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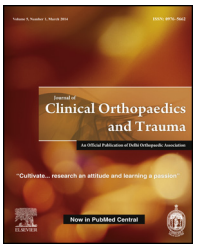

Review Article

Fracture of distal end clavicle: A review

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ABSTRACT

Management of fracture distal end clavicle has always puzzled the orthopaedic surgeons. Now-a-days with a relatively active lifestyle, patients want better results both cosmetically and functionally. Despite so much literature available for the management of this common fracture, there is no consensus regarding the gold standard treatment for this fracture. In this article, we reviewed the literature on various techniques of management for this fracture, both conservative as well as surgical, and their merits and demerits.

1. Introduction

Fracture of distal end of the clavicle is an entity which always creates a doubt in the mind of orthopaedic surgeons. With so many treatment options and numerous recommendations available in the literature, this is one of the most controversial fracture. Till date there is no gold standard treatment recommendation for this injury. The unstable nature of these fractures make them prone for non union and impeding the normal shoulder function. Therefore these fractures should be viewed as special injuries and a definitive line of management has to be outlined. This article reviews the existing literature and puts forward the pros and cons of various treatment modalities available for this fracture.

2. Material and methods

We used three internet search engines – Pubmed, Cochrane and Medline. Following keywords were used – distal clavicle fracture, Neer's type 2 fracture, Neer's type 5 fracture, Tension band wiring, hook plate, coracoclavicular screws, Knowles pin, precontoured locking plate, coracoclavicular cerclage, suture anchors, tight rope for distal clavicle fracture, classification, surgical and conservative management, non union, complications of distal clavicle fracture. We got 160 relevant articles in this search. Out of these we selected 50 articles. Our inclusion criterias were

1. Randomized control trials, case control studies and case series relevant to fracture distal end clavicle published from the year 2000 till date.

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2. Articles published in English language.
3. Articles with 4 or more cases.

Our exclusion criteria were

1. Review articles and meta-analysis.

Finally we had 40 level four studies, 7 level three studies and 3 level two studies. There was no level one study.

3. Epidemiology

Fracture clavicle is one of the most commonly encountered injury in the emergency department. It accounts for 2.6%–4% of the total adult fractures.[1–3] Clavicular fracture has bimodal age distribution. First peak occurs in young active adult males less than thirty years of age. Usually they have a direct force applied to the shoulder as a result of a fall over the shoulder and less commonly by a fall over an outstretched hand. Second peak occurs in elderly females with osteoporotic bones. Distal end fractures occur more commonly in these age group. Though fracture of the shaft is the commonest, lateral end fracture constitutes 21–28% of all clavicle fractures. Of these 10–52% are displaced fractures.[1–3]

4. Classification

Many workers had proposed their own classification systems, each having its own advantages and disadvantages. Initially Allman classified clavicle fractures into three types based on the anatomical location without any prognostic significance.[4] Later Nordqvist and Petersson classified them further based on displacement and comminution.[2] A more useful classification was proposed by Robinson from Edinburgh.[1] He divided them into three basic types of medial fifth, lateral fifth and the intermediate three fifth which were further divided based on displacement, angulation, intra-articular extension and comminution. For the distal end fracture per se, Craig's[5] and Neer's[6,7] classification is more helpful for prognosis and management. While Craig's encompasses the whole clavicle Neer's is specific for the distal end fractures. Basically these classifications are based on the location of the fracture in relation to the coracoclavicular ligament and their intactness. Type 1 Neer's is a fracture lateral to the coracoclavicular ligament attachment, which has very minimal displacement. Type 2 is one which is medial to the ligament attachment. It is again divided into 2A and 2B. In 2A both the conoid and the trapezoid ligaments are attached to the distal fragment and in 2B conoid is detached from the proximal fragment while the trapezoid is attached to the distal fragment. Type 3 is one with intra-articular extension. Type 4 occurs in children where a periosteal sleeve gets avulsed from the inferior cortex with the attached coracoclavicular ligament and the medial fragment gets displaced upwards. Type 5 is similar to type 2 which involves an avulsion leaving behind an inferior cortical fragment attached to the coracoclavicular ligament. Type 2 and 5 are the unstable ones which has many controversies in their management. In Type 2 fractures, the distal clavicle fragment is subjected to the distal pull by the weight of the arm as well as a medial pull by the strong pectoral muscles and Latissimus dorsi, while the proximal fragment is dragged posteriorly by the trapezius. These disturbing forces contribute to the fracture displacement and the unstable nature of Type 2 fractures (Table 1)

5. Clinical and radiological assessment

While fracture of the shaft is a clear cut diagnosis made clinically, diagnosis of the fracture of distal end of clavicle is not so straight. It can be confused with acromioclavicular (AC) joint dislocation, AC joint osteoarthritis and rarely septic arthritis. Patient usually presents with pain and swelling locally and supporting the elbow with the other hand. Tenderness and crepitus can be elicited. Sometimes spike of the medial fragment may be tenting the skin and rarely the fracture may be opened to the external environment. Neurovascular injury is more common in shaft fractures. A plain anteroposterior radiograph of the involved shoulder is usually sufficient for the diagnosis but a 15 ° cephalad AP view and a stress radiograph can be obtained to get additional information about the integrity of the coracoclavicular ligament. Stress view which is more commonly used in the assessment of the coracoclavicular ligament in AC joint dislocation can also be used in distal end fractures too. Five out of the fifty studies chosen had stress radiograph in the diagnostic workup.[8–12] Here the patient is made to stand for the radiograph with 10–15 pounds held in the ipsilateral hand. Classification of distal clavicle by Neer is based on simple anteroposterior radiograph.

6. Treatment

Treatment and outcome of the fracture of distal clavicle depends on displacement and injury to coracoclavicular ligament which makes the fracture unstable. Type 1 injuries generally being stable without any displacement are managed conservatively with a sling to support the weight of the limb. Type 3 injuries are managed similarly which unites as such, but may lead on to AC joint arthrosis which will need surgical resection of the distal fragment. Type 4 is just a periosteal disruption in children and bone fills the periosteal sleeve resulting in union and remodelling. Management of type 2 and 5 are the most controversial topic. Both being similar in instability and displacement can be considered together. Number of treatment modalities are available for their management. Till date no gold standard technique has been described.

For bony union to occur both the fracture ends must be kept opposed. To counter the distractive forces acting on the fracture ends one of the two surgical principles can be done either alone or together – Both the fragments can be fixed internally either with or without the inclusion of the acromion. The difficulty with this type of fixation is that the distal fragment will be very small to get a firm hold with any kind of implant. To counter this problem if we fix the acromion along with them, the normal rotational movement that occur in the

Table 1 – Classifications of fracture clavicle.

Allman	Nordqvist & Petersson	Craig	Edinburgh (Robinson)			Neer
Group 1: mid third	Undisplaced Displaced comminuted	Type 1 : mid third	Medial third (type 1)	Non displaced (1A)	1A1 – Extra-articular 1A2 – Intra-articular	Type 1: fracture lateral to the coracoclavicular ligament attachment, which has very minimal displacement
				Displaced (1B)	1B1 – Extra-articular 1B2 – Intra-articular	Type 2: medial to the ligament attachment 2A – both the conoid and the trapezoid ligaments are attached to the distal fragment 2B – conoid is detached from the proximal fragment while the trapezoid is attached to the distal fragment
			Middle third (type 2)	Cortical alignment fractures (2A)	2A1 – Undisplaced 2A2 – Angulated	Type 3: with intra-articular extension
Group 2: lateral third	Undisplaced Displaced	Type 2: Distal 1/3 fractures a. Minimally displaced b. Displaced fractures, fracture medial to the C–C ligament 1. Conoid and trapezoid intact 2. Conoid torn, trapezoid intact c. Fractures into articular surface d. Fractures in children, intact C–C ligaments attached to periosteal sleeve, proximal fragment displaced e. Comminuted fractures		Displaced fractures (2B)	2B1 – Simple or wedge comminuted 2B2 – Isolated or comminuted segmental	Type 4: occurs in children where a periosteal sleeve gets avulsed from the inferior cortex with the attached coracoclavicular ligament and the medial fragment gets displaced upwards Type 5: avulsion fracture leaving behind an inferior cortical fragment attached to the coracoclavicular ligament
Group 3: medial third	Undisplaced Displaced	Type 3: Proximal 1/3 fractures a. Minimally displaced b. Displaced c. Intra-articular d. Epiphyseal separation e. Comminuted	Distal third (type 3)	Cortical alignment fractures (3A) Displaced fractures (3B)	3A1 – Extra-articular 3A2 – Intra-articular 3B1 – Extra-articular 3B2 – Intra-articular	

AC joint during shoulder abduction and flexion will be hampered and if the joint is violated then it predispose to arthritis. To avoid this removal of the implant at a later date becomes necessary. The second type is bringing the fracture in opposition by fixing the displaced proximal fragment of the clavicle with the coracoid i.e. by reconstructing the torn coracoclavicular ligaments. This will be a rather invasive surgery necessitating the exposure of coracoid and the neurovascular structures near it.

Treatment available can be broadly divided into

1. Conservative management
2. Rigid fixation – osteosynthesis with locking plate, hook plate fixation, fixation with distal radius locking plate, coracoclavicular screws, knowles pin fixation.
3. Flexible fixation – simple k wire fixation, tension band wiring, suture anchors, vicryl tape, dacron arterial graft for coracoclavicular ligament reconstruction.

In this article we reviewed the literature available in the management of these unstable distal clavicular fracture and gave an overview of outcome and complications of the various treatment modalities available. We compared each of the treatment modality under the following aspects – function, time taken for union, complication and re-surgery and revision.

7. Level 4 studies

7.1. Conservative treatment

There is only one level 4 study with 101 patients where conservative treatment was offered.[13] Mean Constant score was 93. 21 patients developed asymptomatic non union. 6 patients had radiological findings suggestive of AC joint arthritis without any symptom. 11 patients had painful non union and 3 patients developed painful AC joint arthritis and all 14 patients needed surgical treatment at a later date. 5 patients developed subacromial impingement which needed steroid injection.

7.2. Precontoured locking plates

Three level 4 studies with a total of 56 patients is available with this type of implant fixation for distal clavicle fractures.[14–16] All fractures united within 6–12 weeks except one which went to non union following a deep infection. These three studies used a number of scoring systems – UCLA (University of California and Los Angeles score), ASES (American Shoulder and Elbow Surgeons score), Constant Murley score, DASH (Disabilities of the arm shoulder and hand score)and shoulder rating questionnaire. On an average all patients had good to excellent results. There were two major complications. One had a fracture at the medial end of the plate and one had deep infection which went to symptomatic non union. In addition to these there were four minor complications – one superficial infection and three hardware symptoms. 10 out of 56 patients had a repeat surgery for plate removal (4 for hardware symptoms, 2 for intra-articular position of screws, 1 for deep infection and 3 had them removed voluntarily).

7.3. Hook plate

There are 10 level 4 studies with 303 patients available on hook plate fixation.[10,17–25] 11 patients developed non union while the rest united within 7 weeks to 4 months, mostly requiring more than 3 months. Functional assessment was done with Constant Murley score in 9 studies, DASH score and Oxford shoulder in two studies, Japanese orthopaedic association shoulder score, ASES and subjective shoulder value in one study each. Most of shoulder functions ranged from good to excellent. There were 30 major complications – 16 dislocation of hook, 8 fracture medial end of the clavicle, 2 symptomatic non union, 2 severe AC joint arthrosis, 1 rotator cuff tear, 1 acromion fracture. Other minor complications include 46 hardware symptoms, 27 acromial osteolysis, 7 superficial infection, 7 asymptomatic non union, 5 minor AC joint arthrosis, 2 hypertrophic scar and 1 frozen shoulder. All except 13 patients had their plates removed by a second surgery under general anaesthesia. These 13 patients refused re-surgery.

7.4. Distal radius plates

There were seven level 4 studies with a total of 110 patients which used distal radius plate for fixation.[11,12,26–30] Among these all except one study[29] used an additional method to fix the displaced clavicle to the coracoid. Fractures united within 6–10 weeks. At follow up patients had excellent shoulder function as assessed by constant and DASH score. Few minor complications were observed – 22 hardware symptoms, 1 imminent perforation, 2 non union with hardware failure and 3 superficial infections. Of these patients with hardware symptoms and non union needed re-surgery.

7.5. Coracoclavicular screws

There were 3 studies with level 4 evidence on coracoclavicular screw fixation for fracture distal end of clavicle comprising a total of 59 patients.[8,31,32] Union was achieved within 6–10 weeks. All the three studies used a separate system for evaluation of shoulder function – Constant Murley's, American Shoulder and Elbow Surgeons shoulder Index and simple shoulder test questionnaire. Though a comparison cannot made between these scoring system all patients on an average had good to excellent functional scores. All patients needed screw removal which was done under local anaesthesia. Three patients had minor complications. One had a superficial infection which resolved with treatment, two had screw back out and one non co-operative patient had implant failure which led on to malunion. But none of them had any compromise with the function.

7.6. Flexible coracoclavicular fixation

Four level 4 studies with 82 patients were available using this method.[9,33–35] All but one united within 6–23 weeks. One patient had asymptomatic fibrous non union. Two studies

used Constant Murley scoring system and the other two used UCLA score and Karlsson's criteria. Nearly all patients had excellent results with few of them having good results. Few minor complications occurred. One developed frozen shoulder, one asymptomatic non union, two minor infections, one titanium wire breakage and one uncomfortable subcutaneous tenting of the mersilene tape. No major re-surgery needed. Few of the above mentioned infected and broken fixation material needed removal under local anaesthesia.

7.7. Arthroscopic treatment

There were four level 4 studies available with a total of 39 patients.[36–39] All but one fracture united, the one had asymptomatic non union. Function was assessed with a variety of scoring system like the Constant Murley, DASH, UCLA and AAOS (American Academy of Orthopaedic Surgeons score). All had good to excellent results. There were 5 minor complications – 2 frozen shoulder, 1 symptomatic AC joint arthritis, 1 superficial infection and 1 asymptomatic non union. No one needed re-surgery.

7.8. Intra-medullary fixation

Four level 4 studies with a total of 69 patients were found on intra-medullary fixation for distal clavicle fractures.[40–43] Among these two studies used Knowles pins and the other two used 4.5 mm AO/ASIF screw. One of the studies that used Knowles pin fixed the fracture trans-acromially and the rest did it extra-acromially. Time for bony union ranged from 6 to 12 weeks and no patient had non union. Functional evaluation was done with UCLA scores in two studies, and the other two used Constant Murley and Oxford shoulder score. On an average patients in all the studies had excellent function as assessed with the above scoring system. No serious complication occurred. 5 of the patients had minor complications. One had a delayed superficial infection, three had irritation of the thread and hub of the Knowles pin, one patient in the study with trans-acromial Knowles pin fixation had AC joint arthrosis, which was mildly symptomatic and did not progress during a five year follow up.

7.9. Tension band fixation

There were four level 4 studies that employed tension band fixation.[44–47] Of these 3 used suture material and one study used K wires and SS wires with 34 and 12 patients respectively. Fracture union occurred within 6–16 weeks. Function as assessed with Constant Murley scoring was excellent. No complication occurred and no re-surgery was necessary.

8. Level 3 studies

8.1. Hook plate compared with K wire tension band wiring

There are three level 3 studies with a total of 207 patients in this category.[48–50] 141 patients were treated with hook plates and 66 were treated with K wire tension band wiring of which 10 were extra-articular and the rest were trans-articular. Average Constant Murley score was 90 for the hook plate group and 86 for the TBW group. In the hook plate group 8 had peri-prosthetic fractures, 6 implant related complications and 2 non union of which one was symptomatic. In the TBW group 15 patients had K wire migration, 14 had loss of reduction, 5 had superficial infection, 2 had asymptomatic non union and one patient had wire breakage. All hook plates and almost all K wires needed implant removal.

8.2. Coracoclavicular sutures compared with non operative management

We had one comparative study with 16 patients treated with a sling and 14 with coracoclavicular sutures.[51] Osseous union occurred by 8–12 weeks in the non operative group and 6–10 weeks in the operative group. No significant difference occurred in function as measured with UCLA, ASES and Constant Scores. 7 of the patients treated non operatively showed non union of which two were symptomatic. But none needed surgery. The other group had no complication and no re-surgery was needed.

8.3. Hook plate compared with distal radius plating with coracoclavicular fixation

There was a single study comparing 10 hook plate fixation with 5 distal radius plating with coracoclavicular fixation.[52] Coracoclavicular fixation was achieved with either endobutton device, suture anchors or coracoid cerclage. There was no significant difference in functional scorings between the two group although return to recreational activity was early in the second group. Complication was more with hook plate, with 5 acromial osteolysis and hook migration, 3 asymptomatic AC joint degeneration, 1 AC joint superior subluxation and 1 non union. The other group had 3 asymptomatic AC joint superior subluxation. Also 9 out of the ten patients needed hook plate removal whereas distal radius plate did not need removal.

8.4. Hook plate compared with locking plate with suture augmentation

One study compared hook plate fixation with superior locking plate plus suture augmentation.[53] 22 patients were fixed with hook plate and 16 patients were fixed with locking plate and augmented with coracoclavicular sutures. Functional outcome as assessed by ASES was almost similar (72.4 for hook plate group and 77.1 for locking plate group). Complications were significantly higher in hook plate group with 3 peri-implant fracture, 1 infection and 1 hardware failure whereas only one case of surgical infection occurred in locking plate group. 13 patients needed hook plate removal whereas only 4 patients needed locking plate removal.

8.5. Trans-acromial pins with and without tension band wire

One study compared the results of fracture distal clavicle fixed with trans-acromial pins with (15 patients) and without (14

patients) tension band wire.[54] Functional outcome as measured by UCLA score and the time required for bony union was almost similar between the two groups. But there was a significant difference in the complication rate – 6 patients in the group without tension band wire had skin erosion and pin migration which needed removal within the third post-operative day, whereas only one patient had similar in the other group, that too after 3 months.

9. Level 2 studies

9.1. *Hook plate compared with tension band wiring*

One level 2 study with 65 patients compared fixation of distal clavicle with hook plate (35 patients) and trans-acromial tension band wiring (TBW) (30 patients).[55] Oxford shoulder score at 3 months was worse in the hook plate group but became comparable at 6 months. Mean time for union was 14.2 weeks for the hook plate group whereas it was 13.8 weeks for the TBW group. 9 patients in the hook plate group had subacromial erosion while 5 patients in the TBW group showed K wire migration externally. Routine removal of implant was done after one year.

9.2. *Cadaveric studies*

There were two cadaveric studies with level 2 evidence.[56,57] In one study[56] 15 cadeveric shoulders were used to create distal clavicle fractures which were fixed with 4 different techniques and the strength of each fixation was compared. Coracoclavicular suturing, distal clavicle locking plate, distal clavicle locking plate with coracoclavicular suture augmentation and hook plating are the four techniques which were employed. They found that there was no significant difference in the biomechanical strength of these techniques but mode of failure was worse in the hook plate and suture – augmented plate groups, where a secondary fracture almost always occurred when the fixation failed. In another cadaveric study done by Madsen et al[57] the stability of distal clavicle fracture fixed with superior locking plate was compared with the combined fixation of the same with coracoclavicular suture anchor and superior locking plate. 6 fresh frozen shoulder was used in each group. Addition of a coracoclavicular suture anchor improved the stability of fixation as evidenced by the increased amount of force needed to disrupt the fixation. Also the mode of failure was simple where anchor pull out occurred in 4 and distal clavicle split occurred in 1, while in the other group without suture augmentation failure occurred by distal clavicle split in 3 and AC joint displacement in 1.

10. Discussion

Management of distal clavicle had taken various turns ever since Neer's observation of the highly unstable nature of the fracture and the high rate of non union associated with it.[6,7] There will be very few fractures in orthopaedics which has so many treatment options available yet still there is no gold standard treatment for this peculiar fracture. We reviewed these methods and made a comparison of the following parameters – time for union, functional outcome, complications and the need for re-surgery.

Starting with conservative management treatment options includes many rigid and flexible fixation methods. Though there is a debate in the exact figure, rate of non union is definitely much more when this fracture is managed conservatively. There was one level 4 study where there was 10% non union rate and one level 3 study where conservative management was compared with flexible coracoclavicular fixation which again showed increased non union rate of almost up to 50%.[7,45] It seems operative intervention is definitely needed as observed in older studies.[6,7]

Plating is one of the surgical option for this fracture. But the distal fragment will be too small to be rigidly held with ordinary plates. Special pre-contoured superior locking plates were particularly developed for this purpose. The lateral end of the plates has multiple 2.7 mm locking screw holes, in diverging configuration for the best possible hold. This allow early mobilization. Out of the 56 patients there was only one major complication directly related to the implant – fracture at the medial end of the plate. Also functional outcome was good. This implant neither cross the AC joint nor hinders the rotational movement of clavicle at the AC joint making implant removal unnecessary. But due to impingement, 10 patients needed plate removal and this had to be done under general anaesthesia. Similarly in one level 3 study where a comparison was made with hook plate this technique proved to be better with no implant related complications whereas 4 of the 22 patients with hook plate fixation had severe implant related complications.[53] Also re-surgery for implant removal was lesser. Sometimes the AC joint can remain mal-reduced even after anatomical reduction. To counter this one of the studies added a suture anchor or a simple non absorbable suture for coracoclavicular fixation.[15] In few cases they used a screw through the plate and fixed it to the coracoid. Loss of fixation in the distal fragment leading to implant failure, entry of screw into the AC joint and infection due to an extensive dissection are some of the possible complications.

AO hook plate for distal clavicular fracture was first introduced in 1997 in Europe.[24] This was designed to overcome the shortcomings of other available implants. With a small distal fragment normal plate, fixation will be difficult and the implants which are used for fixation between clavicle and coracoid or the clavicle and acromion will restrict full shoulder range of motion till union and implant removal there by delaying rehabilitation and increases the chances of implant breakage if the initial precautions are not followed. Hook plate has a small hook which levers under the acromion without any need for fixation in the distal fragment. The mechanics of hook plate is such that it has no rotational stiffness and allow normal rotation at the AC joint allowing undisturbed bone healing. AC joint is left undisturbed. But abduction of the arm beyond 90 ° is not allowed because this causes the subacromial structures to come in contact with the hook there by getting damaged. Increased incidence of complications like subacromial impingement, rotator cuff ruptures, acromion fractures, acromial osteolysis and pain originating from the hook hole enlargement and the need for general anaesthesia for its removal is becoming a major concern. This is the most

frequently studied technique for fracture distal end clavicle with ten level 4 studies and six level 3/2 studies.[10,17–25,48–50,52,53,55] In studies with level 4 evidence though functional outcome was good complication rate was high with 10% of the patients had some major complication.[10,17–25] In three level 3 studies hook plate was compared with wiring where there was slightly better function and less complication rates but major complications occurred with the hook plate patients.[48–50] In other two level 3 studies hook plate was compared with distal radius plate and locking plate where hook plate seemed to have higher complication rate and re-surgery rate for implant removal.[52,53] One level 2 study comparing hook plate with tension band wiring showed both the techniques to have comparable results.[55] Overall it seems that in spite of giving good functional outcome hook plate tend to produce major complications and there is a definite need for implant removal which again puts the patient under risk of one more general anaesthesia.

Distal radius plate can also be used to fix distal clavicle fracture. The broad part of the T plate suits well for the distal fragment and three to four screws can be inserted into it getting a firm hold. Available level 4 studies showed a 22% implant related complications, although they are minor, and the same number of patients needed implant removal under general anaesthesia.[11,12,26–30] As already mentioned the one level 3 study which compared this implant with the hook plate showed it to have lesser complication and re-surgery rate.[52] Technically speaking there should be no need for implant removal as there is no breach into the AC joint. But hardware symptoms and implant failure can occur which needs an implant removal surgery. All the studies concerning distal radius plate except one[29] used coracoclavicular sutures to augment the fixation and prevent screw back out.

Simple isolated coracoclavicular fixation with flexible materials can be used in isolation also. This neutralizes the deforming forces and bring the fracture fragments together so that union takes place. Mersilene tape, Ethibond sutures, titanium cables, dacron graft etc. are used for this purpose. Studies with this type of fixation showed excellent results without any major complications. No need for hardware removal and sparing of the AC joint are the major advantage of this procedure. Stress riser in the coracoid and secondary fracture was a concern. But this being a flexible fixation the chance for such a complication is remote. Also this is particularly seen in cases of AC joint dislocation, whereas in distal clavicle fracture after fracture union stress becomes concentrated on the bone relieving the fixation material. Extensive dissection to reach the coracoid is a disadvantage of this technique. Recently coracoclavicular fixation for fracture distal end clavicle is being done arthroscopically. After entering the joint the scope is passed through the rotator interval and with endobuttons and tight rope coracoclavicular fixation is done. This type of fixation again neutralizes the displacement and brings the fracture fragments together. This procedure does not open the AC joint and there is no need for implant removal at a later date. Four level 4 studies which are available showed good functional outcome with few minor complications and no need for re-surgery.[9,33–35] This procedure is technically demanding, requiring significant skills and anatomical knowledge. Difficulty arises when placing the fixation in the coracoid as it should be in the centre to avoid coracoid fracture and also the neurovascular structures along the medial side should be simultaneously warded off.

Coracoclavicular screws were initially used for treating AC joint dislocations. Today its application has been extended to distal clavicle fractures. It basically nullifies the deforming forces acting on the fracture fragments and keeps them approximated indirectly until union. There were no major complications in the available studies and the functional outcome was also satisfactory.[8,31,32] This fixation method has some limitations too although not encountered in the above studies. Though the fracture site need not be opened always, access to coracoid is needed there by having a chance to injure the neurovascular structures beneath it. Also full range of motion is restricted until screw removal to avoid screw cut out or fracture of the coracoid. Second surgery to remove the implant is a must.

Intra-medullary fixation is also possible for fracture distal end clavicle. Advantage of intra-medullary fixation over extra-medullary implant is a smaller incision, lesser soft tissue handling, relative protection of supra-clavicular nerves and above all these implants could be removed under local anaesthesia. Similarly intra-medullary fixation also seemed to have no major complications with good functional outcome. Among the very few minor complications AC joint arthrosis occurred only when trans-acromial fixation was done implying that this can be avoided by going extra-acromially. Also the hardware related symptoms occurred only with Knowles pin and not with AO/ASIF screw. This is probably because the hub of the Knowles pin is larger than the head of the screw and the tip is more sharper. Also the screw has a larger diameter offering a more rigid fixation. These factors make us believe that extra-acromial fixation with AO/ASIF screw will be the ideal intra-medullary technique. All patients had their implant removed under local anaesthesia after bony union. Problem with this technique is the length and direction of the screw should be perfect otherwise the cortex will be breached and cause irritation. Implant migration and breakage are also a possibility.

Fixation with K wires and applying a tension band is an age old technique for distal clavicle fracture. This is usually done extra-acromially but sometimes the distal fragment will be so small that trans-acromial tension band wiring has to be done. Removal of the implant is always needed in trans-acromial fixation because it hinders the rotational movement of clavicle at the AC joint. Usage of this technique needed no severe soft tissue stripping and no heavy hardware has to be inserted. Technique is also simple. If at all necessary the implant can be removed under local anaesthesia. If not applied trans-acromially AC joint also can be spared. K wire migration is a major concern, particularly with osteoporotic bones. 10–15% of the patients in the available studies had implant migration.[48–50,54,55] This can be avoided if the wire is bent distally so that even if it migrates it does so exteriorly. Further in studies in which suture materials were used for tension band wiring no re-surgery or complications were recorded.[44–46]

All the techniques showed not much difference in the time required for union but union rate was less when conservatively treated. The chance for implant failure was more with

K wire tension band wiring with almost 10% of the patients went for loss of reduction in the three level 3 studies.[48–50] Rest of the fixation techniques showed minimal failure rate. In the two cadaveric studies strength of the fixation techniques showed no great difference.[56,57] Functional outcomes cannot be accurately compared as a variety of assessment techniques were employed in the available studies. Anyways, all the techniques had good to excellent functional outcomes as assessed by various shoulder scoring systems. Complication rate was particularly higher when rigid fixation techniques were employed. Major complications like peri-implant fracture occurred more commonly with hook plate fixation. AC joint arthrosis and rotator cuff tear though commonly anticipated with hook plate were not frequent. Generally implant related complications are more common with rigid fixation techniques like the hook plate, locking plate and the distal radius plates. Although flexible fixation techniques seemed to be weak, such is not the case as seen by the very few failure rate. On a whole, coracoclavicular screw fixation and flexible coracoclavicular fixations had fewer complications. Removal of the implant is also an important parameter to consider. Most of the rigid implants needed implant removal either for biomechanical reason or due to hardware symptoms and this puts the patient under the risk of general anaesthesia. Tension band wires and coracoclavicular screws though needs removal can be done under local anaesthesia. Occurrence of infection was not different between the techniques against our belief that infection rate depends on the invasiveness of the technique. But most of these observations are made from the large number of level 4 studies and few level 3/2 studies. There is not a single level 1 study available. Further, non uniformities of the studies made comparison difficult.

11. Conclusion

Distal clavicular fracture due to its unstable nature needs operative fixation. The purpose of fixation is to avoid the deforming forces acting on the fragments which can be done with flexible or rigid fixation. Though function achieved was nearly equal doing a flexible and semirigid fixations like open or arthroscopic coracoclavicular fixation, tension banding with sutures and coracoclavicular screws seems to avoid most of the implant related secondary complications. Further rigid fixations need a major re-surgery for implant removal whereas flexible fixation, if at all needed implant removal can be done with a simple surgery under local anaesthesia. Further studies with higher levels of evidences are needed to make out the single definitive treatment of this special fracture.

Conflicts of interest

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

1. Robinson CM. Fractures of the clavicle in the adult. Epidemiology and classification. *J Bone Joint Surg Br*. 1998;80:476–484.
2. Nordqvist A, Petersson C. The incidence of fractures of the clavicle. *Clin Orthop Relat Res*. 1994;300:127–132.
3. Postacchini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fractures. *J Shoulder Elbow Surg*. 2002;11:452–456.
4. Allman Jr FL. Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am*. 1967;49:774–784.
5. Craig EV. Fractures of the clavicle. In: Rockwood CA, Matsen FA, eds. *The Shoulder*. Philadelphia: WB Saunders; 1990:367–412.
6. Neer CS. Fractures of the distal clavicle with detachment of the coracoclavicular ligaments in adults. *J Trauma*. 1963;3:99–110.
7. Neer CS. Fractures of the distal third of the clavicle. *Clin Orthop*. 1968;58:43–50.
8. Macheras G, Kateros KT, Savvidou OD, et al. Coracoclavicular screw fixation for unstable distal clavicle fractures. *Orthopaedics*. July 2005;28(7):693–696.
9. Webber MC, Haines JF. The treatment of lateral clavicle fractures. *Injury*. 2000;31:175–179.
10. Renger RJ, Roukema GR, Reurings JC, et al. The clavicle hook plate for Neer type 2 lateral clavicle fractures. *J Orthop Trauma*. 2009;23:570–574.
11. Sclliemann B, Roblenbroich S, Schneider KN. Surgical treatment of vertically unstable lateral clavicle fractures (Neer 2b) with locked plate fixation and coracoclavicular ligament reconstruction. *Arch Orthop Trauma Surg*. 2013;133:935–939.
12. Herrmann S, Schmidmaier G, Greiner S. Stabilisation of vertical unstable distal clavicular fractures (Neer 2b) using locking T – plates and suture anchor. *Injury*. 2009;40:236–239.
13. Robinson CM, Cairns DA. Primary nonoperative treatment of displaced lateral fractures of the clavicle. *J Bone Joint Surg Am*. Apr 2004;86A(4):778–782.
14. Lee SK, Lee JW, Song DG, Choy WS. Precontoured locking plate fixation for displaced lateral clavicle fractures. *Orthopedics*. Jun 2013;36(6):801–807.
15. Anderson JR, Willis MP, Nelson R, Mighell MA. Precontoured superior locking plating of distal clavicle fractures: a new strategy. *Clin Orthop Relat Res*. 2011;469:3344–3350.
16. Tiren D, Joseph P, Vroemen AM. Superior clavicle plate with lateral extension for displaced lateral clavicle fractures: a prospective study. *J Orthopaed Traumatol*. 2013;14:115–120.
17. Meda PV, Machani B, Sinopidis C, et al. Clavicular hook plate for lateral end fractures – A prospective study. *Injury*. 2006;37:277–283.
18. Flinkkila T, Ristiniemi J, Lakovaara M, Hyvonen P, leppilahti J. Hook plate fixation of unstable lateral clavicle fractures. *Acta Orthop*. 2006;77(4):644–649.
19. Good DW, Lui DF, Leonard M, Morris S, McElwain JP. Clavicle hook plate fixation for displaced displaced lateral third clavicle fractures(Neer type 2): a functional outcome study. *J Shoulder Elbow Surg*. 2012;21:1045–1048.
20. Lee KW, Lee SK, Kim KJ, et al. Arthroscopic-assisted locking compression plate clavicular hook fixation for unstable fractures of the lateral end of the clavicle: a prospective study. *Int Orthop*. 2010;34:839–845.
21. Tambe AD, Motkur P, Qamar A, Drew S, Turner SM. Fractures of distal third of the clavicle treated by hook plating. *Int Orthop*. 2006;30:7–10.
22. Haidar SG, Krishnan KM, Deshmukh SC. Hook plate fixation for type 2 fractures of the lateral end of the clavicle. *J Shoulder Elbow Surg*. 2006;15(4):419–423.

23. Kashii M, Inui H, Yamamoto K. Surgical treatment of distal clavicle fractures using the clavicular hook plate. *Clin Orthop Relat Res*. Jun 2006;447:158–164.
24. Muramatsu K, Shigetomi M, Matsunsga 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;127:191–194.
25. Tiren D, Van Bemmel AJM, Swank DJ, Van der Linden FM. Hook plate fixation of acute displaced lateral clavicle fractures: mid -term results and a brief literature overview. *J Orthop Surg Res*. 2012;7:2.
26. Martetschlager F, Kraus TM, Schiele CS, et al. Treatment of unstable distal clavicle fractures (Neer 2) with locking T – plate and additional PDS cerclage. *Knee Surg Sports Traumatol Arthrosc*. 21:1189–1194.
27. Hohmann E, Hansen T, Tetsworth K. Treatment of Neer type 2 fractures of the lateral clavicle using distal radius locking plates combined with tightrope augmentation of the coracoclavicular ligaments. *Arch Orthop Trauma Surg*. 2012;132:1415–1421.
28. Daglar B, Delialioglu OM, Minareci E, et al. An alternative fixation method for the treatment of unstable distal clavicle fractures: locked distal radius plate. *Acta Orthop Traumatol Turc*. 2009;43(4):324–330.
29. Chao YU, Yue-hua S, Chang-qing Z, Ding-wei S, You W. Treatment of distal clavicle fracture with distal radius volar locking compression plate. *Chin J Traumatol*. 2009;12(5):299–301.
30. Kalamaras M, Cutbush K, Robinson M. A method of internal fixation of unstable distal clavicle fractures: early observations using a new technique. *J Shoulder Elbow Surg*. 2008;17(1):60–62.
31. Fazal MA, Saksena J, Haddad FS. Temporary coracoclavicular screw fixation for displaced distal clavicle fractures. *J Orthop Surg*. 2007;15(1):9–11.
32. Esenyel CZ, Ceylan HH, Ayanoglu S, et al. Treatment of Neer type 2 fractures of the distal clavicle with coracoclavicular screw. *Acta Orthop Traumatol Turc*. 2011;45(5):291–296.
33. Yang SW, Lin LC, Chang SJ, et al. Treatment of acute unstable distal clavicle fractures with single coracoclavicular suture fixation. *Orthopedics*. Jun 2011;34(6):e172–e177.
34. Soliman O, Koptan W, Zarad A. Under -corocoid-around -clavicle (UCAC) loop in type 2 distal clavicle fractures. *Bone Joint J*. 2013;95-B:983–987.
35. Li Y, Shi S, Ou-Yang YP, Liu TL. Minimally invasive treatment for Neer 2b distal clavicle fractures with titanium cable. *J Trauma*. 2011;71:E37–E40.
36. Pujol N, Philippeau JM, Richou J, et al. Arthroscopic treatment of distal clavicle fractures: a technical note. *Knee Surg Sports Traumatol Arthrosc*. 2008;16:884–886.
37. Loriaut P, Moreau PE, Dallaudiere B, et al. Outcome of arthroscopic treatment for displaced lateral clavicle fractures using a double button device. *Knee Surg Sports Traumatol Arthrosc*. 2013 Nov 12 [Epub ahead of print].
38. Takase K, Kono R, Yamamoto K. Arthroscopic stabilization of Neer type 2 fracture of the distal clavicle fracture. *Acta Orthop Trauma Surg*. 2012;132:399–403.
39. Checchia SL, Doneux PS, Miyazaki AN, Fregoneze M, Silva LA. Treatment of distal clavicle fractures using an arthroscopic technique. *J Shoulder Elbow Surg*. 2008;17(3):395–398.
40. Ming Jou I, Chiang EP, Lin CJ, et al. Treatment of unstable distal clavicle fractures with Knowles pin. *J Shoulder Elbow Surg*. 2011;20:414–419.
41. Fann CY, Chiu FY, Chuang TY, Chen CM, Chen TH. Transacromial Knowles pin in the treatment of Neer type 2 distal clavicle fractures. A prospective evaluation of 32 cases. *J Trauma*. 56:1102–1106.
42. Lin HH, Wang CS, Chen CF, et al. Treatment of displaced distal clavicle fractures with a single cortical screw. *Orthopedics*. Mar 2013;36(3):199–202.
43. Scadden JE, Richards R. Intramedullary fixation of Neer type 2 fractures of the distal clavicle with an AO/ASIF screw. *Injury*. 2005;36:1172–1175.
44. Mall JW, Jacobi CA, Philipp AW, Peter FJ. Surgical treatment of fractures of the distal clavicle with polydioxanone suture tension band wiring: an alternative osteosynthesis. *J Orthop Sci*. 2002;7:535–537.
45. Badhe SP, Lawrence TM, Clark DI. Tension band suturing for the treatment of displaced type 2 lateral end clavicle fractures. *Arch Orthop Trauma Surg*. 2007;127:25–28.
46. Levy O. Simple, minimally invasive surgical technique for treatment of type 2 fractures of the distal clavicle. *J Shoulder Elbow Surg*. Jan/Feb 2003;12(1):24–28.
47. Kao FC, Chao EK, Chen CH, et al. Treatment of distal clavicle fractures using Kirschner wires and tension-band wires. *J Trauma*. 2001;51:522–525.
48. Lee YS, Lau MJ, Tseng YC, et al. Comparison of the efficacy of hook plate versus tension band wire in the treatment of unstable fractures of the distal clavicle. *Int Orthop*. 2009;33:1401–1405.
49. Wu K, Chang CH, Yang RS. Comparing hook plates and Kirschner tension band wiring for unstable lateral clavicle fractures. *Orthopedics*. 2011;34(11):e718–e723.
50. Flinkkila T, Ristiniemi J, Hyvonen P, Hamalainen M. Surgical treatment of unstable fractures of the distal clavicle. *Acta Orthop Scand*. 2002;73(1):50–53.
51. Rokito AS, Zuckerman JD, Shaari JM, et al. A comparison of non operative and operative treatment of type 2 distal clavicle fractures. *Bull Hosp Jt Dis*. 2002-2003;61(1&2):32–39.
52. Tan HL, Zhao JK, Qian C, Shi Y, Zhou Q. Clinical results of treatment using a clavicular hook plate versus a T plate in Neer type 2 distal clavicle fractures. *Orthopedics*. 2012;35(8):e1191–e1197.
53. Klein SM, Badman BL, Keating CJ, et al. Results of surgical treatment for unstable distal clavicular fractures. *J Shoulder Elbow Surg*. 2010;19:1049–1055.
54. Tsuei YC, Au MK, Chu W. Comparison of clinical results of surgical treatment for unstable distal clavicle fractures by transacromial pins with and without tension band wire. *J Chin Med Assoc*. 2010;73(12):638–643.
55. Hsu TL, Hsu SK, Chen HM, Wang ST. Comparison of hook plate and tension band wire in the treatment of distal clavicle fractures. *Orthopedics*. 2010 Dec 1;33(12):879.
56. Bishop JY, Roesch M, Lewis B, Jones GL, Litsky AS. A biomechanical comparison of distal clavicle fracture reconstructive techniques. *Am J Orthop (Belle Mead NJ)*. 2013 Mar;42(3):114–118.
57. Madsen W, Yaseen Z, La France R, et al. Addition of a suture anchor for coracoclavicular fixation to a superior locking plate improves stability of type 2b distal clavicle fractures. *Arthroscopy*. 2013 Jun;29(6):998–1004.