Hand behind Head, Elbow forward
- ☐ Hand behind Head, Elbow back
- ☐ Hand to top of Head, Elbow forward
- ☐ Hand to top of Head, Elbow back -
- ☐ Full Elevation

8. Internal Rotation

- ☐ Lateral Thigh
- ☐ Buttock
- ☐ Lumbosacral Junction
- ☐ Waist (L3)
- ☐ T12 Vertebra
- ☐ Interscapular (T7)

The Constant Shoulder Score is 0

Grading the Constant Shoulder Score

(Difference between normal and Abnormal Side)

>30 Poor 21-30 Fair 11-20 Good <11 Excellent

KEY TO MASTER CHART

PN - Painful non union

SN# - Scapula neck fracture

F# - Femur fracture

HP - Hardware prominence

SS - Shoulder stiffness

WO - Wound infection