"FUNCTIONAL OUTCOME OF CLAVICLE HOOK PLATE FOR FRACTURES OF LATERAL END OF CLAVICLE & ACROMIOCLAVICULAR JOINT DISRUPTION"

By

DR. EZHIL VIKRAMA VELL G.

Thesis submitted to the

BLDE (DEEMED TO BE UNIVERSITY),
VIJAYAPURA, KARNATAKA

In partial fulfilment of the requirements for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the guidance of

DR. DAYANAND B.B **M.S.ORTHO**
PROFESSOR AND UNIT HEAD.
DEPARTMENT OF ORTHOPAEDICS
B.L.D.E (DEEMED TO BE UNIVERSITY)
SHRI B.M.PATIL MEDICAL COLLEGE
HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

2020

B. L. D. E.(DEEMED TO BE UNIVERSITY)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL AND

RESEARCH CENTRE, VIJAYAPURA. KARNATAKA

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"FUNCTIONAL OUTCOME OF CLAVICLE HOOK PLATE FOR FRACTURES OF LATERAL END OF CLAVICLE & ACROMIOCLAVICULAR JOINT DISRUPTION"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. DR. DAYANAND B.B** Professor **,** Department of ORTHOPAEDICS, Shri.B.M.Patil Medical College , Hospital and Research Center, Vijayapura

Date:28-10-2020

Place: Vijayapura

DR. EZHIL VIKRAMA VELL G.

B. L. D. E.(DEEMED TO BE UNIVERSITY)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA. KARNATAKA

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled "**FUNCTIONAL OUTCOME OF CLAVICLE HOOK PLATE FOR FRACTURES OF LATERAL END OF CLAVICLE & ACROMIOCLAVICULAR JOINT DISRUPTION**" is a bonafide research work done by DR. EZHIL VIKRAMA VELL G. in partial fulfilment of the requirement for the degree of M.S. in ORTHOPAEDICS.

Date : 28-10-2020

Place : Vijayapura

DR. DAYANAND B.B. **M.S.ORTHO**

PROFESSOR & UNIT HEAD
DEPARTMENT OF ORTHOPAEDICS
B.L.D.E .(DEEMED TO BE UNIVERSITY)
SHRI B.M. MEDICAL COLLEGE HOSPITAL
& RESEARCH CENTRE,
VIJAYAPURA.

B. L. D. E.(DEEMED TO BE UNIVERSITY)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA. KARNATAKA

ENDORSEMENT BY THE HEAD OF THE DEPARTMENT

This is to certify that the dissertation entitled **"FUNCTIONAL OUTCOME OF CLAVICLE HOOK PLATE FOR FRACTURES OF LATERAL END OF CLAVICLE & ACROMIOCLAVICULAR JOINT DISRUPTION"** is a bonafide research work done by **DR. EZHIL VIKRAMA VELL G.** under the guidance of **DR.DAYANAND B.B.** Professor Department of orthopaedics, Shri.B.M.Patil Medical College , Hospital and Research Center, Vijayapura.

DR. ASHOK R. NAYAK M.S.ORTHO

PROFESSOR & HEAD
DEPARTMENT OF ORTHOPAEDICS
B.L.D.E .(DEEMED TO BE UNIVERSITY)
SHRI B.M. MEDICAL COLLEGE HOSPITAL
& RESEARCH CENTRE,
VIJAYAPURA.

Place : Vijayapura

Date : 28-10-2020

B. L. D. E.(DEEMED TO BE UNIVERSITY)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPUR. KARNATAKA

ENDORSEMENT BY THE PRINCIPAL

This is to certify that the dissertation entitled **"FUNCTIONAL OUTCOME OF CLAVICLE HOOK PLATE FOR FRACTURES OF LATERAL END OF CLAVICLE & ACROMIOCLAVICULAR JOINT DISRUPTION"** is a bonafide research work done by **Dr. EZHIL VIKRAMA VELL G.** under the guidance of **DR.DAYANAND B.B.** Professor Department of orthopaedics Shri.B.M.Patil Medical College Hospital and Research Center, Vijayapura.

Place : Vijayapura

Date : 28-10-2020

DR.ARVIND PATIL
PRINCIPAL
Date: B. L. D. E.(DEEMED TO BE UNIVERSITY)
SHRI. B. M. PATIL
MEDICAL COLLEGE HOSPITAL &
RESEARCH CENTRE, VIJAYAPURA.

B. L. D. E. .(DEEMED TO BE UNIVERSITY)

SHRI B. M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA. KARNATAKA

COPYRIGHT

DECLARATION BY THE CANDIDATE

I hereby declare that the B. L. D. E.(DEEMED TO BE UNIVERSITY) SHRI B. M. PATIL MEDICAL COLLEGE AND HOSPITAL RESEARCH CENTRE, VIJAYAPURA, KARNATAKA shall have the rights to preserve, use and disseminate this dissertation / thesis in print or electronic format for academic / research purpose.

Date: 28-10-2020

Place: Vijayapura

DR. EZHIL VIKRAMA VELL G.

ACKNOWLEDGEMENT

On completion of this contribution of scientific document it gives me deep pleasure to acknowledge the guidance provided by my distinguished mentors. With privilege and respect I would like to express my gratitude and indebtedness to my guide **Dr.DAYANAND B.B.** M.S. Professor, Department of orthopaedics BLDE(DEEMED TO BE UNIVERSITY) Shri B. M. Patil Medical College, Vijayapur, for his constant inspiration, extensive encouragement and support which he rendered in pursuit of my post-graduate studies and in the preparation of this dissertation. I am extremely grateful to my eminent and esteemed teacher **Dr. ASHOK R NAYAK** M.S. Professor and Head Of Department of Orthopaedics, BLDE University's Shri B.M. Patil Medical College, Vijayapura for his overall guidance and inspiration during my study.

I am extremely thankful to Principal of B.L.D.E(DEEMED TO BE UNIVERSITY) Shri B. M.Patil Medical College Hospital and Research Centre, Vijayapura, for permitting me to utilize the resources in completion of my work.

I find no words to express my indebtness to Dr. O. B. Pattanshetty, Dr. Santosh Nandi, Dr. Ramanagouda B Biradar, Dr. Sandeep Naik, Dr. Anil Bulgond, Dr. Srikant Kulkarni, Dr. Rajkumar Bagewadi, Dr. Sreepad Kulkarni, Dr.Raghavendra kembhavi, Dr. Gireesh Khodnapur, Dr. Sarvesh K, Dr. Vijaykumar Patil without whom completing my thesis would have been difficult.

My heartfelt thanks to the entire co post graduate students Dr.Abhinav Kumar, Dr.Abhishek Shenoy, Dr.Puneet Singh, Dr Rajesh Patel, Dr. Siddhant, Dr. Onkar, Dr. Adithiyaa, Dr. Karthik M.S, Dr. Amit, Dr. Pranav, Dr. Shivaprasad, Dr. Sagar, Dr. Ravikant, Dr. Karthik, Dr. Keyur, Dr. Ronak

I thank **Dr.Vijaya M. Sorganvi,** the statistician for her invaluable help in dealing with all the statistical work in this study .

I express my gratitude to **Library Staff, OT Staff** and all Hospital Staff for their co-operation in my study. Last but not the least, I convey my heartfelt gratitude to all the patients, without whose co-operation, this study would be incomplete.

DR. EZHIL VIKRAMA VELL G.

INTRODUCTION

Fractures of lateral end of clavicle account for 15% of all clavicle fractures (1) whereas 9% of shoulder girdle injuries involve acromioclavicular joint damage (2). These fractures are associated with disruption of the coracoclavicular ligaments and are unstable due to four displacing forces that retard union. The nonunion rate is approximately 30%, causing pain and impaired function of shoulder girdle and upper limb and hence surgery is recommended for unstable distal clavicular fractures (3). A variety of surgical treatment options have been developed with varying success over the years. Currently clavicle hook plate is accepted as a surgical option for these injuries. This study is 2 pronged- analyzes the results of clavicle hook plate compared with the literature and also evaluates the need for repair of soft tissue structures around the acromioclavicular joint. We will be analyzing the results based on clinical outcomes and radiological assessment so as to ascertain the efficacy of this procedure.

1. AIMS AND OBJECTIVES:

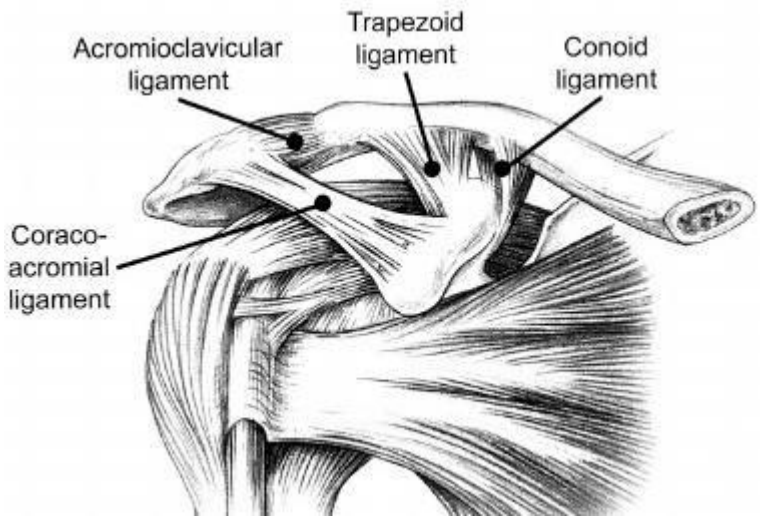
The aim of this study is to analyze:

1. to evaluate the functional outcome of clavicle hook plate for fractures of lateral end of clavicle & acromioclavicular joint disruption

2. ANATOMY

The acromioclavicular joint (AC joint) provides a 'keystone' link between the clavicle and the scapula. The coupling of scapulothoracic and glenohumeral movement dictates that the integrity of the sternoclavicular and acromioclavicular joints is important for the normal coordination of movements of shoulder girdle.

Ligamentous anatomy of acromioclavicular joint complex (4)



Acromioclavicular joint (AC) is approximately 9 mm by 19 mm (4).It is a diarthrodial joint with a fibro-cartilaginous meniscal disk that separates the articular surfaces of distal clavicle and acromial process (2).

Together with the sternoclavicular joint, the AC joint provides the upper extremity with a connection to the axial skeleton.

The capsule surrounding the joint is reinforced by the AC ligaments consisting of superior, inferior, anterior, and posterior ligaments. The superior and inferior ligaments are stronger than the anterior and posterior ligaments.

Vertical stability is provided by coracoclavicular (CC) ligaments, which are composed of conoid and trapezoid and superior and inferior AC ligaments. The trapezoid ligament measures 0.8 to 2.5 cm in length and 0.8 to 2.5 cm in width. The conoid ligament is 0.7 to 2.5 cm in length and 0.4 to 0.95 cm in width.

The distance from the lateral clavicle to the lateral-most fibers of the trapezoid ligament measures 10 mm.

The AC ligaments are the principle restraint to anteroposterior translation (offers 90% anteroposterior and 77% superior translation stability) between the clavicle and the acromion while AC and CC ligaments together form the static stabilizers of the AC joint:

- The horizontal stability is controlled by AC ligament.
- The vertical stability is controlled by coracoclavicular ligaments.

Distraction of the AC joint is limited by the AC ligaments (91%) and compression by trapezoid ligament (75%).

Dynamic stabilizers are the deltoid and trapezius. The fibers of the superior AC ligament blend with the deltoid and trapezius muscles, which are attached to the superior aspect of the clavicle and the acromion. These muscle attachments

are important in strengthening the AC ligaments and adding stability to the AC joint.

Viewed anteriorly, the inclination of the joint may be almost vertical or downward medially, the clavicle overriding the acromion by an angle of 50°. Because of the small area of the AC joint and the high compressive loads transmitted from the humerus to the chest by muscles such as the pectoralis major, the stresses on the AC joint can be very high.

Urist (5) in his study demonstrated that by excising AC joint capsule, the distal clavicle can be completely dislocated anteriorly and posteriorly away from the acromion process. But the vertical displacement of the clavicle relative to the acromion occurred only after the coracoclavicular ligament was transected thereby concluding that the these ligaments may not be the main restrainers to the dislocation of AC joint.

3. REVIEW OF LITERATURE

Hippocrates wrote:

"Physicians are particularly liable to be deceived in this accident (for as the separated bone protrudes, the top of the shoulder appears low and hollow), so that they may prepare as if for dislocation of the shoulder; for I have known many physicians otherwise not expert at the art who have done much mischief by attempting to reduce shoulders, thus supposing it as a case of dislocation".

Galen had obviously paid close attention to Hippocrates, because he diagnosed his own AC dislocation received from wrestling in palaestra. Galen treated himself (i.e., tight bandages to hold the projecting clavicle down while keeping the arm elevated). He abandoned the treatment after a few days because it was not comfortable. It is appropriate that one of the earliest reported cases in literature was related to sports, because today participation in sports is certainly one of the most common causes of AC dislocations (6).

From the earliest publications through the time of Paul of Aegina (7th century), AC joint dislocations have become better recognized. Hippocrates stated that no impediment, small or great, will result from such an injury. He further stated that there would be a "tumefaction" or deformity, for the bone cannot be restored to its natural situation. This statement apparently was, has been, and will be received as a challenge by the orthopedic community. There is probably not

another joint in the body that has been treated in so many different ways as the AC joint in attempts to “properly restore it to its natural situation”.

4.1 ACROMIOCLAVICULAR JOINT INJURIES

4.1.1 BIOMECHANICS OF THE ACROMIOCLAVICULAR JOINT

The coupling of scapulothoracic and glenohumeral movement dictates that the integrity of acromioclavicular and sternoclavicular joints is important for the co-ordination of movements of the shoulder girdle. Until recently, movements at the acromioclavicular joint had not been accurately defined and was perhaps underestimated (7).It is now appreciated that during abduction of the shoulder, there is 15° of protraction, 21° of upward rotation and 22° of posterior tilting of the scapula relative to the clavicle at the joint.

Codman described the AC joint with the scapula as synchronous scapula clavicular rotation The CC ligaments are responsible for the upward rotation of the clavicle and downward rotation of the scapula, during abduction and forward elevation(6).

Kapandji (8) describes a 30º axial rotation in the acromioclavicular joint and reaches the same value by adding 30º rotatory mobility in the sternoclavicular joint. According to **Fischer et al** (8) considered the acromioclavicular joint as a relatively loose joint.

Lanz and Wachsmuth (8) describe 3 directions of motion for the acromioclavicular joint: the lower angle of the scapula moves in the frontal

direction around a sagittal axis, and in the sagittal direction around a frontal axis. The scapula can turn in the acromioclavicular joint around a longitudinal axis up to 50º. The lower angle of the scapula can swing around the longitudinal axis of the clavicle to reach a total of 60º, *2/3rd* of this motion being in the acromioclavicular joint.

4.1.2 MECHANISM OF INJURY

Direct force is the most common mechanism of injury with the patient falling onto the lateral aspect of the shoulder with the arm adducted. The force drives the acromion downward and medially (6). The downward displacement of the distal clavicle is primarily resisted by the sternoclavicular ligaments. If no fracture occurs, the force first sprains the AC ligaments (a mild sprain), then tears the AC ligaments (a moderate sprain) and stresses the coracoclavicular ligament. Finally, if the downward force continues, then the deltoid and trapezius muscle attachments from the clavicle are torn and the coracoclavicular ligaments ruptures (a severe AC sprain), which completes the dislocation. At this point, the upper extremity loses its suspensory support from the clavicle and droops downward.

The mechanism of inferior dislocation of clavicle below the coracoid is a direct force onto the superior surface of the distal clavicle, along with abduction of the arm and retraction of scapula. This type of AC joint dislocation is very rare.

In children though, the acromioclavicular joint lacks inherent structural stability. It is held together in part by the acromioclavicular ligaments, which are

relatively weak secondary stabilizers. The primary stabilizers of the joint are the two coracoclavicular ligaments, the conoid and the trapezoid. The distal clavicle and the acromion are surrounded by thick periosteum that forms a protective tube around the bony structures to which the coracoclavicular ligaments are attached on the inferior surface of the distal clavicle. Because these ligament attachments are stronger than the periosteum, displacement of the distal clavicle occurs through a disruption in the periosteum rather than by detachment of the ligaments.

4.1.3 INCIDENCE

Acromioclavicular (AC) joint injuries account for approximately 9% of shoulder girdle injuries(2). Most commonly seen in active young adults in their second through fourth decades of life. Contact sportspersons like in hockey, rugby players have a higher incidence as there are more frequent injuries to the shoulder joint.

Males are more commonly affected than females, with a male-to-female ratio of approximately 5:1(9). Rowe and Marble retrospectively reviewed the medical records of the Massachusetts General Hospital and found 52 AC joint injuries among 1,603 shoulder-girdle injuries (10). Most occurred in the second decade of life. Thorndike and Quigley reported AC joint involvement in 223 of 578 athletes with shoulder injuries.

4.1.4 INDICATIONS FOR SURGERY

Rockwood I is a sprain and hence stable, not requiring surgery Rockwood II is a rupture of the AC ligament and sprain of CC ligament. The joint retains some of its stability and hence non-operative management has been recommended (2).

Rockwood type I and II – Analgesics are used to relieve pain. Cryotherapy helps reduce swelling and pain. A sling can be used for comfort. Once pain and swelling subsides, active and passive motion and physiotherapy are recommended (2).

Gladstone and colleagues (11) described a four-phase rehabilitation program:

Phase 1, pain control and immediate protected range of motion and isometric exercises;

Phase 2, strengthening exercises using isotonic contractions and proprioceptive neuromuscular facilitation exercises;

Phase 3, unrestricted functional participation with the goal of increasing strength, power, endurance, and neuromuscular control;

Phase 4, return to activity with sport-specific functional drills. Most patients are able to return to normal activity in 2 to 4 weeks.

An athlete is ready to return to competitive sports once the following criteria are met:

1. Full range of motion, no pain or tenderness,
2. Satisfactory clinical examination,
3. Demonstration of adequate strength on isokinetic testing

Most athletes are able to return to their routine in 2 to 4 weeks but few authors reported that some may require up to 12 weeks (2)

There is a lack of consensus regarding the indications for surgical intervention, a wide variety of implants and suture materials and more than 50 operative procedures and numerous modifications have been reported for treating these injuries with variable success rates (9).

Rockwood III-VI

Throughout medical history, both operative and nonoperative methods of treatment of complete AC dislocation have had intervals of popularity as it was considered a transitory type of injury between a stable (type I and II) and unstable (type IV-VI).

Sage and Salvatore (12) analyzed 96 injuries to AC joint. 31 patients were treated nonoperatively with adhesives, casts and strappings for an average period of 3.4 weeks. They noticed that 36% had AC joint in its normal position, 50% were subluxed with some dislocations. The results were excellent in 70.8%, good in 12.5% and poor in 16.7%

30 patients were treated with AC joint transfixation alone using wires or pins which were maintained for an average of 9 weeks. This group had 67.7% excellent results, 22.6% good results and 9.7% poor results.

16 patients were treated with temporary pins inserted across the AC joint, CC ligament were repaired with heavy silk, capsule repaired with catgut and sometimes they used the meniscus to reinforce the superior AC ligament and did repair of the AC ligament whenever possible. The duration to pin removal averaged 9 weeks. 62.5% had excellent, 31.25% had good results and one patient had poor result.

Goss (5) defined the concept of superior shoulder suspensory complex. It is a ring made up of bony superior glenoid, the coracoid process, the distal clavicle, the acromion and soft tissue component of acromioclavicular joint and its ligaments, the coracoclavicular ligaments.

It is likened to the pelvic ring wherein damage to one part of the superior shoulder suspensory complex must also produce disruption of another portion of the osteoligamentous ring, leading to the so-called 'double disruptions

Therefore all type-III to type-VI dislocations fall within this category, since both the acromioclavicular and coracoclavicular ligaments are injured. Dislocations which occur together with fracture of another component of the complex such as the lateral clavicle or coracoid process are also double disruptions.

These types of injuries are unstable and may result in adverse long term effects of healing and function.

He suggested that these injuries should be considered for operative reduction and stabilization of at least one component of the disruption.

Urist (13) in 1946 reviewed 101 previous papers and reported between 10% and 20% unsatisfactory results following conservative management. These unsatisfactory results were attributed to the position of the joint. Interestingly, he had noted variations in the normal anatomy in his evaluation of 100 shoulders.

1. The articular surface of the clavicle overrides the articular surface of the acromion. 49
2. The articular surfaces of acromion and clavicle are nearly vertical and lie in the same plane 27
3. The inferior margin of the articular surface of the clavicle under-rides the superior margin of the acromion 3
4. The articular surfaces are incongruent, and the clavicle overlies the acromion 9
5. The articular surfaces are incongruent and are not in contact at any point 6
6. The articular surfaces are incongruent, and inferior margin of the clavicle under-rides the superior margin of acromion**.** 6

Bannister (14) in the1983 treated 60 patients with AC disruptions, 33 nonoperatively and 27 were operated upon. He found that at 4 months the

nonoperated group did better but at the end of 1 year both faired equal and at 4 years operated group did better. 4 patients initially treated nonoperatively required surgery and around 15% of the patients treated conservatively were reported to have poor results. Of the operated group two had screw cut out, 1 had screw breakage, and 2 had to be re-operated for painful subluxation.

4.1.5 NON OPERATIVE TREATMENT

Numerous methods of nonoperative treatment have been advocated and with varied result (11).

AUTHORS	FORM OF TREATMENT
Thorndike and Quigley	Adhesive strapping
Benson	
Rawlings	
Jones	Sling &Bandage
Watson-Jones	
Hawkins	
Anderson & Burgess	Brace &Harness
Giannestras	
Usadel	Figure of Eight bandage
Goldberg	Sling & pressure bandage
Caldwell	Abduction traction &suspension in bed
Urist	Casts
Strubbins &	
McGaw	
Dillehunt	
Gibbens	

4.1.6 OPERATIVE TREATMENT

Earliest reports of AC joint repair were attributed to **Samuel Cooper** in the year 1861 by using a silver wire (15).

In the late 19th century, he was followed by **Poirier, Rieffel, Tuffier, Baum** who used sutures to repair the AC ligaments and the joint capsule (15)

Paci in the year 1889 advocated arthrodesis of the AC joint. **Budinger** used a screw while **Lambotte and Delbet** used a nail for AC joint fixation (15).

Morestin was the first to resect out the lateral 2.5 cms of the clavicle (5).

Delbet is credited for the first attempt at reconstructing the CC ligaments using a silver wire and later using silk sutures (15).

Cadenat (10) is attributed to the usage of a strip of tendon of short head biceps to reconstruct the CC ligaments but later found anterior displacement of clavicle due to its anterior transposition. In 1917, he used the coracoacromial ligament to reconstruct the CC ligament because of the insertion of the coracoacromial attachment onto the coracoid (it being more posterior than biceps tendon and near the origin of CC ligament) and secondly to the fact that harvesting anterior part of this ligament sufficed in length for the repair.

Bunnel in 1928 used fascia lata to reconstruct the AC joint (5).

Henry (15) in 1929 used autogenous fascia lata with addition of 2 Kirschner wires.

In the decade between 1930 -1940 there was a resurgence of nonoperative treatment modalities for the then Tossy type III.

The surgical options began to develop with growing interest in this type due to the growing conflict of non operative treatment.

Murray recommended smooth Kirschner wires while **Bloom** recommended two 1/32- inch Steinman pins (5)

Excision of the distal 1/3 of clavicle was described by **Mumford and Gurd** in 1941 but the earliest literature suggests **Morestin** as the first person to do this procedure as early as late 19th century.

Bosworth (2) in 1941 was the first to describe a screw inserted from the clavicle into the coracoid and thereby functioning similar to the CC ligament.

Phemister in 1942 reported the use of heavy threaded pins across the AC joint (5).

Stewart described the usage of a screw to fix the AC joint

Caldwell in his 1943 paper stated that he preferred arthrodesis of AC joint (16).

Weaver-Dunn in 1972 reported their results of transfer of coracoacromial ligament to lateral end of clavicle after excision of the lateral end of clavicle (17)

In 1964, **Bailey** presented the transfer of coracoid process with conjoined tendon to the clavicle.

In 1965, **Dewar and Barrington** presented their modified version of Bailey procedure (18).

Balser (in the mid 1980s) presented a new concept on the use of a hook plate and later **Wolter** (late 1980s) presented his modification of the hook plate(19).

4.1.6 A INTRA-ARTICULAR ACROMIOCLAVICULAR REPAIRS

Many authors have described a variety of surgical modalities as mentioned above and though they have had good results, they were also some shortcomings.

While most authors initially began with Kirschner wires alone but later surgeons combined its usage with soft tissue procedures as a mainstay for the treatment.

Lizaur et al (20) in a prospective study of 46 patients used 2 Kirschner wires and proceeded with repair of the damaged deltoid and trapezius fascial insertion. The wires were inserted from the lateral edge of the clavicle and left protruded through the skin for removal at a later date. 10.9% had re-displacement along with other complications like infection, wire migration.

Larsen et al (21) in a randomized controlled trial of 87 patients treated either nonoperatively or by a modified Phemister procedure noted a high incidence

of implant breakage, migration and failure of fixation in 21 patients apart from erosion of bone, skin irritation and infection by metal in 6 patients and hence recommended against the use of smooth wires. All but 2 had maintained reduction with Kirschner wires.

The authors concluded that most patients could be treated nonoperatively with a shorter rehabilitation time.

Thirteen patients in the **Sage and Salvatore** study (12) had a Mumford procedure done on them and found excellent in 69.2%, 15.4 with good results and 7.7% with poor results.

Bateman (12) attempted reconstruction of CC ligament by creating a new suspensory ligament with fascia lata. Intra-operatively, if the AC joint was degenerative then, excision of the lateral end of clavicle was advised.

Neviaser (12) detached the coracoacromial ligament from the coracoid and swung it on top of the distal end of clavicle thereby reconstructing a new superior AC ligament.

4.1.6 B EXTRA-ARTICULAR CORACOCLAVICULAR REPAIRS

They can be divided into:

1. Coracoclavicular ligament repair, fixation or reconstruction
2. Dynamic muscle transfers
3. Excision of the lateral end of clavicle

CORACOCLAVICULAR LIGAMENT REPAIR AND RECONSTRUCTION

In 1917, **Cadenat** (10) transferred the coracoacromial ligament from its coracoid attachment and inserted it to the conoid insertion, the periosteum at the posterosuperior part of clavicle and finally onto the trapezius aponeurosis attachment.

Campos (10) had his modification consisting of disinserting the acromial end and transfixing it through a hole in the lateral end of clavicle.

Harrison and Sisler used a Dacron tube circling coracoid and a hole in the clavicle.

Phemister did an open reduction and internal fixation of the AC joint using a 2 ply stainless steel wire which ran from the acromion to the lateral end of clavicle (10).

Bundens and Cook added to Phemister procedure by imbricating the deltoid and trapezius muscles over the clavicle to help stabilize the clavicle.

Weinstein et al (22) used a No.5 non absorbable suture as their modification of Phemister to avoid the wire break out seen with Phemister procedure.

Tauber M et al and **Gonzalez** et al have developed the use of autogenous semitendinosus and peroneus brevis grafts respectively(23).At present gracilis tendon, toe extensors are also used.

Chen et al used Marsilene prosthetic substitute to reconstruct the CC ligament Dacron or velour Dacron graft has been used by many surgeons like **Goldberg, Kappakas, Tagliabue and Riva, Dahl** and they have found good results especially with double velour Dacron graft (15).

Polydioxanone (5) graft has been described for successfully usage by **Hawkins et al, Krueger-Franke M et al, Morrison DS, Lemos MJ et al, Nicholas SJ et al. Wellmann** et al (24) have used 2 flip buttons to anchor the lateral end of clavicle to coracoid. In their study they used 12 fresh frozen cadaveric shoulders, the AC ligament and CC ligaments reconstructions were tested. They initially severed the coracoacromial ligament off the acromion and then inserted it into the lateral end of clavicle and further reinforced with two No.5 Ethibond suture and tested its stability. For the augmentation, 1mm Ethibond is intertwined between 2 flip buttons, one button is passed through a predrilled hole into the base of coracoid and another button into the clavicle at a distance of 35mm from AC joint. Then he medial half of coracoclavicular ligament is released and inserted into a predrilled clavicle at 20mm from the AC joint. The results showed that an augmented CAL transfer can restore the intact acromioclavicular joint kinematics whereas the selective coracoclavicular ligament transfer cannot.

Lee evaluated the biomechanical properties of the CC ligament repair, Weaver-Dunn procedure, combinations using autogenous tendons and synthetic tapes and sutures in cadavers. He found that simple CC ligament repair was weak and had the worst failure load (25).

Tienen combined the open Weaver-Dunn procedure with AC ligament repair with PDS and showed good results (26)

LaFosse did a modified Weaver-Dunn procedure arthroscopically using fire-wire braids initially stitched thorough the substance of CA ligament and then proceeded to disinsert it by burring and finally attaching it to the clavicle thorough a predrilled hole and securing it with metal wires. The results were comparable to the open procedure but with less incidence of infection,and implant failure (26)

CORACOCLAVICULAR FIXATION:

Bosworth described his technique of coracoclavicular fixation in the year 1941 by using a tapered lag screw with a large flat head which he passed into the coracoid from clavicle superiorly. He did not explore nor repair the CC ligament (10).

Kennedy and Cameron in 1954 modified Bosworth procedure by doing a thorough debridement of AC joint, over correcting the AC joint dislocation with a Bosworth lag screw and finally repair the deltoid and trapezius tear. They believed that the screw will produce an ossification of the CC ligament and thereby create an extra-articular arthrodesis of AC joint. Weitzman had a

similar modification of Bosworth as by Kennedy and Cameron but differed by debriding the AC joint and imbricating the deltoid and trapezius (27).

Jay and Monnet added to the Weitzman modification by repairing the CC ligament.

Tsou inserted a cannulated cancellous screw percutenously has associated complication rates (28).

Tanner and Hardegger used a 6.5-mm screw (29).

Bateman in a prospective study of 60 patients randomly treated operatively (Bosworth method) and nonoperatively. In the nonoperative group 4 patients failed to respond to this method of treatment and underwent surgery for weakness and pain while 45 of the operated patients developed loss of reduction and hardware failure. They thus concluded that non operative treated was superior (30).

Bancha Chernchujit (28) et al operated 32 patients with AC joint disruptions arthroscopicaly using anchor suture to create a synthetic CC ligament. They had no wound complications, free mobility was seen in 12 patients and cosmetic scars were seen in all patients. 10 patients revealed anatomical reduction, 2 patients had a small (2-4mm) loss of reduction and one with complete dislocation. Patient satisfaction was 92% and Constant score averaged 95.

DYNAMIC MUSCLE TRANSFERS:

Bailey in 1964 was the first to do a transfer of the coracoid process with conjoined tendon and showed favorable results (15).

Later in 1965, **Dewar and Barrington** did an addition to the Bailey procedure by using a segment of the detached pectoralis minor tendon (18).

Baumgarten et al., Lafosse L et al and Vargas L et al. have studied the use of conjoined tendon to the superior aspect of clavicle as a 'dynamic muscle transfer'.

They also described modifications to the same by osteotomizing the coracoid insertion with the tendon. They have found this method of conjoined tendon graft transfer has better properties and greater consistency of quality of the graft as compared with those of the coracoacromial ligament. Variations of this procedure, by splitting the lateral half of the conjoined tendon as a distal based, thereby retaining the original coracoid attachment (15).

EXCISION OF THE LATERAL END OF CLAVICLE:

Mumford and Gurd in the year 1941 independently described a surgical procedure for chronic symptomatic subluxed or dislocated AC joints with arthritic changes. The clavicle was resected lateral to the CC ligaments and Mumford repaired the CC ligament.(30)

Weaver and Dunn in 1972 added to the Mumford and Gurd procedure by transferring the coracoacromial ligament to the intramedullary canal of the clavicle (17).

Powers and Bach compared 47 patients with Tossy III type of injuries comprising of 28 nonoperative (20 treated with a body arm cast and 8 in a sling) and 19 operated (14 had AC joint fixation with wires, 4 with excision of the lateral end of clavicle and 1 with fascial repair of ligament). Out of the 28 not operated only 4 had fair results and the rest were good. Among the operated, 9 had good results, 2 fair results and 3 poor results from which they concluded that nonoperative patients had a better result (31).

Various authors have modified this procedure coracoclavicular fixation with heavy nonabsorbable suture, surgical tape, screw, Double-Button with PDS suture material (6), tendon grafts.

This procedure though done open initially is now done arthroscopically also (26).

HOOK PLATE

The earliest descriptive use of hook plate for AC joint disruption was by Balser in the early 1970s. Wolter D published in the journal of Operative Orthopedic and Traumatology in the year 1989 and he was followed by Ramadazade, Keifer (Sterli hook plate), AC hook plate by Best Medical Company, Tokyo and Dreithaler in 2001(19) .

Ernst Sim(8) in 1995 used the Wolter hook plate in 21 patients. They used a longitudinal incision crossing the clavicle for the approach to the AC joint and lateral end of clavicle. They reconstructed the capsule and ligaments along with stabilizing with the hook plate. They had to shorten or bend the hook depending on intraoperative anatomic findings. The joint was immobilized with a Gilchrist or modified bandage. Physiotherapy was initiated after short period of restricted mobilization. Out of the 21 patients, 6 had infections and delayed wound healing, 1 had bending of implant, secondary widening of the hook hole in 13 patients, 1 had resorption of the acromial part of clavicle.

Cosmetically satisfactory scars were seen in only 3 patients, massive ossification and synostosis in 1 patient, minor arthritic changes in 5 patients.

The AO (synthes) hook plate is a side specific, precontoured plate (32). It comes in 2 variations-

1. "Clavicle hook plate" in 2 specific heights of 15mm and 18mm on 6 or 8 holes plate made of commercially pure titanium or 316L stainless steel. The posterior offset of the hook is to avoid entry into the AC joint and is seated behind the AC joint. This offset is unlike Balser or Wolter plate where the hook was seated into the AC joint. All the studies approached the AC joint through a shoulder strap incision (along the langer lines) and consisted of repair of the ligaments.

2. "LCP clavicle hook plate"- side specific, comes as 4, 5, 6, 7 (combiholes) holes, has 3 hook depths of 12mm, 15mm, 18mm and comes in stainless steel and titanium and priced Rs 22,000/-.

A number of articles support the use of a hook plate (9; 33-35)

D. Sunderamoorthy et al studied the use of a hook plate for AC joint disruption and fracture of lateral end of clavicle. Of the 14 patients, 5 were painful nonunions and displaced fractures while the rest were AC joint disruptions. Shoulder strap approach, repair of ligaments (Weaver-Dunn) followed by plate fixation, was done for 9 patients. The mean follow up was 7.2 months.

Functional assessment was done by DASH score and they had a mean score of 12 indicating that this procedure is safe and effective (36).

Alison J McConnell did a cadaveric study comparing 3 fixation constructs- CC sling (5mm Mersilene tape), CC screw (6.5mm partially threaded Bosworth screw) and hook plate (AO synthes hook plate). She found that the CC screw was the most rigid followed by hook plate and then the sling. The CC screw had the highest load to failure and showed greatest amount of stiffness (more than physiological) while the hook plate was near physiological and replicates the stiffness of the AC joint and also allows for physiological movement without pathological deformation.(37)

4.2 FRACTURE OF THE LATERAL END OF CLAVICLE

4.2.1 BIOMECHANISM OF FRACTURE OF THE LATERAL END OF CLAVICLE

The mechanism of injury involves a lateral impaction force on the point of the shoulder. Undisplaced fractures typically occur after trivial injuries, such as a simple fall, whereas displaced fractures involve more significant trauma, such as a fall from a height, a motor vehicle accident, or a violent blow (38).

Displacements are secondary to four displacing forces (6)

1. the weight of the arm
2. the pull of pectoralis major, pectoralis minor and latissimus dorsi
3. scapular rotation which affects the distal segment
4. trapezius muscle which draws the medial segment posterior and superior

4.2.2 INCIDENCE

Fractures of the lateral one third of the clavicle are relatively rare, however, and account for only 10% to 20**%** of all clavicle fracture(3) while another study showed a higher incidence of 21% to 28% with the first and largest peak incidence is in males less than 30 years of age.(39)

Neer reported a 10% incidence of associated head and neck injuries in patients with distal clavicle fractures. Other findings may include coracoid and

first rib fractures, lung injury, brachial plexus injury and subclavian vein injuries(15).

4.2.3 TREATMENT OPTIONS

The surgical indications for Neer type II are: EARLY:

1. Double disruption of the shoulder suspensory complex
2. Fracture in a young active person
3. Athletes

LATE:

1. Symptomatic nonunion
2. Symptomatic malunion
3. AC joint arthritis

The natural course of fracture lateral end of clavicle was studied by Anders **Nordqvist** from 1970-79 during which 336 patients were observed and 110 were reviewed after a period of 15 years (40). He analyzed Neer Type I had a rapid healing with favorable outcome though some had malunion, nonunion and excessive bone formation.11% had persistent symptoms.

Neer Type II had 22% nonunion and on long term follow up 8 out of 10 were painless nonunions due to fibrotic tissue interposition. They did not exhibit deformity or instability.

The treatment options for the fractures of the lateral end of clavicle are varied and some have been given up in course of time- ranging from Kirschner wire fixation, excision of the lateral end of clavicle, stabilizing the clavicle onto the coracoid by a screw, Dacron graft slings, bone grafting (41)

Kasif Khan L.A. et al in their recent review article affirmed nonoperative treatment in Neer type I and operative intervention in Neer type II and III.(42)

They also added that Kirschner wire technique by Neer was to be discontinued due to its high complication rates (43-46). The use of iendo buttons, Trans articular PDS banding, Dacron graft, Coracoclavicular sling have been successfully described.

Rokito et al retrospectively analyzed operative (coracoclavicular stabilization) vs nonoperative (sling immobilization) in Neer type II with14 and16 patients respectively. (47) The UCLA and Constant scores of both groups were similar, but nonoperated group had higher percentage of excellent results. Pain and range of motion scores were similar in both the groups as was the strength and satisfaction. The major difference was the 44% nonunion rate in the nonoperated group and some were symptomatic.

Kyle E Swanson described a minimal invasive surgery wherein they stabilized the proximal fragment with the help of a Nitinol wire and an oblong button.(48) The wire was passed through a predrilled hole in the proximal fragment and coracoid process and fastened with the help of oblong buttons under

the coracoid and on the clavicle while a similar procedure was done by **Nicolas Pujol et al.**(49) In both these reports patient had a good outcome based on the American shoulder and elbow surgeons index (ASES).

C.M.Robinson et al prospectively studied the results of 2 endobuttons fixation for displaced fracture of lateral of clavicle in 14 patients over the age of 60 years.(50) They used a shoulder strap incision and through predrilled holes through the coracoid and clavicle (medial to the fracture) and created a 6 ply sliding pulley effect. They assessed the results based on DASH and SF-36 questionnaire, Constant score and also on radiological findings.

They had no post operative complications, the mean DASH and Constant score continued to improve till 1 year when they had score of 87.1 for Constant and 3.3 for DASH. The advantage of this surgery is in retaining the implants and avoiding another surgery. In this study they have not mentioned whether they have repaired the ligaments during the surgery.

George Macheras et al treated 15 patients with unstable lateral end fractures with a coracoclavicular screw and repair of CC ligament with No.1 Dacron suture. All the patients had good outcome with bony union at a mean of 7 weeks and a mean of 97 points with ASES shoulder score.(51)

Prasad V.K. Meda in a prospective study using hook plate in 31 patients (21 Neer type II and 10 Neer type III) / 23 acute and 8 delayed presentations. The incision was along the line of the clavicle and fracture site was open reduced. The

thickness of the acromion was measured with a depth gauge and appropriate Synthes hook plate used. The CC ligament was repaired with vicryl sutures and fracture site bone grafted. The followed the patients for an average of 40 months and during which time ASES and VAS scoring were done. 6 patients developed impingement, 5 had osteolysis at the tip of the hook. Implant removal was done between 12-16 weeks in all but 6 patients who were asymptomatic and refused the procedure.(3)

Tapio Flinkkilä compared the results of Kirschner wire fixation with hook plate in 39 patients (22 Kirschner wire and 17 hook plates) and found 12 cases of migration, 3 infections, 7 pin migrations, 2 nonunion as compared to 1 fracture of clavicle and 2 nonunion.(52) The same author in another study (53)on the result of hook plate in unstable fractures in 63 patients found 59 unions, 1delayed union, 3 nonunion, 1 infection, 1 frozen shoulder, 3 cases of late fracture medial to the plate. The mean Oxford score was 15 and Constant score was 32.

A.D.Tambe et al retrospectively assessed the outcome of clavicle hook plating in 18 patients with Neer type II injury after an average follow up of 25 months. All incisions were sabre shaped over the lateral end of clavicle, they initially transfixed with Kirschner wires followed by fixation with Synthes clavicle hook plate. They noticed nonunions in 2, deep infections requiring plate removal in one, fracture proximal to the plate in one and asymptomatic osteolysis was seen in 5 patients. Plate removal was done in 17 patients at an average

duration of 5 months. Using a Constant score on 15 of 18 patients, they scored an averaged 88.5 on the affected side as compared to 100 on the unaffected side. (54)

The average pain in the shoulder at rest was 1 (range 0–4), and the average pain on abduction was 2.2 (range 0–5). Patients were asked to grade their shoulder; three said it was back to normal, 11 said it was nearly normal and one said it was abnormal.

Masafumi Kashii et al retrospectively reviewed 34 patients with unstable fracture lateral of clavicle treated by AC hook plate manufactured by Best Medical Company, Tokyo. It was made from a 3.5mm plate (malleable to contour to the clavicle) with 3.5mm screws proximal to the fracture and 2.7mm mini screw for the distal fragment with hook arising in the centre offset, having a depth of 8mm, 10mm and 12mm and hook length of 10 mm was inserted into the AC joint. (19)Ligament repair if done was not mentioned. Functional assessment was based on Japanese Orthopedics Association (JOA) score. All plates were electively removed after bony union.

The mean JOA was 98.3, good pain parameter (29.5/30) and radiological bony union at a mean of 4.1 months. The mean period between surgery and plate removal was 5.3 months.

The complication noticed were plate displacement in one (revised with a standard hook plate), acromion fracture at the hook with cut-out in one, widening

of the hook hole in 19 patients and upward migration into acromion in 13 patients. Rotator cuff tear was seen in one patient.

DASH and Quick DASH questionnaires

DASH questionnaire was introduced by the American Academy of orthopedic surgeons as an outcome measure for upper limb disorders.(55) It consists of 30 questions pertaining to shoulder, arm and hand and the severity of each symptom amounting to a total of 100 points, with a scale of 0 (no disability) to 100 (very severe disability). The reliability was measured by the Cronbach alpha coefficient, which was above 0.9 indicating good internal consistency. Therefore, DASH shows small and large changes in disability and 10 point difference of score is of minimal significance.

Quick DASH based on the Spearman-Brown prophesy- the cross-sectional reliability of a questionnaire will be reduced by shortening the questionnaire, given fairly consistent inter-item correlations- the authors reduced the question to 11 yet still retaining the alpha of 0.90. They created 2 datasets for field-testing and cohort. 3 item-reduction techniques were used, tested and the result was a 11item questionnaire with a Cronbach alpha coefficient of ≥0.92 and an intraclass correlation coefficient of ≥0.94 suggesting that Quick DASH was a more efficient version of DASH.(56; 57)

Constant Score was first described by Constant and Murley in 1986 has a maximum score of 100 points (35%subjective and 65% objective components) and has been widely used in the European countries since 1992.(58-60)

Veronica B. Conboy et al analyzed this scoring system and found that the inter- observer standard deviation, calculated as 8.86, gives 95% confidence limits that a single observer measuring a single subject will be within 17.7 points of the true score.(61) They also noticed that the measurement of power varied with age and sex which was likewise noted by **Leonid Katolik et al**.

In another study by **D. McClelland et al** regarding the application of Constant score for power in elderly patients, they found that age, handedness and occupation bore significant difference in the final score in spite of good scores in the remainder of the categories. He further suggested that Constant score be done excluding the power measurements and have a total score of 75.(58)

4. RADIOLOGICAL ASSESSMENT

An x-ray of the affected shoulder gives information of both AC joint disruption and fracture of the lateral end of clavicle. A standing x ray of both shoulders, in a single large film, would demonstrate a clearer picture of AC joint disruptions than supine, because of the weight of the arm which reveals the true displacement. Axillary view of the shoulder is also necessary in regard to the AC joint disruptions especially for the Rockwood's type 3 and 6 variety which are displaced posteriorly and subacromial / subcoracoid respectively.

Zanca view (developed to address the superimposition of the AC joint on the scapular spine) is a 10- to 15-degree cephalic tilt view to project an unobscured image of the joint. This view is now routinely used in the evaluation of AC joint injuries and is particularly useful when there is suspicion of a small fracture or loose body on routine views (2; 6)

Stryker Notch view for an associated variant of an AC joint injury involves a fracture of the coracoid process.

Stressed radiographic view

Zanca stress view with a 5 kg weight of both shoulder joints simultaneously are taken to evaluate more accurately the integrity of the ligamentous structures by showing the degree of displacement of the acromion relative to the clavicle and also to assess the stability of the AC joint ligaments post healing.(6)

5. CLASSIFICATION

5.1. ACROMIOCLAVICULAR JOINT DISRUPTIONS

Tossy, Mead and Sigmon in the year 1963 described three types of acromioclavicular dislocation (62):

- Stage I- the AC ligament is stretched or partially ruptured and no gross deformity is visible on radiographs.
- Stage II- the AC ligament is ruptured, the coracoclavicular ligament is elongated and on stress radiographs, the AC joint is displaced less half of the AC joint depth.

- Stage III- A rupture of the AC and coracoclavicular ligament is present and standard radiographs the AC joint is displaced over one half of the AC joint depth

This classification was further modified by **Melvin Post** initially in the year 1985 where he proposed what is similar to Rockwood and Young (10)

ROCKWOOD CLASSIFICATION:

Type I - Sprain of the acromioclavicular (AC) ligament.

AC joint tenderness, minimal pain with arm motion, no pain in coracoclavicular interspaces. No abnormality on radiographs.

Type II - AC ligament tear with joint disruption and sprained coracoclavicular ligaments.

Distal clavicle is slightly superior to acromion and mobile to palpation; tenderness is found in the coracoclavicular space.

Radiographs demonstrate slight elevation of the distal end of the clavicle and AC joint widening. Stress films show the coracoclavicular ligaments are sprained but integrity is maintained.

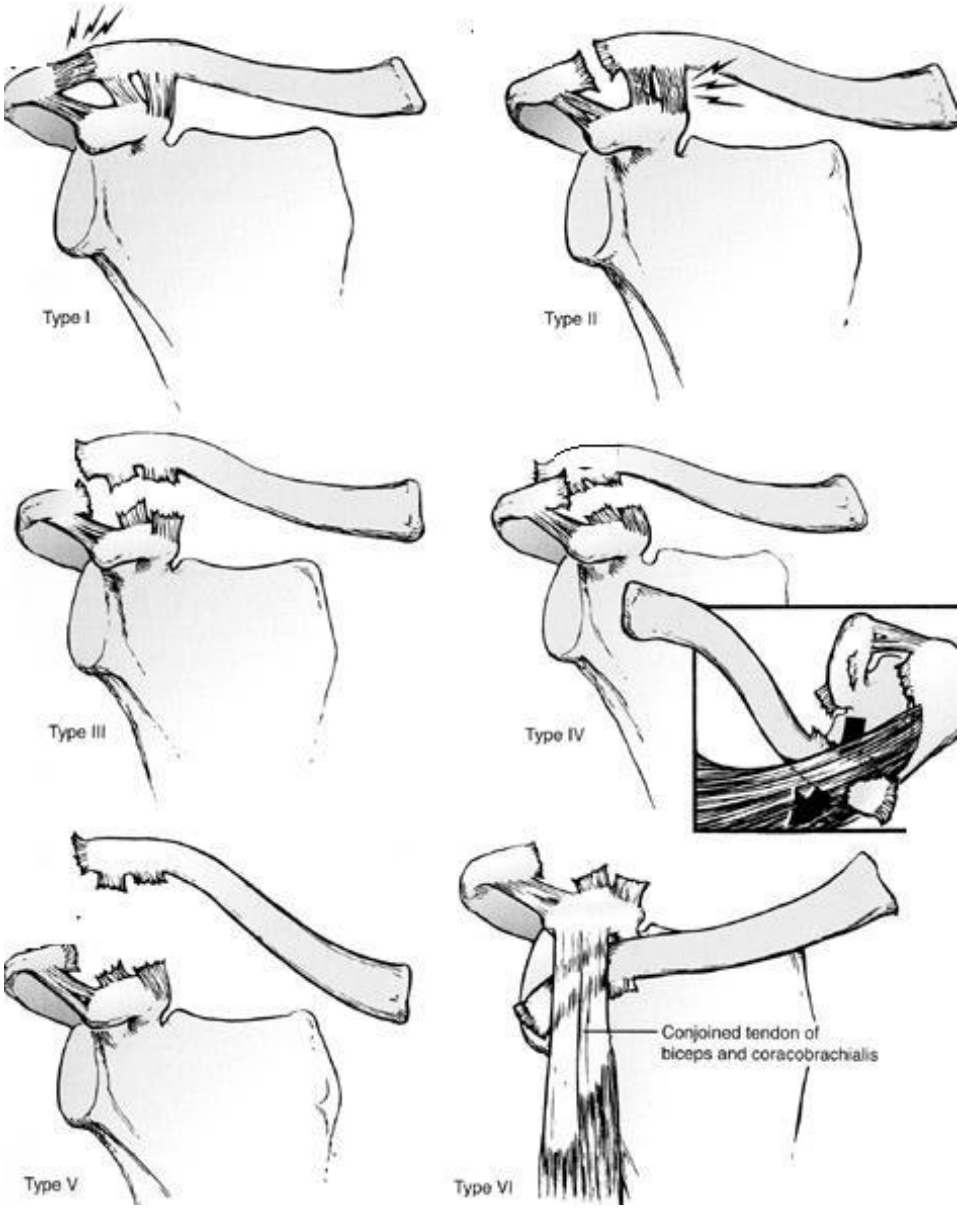


FIGURE**: Rockwood classification of acromioclavicular disruptions**

Type III - AC and coracoclavicular ligaments torn with AC joint dislocation.

Deltoid and trapezius muscles usually detached from the distal clavicle. The upper extremity and distal fragment are depressed, and

the distal end of the proximal fragment may tent the skin. The AC joint is tender, coracoclavicular widening is evident.

Radiographs demonstrate the distal clavicle superior to the medial border of the acromion; stress views reveal a widened coracoclavicular interspace 25% to 100% greater than the normal side.

Type IV - Posterior dislocation of the distal end of the clavicle, into or through the trapezius muscle

Clinically, more pain exists than in type III; the distal clavicle is displaced posteriorly away from the clavicle.

Axillary radiograph or computed tomography demonstrates posterior displacement of the distal clavicle.

Type V- A markedly severe version of the type III injury

The distal clavicle is stripped of all its soft-tissue attachments and lies subcutaneously near the base of the neck superiorly.

This type is typically associated with tenting of the skin.

Radiographs demonstrate the coracoclavicular interspace to be 100% to 300% greater than the normal side.

Type VI - Inferior dislocation of the distal clavicle

AC dislocated, with the clavicle displaced inferior to the acromion or the coracoid; the coracoclavicular interspace is decreased compared with normal. The deltoid and trapezius muscles are detached from the distal clavicle.

The mechanism of injury is usually a severe direct force onto the superior surface of the distal clavicle, with abduction of the arm and scapula retraction.

Clinically, the shoulder has a flat appearance with a prominent acromion; associated clavicle and upper rib fractures and brachial plexus injuries are due to high energy trauma.

Radiographs demonstrate one of two types of inferior dislocation: subacromial or subcoracoid.

Patte's classification:

Grade	Denomination	Coracoclavicular distance	Facet deviation	Rockwood type
I	Simple sprain	Normal	Non	I
II	Acromioclavicular dislocation	Normal	Subluxation	II
III	Scapuloclavicular dislocation	> 50% increase	Subluxation/dislocation	III
IV	Irreducible scapuloclavicular dislocation	> 50% increase	Mainly posterior	IV
V			Mainly superior	V
VI	Inferior dislocation	Negative		VI

The pediatric Rockwood classification:

- Type I - Clavicle stable; joint radiographically normal
- Type II - Partial tear of the periosteal tube, allowing for some mobility of the distal clavicle; AC ligament disrupted
- Types III-VI - Larger tear through the periosteal tube, allowing for greater clavicle mobility and gross instability with clavicle positioning; CC ligament remains attached to the clavicle periosteal tube

5.2 FRACTURES OF THE LATERAL END OF CLAVICLE

Allman proposed a classification based solely on the anatomic location of the fracture (63), and divided clavicle fractures into:

1. Middle third
2. Distal (lateral) to coracoclavicular ligaments
3. Proximal (medial) third

This system does not describe displacement, comminution, or shortening, all potentially important prognostic and treatment variables[4].

Neer (15) recognized the unique behavior of distal clavicle fractures and proposed a separate classification system. He proposed 3 types

Type I: coracoclavicular ligaments intact

Type II: coracoclavicular ligaments detached from the medial segment but trapezoid intact to distal segment

Type III: intra-articular extension into the acromioclavicular joint

Rockwood (15) further subdivided type II into

Type-IIA Injuries the ligaments remains intact

Type-IIB Injuries the coracoclavicular ligaments are partially or completely detached.

Craig (15) further modified the Neer and Allman systems by the inclusion of the additional subdivisions of medial and lateral-end fractures

Type I - minimal displacement (interligamentous)

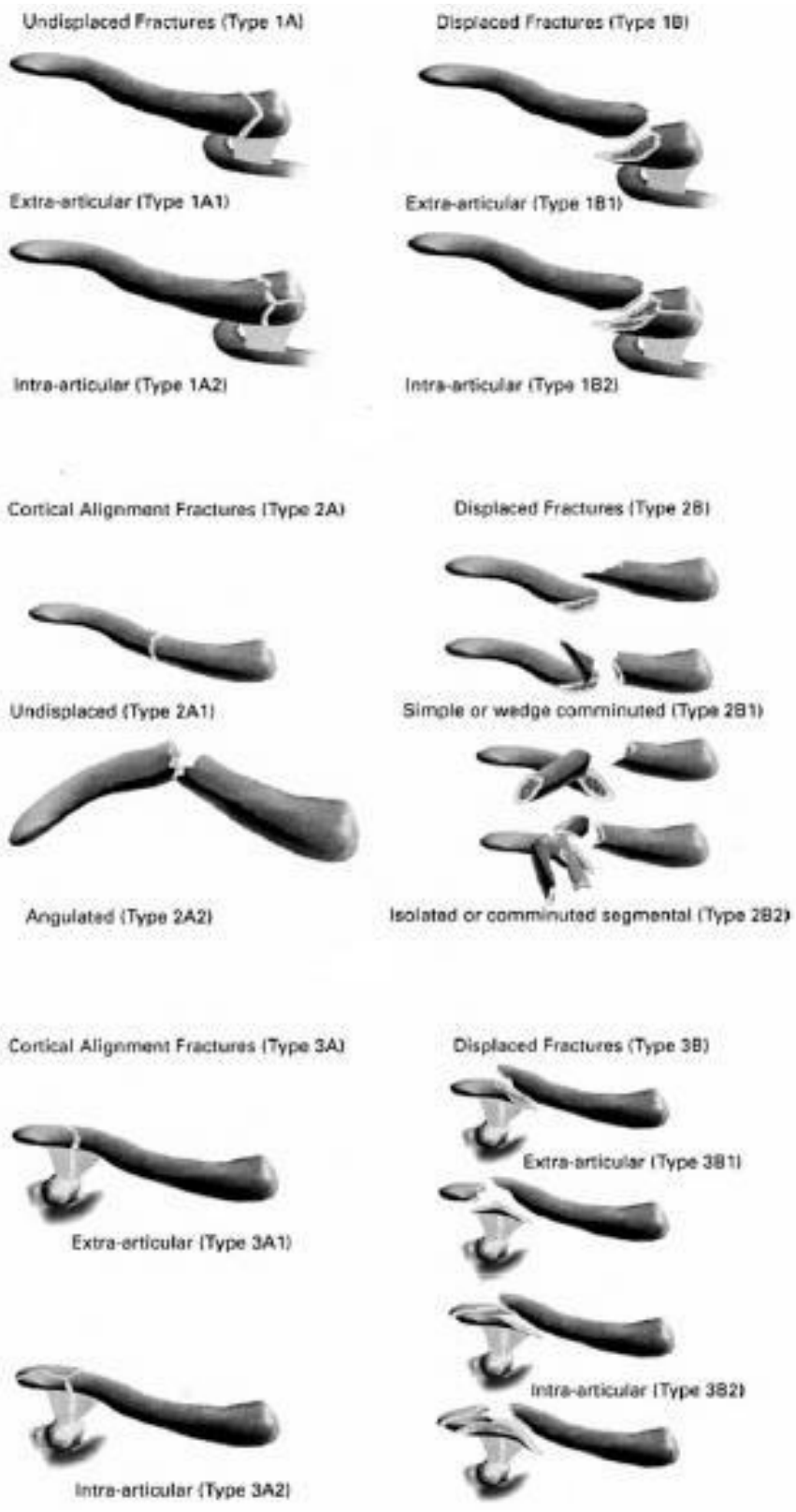
Type II - displaced secondary to fracture line medial to the coracoclavicular ligaments

(A) conoid and trapezoid attached

(B) conoid torn, trapezoid attached Type III - fractures of the articular surface Type IV - periosteal sleeve fracture (children)

Type V - comminuted with ligaments attached neither proximally nor distally, but to an inferior comminuted fragment

Robinson (31) has proposed an Edinbugh classification:



Type 1 medial

A nondisplaced

A1 extraarticular

A2 intraarticular

B displaced

B1 extraarticular

B2 intraarticular

Type 2 middle

A cortical alignment

A1 nondisplaced

A2 angulated

B displaced

B1 simple or single butterfly fragment

B2 comminuted or segmental

Type 3 distal

A nondisplaced

A1 extraarticular

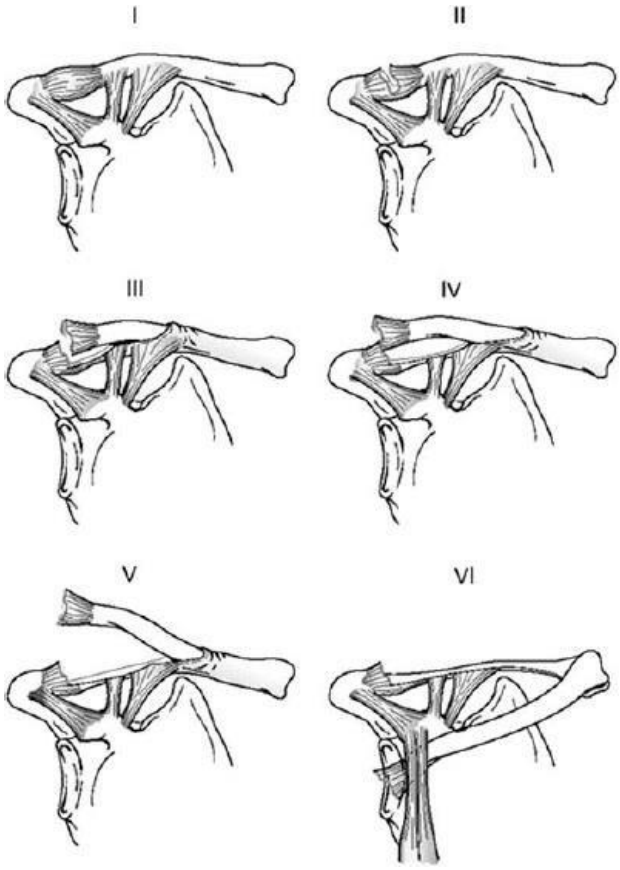
A2 intraarticular

B displaced

B1 extraarticular

B2 intraarticular

In children, distal clavicular injuries lateral to the coracoclavicular ligament and injuries to the acromioclavicular joint are categorized by a system proposed by **Dameron and Rockwood:**



Dameron and Rockwood classification for fractures of the lateral end of clavicle (64)

Type I - Acromioclavicular injuries are caused by low-energy trauma and are characterized by mild strains of the ligaments.

Type II - Complete disruption of the acromioclavicular ligaments, with mild damage to the superolateral aspect of the periosteal sleeve. Mild instability of the

distal clavicle results from this type of injury, and minimal widening of the acromioclavicular joint may be seen on an x-ray.

Type III - Complete disruption of the acromioclavicular ligaments occurs in addition to a large disruption in the periosteal sleeve. Similar soft tissue disruptions are seen in

Type IV - Similar to type III with additional posterior displacement of clavicle and is often embedded in the trapezius muscle; axillary lateral x-ray may be required to identify the posterior clavicular displacement.

Type V - similar to type III injuries; the superior aspect of the periosteal sleeve is completely disrupted in type V injuries. This allows displacement of the distal clavicle into the subcutaneous tissues, occasionally splitting the deltoid and the trapezius muscles. On an AP x-ray, the coracoid-clavicle interval is more than 100% greater than the contralateral uninjured side.

Type VI - Distal clavicle is displaced inferiorly, with its distal end located inferior to the coracoid process

7. MATERIAL AND METHODS

This study is a descriptive analysis, approved by the Institution Review Board and the Ethic Committee for the evaluation of the results of hook plate fixation for acromioclavicular joint disruption (Rockwood and Young III-VI) and unstable fractures of the lateral end of clavicle (Neer type II-III).

7.1 AIMS AND OBJECTIVES:

The aim of this study a case series intended to analyze:

1 The outcome of hook plate fixation for the fracture of the lateral end of clavicle and acromioclavicular joint disruptions operated in our hospital.

2. To assess the reduction of the joint and stability.

3. To identify the complications related with this implant.

7.2 INCLUSION CRITERIA

1. All acromioclavicular joint disruptions of Rockwood type III-VI either acute or chronic symptomatic.

2. All fractures of the lateral end of clavicle of Neer type II and III (Craig II and VI) either acute or with painful nonunion

3. All cases were operated in our hospital.

4. Minimum of 6 months of post-operative follow up

5. All surgeries done at our centre

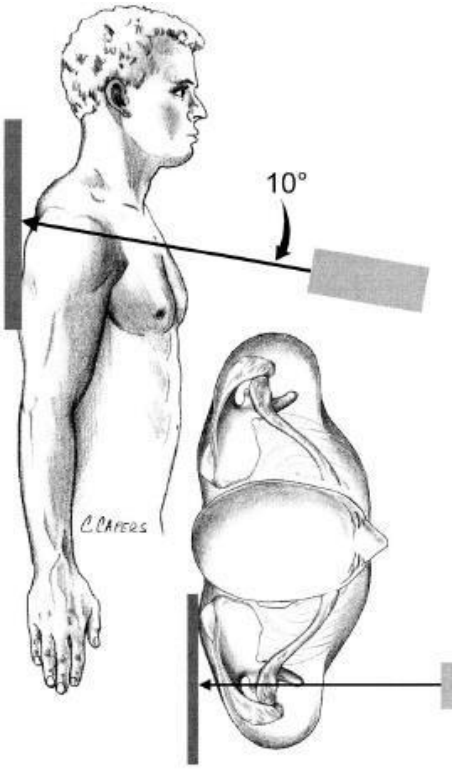
7.3 METHOD

This study is descriptive study of patients from 1st November 2018 to 31st May 2020.

We reviewed all patients who fit our criteria and had undergone surgery with our local customized hook plate and in our hospital. All cases from 1st November 2018 to 31st May 2020 were reviewed.

All operations were done by surgeons of our hospital

1. All patients were either from the Out-patient department or Emergency
2. Preoperative X-ray of shoulder in AP and Axillary view were taken.
3. The injuries were classified as per the inclusion criteria.
4. All surgeries were performed in a specified manner
5. A locally available hook plate was used
6. Specified postoperative protocol was followed for all patients.
7. Outcome was measured based on Quick DASH questionnaire at intervals of 6, 12, 24 weeks by one single examiner.
8. Radiological assessment was done at 6, 12, 24 week intervals.
9. Wound sepsis, time taken to bony union and reaching pre-fall injury status were also noted



Zanca view for the shoulder (6)

The hook plates we used were locally available - a 4 -7 hole, 3.5mm which was available for right and left side for optimal sizing and screw positioning for each individual.

The plate had a hook with posterior offset so as to avoid entry into the AC joint capsule and was hooked beneath the acromion and posterior to the AC joint capsule. The cost of the plate with the screws came to between Rs 3000 to Rs 4000.

All procedures were done with the patient in a supine position with a bolster placed beneath scapula

An incision along the superior margin of the lateral clavicle running posterior to the acromion joint was used in all cases

Negligible soft tissue dissection and handling was practiced. The only soft tissue dissection was the cutting of the deltotrapezial fascia while the AC joint was left undissected. A needle was used to identify the AC joint and also as a guide to the entry point of hook insertion. AC depth was measured with a depth gauge and the appropriate hook plate was used.

Ligament repair was not done in any of the cases and deltoid and trapezium fascia was resutured back at the time of closure. A tube drain was placed after skin suturing.

The surgical procedure described above took about 45 minutes for completion. Pendulum exercises were started on the 2nd post operative date and passive mobilization started as patient tolerated. Within 3 weeks active exercises were started and full range of movement was started after 3 weeks.

We have used the Quick DASH score as they reflect the subjective and objective perspective of the shoulder function. The quick DASH scores range from 0-100 where zero is the best score and indicates excellent results. The forms were filled at each visit and at which time they were evaluated for signs of implant failure, irritation, impingement or infection.

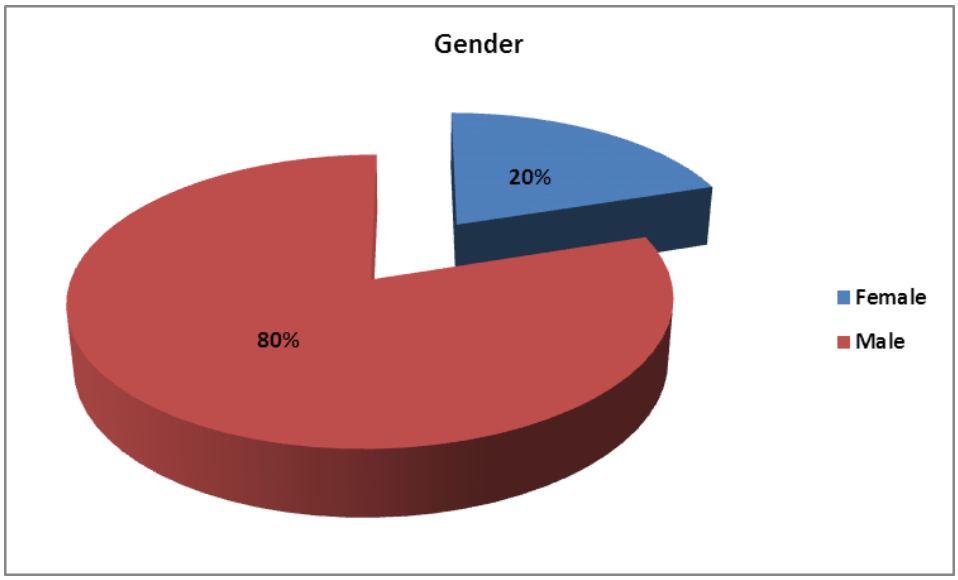
X-rays were taken preoperative, immediate postoperative and subsequently at 6 week and 6 months. Placement of plate, reduction of AC joint or fracture, implant loosening, osteolysis at the tip of the hook, cut out of the hook and union were assessed at serial intervals.

Signs to elicit subacromial impingement were done at each visit and these included the Neer impingement sign, Hawkins-Kennedy sign and Jobe supination test.

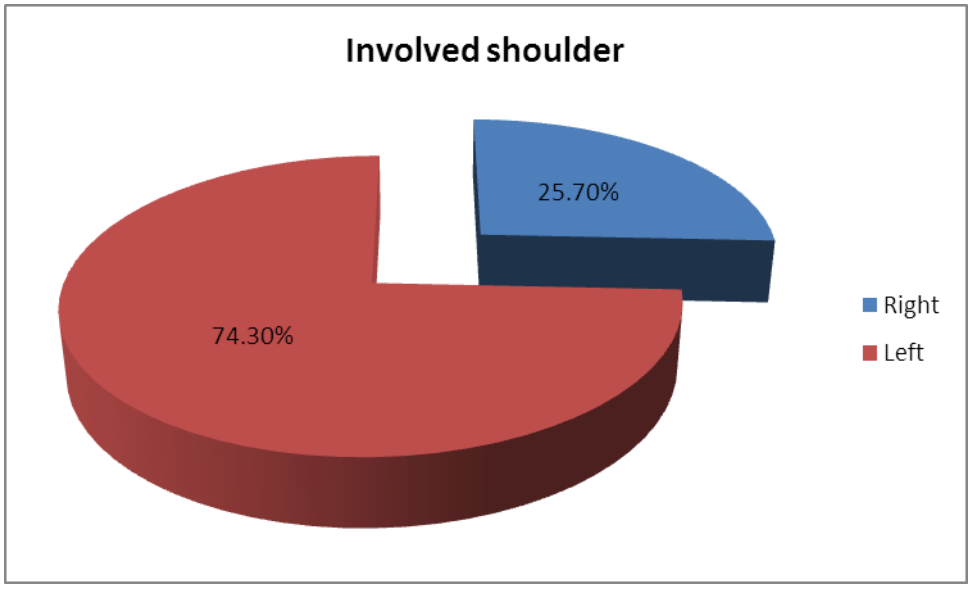
Zanca view was taken to assess the coracoclavicular reduction as compared to the opposite side.

8. RESULTS

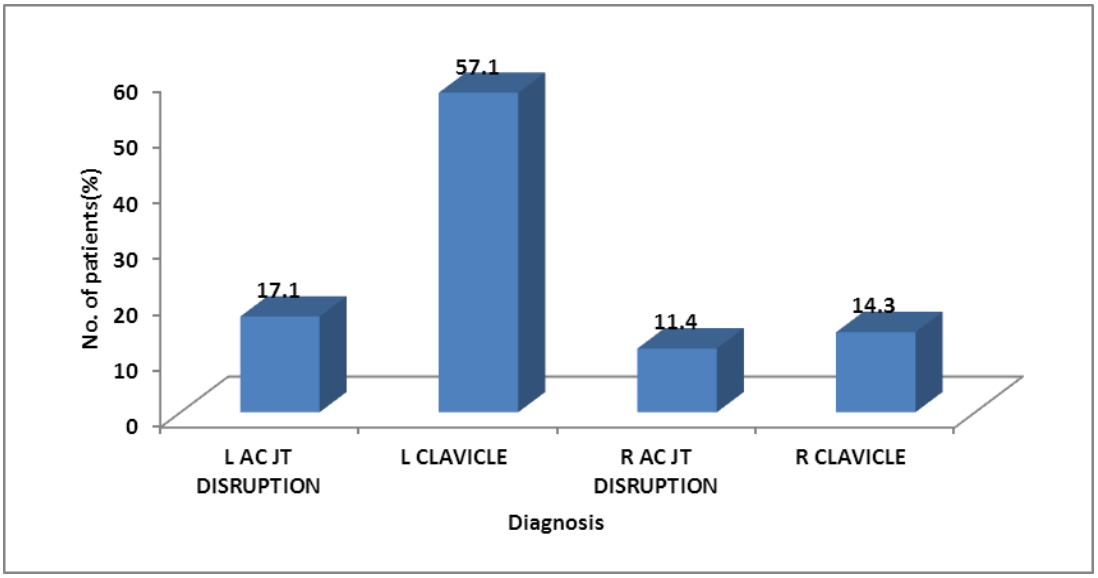
35 patients were followed prospectively from November 2018 to May 2020 of which 28 were males and 7 were females.



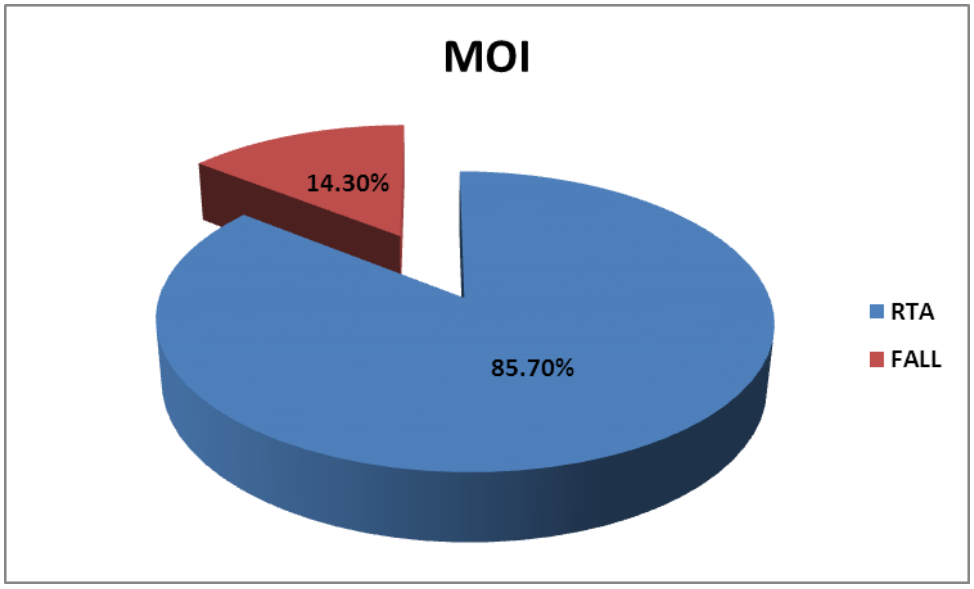
Left shoulder was involved in 26 patients and right shoulder was involved in 9 patients



There were 25 patients with lateral end clavicle fractures and 10 patients with AC joint injury



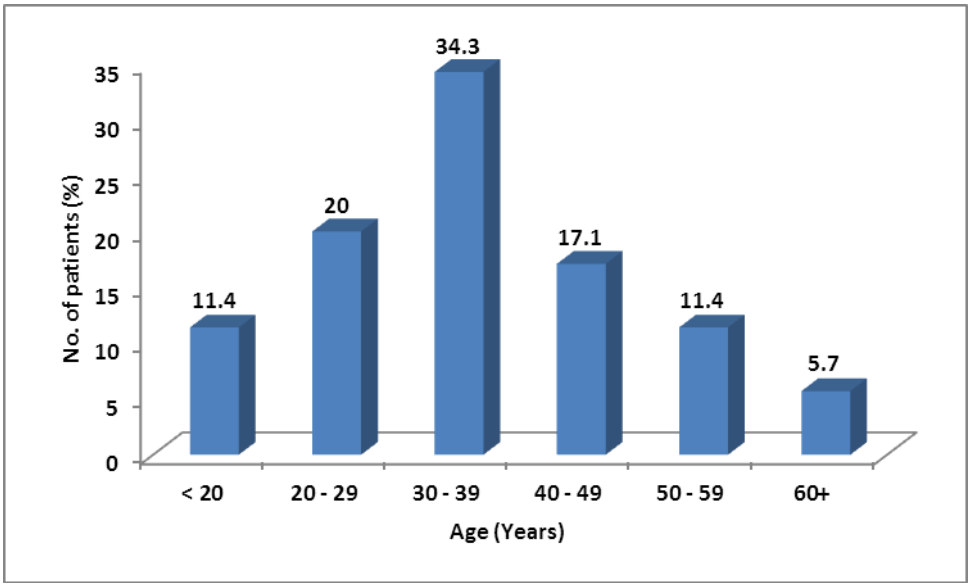
Mode of injury was road traffic accident in 30 patients and fall from height in 5 patients.There were no associated injuries in patients under our study.



The following table shows the distribution of patients according to the age

Table: Distribution of patients according to Age(Years)

Age(Years)	No. of patients	Percentage
< 20	4	11.4
20 - 29	7	20.0
30 - 39	12	34.3
40 - 49	6	17.1
50 - 59	4	11.4
60+	2	5.7
Total	35	100.0



Two patients had Diabetes mellitus and 5 patients had hypertension. One patient had both DM and hypertension.

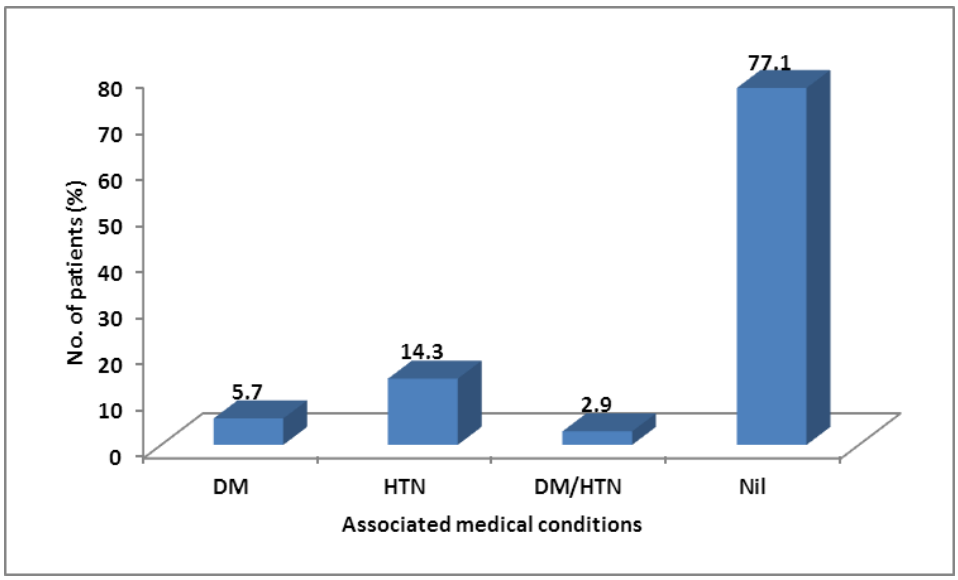


Table: Distribution of patients according Craig's classification for Clavicle fractures

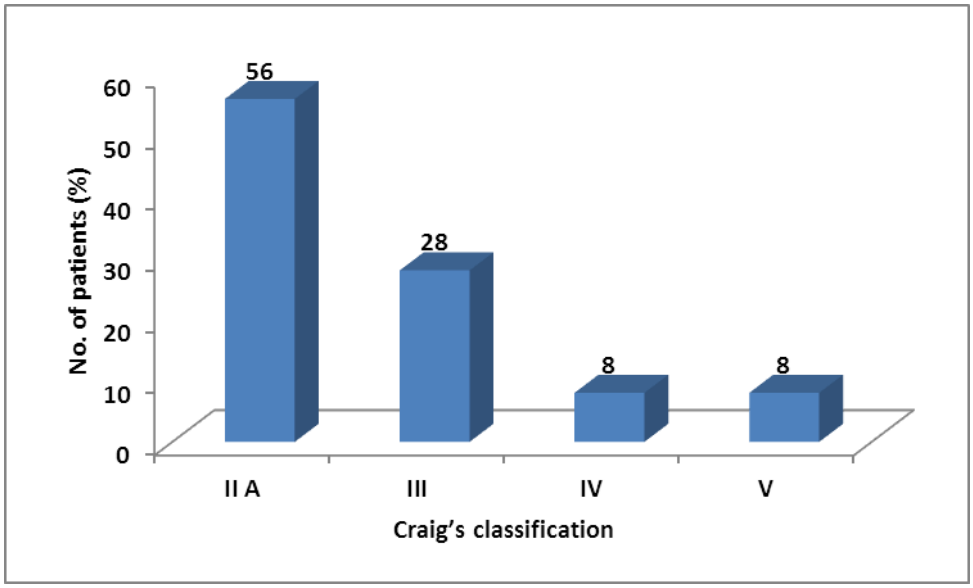
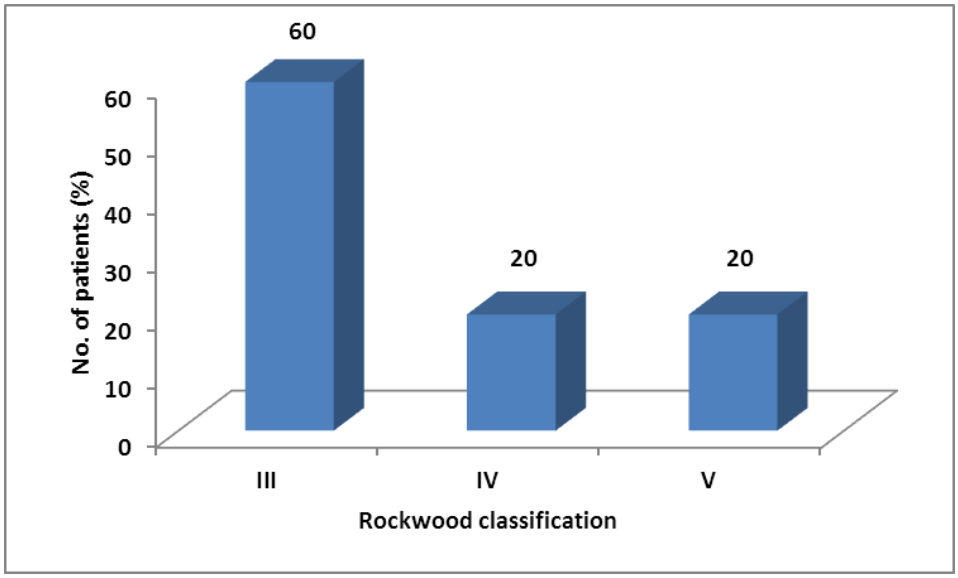
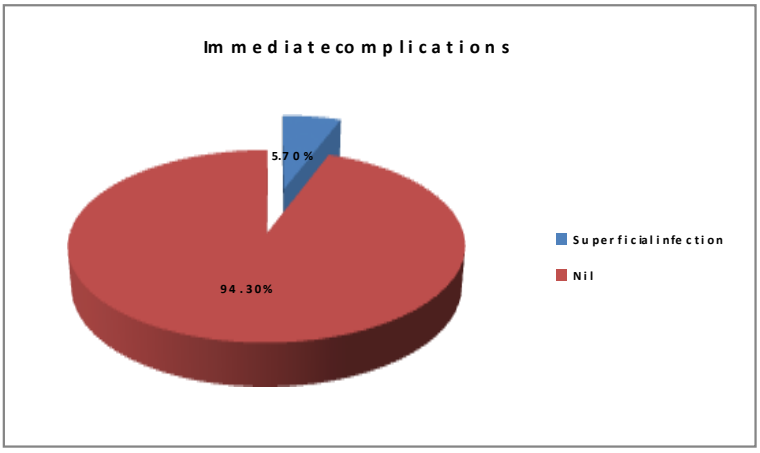


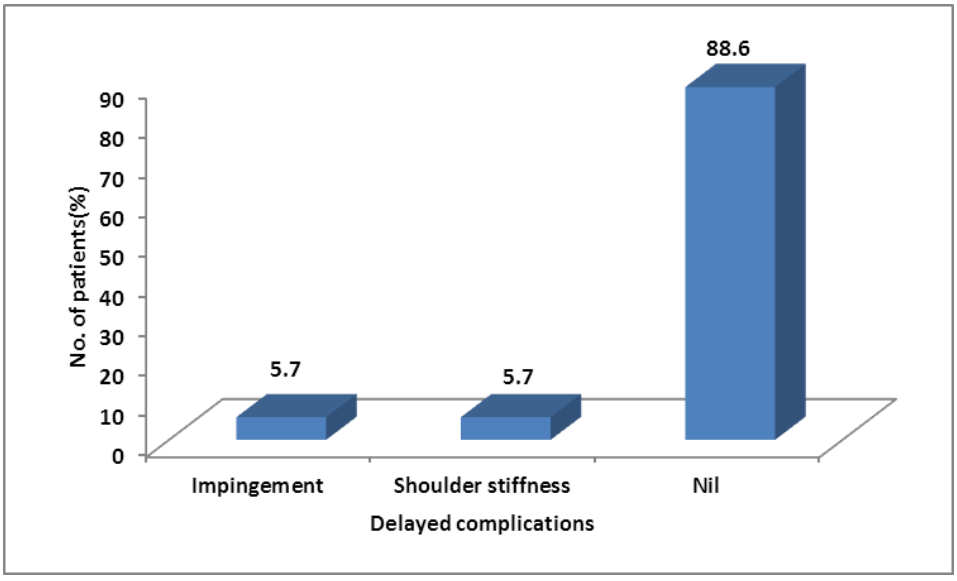
Table: Distribution of patients according Rockwood classification for AC Joint injury

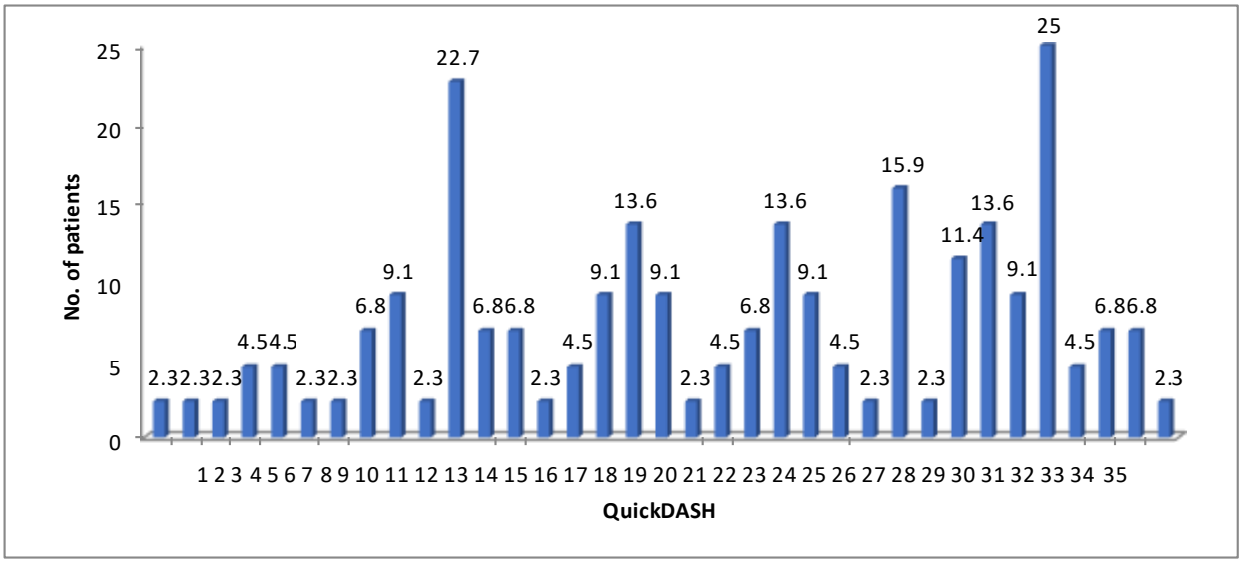


Two patients had superficial wound infection which subsided with antibiotics.

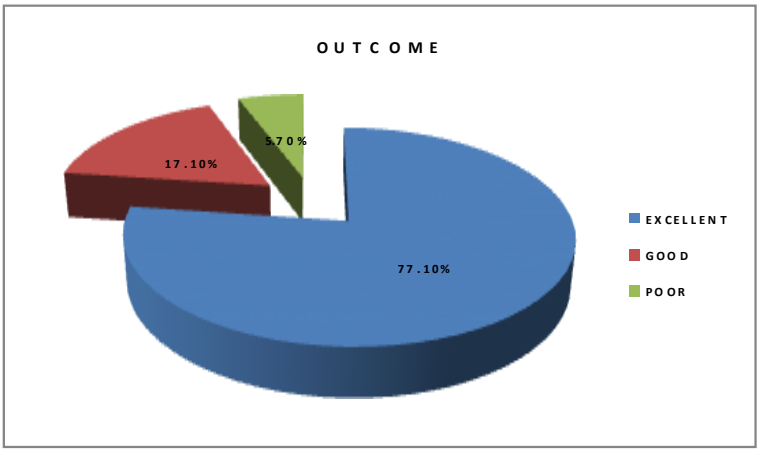


Two patients developed shoulder stiffness and two patients developed impingement during the course of follow up.





All the patients had a unified surgical approach and operative procedure. The post operative protocol regarding medication and physiotherapy was also unified (as mentioned earlier).At the last follow up,27 patients had a excellent outcome according to QuickDASH score. had a good outcome and 2 had a poor outcome. The score ranged from 2.3 to 25 (avg was 7.26)



9. DISCUSSION

Treatment for unstable lateral end clavicle fractures and AC joint disruptions have been shown historically to be an area of much debate in respect to the indications, choice of treatment procedure and choice of implant. In the past a variety of implants have been used such as Kirschner wires(65; 44; 52), tension band wires around coracoid-clavicle, transfixation of clavicle to coracoid with screw (66), repair of CC ligament with augmentations (67; 47), endobuttons (68) and the hook plate (3; 19; 69; 34; 53). Some advocate the excision of the lateral end of clavicle in chronic painful dislocations (30; 70). Debate as to the use of synthetic (71) or autologous fascia slings and tendons for repair of CC ligament (23; 24; 72; 73) and its fixation techniques are yet to be resolved. Surgical approaches may be luggage strap, along the clavicle, mini stab incisions or arthroscopic reconstruction of CC ligament (36; 37) The Weaver Dunn procedure has a weak strength and can result in incomplete reduction or recurrence with a high failure rate of approximately 29% (28).

Kirschner wire fixation has a higher rate of migration (19) while the Bosworth screw needed a wide surgical exposure but provided a rigid fixation leading to loss of rotation and screw cut out (74)

In young patients, there is a need to restore anatomical reduction because of high rates of nonunions and shoulder pain and that the ligaments will not heal without surgery.

The use of hook plate in the treatment of AC joint disruptions and lateral end of clavicle fractures is shown to be a good and acceptable treatment option (3; 75; 76).

AC joint dislocation results in an inferior sag of the scapula (33) and stability at this joint must be achieved either by repair of the ligaments and/or stabilizing with a plate or other fixation devices. Implants like endobuttons™ (Smith & Nephew) need not be removed and this avoids an additional surgery to the patient (50). In regards to the use of a hook plate, there are debatable statements regarding retaining the implant for a more longer duration as against removal when the patient is symptomatic (77) Most of the patients in this study had an excellent or good outcome which is similar to the findings of various other studies(1; 3; 9; 19; 33; 53; 54)

There is literature questioning the need for either simultaneous reconstruction or repair of the ligaments along with hook plate method of fixation, further suggesting implant removal after radiological or clinical indication and /or reconstruction after plate removal depending on the instability.(33)

In this study, 27 patients had an excellent outcome as assessed by Quick DASH scores. 6 patients had good outcome and 2 had poor outcome. These results are comparable to other studies using a hook plate.(3; 53; 54)

We have noted the following complications: impingement occurred in 2, frozen shoulder in 2 .

These results are comparable with other studies (3; 53; 54) though the exact reason of shoulder stiffness is unknown, it appears to be a post-traumatic frozen shoulder.

The origin of impingement pain may be as a result of decrease in subacromial space or the irritation of the subacromial bursa.(78)

The time taken to return to pre-injury status was at a mean of 51 weeks, this is partly attributed to the lack of personal initiative from the patients, lack of timely follow-up and inability to attend physiotherapy session due to distance and financial burdens.

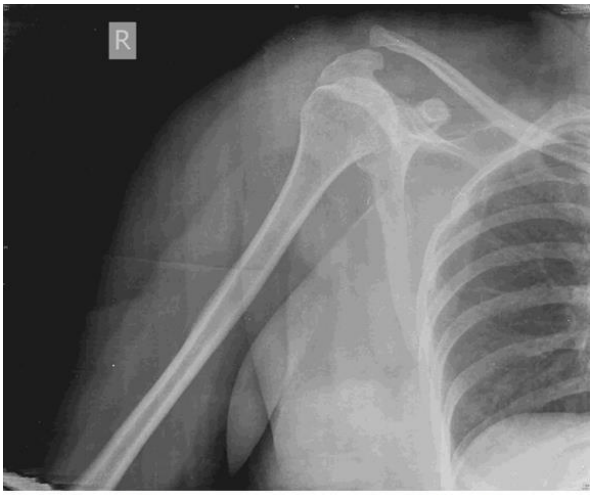
10. SUMMARY AND CONCLUSION

From the analysis of this study the following were noted:

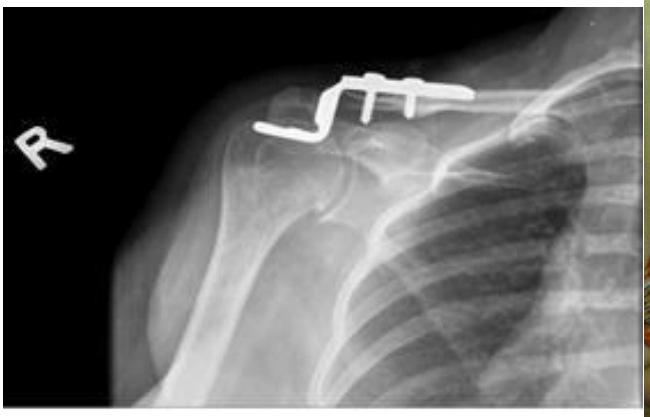
1. Hook plate is a good option for treatment of AC joint disruption and unstable lateral end clavicle fractures
2. Limited use of instrumentation
3. Short duration of the procedure
4. Low incidence of complications
5. Good objective and subjective outcomes
6. Stability to the AC joint attained without the need for ligament repair or reconstruction.
7. Short learning curve
8. Implant removal is advisable but the decision depends on the presence or absence of osteolysis and impingement.

The hook plate is a relatively less analyzed treatment option for displaced lateral end clavicle fractures and acromioclavicular joint disruptions. These injuries are rare and diagnosing and treating them proves to be a challenge as there is an array of treatment options, all of which were associated with their own set of problems.

Secondly, the procedure is simple enough to be practiced by all orthopedicians with good results.



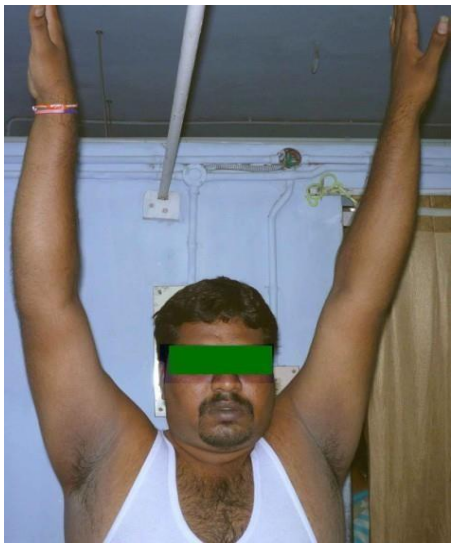
38 year old lady presented with an alleged history of RTA and complained of pain over the right shoulder



Immediate post-op

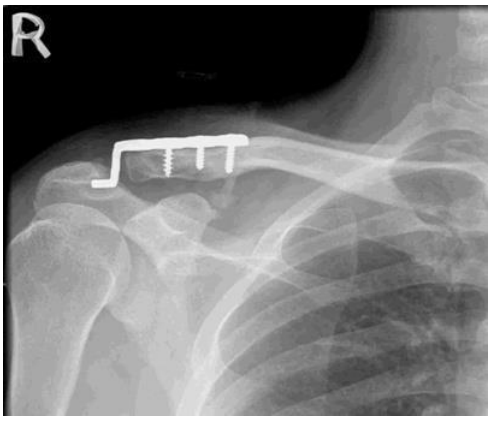
22 year male presented with right shoulder pain and deformity following a RTA

Immediate post op



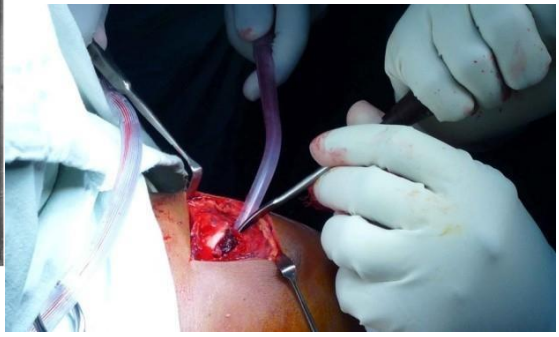
35 year male with pain over the right shoulder following a RTA

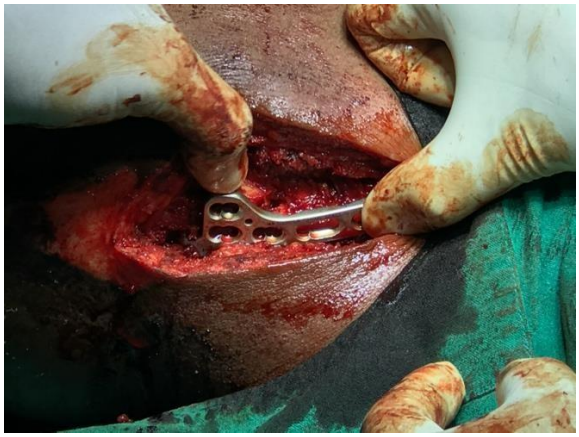
Immediate post-operative

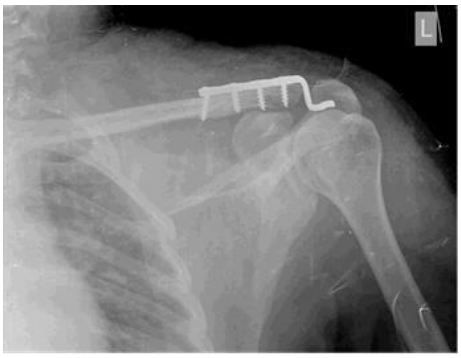


At 6 month post op period

32 years male with pain over the left shoulder following a RTA







Immediate post-op

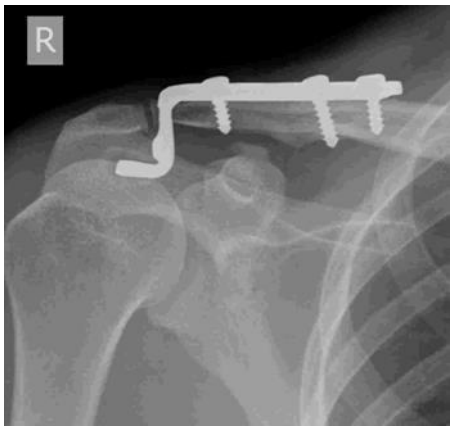
37 year male with an alleged history period of RTA came with pain and deformityat the left shoulder

Immediate post operative

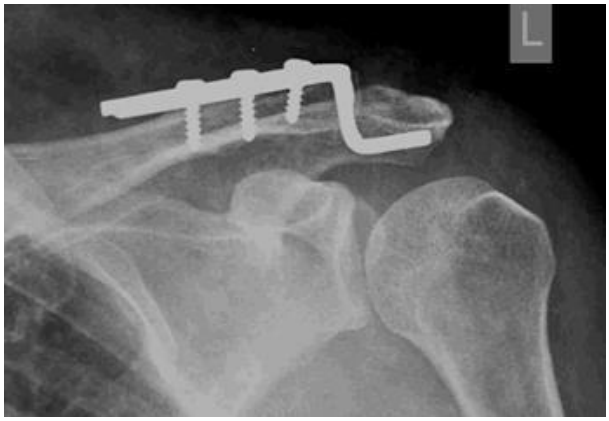
At 6 months post-op

24 year male post RTA

Immediate post-op

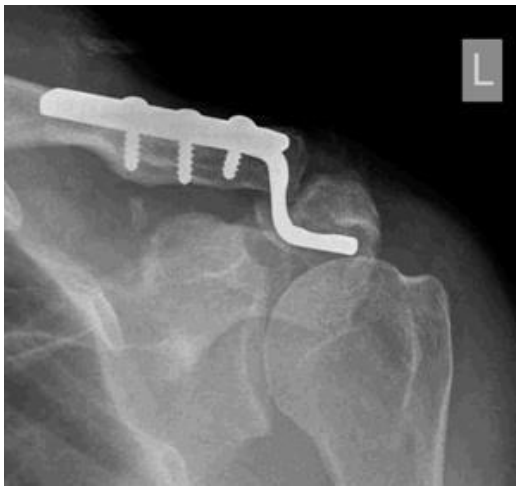


At last follow-up (6 months)



Pre-op of 35 year male following a RTA

Immediate post-op



Last follow-up (6 months)

Quick DASH score

1. Open a tight or new jar

   [ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

   [ ] Severe difficulty [ ] Unable

2. Do heavy household chores (eg wash walls, wash floors)

   [ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

   [ ] Severe difficulty [ ] Unable

3. Carry a shopping bag or briefcase

   [ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

   [ ] Severe difficulty [ ] Unable

4. Wash your back

   [ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

   [ ] Severe difficulty [ ] Unable

5. Use a knife to cut food

   [ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

   [ ] Severe difficulty [ ] Unable

6. Recreational activities in which you take some force or impact through your arm, shoulder or hand (eg golf, hammering, tennis, etc)

   [ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

   [ ] Severe difficulty [ ] Unable

7. During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family, friends, neighbours or groups?

[ ] Not at all [ ] Slightly [ ] Moderately [ ] Quite a bit [ ] Extremely

8. During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem?

[ ] Not limited at all [ ] Slightly limited

[ ] Moderately limited [ ] Very limited [ ] Unable

Please rate the severity of the following symptoms in the last week

9. Arm, shoulder or hand pain

[ ] None [ ] Mild [ ] Moderate [ ] Severe [ ] Extreme

10. Tingling (pins and needles) in your arm, shoulder or hand

[ ] None [ ] Mild [ ] Moderate [ ] Severe [ ] Extreme

11. During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand?

[ ] No difficulty [ ] Mild difficulty [ ] Moderate difficulty

[ ] Severe difficulty [ ] Unable

BIBLIOGRAPHY:

1. Renger RJ, Roukema GR, Reurings JC, Raams PM, Font J, Verleisdonk EJMM. The Clavicle Hook Plate for Neer Type II Lateral Clavicle Fractures. Journal of Orthopaedic Trauma [Internet]. 2009;23(8). Available from: http://journals.lww.com/jorthotrauma/Fulltext/2009/09000/The_Clavicle_Hook_Plate_for _Neer_Type_II_Lateral.5.aspx

2. MacDonald PB, Lapointe P. Acromioclavicular and sternoclavicular joint injuries. Orthopedic Clinics of North America. 2008;39(4):535–545.

3. Meda PVK, Machani B, Sinopidis C, Braithwaite I, Brownson P, Frostick SP. Clavicular hook plate for lateral end fractures:- a prospective study. Injury. 2006 Mar;37(3):277-283.

4. Rockwood and Green's Fractures in Adults, 7th edition - home [Internet]. [cited 2010 Nov 27];Available from: http://www.rockwoodadultsfractures.com/pt/re/bucholz7e/home.htm;jsessionid=MwDFC DcKBQNp21m3pZ1135htv8JbTXTV2xh9JlyhLK27vTzQN8Jf!628309595!18119562 8!8 091!-1

5. Repair of Complete Acromioclavicular Separations Using the Acromioclavicular-Hook Plate.pdf.

6. Salem KH, Schmelz A. Treatment of Tossy III Acromioclavicular Joint Injuries Using Hook Plates and Ligament Suture. Journal of Orthopaedic Trauma [Internet]. 2009;23(8). Available from: http://journals.lww.com/jorthotrauma/Fulltext/2009/09000/Treatment_of_Tossy_III_Acro mioclavicular_Joint.4.aspx

7. SAGE FP, SALVATORE JE. Injuries of the Acromioclavicular Joint: A Study of Results in 96 Patients. Southern Medical Journal [Internet]. 1963;56(5). Available from: http://journals.lww.com/smajournalonline/Fulltext/1963/05000/Injuries_of_the_Acromioc lavicular_Joint A_Study.9.aspx

8. Dias J, Steingold R, Richardson R, Tesfayohannes B, Gregg P. The conservative treatment of acromioclavicular dislocation. Review after five years. J Bone Joint Surg Br. 1987 Nov 1;69-B(5):719-722.

9. Bannister G, Wallace W, Stableforth P, Hutson M. The management of acute acromioclavicular dislocation. A randomised prospective controlled trial. J Bone Joint Surg Br. 1989 Nov 1;71-B(5):848-850.

10. Rockwood CA. The Shoulder. Elsevier Health Sciences; 2009.

11. Post M. Current concepts in the diagnosis and management of acromioclavicular dislocations. Clin. Orthop. Relat. Res. 1985 Nov;(200):234-247.

12. URIST MR. COMPLETE DISLOCATIONS OF THE ACROMIOCLAVICULAR JOINT: The Nature of the Traumatic Lesion and Effective Methods of Treatment with an Analysis of Forty-One Cases. J Bone Joint Surg Am. 1946 Oct 1;28(4):813-837.

13. WEAVER JK, DUNN HK. Treatment of Acromioclavicular Injuries, Especially Complete Acromioclavicular Separation. J Bone Joint Surg Am. 1972 Sep 1;54(6):1187- 1194.

14. Dewar FP, Barrington TW. THE TREATMENT OF CHRONIC ACROMIO- CLAVICULAR DISLOCATION. J Bone Joint Surg Br. 1965 Feb 1;47-B(1):32-35.

15. Kashii M, Inui H, Yamamoto K. Surgical Treatment of Distal Clavicle Fractures Using the Clavicular Hook Plate. Clinical Orthopaedics and Related Research [Internet]. 2006;447. Available from: http://journals.lww.com/corr/Fulltext/2006/06000/Surgical_Treatment_of_Distal_Clavicle_Fractures.28.aspx

16. Lizaur A, Marco L, Cebrian R. Acute dislocation of the acromioclavicular joint. Traumatic anatomy and the importance of deltoid and trapezius. J Bone Joint Surg Br. 1994 Jul 1;76-B(4):602-606.

17. Larsen E, Bjerg-Nielsen A, Christensen P. Conservative or surgical treatment of acromioclavicular dislocation. A prospective, controlled, randomized study. J Bone Joint Surg Am. 1986 Apr 1;68(4):552-555.

18. The Panel. Treatment of Complete Acromioclavicular Dislocation. J Bone Joint Surg Am. 1962 Jul 1;44(5):1008-1012.

19. Weinstein DM, McCann PD, Mcllveen SJ, Flatow EL, Bigliani LU. Surgical Treatment of Complete Acromioclavicular Dislocations. The American Journal of Sports Medicine. 1995 Jun;23(3):324 -331.

20. Mathias Wellmann, Ina Lodde, Steffen Schanz, Thore Zantop, Michael J. Raschke, Wolf Petersen. Biomechanical Evaluation of an Augmented Coracoacromial Ligament Transfer for Acromioclavicular Joint Instability. Arthroscopy. 2008 Dec 1;24(12):1395-1401.

21. Lafosse L, Baier GP, Leuzinger J. Arthroscopic Treatment of Acute and Chronic Acromioclavicular Joint Dislocation. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2005 Aug;21(8):1017.e1-1017.e8.

22. Kennedy JC, Cameron H. COMPLETE DISLOCATION OF THE ACROMIO-CLAVICULAR JOINT. J Bone Joint Surg Br. 1954 May 1;36-B(2):202-208.

23. Ceccarelli E, Bondì R, Alviti F, Garofalo R, Miulli F, Padua R. Treatment of acute grade III acromioclavicular dislocation: a lack of evidence. Journal of Orthopaedics and Traumatology. 2008 Jun 1;9(2):105-108-108.

24. Chernchujit B, Tischer T, Imhoff A. Arthroscopic reconstruction of the acromioclavicular joint disruption: surgical technique and preliminary results. Archives of Orthopaedic and Trauma Surgery. 2006 Nov 1;126(9):575-581-581.

25. MUMFORD EB. ACROMIOCLAVICULAR DISLOCATION: A New Operative Treatment. J Bone Joint Surg Am. 1941 Oct 1;23(4):799-802.

26. Spencer EEJ. Treatment of Grade III Acromioclavicular Joint Injuries: A Systematic Review. Clinical Orthopaedics and Related Research [Internet]. 2007;455. Available from: http://journals.lww.com/corr/Fulltext/2007/02000/Treatment_of_Grade_III_Acromioclavi cular_Joint.9.aspx

27. Sim E, Schwarz N, Höcker K, Berzlanovich A. Repair of Complete Acromioclavicular Separations Using the Acromioclavicular-Hook Plate. Clinical Orthopaedics and Related Research [Internet]. 1995;314. Available from: http://journals.lww.com/corr/Fulltext/1995/05000/Repair_of_Complete_ Acromioclavicul ar_Separations.17.aspx

28. synthes_clavicle_hook.pdf [Internet]. [cited 2010 Nov 18];Available from: http://www.shoulderdoc.co.uk/documents/synthes_clavicle_hook.pdf

29. De Baets T, Truijen J, Driesen R, Pittevils T. The treatment of acromioclavicular joint dislocation Tossy grade III with a clavicle hook plate. Acta Orthop Belg. 2004 Dec;70(6):515-519.

30. Ejam S, Lind T, Falkenberg B. Surgical treatment of acute and chronic acromioclavicular dislocation Tossy type III and V using the Hook plate. Acta Orthop Belg. 2008 Aug;74(4):441-445.

31. Sunderamoorthy D, Saldanha K, Madhusudhan S, Waseem M. Hook plate in clavicular pathology in a DGH. Injury Extra. 2007 Jan;38(1):3-4.

32. McConnell AJ, Yoo DJ, Zdero R, Schemitsch EH, McKee MD. Methods of operative fixation of the acromio-clavicular joint: a biomechanical comparison. J Orthop Trauma. 2007 Apr;21(4):248-253.

33. Clarke H, McCann P. Acromioclavicular joint injuries. Orthop Clin North Am. 2000 Apr 1;31(2):177-87.

34. Robinson CM. Fractures of the clavicle in the adult: EPIDEMIOLOGY AND CLASSIFICATION. J Bone Joint Surg Br. 1998 May 1;80-B(3):476-484.

35. Nordqvist A, Petersson C, Redlund-Johnell I. The natural course of lateral clavicle fracture: 15 (11–21) year follow-up of 110 cases. Acta Orthopaedica. 1993 Jan 1;64(1):87-91.

36. Webber MCB, Haines JF. The treatment of lateral clavicle fractures. Injury. 2000 Apr;31(3):175-179.

37. Khan LAK, Bradnock TJ, Scott C, Robinson CM. Fractures of the clavicle. J Bone Joint Surg Am. 2009 Feb;91(2):447-460.

38. Potter F, Fiorini A, Knox J, Rajesh P. The migration of a Kirschner wire from shoulder to spleen: brief report. J Bone Joint Surg Br. 1988 Mar 1;70-B(2):326-327.

39. Lyons F, Rockwood C. Migration of pins used in operations on the shoulder. J Bone Joint Surg Am. 1990 Sep 1;72(8):1262-1267.

40. NORRELL H, LLEWELLYN RC. Migration of a Threaded Steinmann Pin from an Acromioclavicular Joint into the Spinal Canal: A CASE REPORT. J Bone Joint Surg Am. 1965 Jul 1;47(5):1024-1026.

41. Mazet R. MIGRATION OF A KIRSCHNER WIRE FROM THE SHOULDER REGION INTO THE LUNG: Report of Two Cases. J Bone Joint Surg Am. 1943 Apr 1;25(2):477- 483.

42. Rokito AS, Zuckerman JD, Shaari JM, Eisenberg DP, Cuomo F, Gallagher MA. A comparison of nonoperative and operative treatment of type II distal clavicle fractures. Bull Hosp Jt Dis. 2002;61(1-2):32-39.

43. Swanson KE, Swanson BL. A minimally invasive surgical technique to treat distal clavicle fractures. Orthopedics. 2009 Jul;32(7):509.

44. Pujol N, Philippeau JM, Richou J, Lespagnol F, Graveleau N, Hardy P. Arthroscopic treatment of distal clavicle fractures: a technical note. Knee Surg Sports Traumatol Arthrosc. 2008 Sep;16(9):884-886.

45. Robinson CM, Akhtar MA, Jenkins PJ, Sharpe T, Ray A, Olabi B. Open reduction and endobutton fixation of displaced fractures of the lateral end of the clavicle in younger patients. J Bone Joint Surg Br. 2010 Jun 1;92-B(6):811-816.

46. Macheras G, Kateros KT, Savvidou OD, Sofianos J, Fawzy EA, Papagelopoulos PJ. Coracoclavicular screw fixation for unstable distal clavicle fractures. Orthopedics. 2005 Jul;28(7):693-696.

47. Flinkkilä T, Ristiniemi J, Hyvönen P, Hämäläinen M. Surgical treatment of unstable fractures of the distal clavicle: A comparative study of Kirschner wire and clavicular hook plate fixation. Acta Orthopaedica. 2002 Jan 1;73(1):50-53.

48. Flinkkilä T, Ristiniemi J, Lakovaara M, Hyvönen P, Leppilahti J. Hook-plate fixation of unstable lateral clavicle fractures: a report on 63 patients. Acta Orthop. 2006 Aug;77(4):644-649.

49. Tambe A, Motkur P, Qamar A, Drew S, Turner S. Fractures of the distal third of the clavicle treated by hook plating. 2006 Feb 1;30(1):7-10.

50. Gummesson C, Atroshi I, Ekdahl C. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. BMC Musculoskeletal Disorders. 2003;4(1):11.

51. Beaton DE, Wright JG, Katz JN, The Upper Extremity Collaborative Group. Development of the QuickDASH: Comparison of Three Item-Reduction Approaches. J Bone Joint Surg Am. 2005 May 1;87(5):1038-1046.

52. Gummesson C, Ward M, Atroshi I. The shortened disabilities of the arm, shoulder and hand questionnaire (QuickDASH): validity and reliability based on responses within the full-length DASH. BMC Musculoskeletal Disorders. 2006;7(1):44.

53. McClelland D, Krishnamurthy S, Dodenhoff R. CONSTANT SCORE ASSESSMENT OF SHOULDER FUNCTION - IS STRENGTH MEASUREMENT USEFUL? J Bone Joint Surg Br. 2002 Jul 1;84-B(SUPP_II):197-d.

54. Katolik LI, Romeo AA, Cole BJ, Verma NN, Hayden JK, Bach BR. Normalization of the Constant score. Journal of Shoulder and Elbow Surgery. May;14(3):279-285.

55. CONSTANT CR, MURLEY AG. A Clinical Method of Functional Assessment of the Shoulder. Clinical Orthopaedics and Related Research

[Internet]. 1987;214. Available from: http://journals.lww.com/corr/Fulltext/1987/01000/A_Clinical_Method_of_Functional_As sessment_of_the.23.aspx

56. ALLMAN FL. Fractures and Ligamentous Injuries of the Clavicle and Its Articulation. J Bone Joint Surg Am. 1967 Jun 1;49(4):774-784.

57. Shah RR, Kinder J, Peelman J, Moen TC, Sarwark J. Pediatric Clavicle and Acromioclavicular Injuries. Journal of Pediatric Orthopaedics [Internet]. 2010;30. Available from: http://journals.lww.com/pedorthopaedics/Fulltext/2010/03001/Pediatric_Clavicle_and_Ac romioclavicular_Injuries.16.aspx

58. Beim GM. Acromioclavicular Joint Injuries. J Athl Train. 2000;35(3):261-267.

59. Imatani R, Hanlon J, Cady G. Acute, complete acromioclavicular separation. J Bone Joint Surg Am. 1975 Apr 1;57(3):328-332.

60. Assaghir Y. Rockwood type III acute acromioclavicular dislocations: 14 years of experience comparing direct anatomic repair and percutaneous coracoclavicular screw. European Journal of Orthopaedic Surgery & Traumatology. 2010 Jul 16;:1-7-7.

61. Pavlik A, Csépai D, Hidas P. Surgical treatment of chronic acromioclavicular joint dislocation by modified Weaver-Dunn procedure. Knee Surgery, Sports Traumatology, Arthroscopy. 2001 Sep 10;9(5):307-312-312.

62. Breslow MJ, Jazrawi LM, Bernstein AD, Kummer FJ, Rokito AS. Treatment of acromioclavicular joint separation: Suture or suture anchors? Journal of Shoulder and Elbow Surgery. 2002 Jun;11(3):225-229.

63. Muramatsu K, Shigetomi M, Matsunaga T, Murata Y, Taguchi T. Use of the AO hook- plate for treatment of unstable fractures of the distal clavicle. Arch Orthop Trauma Surg. 2007 Apr;127(3):191-194.

64. ESKOLA A, SANTAVIRTA S, VILJAKKA T, WIRTA J, PARTIO E, HOIKKA V. The Results of Operative Resection of the Lateral End of the Clavicle. J Bone Joint Surg Am. 1996 Apr 1;78(4):584-7.

65. Zooker CC, Parks BG, White KL, Hinton RY. TightRope Versus Fiber Mesh Tape Augmentation of Acromioclavicular Joint Reconstruction: A Biomechanical Study. Am. J. Sports Med. 2010 Jun 1;38(6):1204-1208.

66. Tauber M, Gordon K, Koller H, Fox M, Resch H. Semitendinosus Tendon Graft Versus a Modified Weaver-Dunn Procedure for Acromioclavicular Joint Reconstruction in Chronic Cases: A Prospective Comparative Study. Am. J. Sports Med. 2009 Jan 1;37(1):181-190.

67. Michlitsch MG, Adamson GJ, Pink M, Estess A, Shankwiler JA, Lee TQ. Biomechanical comparison of a modified Weaver-Dunn and a free-tissue graft reconstruction of the acromioclavicular joint complex. Am J Sports Med. 2010 Jun;38(6):1196-1203.

68. Gonzalez R, Damacen H, Nyland J, Caborn D. Acromioclavicular joint reconstruction using peroneus brevis tendon allograft. Arthroscopy. 2007 Jul;23(7):788.e1-4.

69. Lee K, Lee S, Kim K, Kim Y, Kwon W, Choy W. Arthroscopic-assisted Locking Compression Plate clavicular hook fixation for unstable fractures of the lateral end of the clavicle: a prospective study. 2009 Dec 9;

70. Xie S, Gu K, Wang H, Qin S, Hu X, Zhang Z. [Analysis of clinical effects on surgical operation with clavicular hook plate fixation]. Zhongguo Gu Shang. 2009 May;22(5):374-375.

71. Xue L, Chen Q, Zhou Z. [Clinical effects of clavicular hook plate for Neer type II fracture of distal clavicle]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2007 Sep;21(9):979- 981.

72. ElMaraghy AW, Devereaux MW, Ravichandiran K, Agur AM. Subacromial morphometric assessment of the clavicle hook plate. Injury. 2010 Jun

ETHICAL CERTIFICATE

INFORMED CONSENT FOR PARTICIPATION IN DISSERTATION/RESEARCH

I, the undersigned,_____, S/O D/O W/O_____, aged ____years, ordinarily resident of _____do hereby state/declare that Dr. Ezhil Vikrama Vell G. of Shri. B. M. Patil Medical College Hospital and Research Centre has examined me thoroughly on_____at _____(place) and it has been explained to me in my own language that I am suffering from_____disease (condition) and this disease/condition mimic following diseases. Further Dr. Ezhil Vikrama Vell G. informed me that he/she is conducting dissertation/research titled "Functional outcome of clavicle hook plate for fractures of lateral end of clavicle & acromioclavicular joint disruption." under the guidance of Dr. Dayanand B.B. requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and follow-up observations will be utilized for the study as reference data.

Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in evaluation of the results of the study

which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same time I have been informed that I can withdraw from my participation in this study at any time if I want or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt _____ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of patient:

Signature of doctor:

Witness: 1.

2.

Date:

Place

PROFORMA

CASE NO. :

NAME :

AGE/SEX :

I P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized lymphadenopathy:	present/absent
Built:	poor/moderate/well
Nourishment:	poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Right/ Left Clavicle

Inspection:

a) Attitude/ deformity

b) Abnormal swelling

- Site
- Size
- Shape
- Extent

d) Skin

e) Compound injury if any

Palpation:

a) Local tenderness

b) Bony irregularity

c) Abnormal movement

d) Crepitus

e) Swelling

Movements:	Active	Passive
Shoulder Joint: Flexion		
Extension		
Adduction		
Abduction		
External rotation		
Internal rotation		
Circumduction		

KEY TO MASTERCHART

IP No - Inpatient Number

M - Male

F - Female

DOS - Date of Surgery

MOI - Mechanism of Injury

L. - Left

R - Right

AC Jt - Acromioclavicular Joint

Med - Medical

Asso. - Associated

Imm Comp - Immediate Complications

D Comp. - Delayed Complications

MASTER CHART