"CLINICAL OUTCOME OF PLATING IN COMMINUTED (3 PIECE) CLAVICLE FRACTURES A PROSPECTIVE STUDY"

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LIST OF ABBREVIATIONS

SR NO.	GLOSSARY	ABBREVIATION
1.	OXFORD SHOULDER SCORE	OSS
2.	VISUAL ANALOGUE SCALE	VAS
3.	STERNOCLAVICULAR JOINT	SC JOINT
4.	ACROMIOCLAVICULAR JOINT	AC JOINT
5.	CORACOCLAVICULAR LIGAMENTS	CC LIGAMENTS
6.	STERNOCLEIDOMASTOID MUSCLE	SCM
7.	FALL OVER OUTSTRETCHED HAND	FOOSH
8.	FALL FROM HEIGHT	FFH
9.	ROAD TRAFFIC ACCIDENT	RTA

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ABSTRACT

Clavicle fracture is responsible for approximately 05 % to 10 % of all fractures. 70 % of clavicle fractures are midshaft fractures in adult population

Most adults with midshaft clavicle fractures treated nonoperatively will achieve full healing. However, in recent studies it is shown that traditional management in comminuted clavicle fractures may result in higher rates of malunion, pain, and deformity than previously thought. Current evidence suggests that surgical treatment for these fractures can lead to superior functional outcomes, greater patient satisfaction compared to nonoperative treatment in patients who meet specific criteria.[3]

Objectives- To study the clinical outcomes of plating in comminuted clavicle fractures. This was done using the following –

1. Oxford Shoulder Score to evaluate the day to day activities and hindrance in these owing to the surgery
2. Visual Analogue Scale to assess any chronic pain experienced by these patients.
3. Anatomical length restoration of operated side when compared to contralateral side after a 6 month follow up period.

Materials Of Study-

A prospective study was conducted in Dr.PKH for a span of 1 year.

Patients with comminuted 3 piece clavicle fractures were selected keeping in mind aforementioned inclusion criteria.

Results and Conclusion-

From this prospective study with 41 participants it was concluded that-

- In comminuted fracture clavicles, primary open reduction and internal fixation is the preferred method of management.
- Due to benefits of plate osteosynthesis like immediate post op mobilisation, significantly low rates of malunion/ nonunion we have established plate osteosynthesis as the gold standard of comminuted clavicle fracture management.
- Anatomical length was restored without any incidence of shortening in any of the 41 patients thus proving the significantly low incidence of long term complications of primary plate osteosynthesis.
- A statistically significant improvement in Oxford Shoulder Score in a 2 week, 1 month and 6 months duration proved the improved patient outcomes in terms of return to normal day to day activities of these patients.

A nil to minimal VAS score at a 6 month follow up period proved how plating did not cause any chronic pain to the patient

Key Words- clavicle fracture fixation, comminuted clavicle fracture

INTRODUCTION

"Clavicle fractures account to approximately 5 % -10 % of all fractures. In adults, around 70 % of these fractures occur in the midshaft of clavicle. Comminuted Clavicle fractures are more common in younger individuals. Operative management is increasingly preferred as the primary treatment for displaced midshaft clavicle fractures, as recent studies have proven that surgical management results in lower rates of non-union and painful malunion compared to conservative management."[1]

"Fractures of the middle third of the clavicle, which were the most frequent (81 %), were displaced in 48 % of cases and comminuted in 19%. Fractures of the medial third were the rarest (2 %)". [2] The incidence of high-energy clavicle fractures is rising and may contribute to these findings, as greater fracture displacement, shortening, and comminution are predictive of non-union and poor patient outcomes with conservative management. Traditionally, midshaft clavicle fractures are managed nonoperatively using a sling or a figure-of-eight bandage. Most adults treated conservatively for undisplaced midshaft clavicle fractures will heal completely.

However, recent studies show that the rates of malunion, pain, and deformity may be higher with traditional management than previously seen. "Current evidence shows that surgical treatment of midshaft clavicle fractures can lead to better functional outcomes and higher patient satisfaction compared to nonoperative treatment in patients who meet specific criteria".[3] Internal fixation with plating is not without complications. Common issues include plate prominence causing local skin reactions, non-union, broken implants, paresthesia around the surgical wound, and infections. [4]

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Open reduction & plating thus may be a superior means of management of comminuted clavicle fractures.

In this study we will provide evidence for the superiority of Plate osteosynthesis for comminuted clavicle fractures as a treatment modality and find clinical outcomes of the same in a 6 month follow up period, comparing rate of incidence of complications like axial length shortening with that of non operative conservative treatment for the same. Comminuted clavicle fractures pose significant challenges in surgical management due to their complex nature and potential for adverse clinical outcomes. In recent years, the use of plating techniques has gained popularity as a promising approach in treating these fractures.

Although a more popular technique for clavicle fixation, little is known about clinical outcome for comminuted clavicle fractures in terms of return of normal functionality of affected shoulder and persistent pain and clavicle length restoration.

AIM OF THE STUDY

The objective of this prospective study was to show the functional outcome of plating in comminuted clavicle fractures in a 6 month follow up period.

The functional outcome was derived in the form of Oxford Shoulder Score (OSS), Visual Assessment Score (VAS) and for clavicular length restoration when compared to contralateral clavicle.

Patients who qualified in the inclusion criteria were selected to undergo treatment in the form of Open Reduction Internal Fixation with Plating for comminuted clavicle fractures and were evaluated in a follow up period of 2 weeks, 1 month and 6 months post op

REVIEW OF LITERATURE

1. Older studies suggested that a fracture of the shaft of the clavicle, even when significantly displaced, was an essentially benign injury with an inherently good prognosis when treated nonoperatively as documented by Neer.[11]
2. Rowe showed an overall incidence of nonunion of 0.8% in 566 clavicle fractures treated conservatively with a figure of eight bandage.[12]
3. In 1997, Hill et al.68 were the first to use patient-oriented outcome measures to examine 66 consecutive patients with displaced midshaft clavicle fractures and they found an unsatisfactory outcome in 31%, as well as a nonunion rate of 15%.[13]
4. Zlowdzki's systemic review showed a relative risk reduction of 86% (from 15.1% to 2.2%) for nonunion with primary plate fixation compared to nonoperative treatment.[14]
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CLINICAL ANATOMY

"The clavicle is a sigmoid-shaped long bone with a convex surface along its medial end when viewed from a cephalad position. It connects the axial and appendicular skeletons, in conjunction with the scapula, and together these structures form the pectoral girdle."[5] Although not prominent as other supports of the shoulder joint, attachments of clavicle provide significant function in mobility for upper extremity, as well as protect neurovascular structures behind it. Every section of clabicle have specific attachments that impact overall functioning of shoulder girdle.

Medially , the clavicle has articulation with manubrium sternum , forming sterno-clavicular joint (S-C joint). This joint is surrounded by a fibro-capsule containing an intraarticular disc between articulating surfaces. An interclavicular ligament provides structural support between the two clavicles on medial end.[6]

Laterally , clavicle has articulation with acromion process, forming acromio-clavicular joint (A-C joint). The surrounding region gives attachment for capsule of shoulder joint. This joint, like S-C joint, lined by fibro-cartilage and containing intra-articular disc. The three main ligamentous supports to joint are A-C ligament, coraco-clavicular ligament (CC), and the coraco-acromial ligament (C-A).[7]

"The actual shaft of clavicle is clinically divided into two parts : medial two-thirds and lateral third. These locations are used to identify where muscles are attached. The medial two-thirds has an attachment site for the sterno-cleido-mastoid (SCM) muscle and subclavius muscle along subclavian groove superiorly and inferiorly , respectively. The anterior surface is an attachment for pectoralis major and posterior for sternohyoid muscle. The costal tuberosity, which is where costoclavicular ligament inserts and supports SC joint, is also found on inferior surface."[8] Deltoid

and Trapezius are attached to Later 1/3rd of clavicle anteriorly and posteriorly. Inferiorly, conoid and trapezoid ligaments give stability to clavicle and coracoid process.[8]

"The clavicle happens to be one of most commonly fractured bones in the human body ; fracture can be as a result of direct contact or force transmission from falling onto an outstretched hand. Depending on level of displacement of fracture, surgery may be indicated, and proper management is determined on an individual basis due to differentiating factors surrounding such injury."

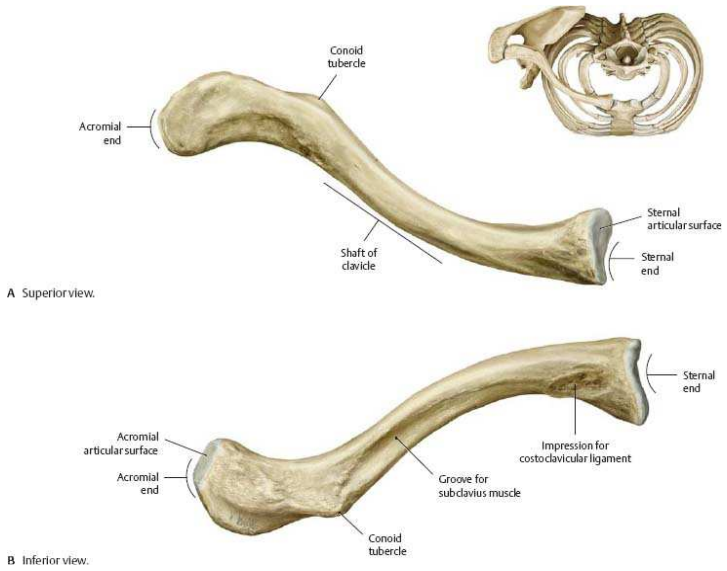


Figure 1. Diagram depicting anatomical landmarks of the clavicle in superior and inferior view

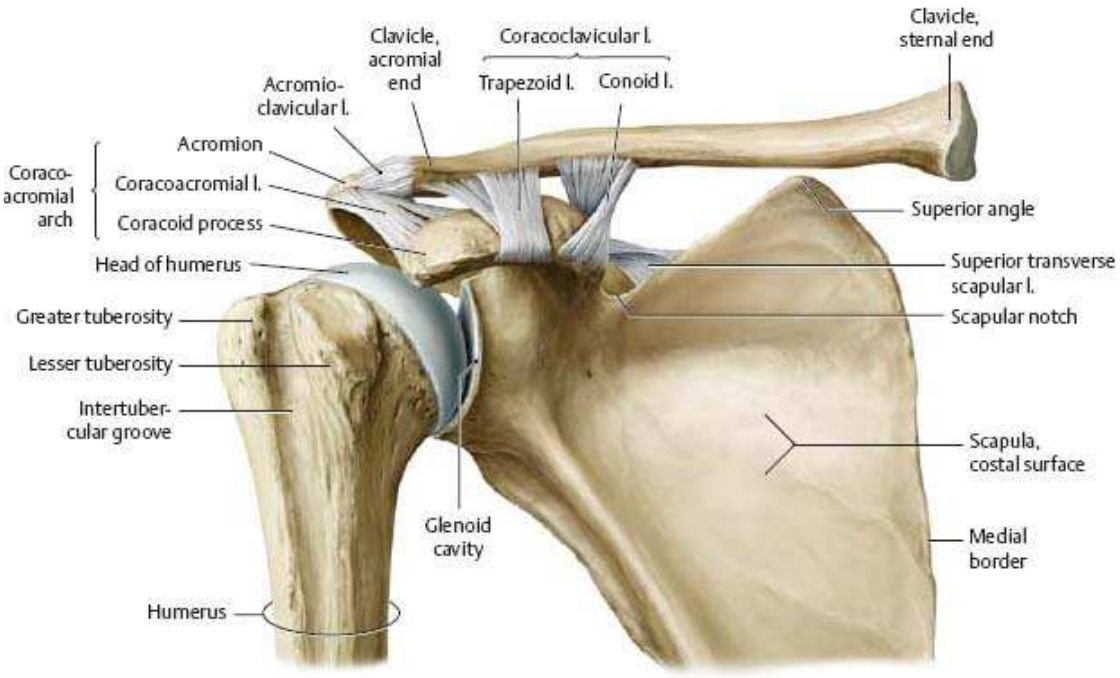


Figure 2. Diagram depicting anatomy of lateral end of clavicle

BLOOD SUPPLY

The main arterial supply is periosteal, devoid of nutrient artery. Three arteries were found to supply the clavicle; the suprascapular artery, thoraco-acromial artery and internal-thoracic artery. [9] Secondary supply of clavicle involves a nutrient artery entering through foramina. Nutrient foramen us a natural opening in diaphysis usually from where blood vessels enter the medullary cavity of a bone and supplies blood. Although clavicle is termed as a peculiar bone devoid of medullary cavity, it still has a nutrient foramen on the middle third of diaphysis usually on the posterior surface. [10]

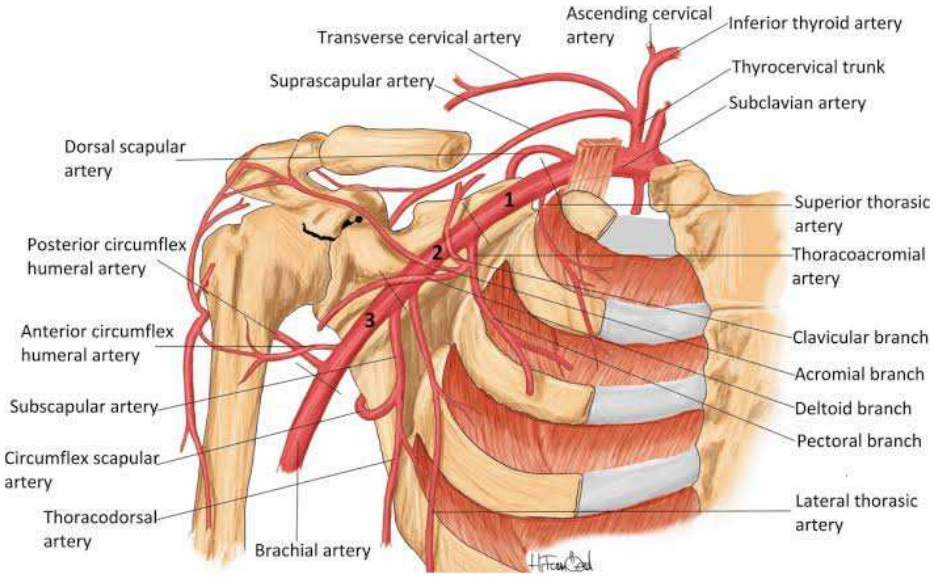


Figure 3. Diagram depicting blood supply to the clavicle with close association of the clavicle with major vessels

NERVE SUPPLY

The clavicle derives innervation majorly from the Subclavian, Lateral pectoral and supraclavicular nerves respectively.

Supraclavicular nerve supplies along length of clavicle.

caudal and dorsal aspect is supplied by the Subclavian nerve (medial 1/3 and midshaft).

The lateral pectoral nerve supplies the midshaft and lateral aspect of clavicle.

sternoclavicular joint is solely supplied by Subclavian nerve.

acromioclavicular joint is supplied by supraclavicular and lateral pectoral nerve.

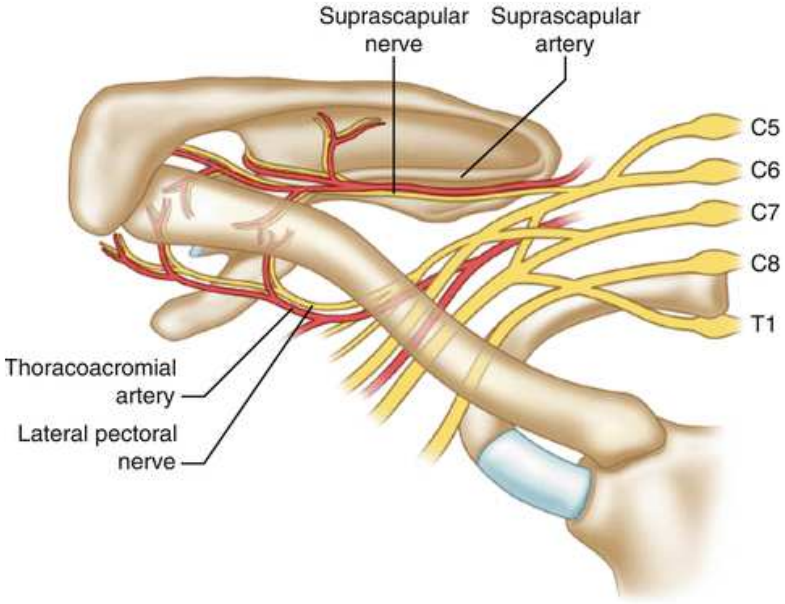


Figure 4. Diagram depicting nerve supply and surrounding neurvascular bundle

MUSCULAR ATTACHMENTS

Five muscles are attached to the clavicle, distributed either in lateral 1/3rd or medial 2/3rd clavicle.

Two muscles are attached to the lateral 1/3rd of clavicle which are-

1. trapezius muscle, which is attached at posterior surface of the lateral 1/3rd of clavicle.
2. Deltoid muscle anterior fibres are attached to periosteum on ventral surface of clavicle

Three muscles are attached to medial 1/3rd of clavicle-

1. Sterno-cleido-mastoid muscle

2.Pectoralis major muscle attached to anterior surface of clavicle.

3.Subclavius muscle attached to sub-clavian groove on inferior surface of clavicle.

Among these, deltoid and trapezius muscle give dynamic stability to acromio-clavicular joint.

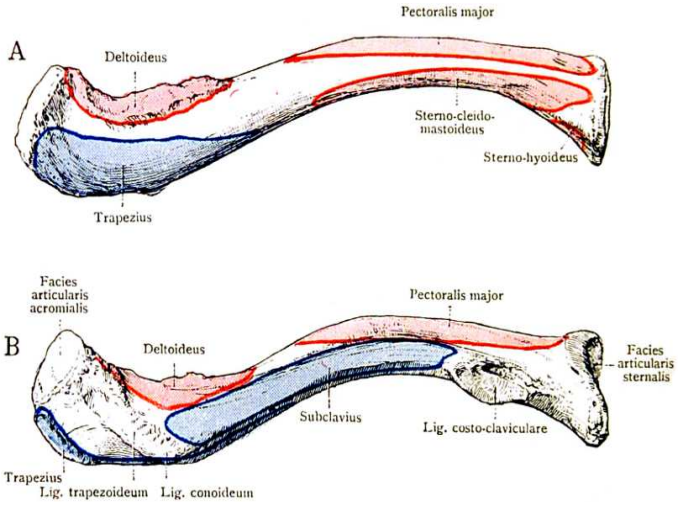


Figure 5. Diagram depicting the muscular attachments of the clavicle

INJURY MECHANISM

The most common mechanism of injury is thought to be a direct trauma to the shoulder joint.[13] A lateral blow to the shoulder leading to a loss of strut mechanism of the clavicle leads to fracture of clavicle in most cases. Other mechanisms involved include a fall over outstretched hand (FOOSH) injury.[14]

This mechanism of trauma can occur in a number of ways including fall from vehicles or bicycles, during a sports or from impact of objects or vehicular objects during a road traffic accident.

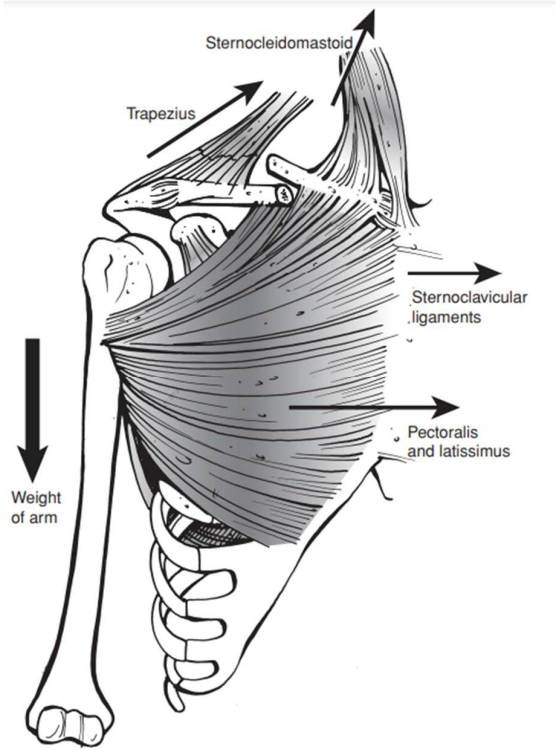
Commonly displaced midshaft clavicle fractures are due to motorcycle/ motorcycle accidents, bicycling accidents, falls from height, sporting events as the most common mechanisms of injury.[15]

"As the shoulder girdle is subjected to compression force directed from lateral direction , main strut maintaining position is clavicle and its articulations." As force exceeds capacity of this structure to withstand it, failure can occur in following methods . The acro-mioclavicular (A-C) articulation may disrupt, clavicle fractures may occur , or the sterno-clavicular (S-C) joint may dislocate.[16]

"The shoulder is typically pulled downward in patients with fractures of midshaft of clavicle, due to effect of pectoralis major and latissimus dorsi muscles on distal 1/3rd . The sterno-cleido-mastoid displaces proximal fragment upward. Locally there may be tenderness, crepitus, ecchymoses, or oedema."

Fracture angulation or displacement may lead to tenting of skin locally, leading to higher chances of open fractures .[17]

Figure 6. Diagram depicting mechanism of injury leading to midshaft clavicle fractures



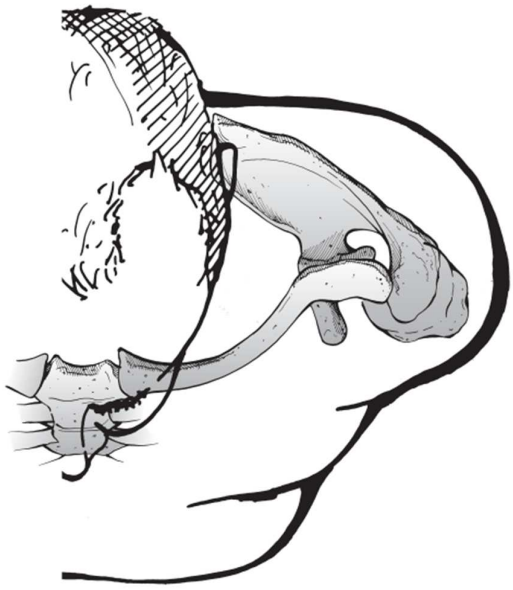


Figure 7. Diagram depicting strut mechanism in axial view

CLASSIFICATION OF FRACTURE CLAVICLE

Depending on the fracture site, many systems of classifications have been proposed such as-

1. Allman Classification
2. Robinson Classification
3. Neers Classification
4. Craig Classification

- Allman Classification on the basis of position of fracture site is divided into-

1. Group 1 (proximal 1/3)
2. Group 2 (midshaft)
3. Group 3 (distal 1/3)

This basic scheme of classification does not take into account various factors that influence the plan for treatment of these fractures such as displacement, comminution, fracture pattern, shortening etc. Thus other systems of classification were developed.

- Neers Classification was developed for classifying fractures of distal end of the clavicle owing to its highly unstable nature and high rates of non union and delayed union.

  Based on their ligamentous attachments and degree of displacement they were divided into three groups-

1. Type-1 – Distal clavicular fractures with intact coraco-acromial ligaments
2. type-2 – Coraco-acromial ligaments detached from medially, with trapezoid intact to lateral fragment.

Type 2a – (Rockwood) Both Trapezoid and conoid attached to distal fragment

Type 2b (Rockwood) Conoid detached with intact trapezoid ligament to medial fragment.

3. Type 3 – Distal clavicular fractures with intraarticular extension into acromioclavicular joint

- Robinson Classification – This system takes into account the following factors

    1. Location of the fracture site
    2. Displacement /angulation at the fracture site
    3. Articular involvement/ fragmentation

    These factors help in determining the prognosis of fractures.

    1. Type 1 – fractures involving medial end of clavicle

        A – undisplaced fracture

        A-1 – extraarticular fracture

        A-2 – intraarticular fracture

        B – displaced fractures

        B-1 – extraarticular fractures

        B-2 – intraarticular extension

    2. Type 2 – fractures involving midshaft clavicle

        A – cortex aligned

        A-1 – undisplaced

        A-2 – angulated

    B – displaced fracture

        B-1- simple or butterfly fragment

        B-2 – segmental/ comminuted fractures

3. Type 3 – distal clavicle fractures

   A – undisplaced

   A-1 – extraarticular fracture

   A-2 – intraarticular fracture

   B – displaced fracture

   B-1 – extraarticular

   B-2 – intraarticular

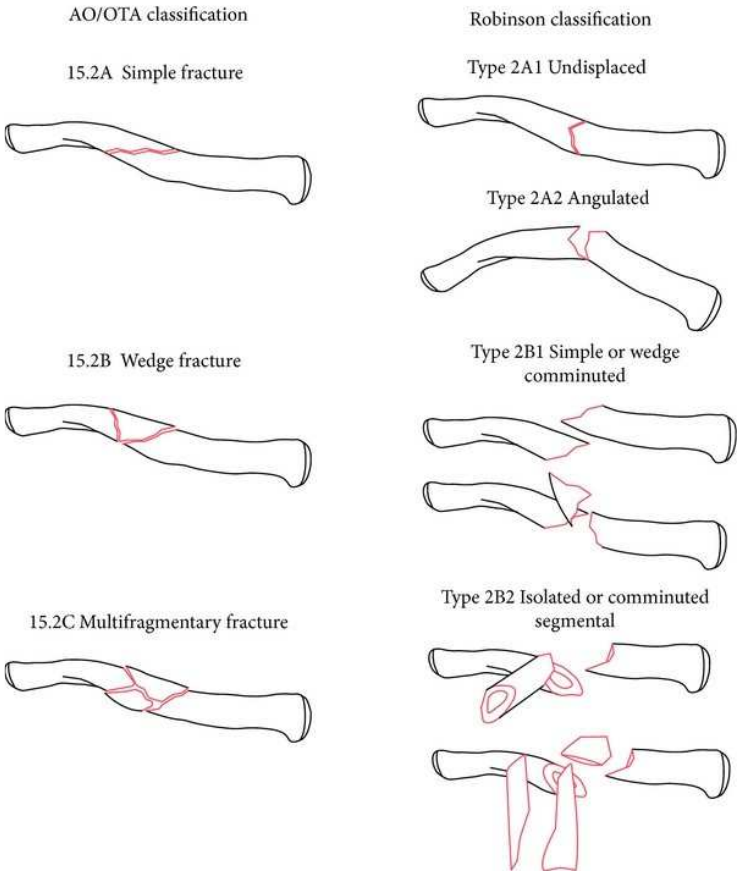


Figure 8. Diagram depicting AO/OTA classification and robinson classification

TREATMENT OPTIONS

Treatment options in form of non operative or operative intervention is decided after careful evaluation of patients for neurovascular compromise , open fractures , skin tenting , significant angulation or displacement or any puncture wounds , which are absolute indications for surgery.[14] Relative indications for surgery are Neer Type II displaced lateral 1/3rd fractures , shortening of more than 1.5 cm , or 15 % of contralateral side , floating shoulder , polytrauma , neuromuscular involvement and cosmetic reasons due to displacement.[15]

The mainstay of treatment either conservative or operative is for analgesia, return of functionality, avoidance of complications related to fracture clavicle.

In group 1 mid-shaft clavicle fractures , nonoperative management is most adequate approach. Treatment of these fractures consists of immobilisation or reduction measures. Immobilisation involves placing a sling, while reductive treatment includes placing a figure of eight brace. Same union rates have been achieved by both methods. “In uncomplicated nondisplaced midshaft fractures, patients treated nonoperatively with these conservative measures have fewer complications and a faster recovery than those treated operatively.” However, patients with complications like displaced fractures, shortening or comminuted fractures are at greater risks of non union/ malunion and are generally preferred to undergo surgical management resulting in a preferrable and statisfactory outcome. Surgical fixation is performed with plate osteosynthesis or intramedullary devices.

In group 2 distal clavicle fractures, patients are immobilized by slings . Figure-of-eight braces to be avoided , as they can displace fracture further . An extended management is required due to a 30 % rate of non union in these cases . “Definitive treatment is still debated , with some studies showing improved outcomes with

surgical fixation while others show similar outcomes in patients managed nonoperatively."[16]

Undisplaced , medial 1/3rd group 3 clavicle fractures are treated conservatively , with slings used for immobilisation & stability . Early mobilisation is permitted. Prominently displaced proximal clavicle fractures are rare because of strong ligament supports in this region. Grave associated injuries are found in approximately 90 % of displaced medial 1/3rd clavicle fractures. When associated with neuro-vascular deficits and other complications like pneumothorax , displaced medial 1/3rd fractures should be promptly addressed. These patients need to be promptly evaluated for severe intra-thoracic injury.[17]

CONSERVATIVE MANAGEMENT OPTIONS

In most un-displaced clavicle fractures and those patients in whom operative intervention is contraindicated, a conservative approach is taken.

These treatment options include the following-

- Arm-slings
- Strapping (Jones strapping)
- Figure of eight bandages

popular methods of conservative treatment include Figure-of-eight bandage and Jone's strapping.

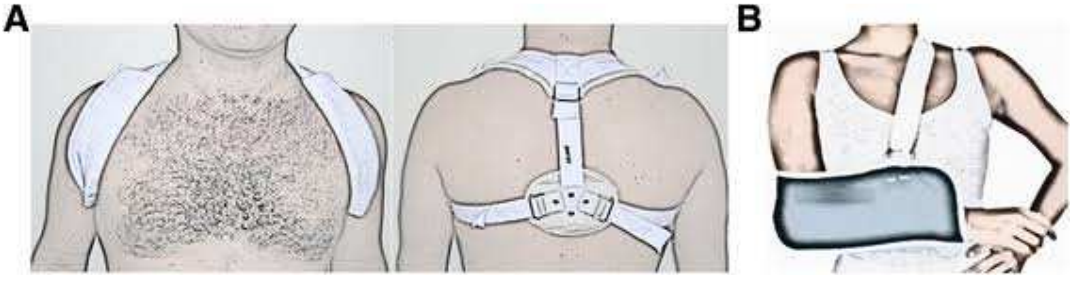


Figure 9. Diagram depicting various methods of conservative management of clavicle fractures

OPERATIVE TREATMENT OPTIONS

Patients requiring operative management of clavicle fractures are carefully selected by their level of physical activity and comorbidities. These being the ones who will benefit most from a rapid restoration of normal functionality and rigid fixation.

Indications of operative management of clavicle fractures include-

BASED ON FRACTURE -

- Displacement >2 cm
- Shortening of >2 cm
- Comminuted fractures (>3 fragments)
- open-fractures
- Impending open-fractures
- Scapular mal-position and winging in primary assessment

ASSOCIATED INJURIES

- Blood vessel disruptions
- Progressive neurologic deficit
- Ipsi-lateral upper limb injuries/ fractures
- Floating- Shoulder
- Bi-lateral clavicle fractures.

PATIENT FACTORS

1. Polytrauma patients requiring early upper limb mobility
2. Patient motivation in speedy return to normal functionality.

MATERIALS AND METHODS

MATERIALS OF STUDY

A prospective study was conducted in Dr.PKH for a span of 1 year.

Patients with comminuted 3 piece clavicle fractures were selected keeping in mind of the following criteria.

INCLUSION CRITERIA -

1. Adults of age group of 18- 70 will be included

2. Individuals with radiologically proven comminuted clavicle fractures with significant displacement will be included.

3. Other associated lower limb fractures

4. Without contraindications to general anaesthesia.

5. Provided informed written consent and ability to maintain regular follow up.

6. Patients choosing to undergo treatment modality being studied after explaining the choice of patient to undergo non operative treatment as well.

EXCLUSION CRITERIA

1) Age less than 18 years and greater than 70 will be excluded

2) Patients lost in follow up

3) Patients with neurovascular injuries and other complications

4) Simple or 2 part fractures of the clavicle.

5) Pathological fractures

6) Established non union

7) Contraindications to general anaesthesia.

8) Non consenting patients.

9) Patients unwilling to maintain a regular follow up.

STUDY DESIGN – Prospective study

STUDY PERIOD – One year

CALCULATED SAMPLE SIZE – 41

SAMPLING TECHNIQUE –

Sample size formula:

"The minimum sample size formula based on prevalence rate is

$n=[z\alpha^2P(1-P)]/d^2$"

Where "P" is prevalence rate and "d" is percentage likely difference in the prevalence.

z α is associated with level of significance. For 5% level of significance "z α = 1.96."

The parameter considered in the calculation is the prevalence rate of middle third clavicle

Comminuted fractures.

With P = 70% and d = 20% of P = 14%, the sample size is 41.

STUDY PROTOCOL-

All patients undergoing Primary Open reduction and internal fixation with plating for comminuted fracture clavicle.

All patients fulfilling the inclusion criteria set for this study will be advised to undergo above stated procedure at Dr.PKH for a period of 1 year.

DATA COLLECTION PROCEDURE-

Chest X ray with bilateral clavicle will be assessed for every patient undergoing procedure under evaluation at regular follow up at intervals of 2, 4, 6 and 12 weeks.

Radiographs will be taken at each visit and union will be assessed.

Other complications associated with plating will be assessed like plate prominence, skin irritation, axial length defects and non union rates.

Oxford Shoulder Score and VAS will be used to evaluate clinical outcomes

Oxford Shoulder Score is a questionnaire-based subjective assessment of the patient's pain and impairment of activities of daily living.

DATA PROCESSING AND ANALYSIS-

"Since the study is of observational study the plan of analysis will be as follows. For the continuous quantitative variables mean and standard deviation will be calculated. For the purpose of comparison if the data is divided into two groups with respect to certain qualitative characteristic, the continuous variables will be compared using suitable tools of statistics like student's unpaired t test. The pre and post treatment measures will be compared using student's paired t test Discrete variables will be represented by median. The categorical data will be expressed in terms of rates, ratios and percentages. The association between the outcome, clinical and demographic characteristics will be tested using Chi-square test, test of proportion or Fisher's exact test. For discrete variables nonparametric tests will be used.Apart from the above suitable tools like ANOVA, correlation, regression etc., will be used according to the need. Suitable graphs will be used to depict the comparison.For all the tests the value of p less than 5% (0.05) will be considered significant."

STEPS OF STUDY –

After a thorough routine evaluation of patients with comminuted clavicle fractures the study group was carefully selected keeping the inclusion criteria in mind.

Patients fit for the procedure under evaluation were selected and operated on an average of 3 days post injury.

The following were conducted prior to surgery-

1. Routine investigations ruling out any contraindications for anaesthesia
2. Viral markers were checked
3. Chest x ray radiograph with bilateral clavicles.

SURGICAL INSTRUMENTS-

Figure 10. Figure depicting various plate implants that are routinely used in plate osteosynthesis of clavicle

Figure 11.“3.5 mm anatomical locking plate” with a lateral extension of varying sizes

Figure 12. “3.5 mm anatomical locking plates” of varying sizes

PATIENT POSITIONING -

Patient is placed in “beach chair position” with a bolster under interscapular region facilitating a lift in ipsilateral shoulder and aiding in reduction of the fracture. 2 bolsters are placed 1 underneath the calves and 1 underneath the midthigh region thus reducing pressure over weight bearing areas and minimizing chances of skin necrosis.

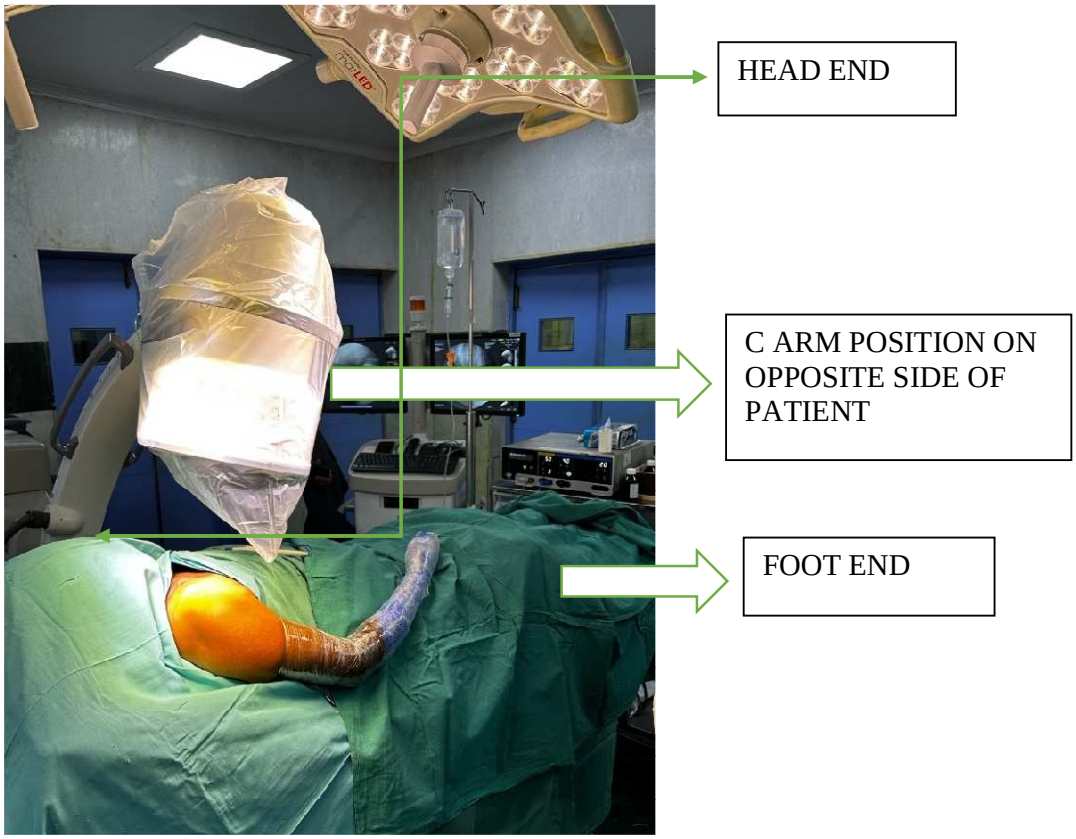


Figure 13. Patient In “Beach Chair Position” With Bolster In Interscapular Region.

SKIN MARKING –

Fracture site upto the mid forearm was scrubbed, painted and draped following all sterile aseptic precautions.

Skin marking was done first at sternoclavicular joint, acromioclavicular joint. Fracture site was marked.

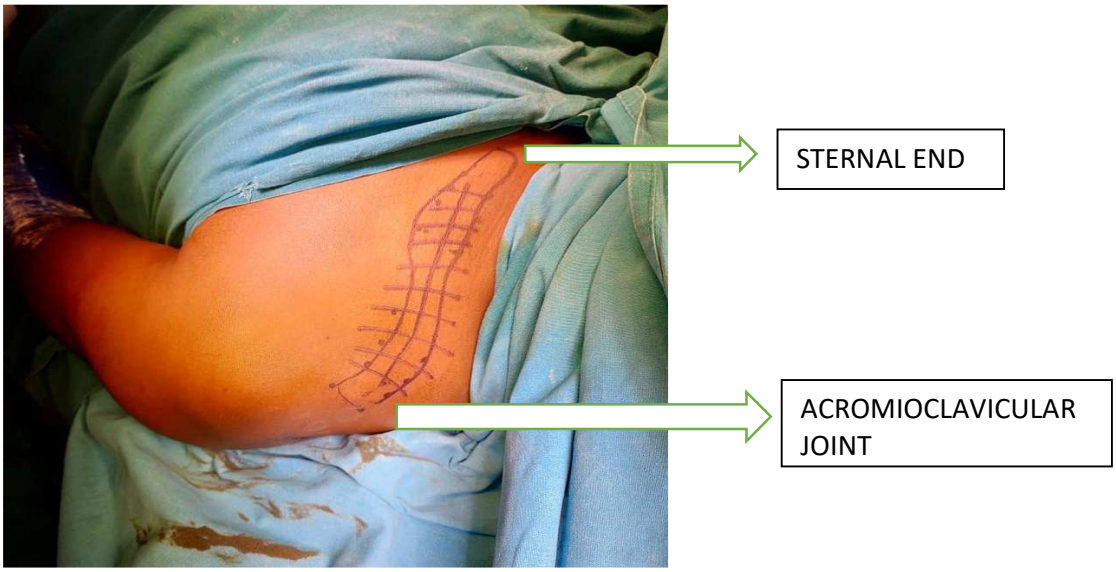


Figure 14. Figure depicting skin marking and position of patient.

APPROACH AND INCISION –

A standard Anterosuperior approach was taken. 5-8 cm skin incision was taken superior to the clavicle, extending 2-3 cm from proximal and distal to fracture site for adequate exposure and plate fixation.

Soft tissue dissection was done next, with care taken to cause minimal haemorrhage.

supraclavicular nerve was identified and preserved in cases where the nerve was not injured as a result of the mode of injury.

Supraclavicular nerve was retracted laterally.

The Platysma muscle was identified and incised taking care of minimal muscle bleed. The fibres of platysma run in an oblique fashion and were retracted. Periosteal stripping was done and fracture site was exposed along an epiperiosteal plane.

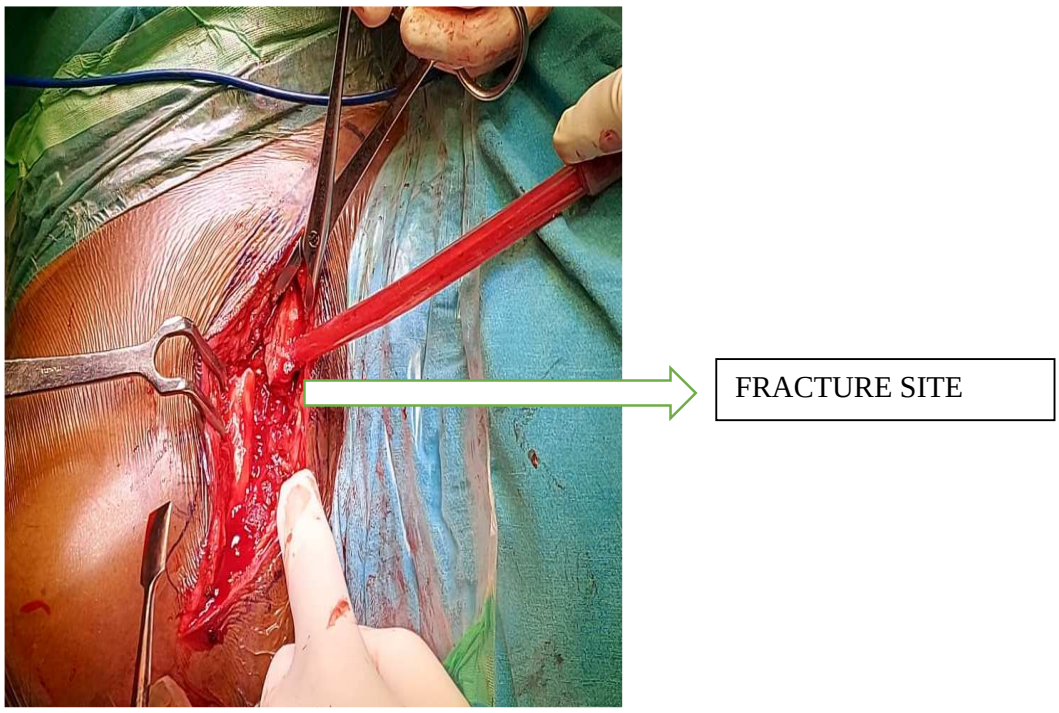


Figure 15. Figure depicting complete visualization of fracture site after superficial and deep dissection

REDUCTION AND FIXATION

Once fracture fragments were mobilised, they were held in reduction using reduction clamps. The comminuted fracture fragment was fixed using either vicryl sutures or using a “2.7 mm lag screw”.

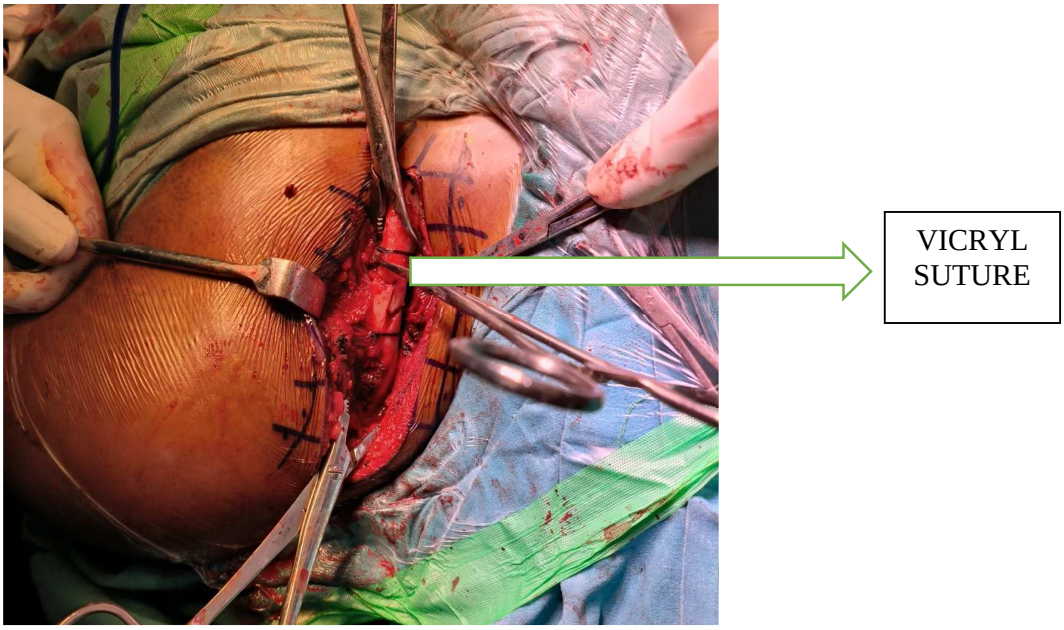


Figure 16. Figure Depicting Reduction Achieved Using VICRYL Sutures

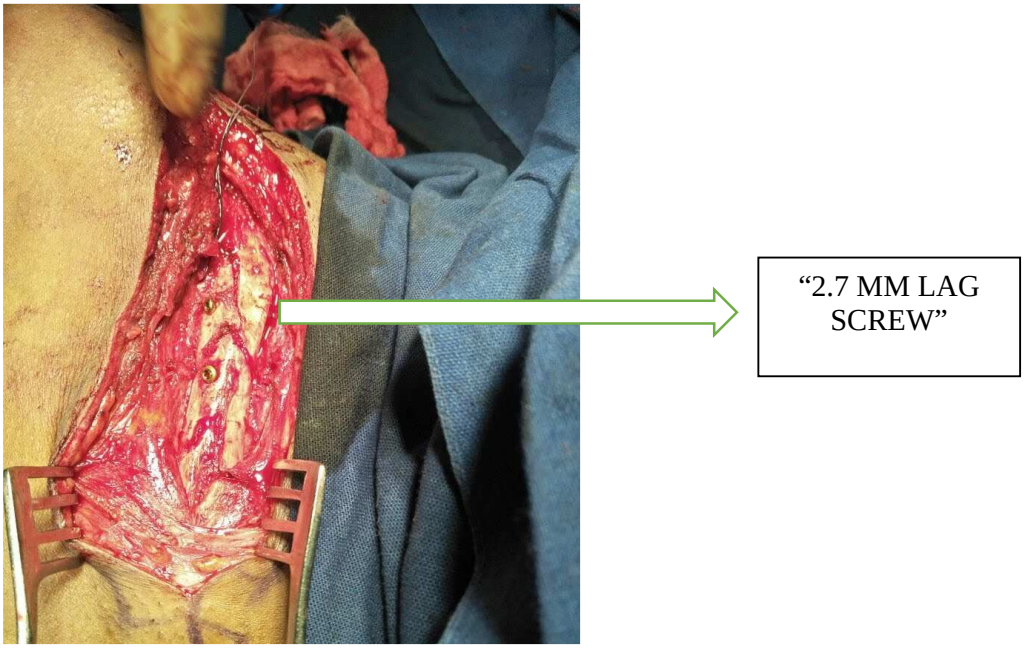


Figure 17. Figure depicting reduction of fracture using lag screw fixation

FIXATION-

Fixation of reduced fracture fragments was done with either of the following options-

1. Anatomical Locking Plates
2. Reconstruction Plates
3. Anatomical Plates with Lateral extension

A 3.5 mm system was used with 2.7 mm drill bit size for cortical screws and in case of lateral plates 2.7 mm screws for fixed distally.

Lengths of screws were decided intraoperatively after adequate depth measurement using a depth gauge.

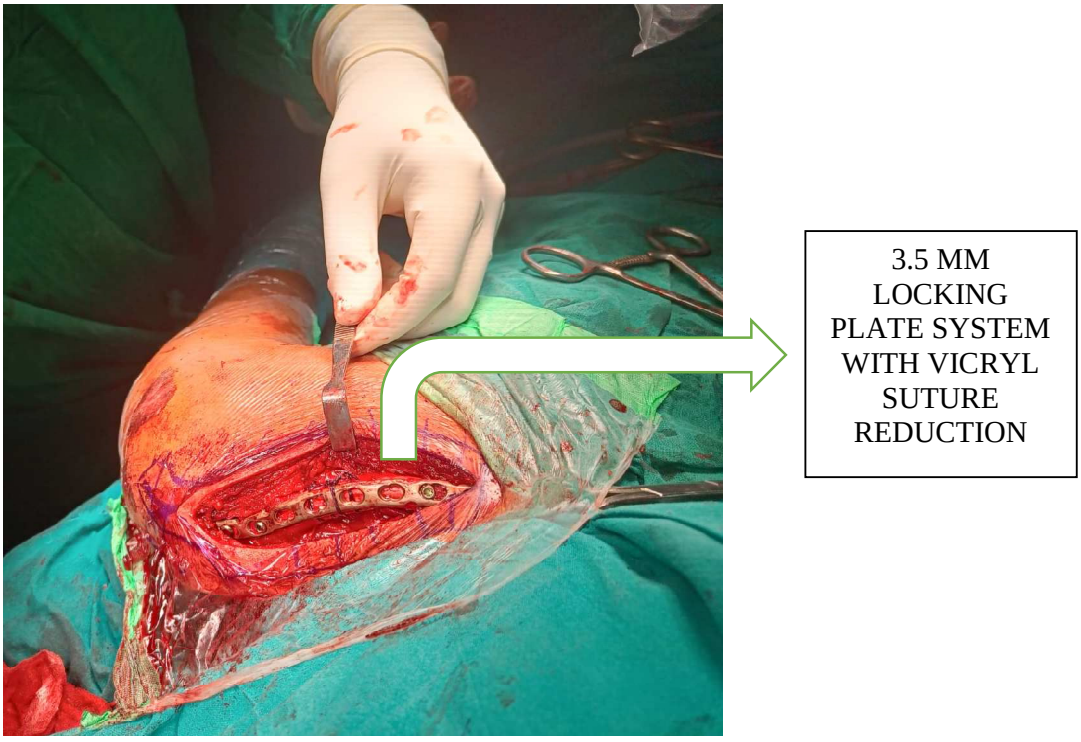


Figure 18. Figure depicting final fixation using an 8 hole anatomical locking plate with VICRYL suture reduction of comminuted fragment

INTRAOPERATIVE FLOUROSCOPY

C arm guided fluoroscopy images were taken at each step to confirm reduction and plate fixation with adequate screw length.

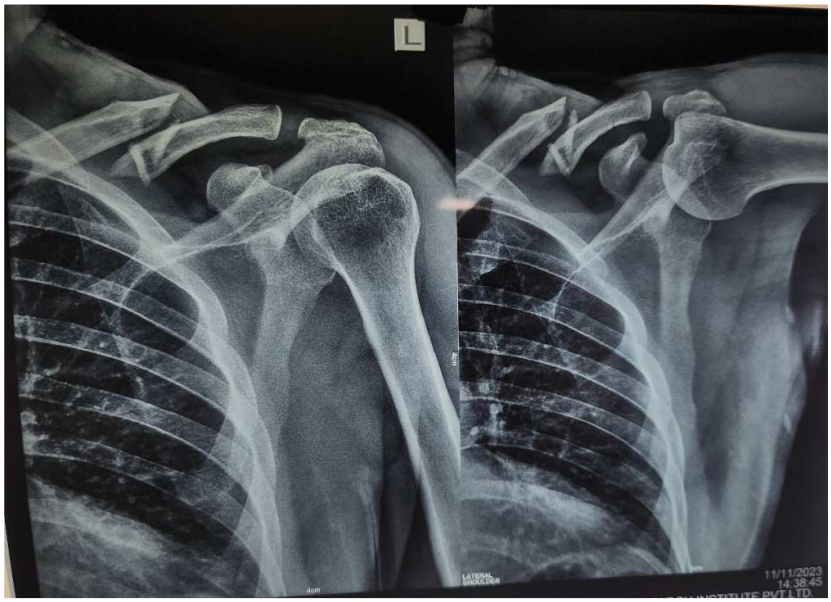


Figure 19. Preoperative X Ray Showing Displaced Comminuted Clavicle Fracture of The Left Side

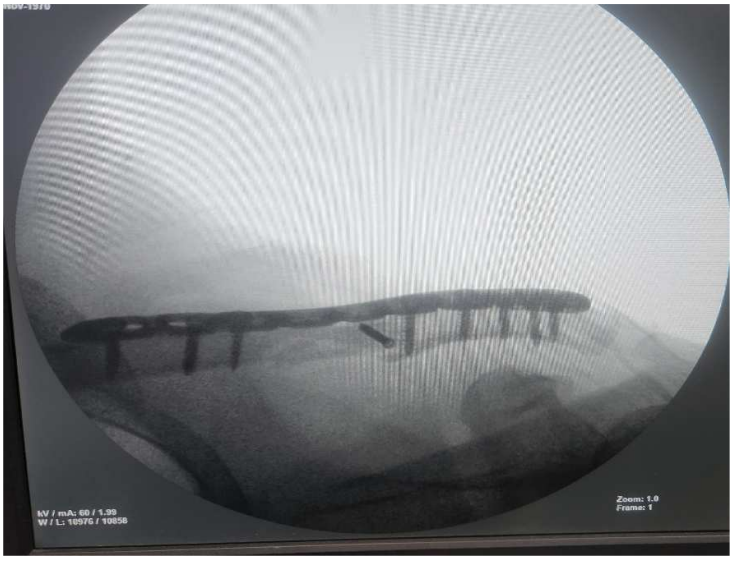


Figure 20. Intraoperative c arm images showing final fixation of clavicle using 3.5 mm 8 hole anatomical locking plate

WOUND CLOSURE

Surgical wound closure was done in a standard manner from periosteal coverage, platysma muscle closure, subcutaneous layer closure and skin.

Care was taken so as to not injure the supraclavicular nerve and its branches.

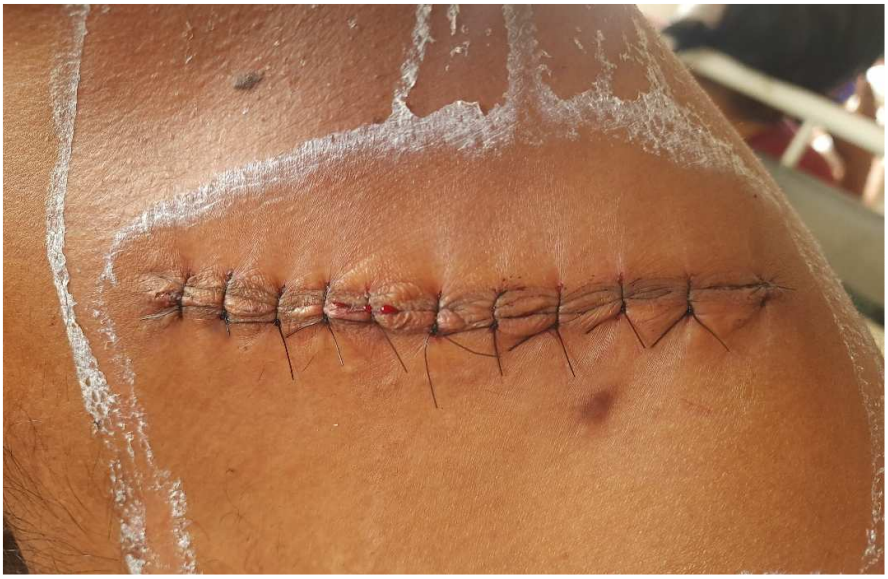


Figure 21. Figure showing closure of surgical wound as taken on post operative day 2

POST OPERATIVE PROTOCOL –

Patients who underwent procedure was encouraged to start mobilising on post operative day 1 starting from elbow and wrist range of motion exercises to prevent joint stiffness.

Shoulder range of motion exercises were encouraged immediately post operative as per pain tolerated by each patient.

Operated limb was immobilised using arm sling for a period of 4 weeks.

Patients were encouraged to start abduction movements of shoulder joint from 1 week post operative period.

An Abduction of more than 90 degrees was started after 2 weeks post operative period.

Pendular shoulder exercises were advised immediately post op and as per pain tolerance.

Union of fracture was evaluated with follow up x rays in a 4 week period.

FOLLOW UP-

Patients who came in for follow up visits were evaluated in their return to normal function of affected upper limb.

OSS score, VAS score and follow up x rays were recorded on each visit up to a period of 6 months post op.

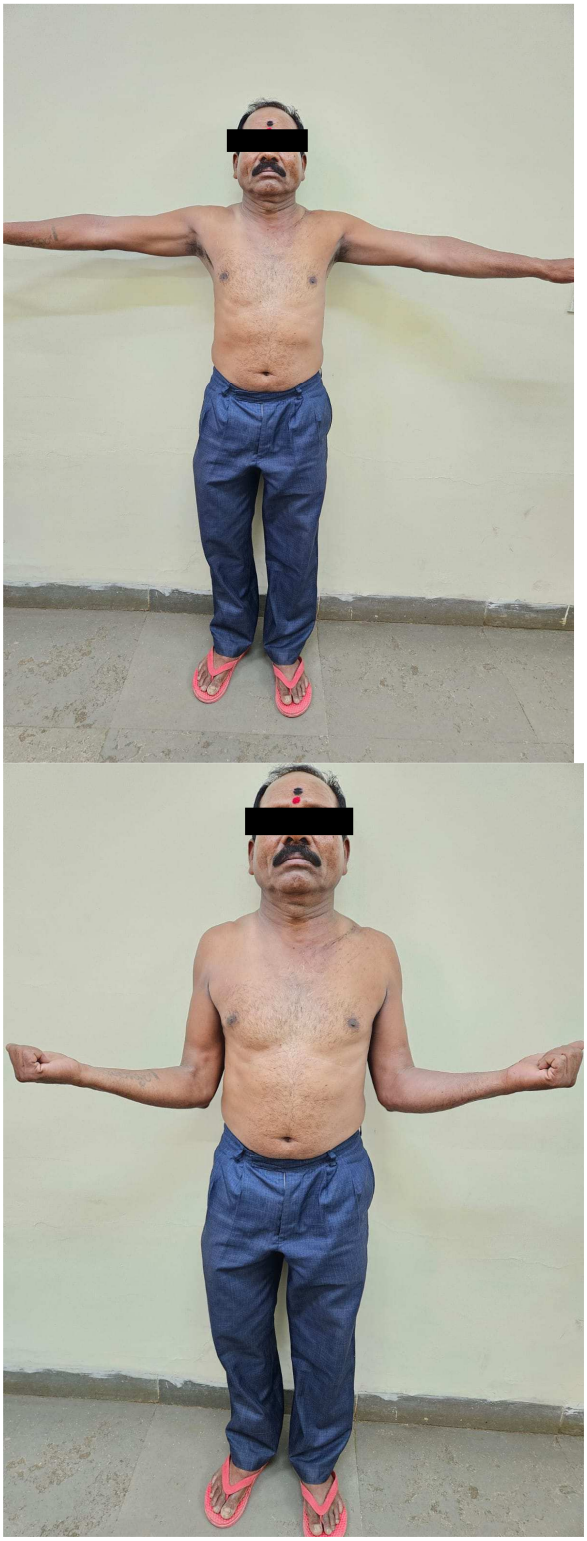
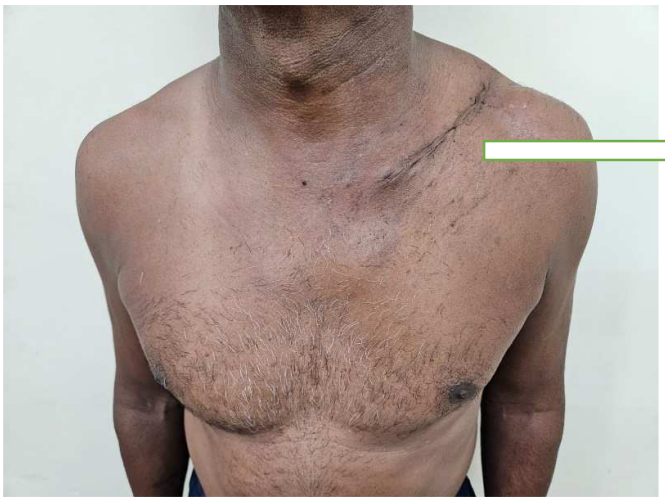


Figure 22. Follow Up Images Showing Return To Normal Range Of Motion



SURGICAL SITE SHOWING A HEALTHY AND HEALED SCAR

Figure 23. Figure depicting follow up range of motion and skin condition at 4 weeks post op

FOLLOW UP RADIOGRAPHS

X ray radiographs of chest with bilateral clavicle were taken at 1 month and 6 months post op and evaluated for union and anatomical length restoration.

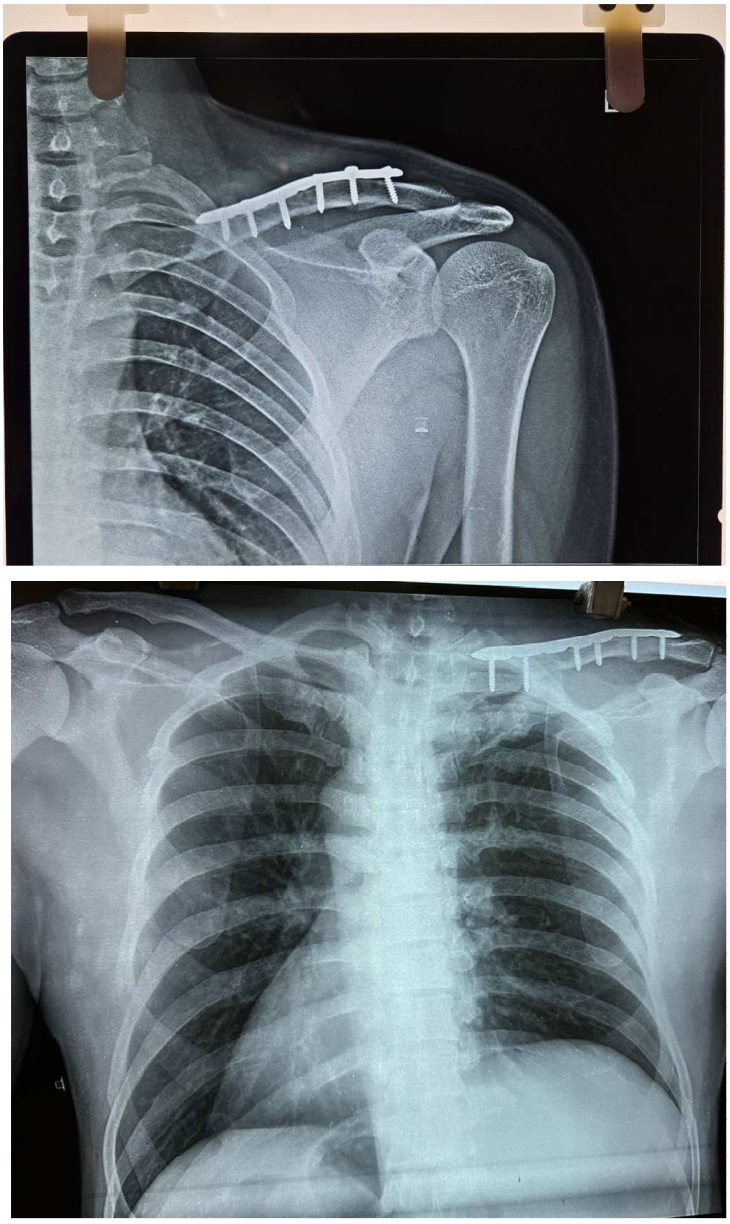


Figure 24. Follow up x ray at 1 month and 6 months respectively

RESULTS

Table. 1 – AGE DISTRIBUTION

		Frequency	Percent
Age Group	19 to 30 years	9	22.0%
	31 to 40 years	15	36.6%
	41 to 50 years	8	19.5%
	51 to 61 years	9	22.0%
	Total	41	100.0%

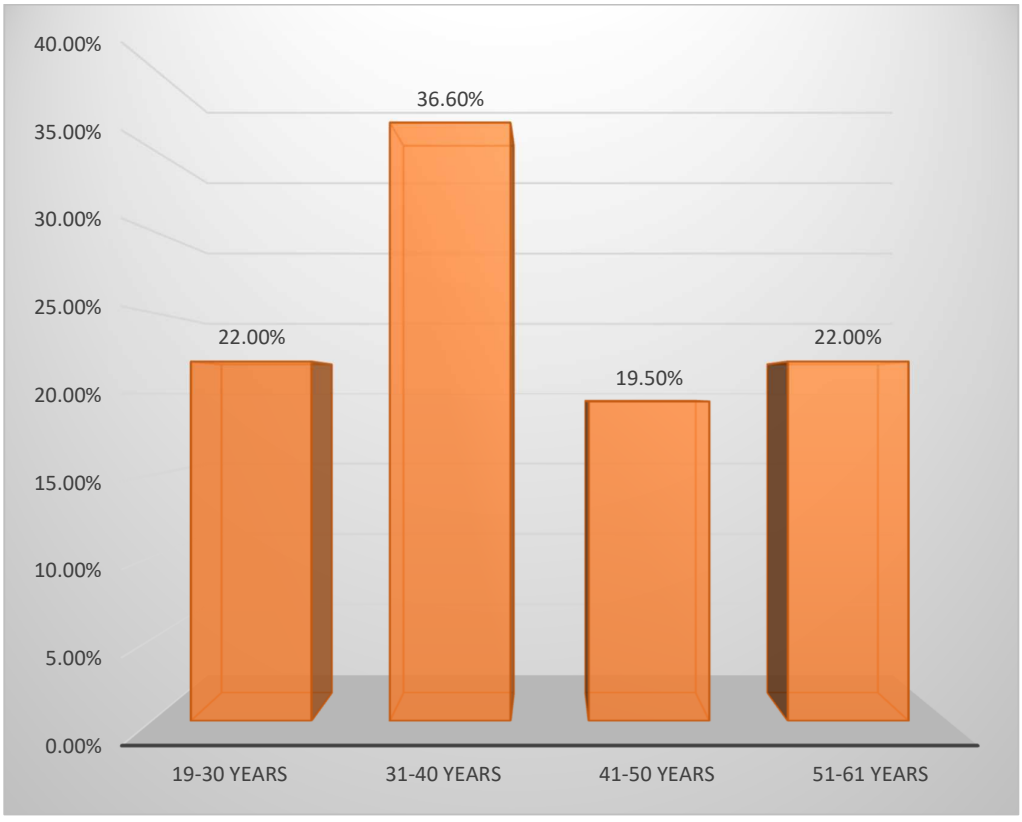


Table. 2 – GENDER DISTRIBUTION

		FREQUENCY	PERCENT
GENDER	MALE	33	80.5 %
	FEMALE	8	19.5 %
	TOTAL	41	100.0 %

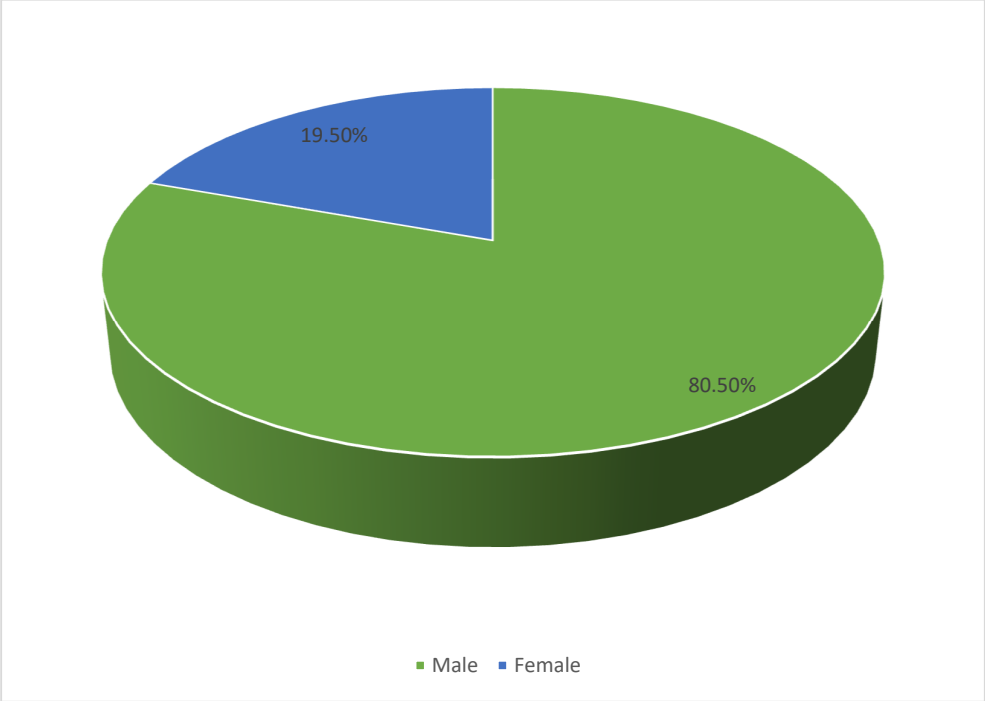


Table. 3 -MODE OF INJURY

		Frequency	Percent
MODE OF INJURY	FFH	1	2.4%
	FOOSH	5	12.2%
	RTA	35	85.4%
	Total	41	100.0%

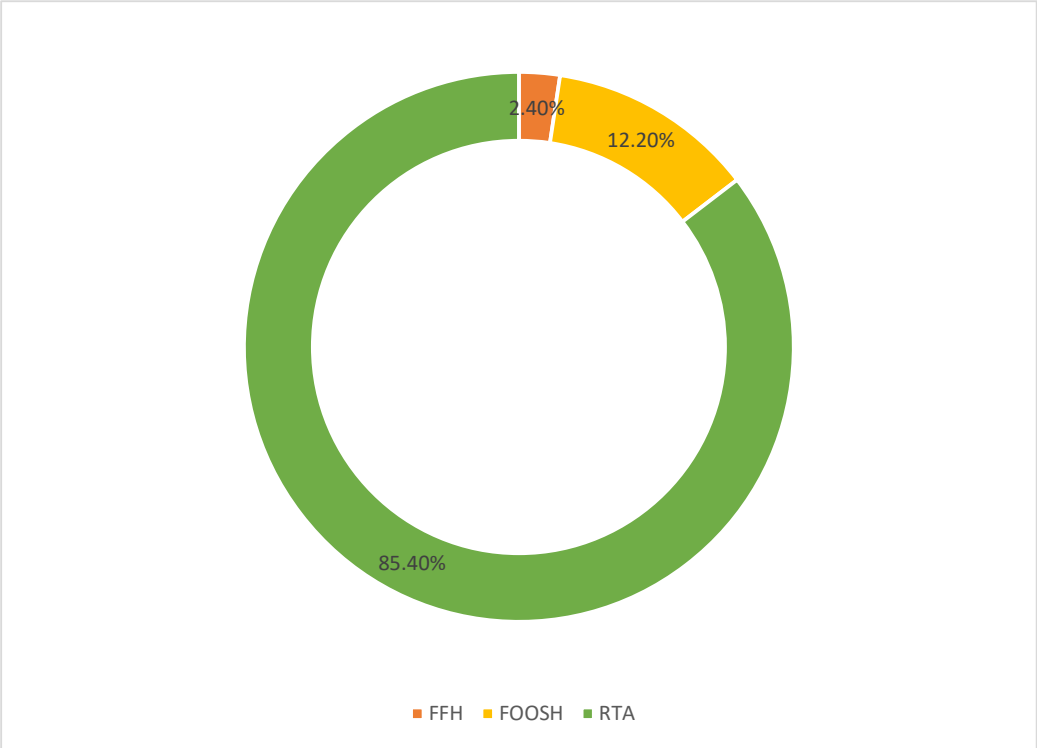


Table. 4 – TREATMENT GIVEN

		Frequency	Percent
TREATMENT GIVEN	ORIF+ PLATING	41	100.0%

Table. 5 – IMPLANTS USED

		Frequency	Percent
IMPLANT USED	5 HOLED ANATOMICAL PLATE	2	4.9%
	5 HOLED ANATOMICAL PLATE + INTERFRAG SCREW	3	7.3%
	5 HOLED BRIDGE PLATE	1	2.4%
	6 HOLED RECON PLATE	1	2.4%
	6 HOLED ANATOMICAL PLATE	14	34.1%
	6 HOLED ANATOMICAL PLATE + INTERFRAG SCREW	3	7.3%
	7 HOLED ANATOMICAL PLATE	7	17.1%
	7 HOLED ANATOMICAL PLATE+ INTERFRAG SCREW	3	7.3%
	7 HOLED RECON PLATE	2	4.9%
	8 HOLE ANATOMICAL PLATE	5	12.2%
	Total	41	100.0%

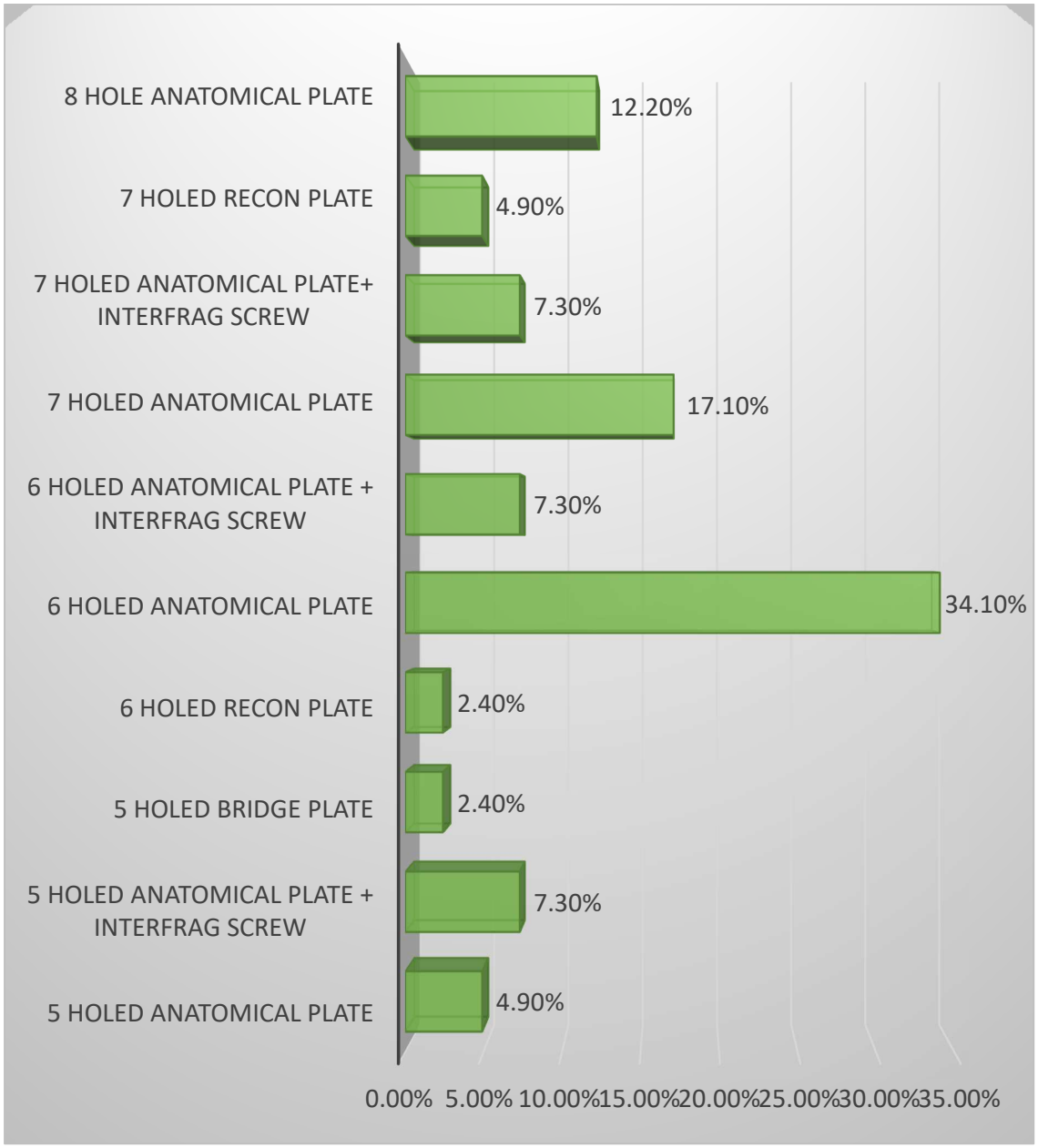

8 HOLE ANATOMICAL PLATE
12.20%
7 HOLED RECON PLATE
4.90%
7 HOLED ANATOMICAL PLATE+ INTERFRAG SCREW
7.30%
7 HOLED ANATOMICAL PLATE
17.10%
6 HOLED ANATOMICAL PLATE + INTERFRAG SCREW
7.30%
6 HOLED ANATOMICAL PLATE
34.10%
6 HOLED RECON PLATE
2.40%
5 HOLED BRIDGE PLATE
2.40%
5 HOLED ANATOMICAL PLATE + INTERFRAG SCREW
7.30%
5 HOLED ANATOMICAL PLATE
4.90%
0.00% 5.00% 10.00% 15.00% 20.00% 25.00% 30.00% 35.00%

Table. 6 -REDUCTION TECHNIQUE

		Frequency	Percent
REDUCTION METHOD	LAG SCREW	9	22.0%
	VICRYL SUTURE	30	73.2%
	NIL	2	4.9%
	Total	41	100.0%

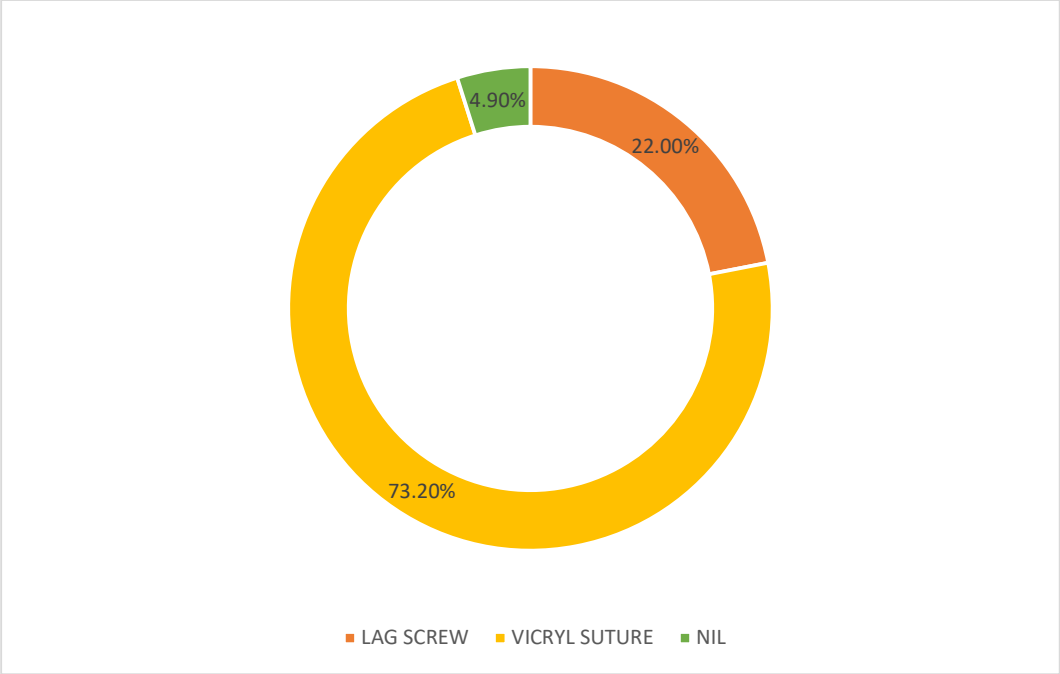


Table. 7- OXFORD SHOULDER SCORE

		Mean	SD	T Test	P Value
OSS SCORE	AT 2 WEEKS	27.32	3.020	-18.54	0.001
	AT 1 MONTH	37.46	2.758		
OSS SCORE	AT 2 WEEKS	27.32	3.020	-27.65	0.001
	AT 6 MONTH FOLLOW UP	44.76	2.478		
OSS SCORE	AT 1 MONTH	37.46	2.758	-13.70	0.001
	AT 6 MONTH FOLLOW UP	44.76	2.478		

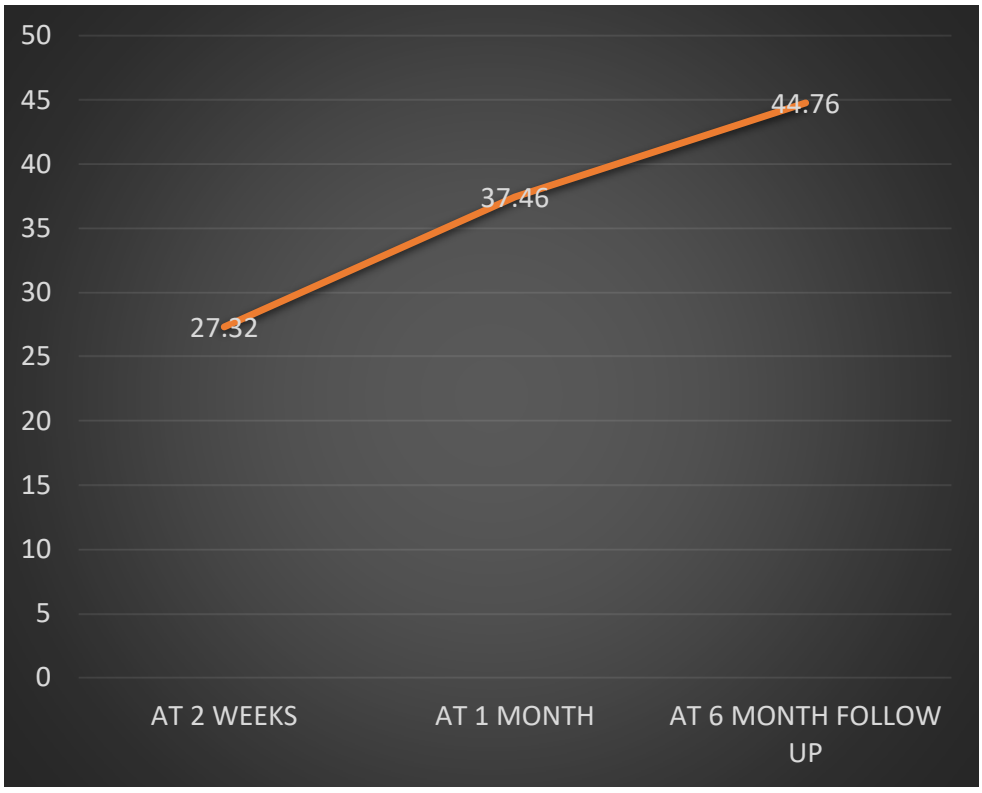


Table. 8 – VAS SCORE

		Frequency	Percent
VAS SCORE AT 6 MONTHS FOLLOW UP	1	15	36.6%
	2	13	31.7%
	3	5	12.2%
	4	7	17.1%
	5	1	2.4%
	Total	41	100.0%

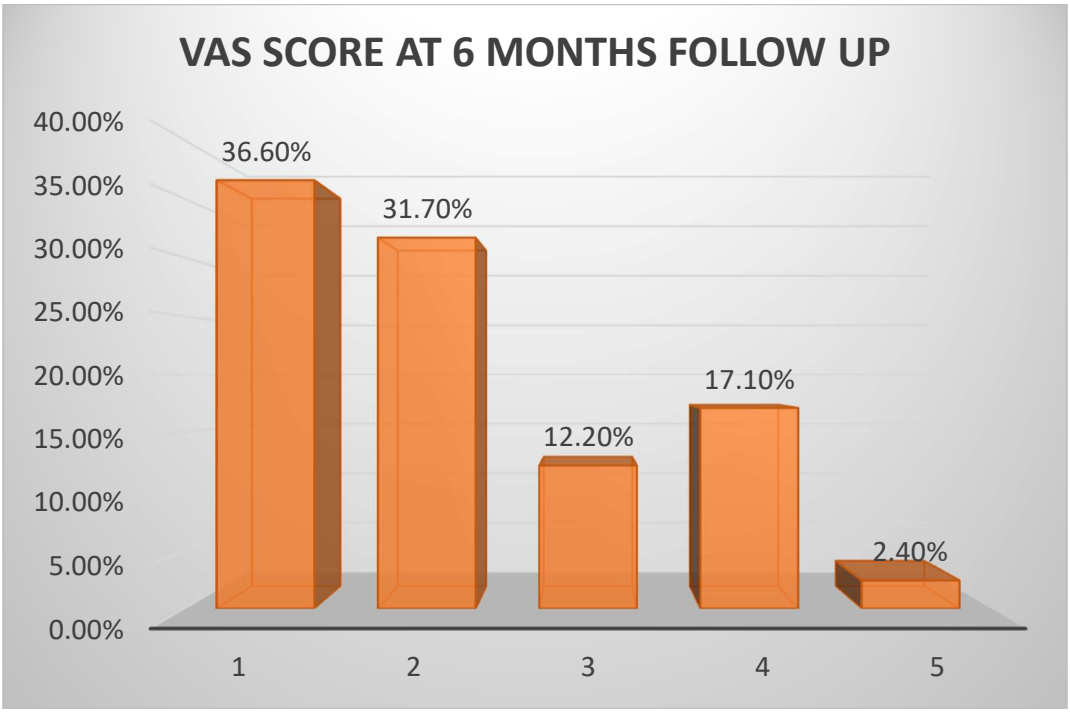


Table. 9 – CLAVICULAR LENGTH

	Minimum	Maximum	Mean	Std. Deviation
CLAVICLE LENGTH	12.1	16.8	15.012	1.3111

Table. 10 – SCAR HEALTH

		Frequency	Percent
SCAR HEALTHY	Yes	41	100.0%

DISCUSSION

Plate osteosynthesis is an established method for fixation for fracture clavicle. Plate osteosynthesis is a highly effective treatment option for comminuted clavicle fractures, offering reliable fixation and promoting optimal healing conditions. Its ability to provide stable fixation and allow for early mobilization makes it a preferred choice in complex clavicular fractures.

One of the primary benefits of plate osteosynthesis is the early mobilization it allows. Patients can often begin gentle shoulder exercises soon after surgery, reducing the risk of joint stiffness and muscle atrophy. This early mobilization contributes to quicker functional recovery, which is particularly beneficial for athletes and individuals with high physical demands.

"So there are specific indications like displacement, with or without comminuted middle third clavicle fracture (Robinson type-2B1, 2B2) and displaced lateral third clavicle fracture (Robinson type-3B1, 3B2) for which operative treatment is needed."[16]

In this study we have evaluated 41 patients with comminuted clavicle fractures who have undergone primary open reduction internal fixation with plate osteosyntheis.

AGE AND SEX DISTRIBUTION-

Out of 41 patients 15 patients belonged to the 31-40 year old group representing 36.6% on the sample size. Whereas the lowest number of patients were seen in the age group of 41-50 year old representing 19.5% of total sample size.

Out of 41 patients 33 were males representing 80.5% of sample size and 8 were females which accounted to 19.5% of the sample size.

MODE OF INJURY-

Out of the 41 patients evaluated 35 were a result of Road traffic accidents (RTA) representing 85.4% of the sample size.

5 patients suffered a fall on outstretched hand (FOOSH) injury that accounted to 12.2% of the sample size.

1 patient suffered a fall from height (FFH) and accounted to 2.4% of the sample size.

TREATMENT GIVEN-

All 41 patients were given treatment in the form of primary open reduction and internal fixation with plate osteosynthesis.

IMPLANTS USED-

Out of the 41 patients evaluated, the choice of implant for 14 patients was a 6 hole anatomical locking plate which represented 34.1% of total patients.

Additionally in 3 patients an anatomical locking plate with interfrag screw fixation was used and accounted to 7.3% cases.

In 5 patients an 8 hole anatomical locking plate with lateral extension was used which accounted to 12.2% of total cases.

In 2 cases a 5 hole anatomical locking plate was used which surmounted to 4.9% cases.

Furthermore, in 3 cases a 5 hole anatomical locking plate with interfrag screw fixation was used amounting to 7.3% total cases.

In 1 patient a 6 hole recon plate was used amounting to 2.4% of all cases.

In 2 patients a 7 hole recon plate was used amounting to 4.9% cases.

SCAR HEALTH –

Out of the 41 patients evaluated, no patient was found to have any signs of delayed healing or gaping.

None of the patients evaluated had any signs of surgical site infections.

CLAVICULAR LENGTH-

The mean clavicular length out of 41 patients evaluated was found to be 15.012cms with a standard deviation of 1.3111.

The minimum length was calculated to be 12.1 cm

The maximum length being 16.8 cm.

None of the patients evaluated were found to have shortening in operated clavicle on 6 months follow up period when compared to contralateral side.

REDUCTION METHOD-

The most preferred method of reduction of comminuted clavicle fracture fragment was found to be a vicryl suture reduction which were 30 patients out of 41 amounting to 73.2% of all cases.

In 9 cases a 2.7 mm lag screw fixation was used which amounted to 22.0% of all cases.

2 cases were reduced using a plate reduction method alone and amounted to 4.9% of all cases.

OXFORD SHOULDER SCORE-

The OSS calculated had the following values noted on a period of 2 weeks post op, 1 month post op and a 6 months post op period-

1. The mean OSS for 2 weeks follow up was found to be 27.32 ± 3.020 (SD)

2. The mean OSS for a 1 month follow up period was found to be 37.46 ± 2.758 (SD)
3. The mean OSS for 6 months follow up period was 44.76 ± 2.478 (SD)

Hence when patients at 2 weeks follow up were compared to patients at 1 month follow up a T Test value of -18.54 was calculated

When patient at 2 weeks follow up were compared to 6 months follow up they showed a T Test value of -27.65

1 month follow up patients when compared to 6 months follow up patients showed a T Test value of -13.70

Thus, the P value of all above comparisons were calculated to be 0.001, 0.001, 0.001 respectively making the above study statistically significant.

VISUAL ANALOGUE SCALE-

In the 41 patients studied, the VAS scores at 6 months follow up period were as follows-

VAS 1 – 15 patients had a score of 1 (36.6% cases)

VAS 2 – 13 patients had a score of 2 (31.7% cases)

VAS 3 – 5 patients had a score of 3 (12.2% cases)

VAS 4 – 7 patients had a score of 4 (17.1% cases)

VAS 5 – 1 patient had a score of 1 (2.4% cases)

Here we can see that a majority of patients had minimal to no pain and thus made it established as to minimal pain post op at a 6 month follow up period.

SUMMARY

To summarise this study, a prospective study included 41 patients havingcomminuted clavicle fractures who have undergone primary orif & plate osteosynthesis.

- mean age group was found to be 31-40 year olds (36.6%)
- 33 were males (80.5%) and 8 were females (19.5%)
- 35 patients suffered a Road Traffic Accident (85.4%)
- 5 patients suffered a fall on outstretch hand (12.2%)
- 1 patient suffered a fall from height (2.4%)
- 6 hole anatomical locking plate was the choice of implant in 34.1% of cases.
- All cases were found to have a healthy scar without gaping and devoid of any signs of surgical site infections
- The clavicle length was an average of 15.012 ± 1.3111 cms
- No patient was found to have shortening in affected clavicle when compared to contralateral side at a 6 month follow up period.
- The choice of reduction method for comminuted fragment was a vicryl suture tie which was in 30 cases (73.2%)
- The mean OSS score at 2 weeks follow up was 27.32 ± 3.020
- Mean OSS at 1 month post op was 37.46 ± 2.758
- Mean OSS at 6 months post op was 44.76 ± 2.478
- P value of 0.001 was calculated when OSS was compared between 2 weeks and 1 month, 2 weeks and 6 months and 1 month and 6 months respectively making it statistically significant.

- VAS at 6 months follow up was a score of 1 in 15 patients (36.6%) 2 in 13 patients (31.7%) 3 in 5 patients (12.2%) 4 in 7 patients (17.1%) 5 in 1 patient (2.4%) thus showing the minimal pain experienced in most patients and minimal hinderance in their day to day living following procedure.

CONCLUSION

From this prospective study with 41 participants it was concluded that-

- In comminuted fracture clavicles, primary open reduction and internal fixation is the preferred method of management.
- Due to benefits of plate osteosynthesis like immediate post op mobilisation, significantly low rates of malunion/ nonunion we have established plate osteosynthesis as the gold standard of comminuted clavicle fracture management.
- Anatomical length was restored without any incidence of shortening in any of the 41 patients thus proving the significantly low incidence of long-term complications of primary plate osteosynthesis.
- A statistically significant improvement in Oxford Shoulder Score in a 2 week, 1 month and 6 months duration proved the improved patient outcomes in terms of return to normal day to day activities of these patients.
- A nil to minimal VAS score at a 6 month follow up period proved how plating did not cause any chronic pain to the patient.

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ANNEXURES - I

INFORMED CONSENT

I am making a voluntary decision to participate in the study "**CLINICAL OUTCOME OF PLATING IN COMMINUTED (3 PIECE) CLAVICLE FRACTURES A PROSPECTIVE STUDY**." My signature below indicates that I have decided to participate and I have read the information provided above or the information provided above has been read to me in the language that I understand best. I was given the opportunity to ask questions and that they have been answered to my satisfaction.

Name of the participant:

Signature or left thumb impression of the participant:

Name of the witness:

Signature or left thumb impression of the witness:

Name of the investigator:

Signature of the investigator:

ANNEXURE 2

PROFORMA

"CLINICAL OUTCOME OF PLATING IN COMMINUTED CLAVICLE FRACTURES (3 PIECE FRACTURES) , A PROSPECTIVE STUDY"

PATIENT NO. IP NO.

AGE-

ADDRESS –

CHIEF COMPLAINTS –

PRE TREATMENT (VISIT 1)

HISTORY-

INVESTIGATIONS DONE – CHEST X RAY WITH BILATERAL CLAVICLE IN AP VIEW

TREATMENT GIVEN – OPEN REDUCTION AND INTERNAL FIXATION + LOCKED COMPRESSION PLATING

INTRA OPERATIVE EVIDENCE AS ATTACHED-

POST OPERATIVE INVESTIGATION IN THE FORM OF – CHEST X RAY WITH BILATERAL CLAVICLE IN AP VIEW.

VISIT – 2

POST OPERATIVE 6 MONTH FOLLOW UP VISIT

CHIEF COMPLAINTS-

6 MONTH FOLLOW UP INVESTIGATION IN THE FORM OF CHEST X RAY WITH BILATERAL CLAVICLE –

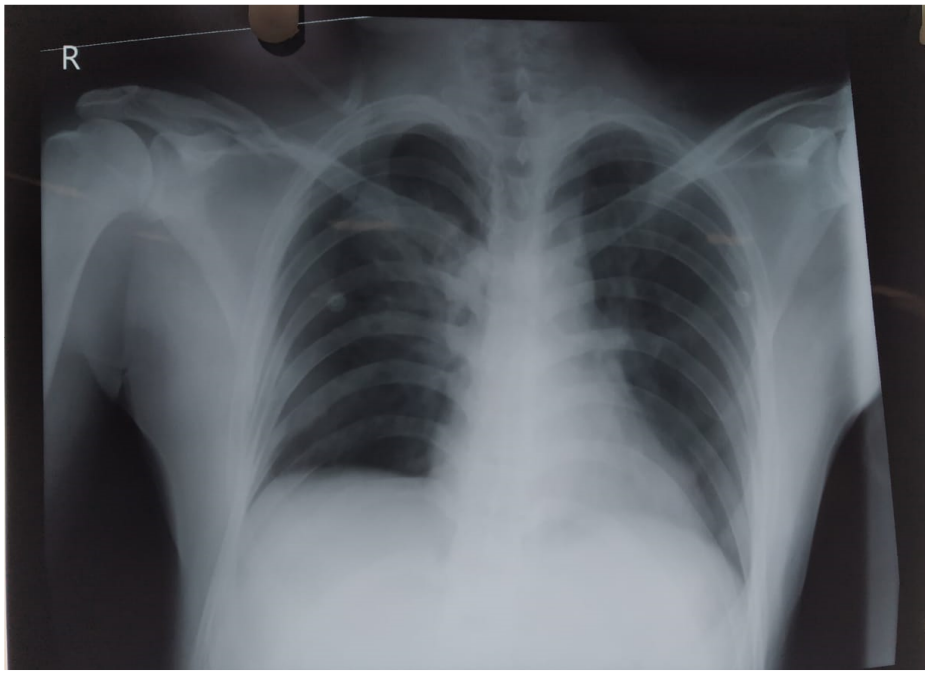
OXFORD SHOULDER SCORE-

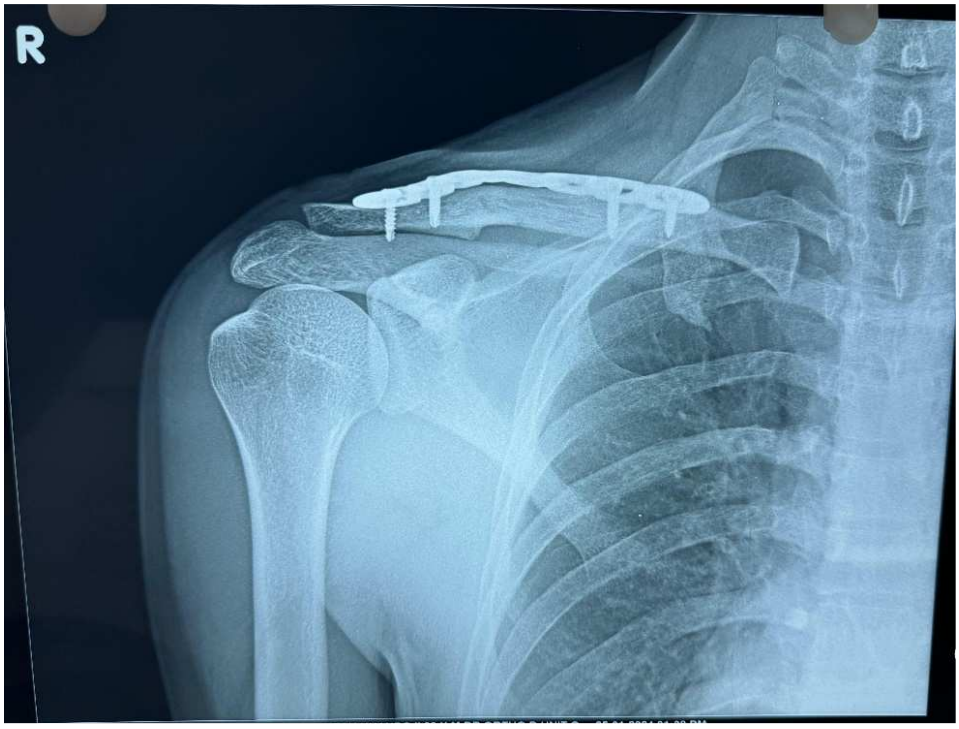
No.	Question (During the past four weeks...)	Answers	Score (old)	Score (new)
1	How would you describe the worst pain you had from your shoulder?	None Mild Moderate Severe Unbearable	1 2 3 4 5	4 3 2 1 0
2	Have you had any trouble dressing yourself because of your shoulder?	No trouble Little trouble Moderate trouble Extreme difficulty Impossible to do	1 2 3 4 5	4 3 2 1 0
3	Have you had any trouble getting in and out of a car or using public transport because of your shoulder?	No trouble Little trouble Moderate trouble Extreme difficulty Impossible to do	1 2 3 4 5	4 3 2 1 0
4	Have you been able to use a knife and fork – at the same time?	Yes, easily Little difficulty Moderate difficulty Extreme difficulty No, impossible	1 2 3 4 5	4 3 2 1 0
5	Could you do household shopping on your own?	Yes, easily Little difficulty Moderate difficulty Extreme difficulty No, impossible	1 2 3 4 5	4 3 2 1 0
6	Could you carry a tray containing a plate of food across the room?	Yes, easily Little difficulty Moderate difficulty Extreme difficulty No, impossible	1 2 3 4 5	4 3 2 1 0
7	Could you brush/comb your hair with the affected arm?	Yes, easily Little difficulty Moderate difficulty Extreme difficulty No, impossible	1 2 3 4 5	4 3 2 1 0
8	How would you describe the pain you usually had from your shoulder?	None Very mild Mild Moderate Severe	1 2 3 4 5	4 3 2 1 0
9	Could you hang your clothes up in the wardrobe using the affected arm?	Yes, easily Little difficulty Moderate difficulty Extreme difficulty No, impossible	1 2 3 4 5	4 3 2 1 0
10	Have you been able to wash and dry yourself under both arms?	Yes, easily Little difficulty Moderate difficulty Extreme difficulty No, impossible	1 2 3 4 5	4 3 2 1 0
11	How much has the pain from your shoulder interfered with your usual work (including housework)?	Not at all A little bit Moderately Greatly Totally	1 2 3 4 5	4 3 2 1 0
12	Have you been troubled by pain from your shoulder in bed at night?	No nights Only 1–2 nights Some nights Most nights Every night	1 2 3 4 5	4 3 2 1 0

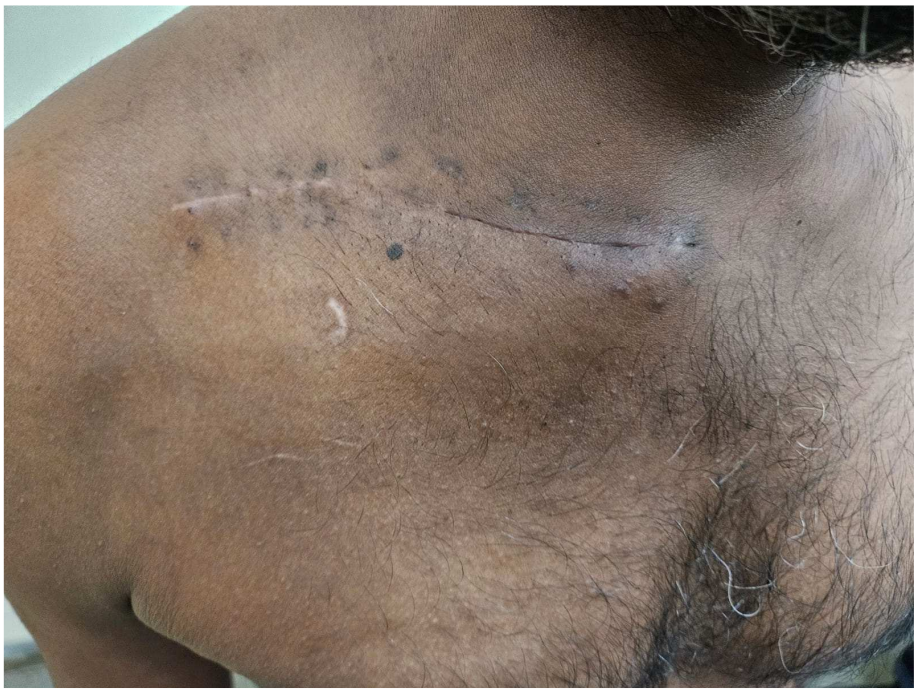
CALCULATED OXFORD SHOULDER SCORE-

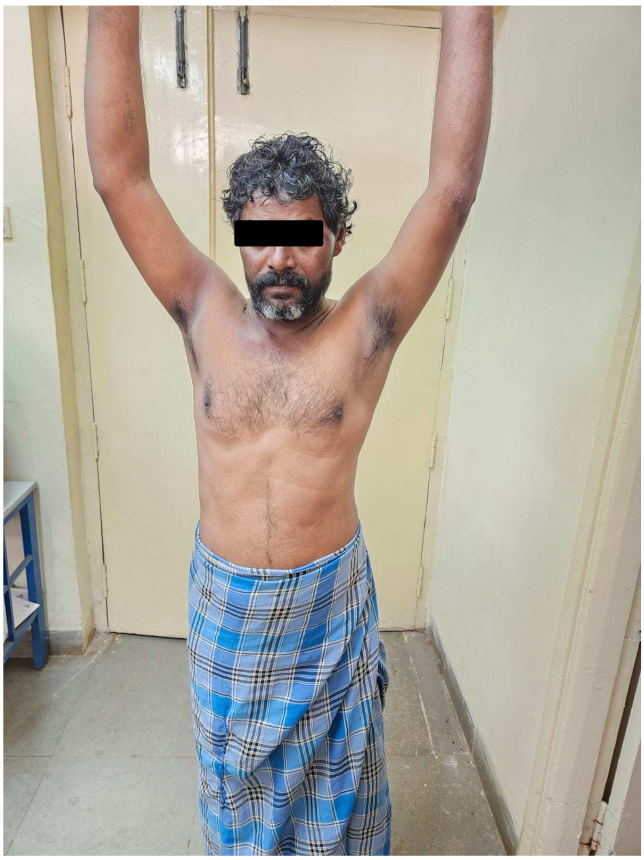
6 MONTH FOLLOW UP RANGE OF MOTION-

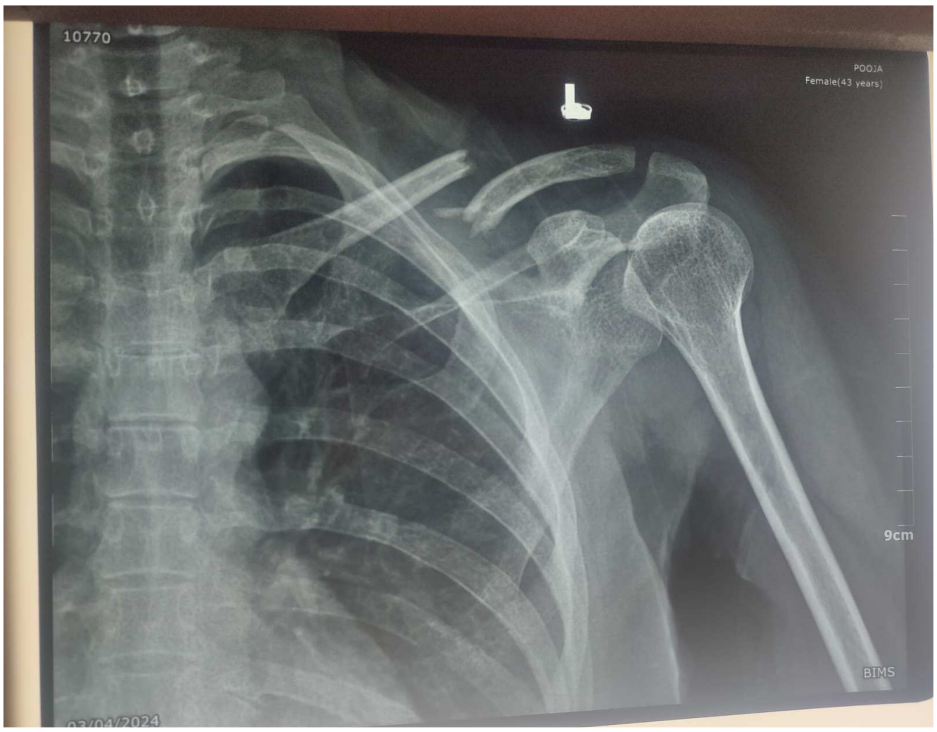
ANNEXURE III – PHOTOGRAPHS

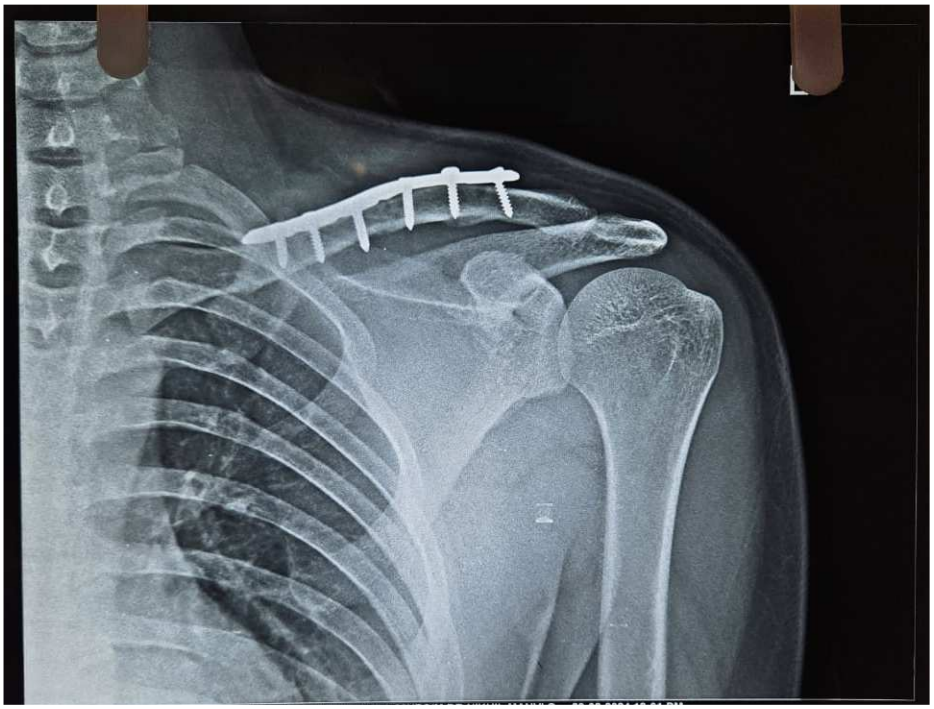


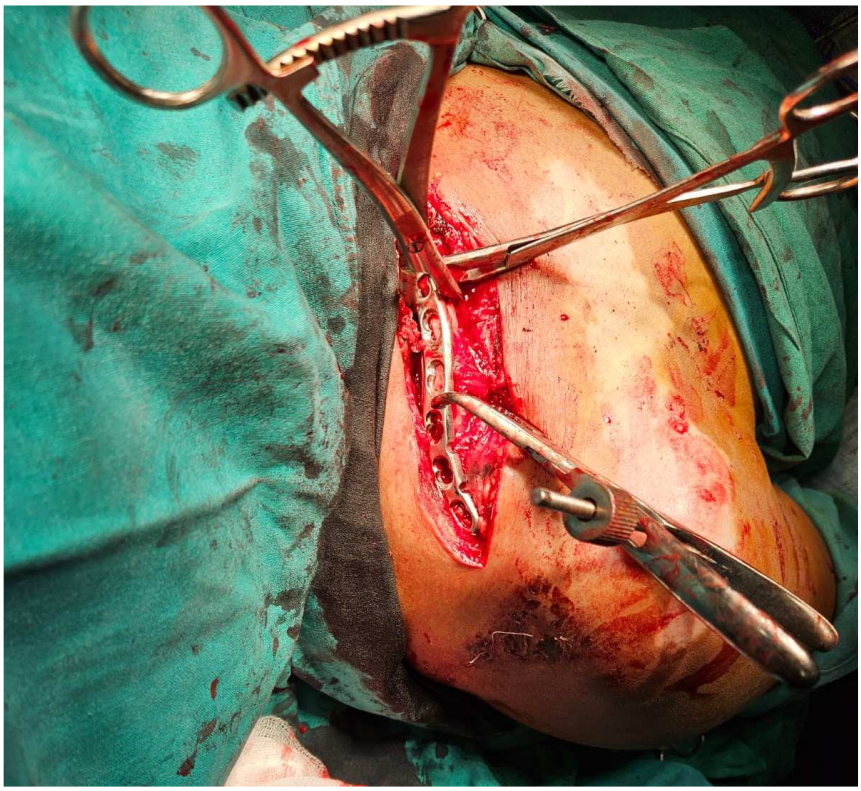


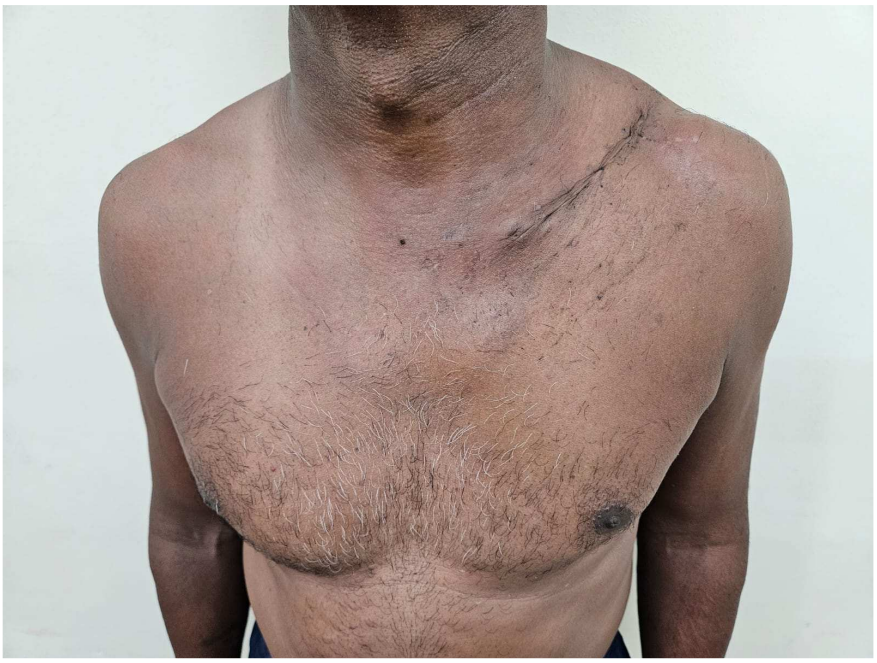





10770
POOJA
Female(43 years)
9cm
BIMS







ANNEXURE IV - MASTERCHART

	A	B	C	D	E	F	G	H	I	J	K	L
1	PATIENT	AGE/SE	OSS SCORE AT 2 WEE	OSS AT 1MONTH	OSS AT 6 MONTH FOLL	VAS SCORE AT 6 MONTHS FOLL	MODE OF INJU	TREATMENT GIV	IMPLANT USED	SCAR HEAL	CLAVICLE LENG	REDUCTION METHOD
2	1- shravan	32/M	30	36	42		1 RTA	ORIF+PLATING	7 HOLED ANATOMICAL PLATE	Y		14.5 VICRYL SUTURE
3	2-malagouda	34/M	28	40	44	4	RTA	ORIF+PLATING	5 HOLED ANATOMICAL PLATING+INTERFRAG SCR	Y		16.1 LAG SCREW
4	3-lagmanna	25/M	20	38	44	5	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		14.8 VICRYL SUTURE
5	4- hussein	49/M	22	40	42	2	RTA	ORIF+PLATING	7 HOLED RECON PLATE	Y		13.5 VICRYL SUTURE
6	5-dasharath	56/M	30	38	40	1	FOOSH	ORIF+PLATING	7 HOLED RECON PLATE	Y		16.4 VICRYL SUTURE
7	6-nilayya	42/M	28	36	48	2	RTA	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		15.4 VICRYL SUTURE
8	7- tukaram	57/M	26	40	48	1	RTA	ORIF+PLATING	7 HOLED ANATOMICAL PLATE	Y		14.7 VICRYL SUTURE
9	8-sunil	52/M	24	36	44	3	FOOSH	ORIF+PLATING	5 HOLED ANATOMICAL PLATING+ INTERFRAG SCR	Y		16.7 LAG SCREW
10	9-zaffarullah	38/M	30	42	46	4	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		15.3 VICRYL SUTURE
11	10-hanmanth	40/M	32	40	48	1	RTA	ORIF+PLATING	5 HOLED ANATOMICAL PLATING	Y		14.9 VICRYL SUTURE
12	11-ravendra kot	52/M	28	38	44	2	RTA	ORIF+PLATING	8 HOLE ANATOMICAL PLATE	Y		15.2 VICRYL SUTURE
13	12- mahadevi	40/F	24	30	42	1	FOOSH	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		12.5 VICRYL SUTURE
14	13-asif	36/F	28	36	46	3	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE+ INTERFRAG SCREW	Y		12.1 LAG SCREW
15	14-raghavendr	38/M	28	32	42	2	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		16.6 VICRYL SUTURE
16	15-nagaratna	56/F	22	36	48	1	FOOSH	ORIF+PLATING	6 HOLE RECON PLATE	Y		13.2 NIL
17	16-sunil	35/M	30	40	44	1	RTA	ORIF+PLATING	5 HOLED ANATOMICAL PLATE+ INTERFRAG SCREW	Y		16.5 LAG SCREW
18	17- gangavva	44/F	28	34	48	2	RTA	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		14.6 VICRYL SUTURE
19	18-mahadev	33/M	30	36	42	2	RTA	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		15.7 VICRYL SUTURE
20	19-anand	33/M	24	38	48	2	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		16.4 VICRYL SUTURE
21	20-arun	54/M	28	32	46	1	RTA	ORIF+PLATING	8 HOLE ANATOMICAL PLATE	Y		15.6 VICRYL SUTURE
22	21-nihal	30/M	26	40	48	3	RTA	ORIF+PLATING	5 HOLED ANATOMICAL PLATE	Y		16.3 VICRYL SUTURE
23	22-rajani	43/F	30	38	44	4	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE+ INTERFRAG SCREW	Y		12.3 LAG SCREW
24	23-vanita	40/F	26	34	42	1	RTA	ORIF+PLATING	7HOLED ANATOMICAL PLATE +INTERFRAG SCREW	Y		13.6 LAG SCREW
25	24- nagarai	19/M	28	36	44	2	RTA	ORIF+PLATING	7 HOLED ANATOMICAL PLATE	Y		15.5 VICRYL SUTURE
26	25-rehmansab	50/M	26	38	48	4	FOOSH	ORIF+PLATING	8 HOLE ANATOMICAL PLATE	Y		16.4 VICRYL SUTURE
27	26-mallikarjun	38/M	30	36	46	2	RTA	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		15.7 VICRYL SUTURE
28	27 siddharth	29/M	24	38	42	1	RTA	ORIF+PLATING	8 HOLE ANATOMICAL PLATE	Y		14.9 VICRYL SUTURE
29	28- savita	32/F	30	40	48	3	RTA	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		13.1 VICRYL SUTURE
30	29- archana	38/F	28	38	42	2	FFH	ORIF+PLATING	7 HOLED ANATOMICAL PLATE+INTERFRAG SCREW	Y		12.7 LAG SCREW
31	30 SOMAYYA	57/M	30	40	41	1	RTA	ORIF+ PLATING	7 HOLED ANATOMICAL PLATE+ INTERFRAG SCREW	Y		16.8 LAG SCREW
32	31 JOMALING	32/M	32	38	44	4	RTA	ORIF+ PLATING	7 HOLED ANATOMICAL PLATE	Y		15.5 VICRYL SUTURE
33	32 SURESH	54/M	28	40	42	1	RTA	ORIF+ PLATING	7 HOLED ANATOMICAL PLATE	Y		16.3 VICRYL SUTURE
34	33 MOINUDDIN	50/M	30	40	46	2	RTA	ORIF+ PLATING	5 HOLED BRIDGE PLATING	Y		14.9 NIL
35	34 SANTOSH	26/M	28	38	48	4	RTA	ORIF+PLATING	7 HOLED ANATOMICAL PLATE	Y		16.3 VICRYL SUTURE
36	35 ASHUTOSH	25/M	22	32	44	1	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		15.8 VICRYL SUTURE
37	36 MANJU	26/M	28	36	46	2	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		14.2 VICRYL SUTURE
38	37 MADIWALLA	61/M	30	38	42	3	RTA	ORIF+PLATING	7 HOLED ANATOMICAL PLATE	Y		13.9 VICRYL SUTURE
39	38 SIDDHARTH	22/M	28	40	44	1	RTA	ORIF+ PLATING	6 HOLED ANATOMICAL PLATE + INTERFRAG SCREW	Y		15.8 LAG SCREW
40	39 BASAVRAJ	25/M	30	42	46	4	RTA	ORIF+PLATING	6 HOLED ANATOMICAL PLATE	Y		14.2 VICRYL SUTURE
41	40 KAREPPA	48/M	24	38	44	2	RTA	ORIF+PLATING	8 HOLE ANATOMICAL PLATE	Y		15.9 VICRYL SUTURE
42	41 ALTAF	48 M	22	38	48	1	RTA	ORIF+PLATING	6 HOLE ANATOMICAL PLATE	Y		14.7 VICRYL SUTURE