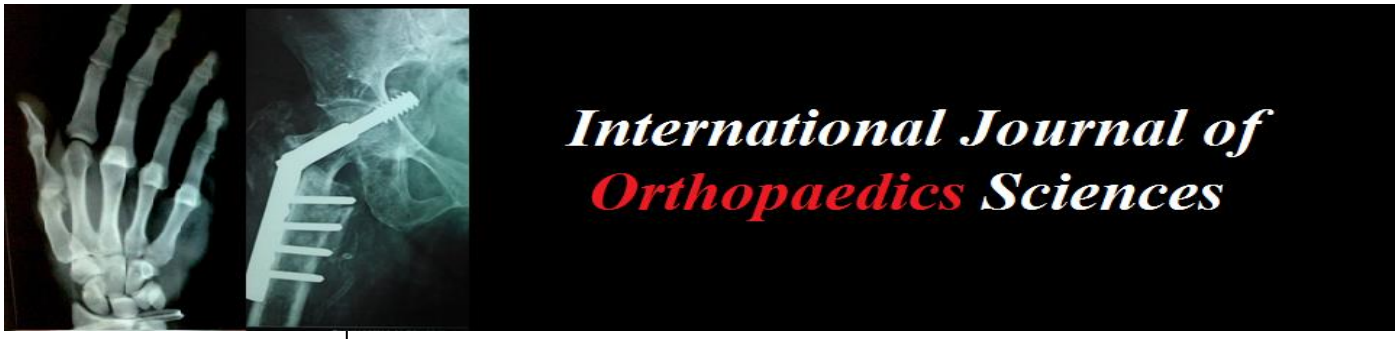

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Indirect osteosynthesis for unstable distal end of clavicle fracture with endobutton and Fibertape: A Prospective study

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Abstract
Introduction: Fracture clavicle is one of the most common fractures present to orthopedic emergency and near about 10 % of all fracture. Fracture lateral end of clavicle is relative less in comparison to shaft fracture. Due to fracture geometry and deforming forces Neer"s type 2 fracture is unstable one and required surgical intervention. We can divide surgical procedure into rigid & flexible one with or without involvement of acromioclavicular joint.
Material Methods: We treated 38 Neer's type 2 fracture with two loose endobutton with fiber tape in tight rope fashion from February 2018 to December 2021. Pre-operative assessment done with X-ray AP view, standing position. Post-operative pendulum exercise started on suture removal at 12th day. Passive, active assisted and active range of motion exercise added depending upon the patient's recovery and tolerability at regular 2-3 weeks interval. X-Ray taken at subsequent interval of one month till fracture union.
Results: All fracture united well, five cases had minimal loss of reduction radiological without affecting the shoulder function. Assessment of shoulder function done by UCLA Shoulder Score score at four-month post operatively.
Conclusion: Treating lateral end of clavicle with indirect osteosynthesis without incorporation of acromioclavicular joint and acromion is very effective, minimal invasive and without complication of hardware, sub acromion impingement and AC joint arthrosis.

Keywords: Indirect osteosynthesis, Neer"s type 2, endobutton, Fibertape, AC joint arthrosis.

Introduction
Fracture distal end of clavicle is not as common as the mid shaft fracture it only comprises of 10 to 30 % of the clavicle fracture [1]. The pathomechanism of injury for distal clavicle fracture is different and usually due to direct blow on the lateral aspect. Proper classification is must because some subset of the fracture is unstable and prone for more nonunion, shoulder dysfunction and visible deformity. Neer's classification of lateral end of clavicle is widely accepted [2, 3]. 30 to 35 % of nonunion is reported on displaced type 2 Neer's distal clavicle fracture [4]. 10-15% patients who opt a conservative treatment underwent surgery due to symptoms [4]. Still there is no gold standard consensus available for the treatment of the distal clavicle fracture in spite of availability of so many treatment option [5]. There are various surgical treatment available for the distal clavicle fracture and we can broadly divide into a) Rigid fixation with or without incorporation of acromioclavicular joint lateral clavicle locking plate, Hook plate b) Rigid coracoclavicular fixation by CC screw (Bosworth) with or without incorporation of acromioclavicular joint, c) Flexible coracoclavicular fixation with endobuttons and fiber tape or with suture anchor with or without incorporation of acromioclavicular joint. Incorporation of acromioclavicular joint can be done with transfixing fracture with K-wire or with TBW. So broadly we can divide into a direct fracture fixation with the help of plating or K wire or TBW and indirect osteosynthesis with help of suture anchors, fiber tape and endobutton. Indirect osteosynthesis avoid penetration of acromioclavicular joint that leads to acromioclavicular joint arthritis. Rigid fixation with hard ware have its own complication like second surgery with hardware removal and rotator cuff tear with limitation of lateral clavicle gliding. We have used to two endobutton with fiber tape in a tight rope fashion for indirect osteosynthesis of distal clavicle fracture treatment.

Material and Methods

We treated 38 patients of Neer's type 2 lateral end of clavicle fracture from February 2018 to December 2021 at Joint & sports injury center with two endobutton and fiber tape with two incision techniques (Fig.1). 29 patients were male and 9 were female. 26 patients had involvement of right side and 12 had involvement on left side. Average age of the patients was 38.4. Majority of patients had road traffic accident; two cases had history of fall on the affected the shoulder. 7 patients had associated orthopedic injury. Patient with other system involved during trauma excluded from the study like head injury and blunt trauma abdomen. Shoulder X-ray taken in upright position (Fig.2) and classification done on the basis of Neer's classification. All patients with associated injury stabilized first. Average interval of surgery was 3-5 days. Patients taken under with inter scalene block with supplementation of shorts GA if required. Fracture table rotated in order to make foot end of table to make it head end, this help image intensifier for smooth passage. C-ARM come from the uninjured side and screen placed on the injured side for better visualization. Patients placed supine with head up 20 degree and image intensifier also rotated 20 degrees for proper AP view. A 3–5-inch folded sheet place in interscapular region, that allow outer border of scapula fall and it makes it more parallel to OT table. Head of the patient place on the ring with face away and neck should be tilted towards the uninjured side. First incision taken over the clavicle around two cm, 2 to 3 cm medial to acromioclavicular joint and the fracture centered over the anterio-posterior border of flat end of the lateral clavicle. A second incision, roughly around 2 to 2.5 cm taken over the tip of coracoid. After blunt dissection tip identified and undersurface of the coracoids is cleared (Fig.3). Undersurface of coracoid should be free to negotiate finger of blunt surgical instrument. Starting point over the clavicle should be mark and check under the C-Arm too, it should be in center in reference to anterio-posterior direction and well medial from the fracture site. 2.8 mm beath pin used in direction from clavicle to the coracoid center with a blunt instrument placed under coracoids. Position of the wire confirms in C-arm and once the position of wire is satisfactory, over drilling of the wire done with 4.5 mm drill bit. A fiber wire or any strong suture pass through the eye of beath pin for shuttling of suture from above downward direction. With the help of suture retriever loop is pulled out from the incision taken over the coracoids. Assembly of endobutton and fiber tape in tight rope fashion done at instrument trolly by using two central hole endobutton by making circle and two ends of fiber tape over proximal endobutton make sure sufficient length between the endobutton (Fig.4). Outer hole of distal endobutton tide with shuttling fiber wire or suture. It makes endobutton vertical and smooth passage through the drill hole of clavicle and coracoids. Pull out the distal endobutton from coracod incision and untied the shuttle suture. Pull all the four strands below the proximal endubutton and place the distal endobutton below the coracoids flat with maximum bone contact and any pullout of distal endobutton. Now pulling the two loose end of fiber tape leads to proximal endobutton sit over the clavicle flat (Fig.5). Position of the endobutton confirm under C-arm, with help of tightening fracture ends comes in oppose to each other, slightly over tightening done leads to medial end of fracture drop 2-3 mm below to lateral end of fracture. 7-8 turns of fiber tape taken over the clavicle and suture cut in appropriate length (Fig.6). Tight closure of the soft tissue over the cut end of the suture with skin closure done (Fig.7).

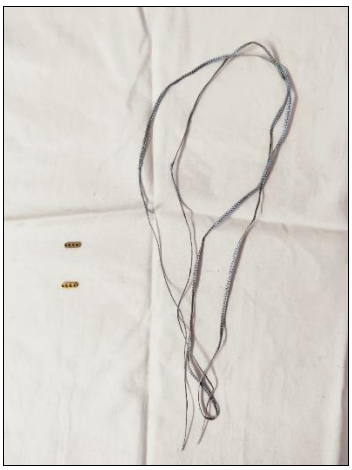


Fig 1: Two loose endobutton, with fiber tape

Fig 4: Assembly of endobutton and fiber tape in tight rope fashion using central two with two turns and two free ends on one side

Fig 2: X ray in upright position involved arm in unsupported

Fig 3: Blunt dissection and keeping a protective instrument below coracoid

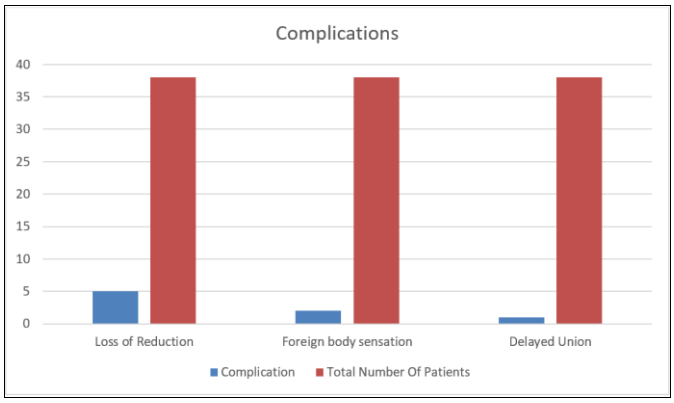
Fig 4: C- arm image post tightening of fiber tape with position of endobutton

Fig 5: Post closure surgical site

Fig 6: Post-operative X-ray in upright position

Results

Elbow supported arm pouch advocated for two weeks to minimize the extremity weight along with soft tissue healing. Suture removal done at two weeks. As patients' tolerability pendulum exercises started from two weeks followed passive ROM, assisted active and active ROM added in every 2-3 weeks interval. X-ray taken at four weeks interval. Average union was observed in 3rd to 4th month post operatively. One clinically asymptomatic patient showed sign of delayed union and radiological union observed at 6 month follow up. 5 cases showed radiological loss of reduction around 2-4 mm during 1st month post op radiological evaluation. None of 5 cases shows any further progression of the loss of reduction of clinical symptoms. Two female patients complain about foreign body sensation over the clavicular endobutton. Removal of excessive fiber tape done under local anesthesia and tight closure of the soft tissue at 2 months. No local surgical site wound complication, neurovascular complication, nonunion, fracture of clavicle or coracoids was noted in our cases. UCLA Shoulder Score score was done at four-month post operatively. 35 out of 38 patients shows excellent/good results and their score was above 27. 3 patients had fair/poor and their score was less than 27 at four months. Brief period of immobilizations leads to development of adhesive capsulitis, which reduce the shoulder function and range of motion. All three patients were female with age range 38-43. So, cutting fiber tape appropriate length and the closure of soft tissue with aggressive physiotherapy and close observation needed for female patients.



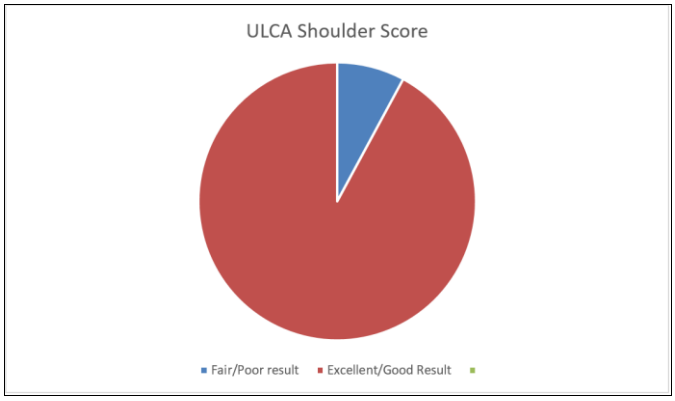


Fig 7: Tight closure of the soft tissue over the cut end of the suture with skin closure

Discussion

Availability of multiple surgical options makes treatment difficult for surgeon [5]. Distal end of clavicle form a plane type synovial joint which permit gliding movement [6]. Incorporation of acromioclavicular joint or penetration of acromioclavicular joint leads to rigidity of the joint and limit the sliding movement. Tension band wiring leads to acromioclavicular joint arthritis, hardware symptoms and a second surgery to removal of hardware [7]. As the TBW or alone K-wire construct is not very rigid in vertical direction so loss of reduction, nonunion, implant breakage are few of the complications [8, 9]. Conventional hook plate where one limb or supported limb of the plate placed under the acromion reduces the sub acromion space lead to complication like rotator cuff tear and osteolysis of the acromion [10, 11, 12]. As hardware symptoms noted removal of plate required the second surgery [13, 14]. Pre contour lateral end clavicle plate is

good surgical option with multi directional screw in distal fragments [15]. Size of the distal fragment and deforming force around fracture poses a great stress on fracture site so loss of reduction is noted and removal of hardware require second surgery. To add additionally stability in vertical direction many study included suture anchor over the coracoids [16]. Rigid fixation with 4.5 mm CC screw or Bosworth screw lead to absolute rigid fixation, associated with clavicle fracture and AC joint arthritis.

Principle of osteosynthesis is to reduce fracture and hold the reduction. Flexible Coracoclavicular fixation leads to indirect reduction of the fracture. Deforming forces as gravity, weight of extremity work in downward direction while upward pull in the clavicle by trapezius make deforming forces works in vertical direction so if fracture fixation work in same vertical direction so it holds the reduction better. A biomechanical study using fresh frozen section shows the direct osteosynthesis using locking plate is inferior to fail on load compare to Coracoclavicular fixation using button or as an augmentation [17]. Coracoclavicular fixation was first described by Neer in 1990 since then it has several modification with use of sutures only, suture anchor suture button, fiber tape or combination of these devices in different method. Flexible fixation without incorporation of the acromioclavicular joint allows the gliding movement of the clavicle leads to better shoulder function. Fracture union rate and the minimal complication associated with flexible fixation makes it more novel and results are comparable to the prior studies [18]. Tight rope is one of the methods of flexible fixation of Coracoclavicular with comparable result other flexible fixation but it requires a specific instrumentation along with higher price. Few studies of flexible Coracoclavicular fixation showed coracoids fracture and that is due to eccentric drilling of coracoid [19]. In our method we use an incision over the coracoid to get the access it, it helps in protecting neurovascular structure, precise positioning of the guide wire over the coracoid and proper flat positing of the endobutton. Once fracture unite it work as an additional stability and does not requires implant removal. Four strand of fiber tape in fashion of tight rope make construct very strong. Loose endobuttons and fiber tape is readily available and economical. No special instruments or system require.

Two small incision makes it cosmetically appalling and safety incision below the coracoid helps in protection of neurovascular structure, along with proper placement of distal endobutton. As minimal loss of reduction observed overtightening of the fiber tape compensate the loss of reduction.

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