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Different Modalities of Fixation of Displaced Lateral End Clavicle Fracture and Their Functional Outcome

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Abstract

Background: Due to high rate of nonunion in displaced lateral end clavicle fracture, open reduction and internal fixation usually preferred. But dilemma over the choice ofimplant and surgical procedure is still continue.

Aims: our aims of this prospective study were to assess outcome of different modalities offixation of lateral end clavicle fracture in terms of radiological union, pain, range of motion, return to activity .To assess the merits and demerits of different modalities of fixation. To determine which surgical treatment is most preferred for this fracture.

Material and methods: 46 patients who fulfill our inclusion criteria were included in our study. All patients were treated randomly with different modalities. Post operatively patientswere assessed at 8 weeks, 12weeks, 6 months and one year. Two were lost to follow up, final outcome of 44 patients were assessed in terms of radiological union and by constant shoulder score.

Observation and results: Most of cases were in between 3rd to 4th decade of life with mean age 38.96±8.40 years. M: F ratio was- 4.5: 1. R: L ratio was = 2.38: 1. Mean constant score of Endobutton group was 93.5±6 which was better than the mean constant score of k-wire group [83.25±13], TBW group[84.22±10.75], CC screw group[87.75±12.05] and hook plate group[90±7.24]. The complications in K-wire group, TBW group, CC screw group, Hook plate group and Endobutton group were 50%, 44.44%, 22.22%, 40% and 0% respectively. All treatment modalities except Endobutton needs implant removal. Early return to activity in Endobutton group as compared toother modalities.

Conclusion: Endobutton fixation is the preferred surgical technique for displaced lateral endclavicle fracture.

Keywords: Lateral End Clavicle Fracture, Constant Shoulder Score, Endobutton Fixation

Introduction

Despite easy to diagnose, lateral end clavicle fracture management poses a great controversy because complications of various treatment modality and rarity of litrature regarding the most preferred strategy among the available surgical options.

Clavicle fractures are 44% of all shoulder girdle injuries and 2.6% of all fractures[3,4]. Mid shaft clavicle fracture is the most common type(80 to 85% of clavicle fractures) followed by lateral third(20%) and medial third(5%) fracture[1,2,3,4]. Conservative treatment is satisfactory for most of the middle third fracture, but rotational movement and deforming force acting of lateral end clavicle make it more susceptible to nonunion and so treat as different entity. In 1960, Neer came to know that inherent difficulty while treating lateral end clavicle fracture[5]. In 1968, Neer classified lateral end clavicle fracture for better treatment plan[1].

Neer Classification

Type I; stable fracture located lateral to coracoclavicular ligament.

Type II; unstable fracture in which coracoclavicular ligament detached from medialfragment.

In 1982 Rockwood classified type II fracture in IIa and IIb.

Type IIa; both conoid and trapezoid ligament connected to distal fragment. Type IIb; trapezoid ligament remains intact and conoid ligament is ruptured. Type III; intra-articular extension into acromioclavicular joint.

Unstable type 2 fracture pose 20-50%(Neer[5] 1960, Nordqvist[4] 1997, Robinson and Carin[7] 2004) chance of nonunion when nonoperative treatment is elected[5]. To reduce the chance of nonunion most investigators (Neviaser 1963, Neer 1960, Eskola[9] 1987,Post 1989,Kona et al 1990, Ballmer and Gerber[11] 1991, Edward et al[10] 1992) preferred surgical intervention by means of open reduction and internal fixation for displaced lateral end clavicle fracture but harmony regarding the ideal surgical treatment is still in great debate.

Aims and objectives

1. To assess the outcome of various modalities of fixation of displaced lateral end clavicle fracture.
2. To assess various complications and complication rate pertaining to particular treatment modalities.
3. To evaluate merits and demerits.
4. To compare intra operative parameters.
5. To define indications and contraindications of particular treatment modalities. 6. To study the most preferred treatment modality among the available options.

Materials and methods

After clearance from ethical committee, this prospective study was conducted on 46patients with displaced lateral end clavicle fracture, aged from 24 to 56 years (meanage 38.96±8.40years) who were treated with different modalities of fixation. All fresh cases (<3 weeks of injury) of displaced(type 2) lateral end clavicle fracture, both male and female were included in our study. The patients with malunited, nonunited, compound, pathological and/or bilateral clavicle fracture, less than 18year of age, same side scapular, humeral, forearm bone fractures and medically unfit patients were excluded from out study. Fractures were classified according to Neer's classification after antrioposterior skiagram.

Informed and written consent was taken prior to surgery. All patients were randomly treated with different modalities. Our modalities of fixation were K-Wire, endobutton, tension band wiring, coraco-clavicular screw and hook plate fixation. Sling protection was given postoperatively until radiological and clinical sings of union was not noted. Patients were followed up at 8week, 12 weeks, 6 month and 1 year. Mean follow up was 10±1.8months (range 6-14months). Complications like infection, nonunion, subacromial impigment, acromial osteolysis, malunion were noted. Radiological outcome

was measured in terms of skiagram. Visible bridging callus formation in three cortex or disappearance of fracture line on skiagram and absence of pain clinically, considered as union. Functional outcome was assessed using constant shoulder score.

Statistical analysis was done using Microsoft excel 2010 software in terms of mean,standard deviation, percentage and proportion.

Observations and results

In this prospective study 46 cases of displaced lateral end clavicle fracture were included. Among them two were lost to follow up. Final outcome of 44 patients were evaluated (Table 1).

Table 1: Various parameters of patients included in this study

Parameters		K-Wire group	TBW group	CC Screw group	Hook Plate group	Endobutton Group
No of cases		08	09	09	10	08
Mean age(years)		37.63±8.93	36.67±8.44	39.1±7.37	40±9.23	40.875±9.20
Mean duration of surgery (mins)		40±3.78	70±9.60	54.44±3.91	64.9±10.71	51.25±8.35
Mean intraoperative blood loss(ml)		45.00±10.69	56.67±15.81	51.11±14.53	64.00±18.97	61.25±14.5 8
Union time (for united fractures)	<9 Weeks	57.14%	100%	88.89%	80%	75%
	10-12 Weeks	42.86%	-	11.11%	20%	25%
Mean time for radiologicalunion		9.42±1.27	8.5±0.53	7.89±1.36	8.5±1.08	8.375±1.60
Percentage of nonunion		12.5%	11.11%	-	-	-
Complication rate		50%%	44.44%	22.22%	40%	0%
Implant removal done in		All cases	All cases	All cases	All cases	Not needed
Mean time interval for implant removal[weeks] [Mean±SD]		9.63±2.56	10.89±2.26	9.1±1.05	24.4±2.95	-
Mean constantscore [Mean ± SD]		83.25±13	84.22±10.75	87.75±12.05	90±7.24	93.5±6
Functional result	Excellentt	62.5%	77.78%	77.78%	80%	87.5%
	Good	25%	11.11%	11.11%	10%	12.5%
	Fair	12.5%	11.11%	11.11%	10%	0%
	Poor	0%	0%	0%	0%	0%

All demographic data of different modalities were comparable. Most of cases were in between 3rd to 4th decade of life with mean age 38.96+8.40 years. Males were affected more than females with M:F ratio was- 4.5 : 1. Right side involved more than left side with most cases were right dominant. The R:L ratio was = 2.38 : 1.

Most cases were labourer or servicemen in our study. Fall from height on outstretched hand was the most common mechanism of injury. 41 cases (93.18%) were operated within 7 days after injury. 84.09% in our series did not require hospital stay more than 7 day. 8 cases(18.18%) had associated injuries like chest injury, head injury, leg bone fracture, face injuries which were managed accordingly. various complications were observed like infection, screw cut out, subacromial impigment, subacromial osteolysis, nonunion, implant failure etc. Percentage of cases Return to previous activity within 6 month in k- wire group, TBW group, CC screw group, Hook plate group and Endobutton group was respectively 25%, 22.22%, 55.56%, 20%, 100%.

Discussion

Fractures of lateral end clavicle are easy to diagnose but still there is controversy regarding treatment and a matter of great debate till date. Fractures of the lateral end of clavicle carries a high non-union rate because of deforming force and rotational movement acting on clavicle. Therefore it is better to identify this distinct clavicle fracture as different entity and treat it properly.

The Nordqvist[4] [1994] study concluded that fracture of the lateral end of clavicle does not require surgery. Rokito et al[6] [2002] study concluded that a satisfactory outcome with regards to pain, function and strength can be achieved after operative and nonoperative treatment of type 2 distal clavicle fractures. If nonoperative treatment is elected, however, patients need to understand and accept the possibility of prolonged sling wear to achieve union, as well as high probabilityof nonunion that may be associated with a cosmetic deformity. Furthermore surgerymay be required for those fractures that do not heal, thus prolonging the duration of overall morbidity. Operative intervention should be considered for those cases in which the fracture fragments are significantly displaced or button holed through fascia and in young, active individuals involved in overhead sports or manual labor. In the Robinson CM, Cairns DA study[7], conservative management has good mid-term results of displaced lateral end clavicle fracture in middle age and elderly patients. But many authors (Neer[5,8] 1960, 1963), Neviaser (1963), Zenni et al (1981), Jager and Rreitner (1984), Eskola et al[9] (1987), Edward et al[10] [1992] have recommended open reduction and internal fixation in type II fractures of the lateral end clavicle because of their tendency to nonunion. Many surgical methods have been introduced for lateral end clavicle fracture which includes K-wire fixation, TBW fixation, Knowles pin fixation, Circlage wire fixation, plate fixation, Dacrone loop, suture anchor method, endobutton fixation, Weaver dun procedure, ligament reconstruction etc. But ideal method of fixation remains to be ascertained, this is probably due to associated complication of many of these surgical techniques.

In our study out of 44 cases, 42[95.46%] cases were united and 2[4.54%] cases had nonunion. Among 42 fracture which united, 34 [80.95%] cases were united within 9 weeks. 8[19.5%] cases took more than 9 weeks to unite. Mean time to unionof all patients was 8.537$\pm$1.25 weeks. Among 8 cases treated with K-Wire, 7 [87.5%] cases were united and one case[12.5%] had nonunion. Among 7 cases which united, 4[57.14%] cases were united in $\leq$ 9 weeks while 3[42.86%] cases took >9 weeks to unite. The average timeof union was 9.42$\pm$1.27 weeks. Average union time in Yu-Chuan Tsuei [2010] studywas 8.93 ± 3.60, 8 weeks in Flinkkilä 2002 study and 12 weeks in Kao et al 2001 study. Neer who reported 100% union with K-wires, Kona et al showed 52.6% union,

Kao et al reported 92% union. All this studies suggest that results of K-Wirefixation are not consistent because less stability of fixation and variouscomplications.

Nine cases were treated with TBW, among them 8[88.89%] cases were unitedand 1[11.11%] case had non union. Among 8 cases, all were united in ≤ 9 weeks. The mean union time was 8.5±0.53 weeks. Average union in Yu-Chuan Tsuei [2010] study was 8.33 ± 1.50weeks, 10.75±3.92 weeks and 95% union in Laxman Rijal 2012 study. 95% union in Lee et al study 2009.

Among 9 cases treated with CC screw fixation, all [100%] cases were united. 8[88.89%] Cases were united in ≤ 9 weeks and 1[11.11%] cases took >9weeks to unite. The mean union time was 7.89±1.36 weeks. Average union time and union percentage in Ballmer and Gerber [1991] study was 6 to 9weeks and 100% respectively, 100% union in MA Fazal 2007 study.

Ten cases were treated with Hook plate fixation and all[100%] were united. 8[80%] Cases were united in ≤ 9 weeks and 2[20%] cases took >9weeks to unite. The mean union time was 8.5±1.08weeks. Average union time in Tan et al 2014 study was 8.75 + 2.55 weeks , 12weeks in Tambe et al 2006 which is contrary to our observation. 100% union was observed in study of Lee et al 2009 , Kashi et al 2006,Chen et al 2014, Tan et al 2014. 96% union in Tirent et al 2012 study, 97% union in Chunlin Zhang et al 2014 study. All 8 cases [100%] treated with endobutton fixation were united. Among them 6[75%] cases were united in ≤ 9 weeks and 2[25%] case took >9 weeks to unite. The mean union time was 8.375±1.60weeks. 100% union in Steven Struhl 2016 and C.

M. Robinson 2010 study, in Peter Kenyon 2014 study union time was 6-10 weeks. Out of 44 cases, 30 cases [68.18%] had no complications. 12 cases [31.82%] suffered from various complications.

Among 8 cases operated with K-Wire, 4[50%] had complications. 1[12.5%] case had nonunion which was asymptomatic and manage conservatively, 1 case hadpin migration, 1 case had pin tract infection, 1 case had AC joint arthritis.

Out of 9 cases treated with TBW fixation, 4[44.44%] had complications. 1[11.11%] case had nonunion probably because of loss of reduction, nonunion wasasymptomatic and manage conservatively. 1 case had pin migration, 1 case had ACjoint arthritis with mild pain, 1 case had wire breakage.

The cause of pin migration is rotational movement of clavicle and AC joint during shoulder mobilization [Fung M *et al 2001 and* Rockwood and Green]. There may be chance of wire breakage due to this strong force. So it is advise to avoid overhead shoulder mobilization until implant is removed. It is disadvantage that second procedure needs for implant removal once union has been achieved. All patients treated with K-Wire or TBW fixation needs implant removal. The mean implant removal time in K-Wire group was 9.63±2.56 weeks, similar observation noted by Flinkkilä 2002 2 month, Kao et al 3 month, Yu-Chuan Tsuei 2010 after union. The mean implant removal time in TBW group was 10.89±2.26 weeks, similar observation made by Yu-Chuan Tsuei 2010 at 3 month. In Laxman Rijal 2012 study implant removed at 6 week which is contrary to our observation.

K-Wire and TBW fixation might not be the better option for fracture with higher degree of comminuation because there is chance of loss of reduction. Though we did not document medial pin migration and lethal complications like death but it is documented in literature [Fueter-

Tondury 1976], so the method with such dangerous complications is not accepted if other safe methods are there. Tension band wiring also does not fully protect from pin migration[Albrecht and Bamert 1981] and technically demanding and general aneasthesia is required for implant removal. Among 9 cases treated with CC screw fixation, 2[22.22%] cases had complications. 1 case suffered from superficial wound infection probably due to extensive dissection for exposure, it was treated with oral antibiotics for 5 days and wound care. 1 case had screw cut out at 8 weeks, union was there and implant was removed. Ma Fazal et al 2007 noted Complications like mild backing out of the coracoclavicular screw at 4 weeks in 2 patients. Chen et al 2002, Jin CZ et al 2006,Lopez JM et al 1999 reported failure rate as high as 32% of CC screw fixation.

The reason of screw cut out was the rotation of clavicle and AC joint while mobilization of shoulder. This is supported by observation of Fung M *et al* [2001]. So it is advised to avoid forward flexion and abduction more than 90^0 until implant has been removed. Ballmer and Gerber 1991 limited forward flexion and abductionto 60^0 to prevent screw cutout. Here is also necessary to remove implant when unionhas been achieved. All patients needs implant removal with mean implant removal time was 9.1 ± 1.05 weeks. Similar observation was noted in study of H. Yamaguchi [1998] 6-10 weeks, MA Fazal 2007, Ballmer and Gerber 1991. We feels that CC screw fixation is relatively safe, simpler , reliable technique but risk of neurovascular injury sometimes or other complications like screw cut out etc, need of strict sling protection and implant removal later on.

Among 10 cases treated with hook plate fixation, 4 [40%] cases had complications. 3 [30%] cases had encounter subacromial impigment and 1 [10%] case had acromian osteolysis. Both managed by implant removal with improvementin impigment symptoms and reversal of acromian osteolysis[similar results in study of Tan et al, Lin et al, Chen et al]. Lee et al 2009 study shows 34% symptomatic hardware, Tambe et al 2006 noticed 2 nonunion and 5 acromial osteolysis out of 18cases, Tiren et al 2012 observed 34% impigment syndrome and 25% acromial osteolysis, Chunlin Zhang 2014 noticed 23.3% complications, In our study coracoclavicular ligament was not repaired. Bony union was achieved in all patients and no instability found after plate removal. This observation is supported by Jin etal[12] study. Though hook plate maintain AC joint biomechanics but complications encounter due to mismatch between hook of plate and differnt anatomy of acromian. This variation of anatomy makes difficulty in prediction of hook impigment during surgical procedure. We did not found other complications like rotator cuff tear and AC joint arthrosis probably due to plate had been removed once radiological union was achieved. We also did not observe fixation failure and deep infection. To avoidhook related complications it is advisable to avoid abduction more than 90^0 until plate has been removed. All patients treated with hook plate needs implant removal once union had achieved as a secondary procedure with mean implant removal timewas 24.4 ± 2.95 weeks. Mean implant removal time in study of Karl Wu 2011 was 5.2 ± 1.96 months, 5 months in study of Tambe et al 2006, 6 months in study of Tiren et al 2012. Hook plate is stress shielding and potential of refracture after implant removal but we did not encounter this complication. Among 8 cases treated with endobutton, none had complication. Implant removal was not needed. Steven Struhl 2016, C. M. Robinson 2010 noted same results in their case series.

Out of 8 cases treated with K-Wire, 5[62.5%]cases had excellent outcome, 2[25%] cases had good out come and 1[12.5%] case had fair outcome with mean constant score was 83.25±13. Mean constant score in study of Flinkkilä 2002 was 84[68-95]. In TBW group, out of 9 cases, 7[77.78%] cases had excellent outcome, 1[1.11%] cases had good outcome and 1[11.11%] cases had fair outcome with meanconstant score was 84.22±10.75. There was no case with poor outcome. Mean constant score in study of KARL WU 2011 was 85.63±5.38. In CC screw group, out of 9 cases, 7[77.78%] cases had excellent outcome, 1[1.11%]cases had good outcome and 1[11.11%]cases had fair outcome with mean constant score was 87.75±12.05. There was no case with poor outcome. Mean constant score in study of Rokito et al 2002 was 92.5. Out of 10 cases treated with hook plate fixation, 8[80%] cases had excellent outcome, 1[10%] case had good outcome and 1[10%] case had fair outcome with mean constant score was 90±7.24. Mean constant scorein study of Lee et al 2009 was 90. In Endobutton group , out of 8 cases, 7[87.5%] cases had excellent outcome and 1[12.5%]cases had good outcome with mean constant score was 93.5±6. There was no case with fair and poor outcome. Mean constant score in the study of Steven Struhl 2016 was 97. We observed that out of 44 cases, 42 cases return to their same occupation. Two patients had changed their occupation one each in K-Wire group and TBW groupprobably due to non union and fair functional outcome. Percentage of cases Return to previous activity within 6 month in k- wire group, TBW group, CC screw group, Hook plate group and Endobutton group was respectively 25%, 22.22%, 55.56%, 20%, 100%.

Conclusion

Non operative treatment usually results in higher rate of nonunion therefore surgical treatment is preferred for displaced lateral end clavicle fracture. But it is still confusing for surgeon to choose better implant for this fracture.

K-Wire and TBW fixation is cheap and simple techniques with easily available implant but they associated with higher complication rate and should be avoided when other safe alternatives are available.

Coraco-clavicular screw stabilization is an inexpensive good alternative but has its own complications, needs second procedure for implant removal and closed follow up of patients required till implant removal.

Hook plate fixation gives promising results but hook related complications areunavoidable. It needs extensive dissection and closed follow up necessary. Fractureafter implant removal may occur due to stress shielding property and relatively higher coast is a limiting factor.

Based on our results we concluded that endobutton fixation is a preferred modality over other modalities of fixation for displaced lateral end clavicle fractureiin terms of union, functional outcome, early return to previous activity, least complications and no need of second procedure for implant removal. Only drawbackis the cost when compared with other cheaper alternatives.

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Legend Figures

Figure 1: Fixation with Hook plate, immediate post-op x-ray of left shoulder.

Figure 2: Fixation with CC Screw, immediate post-op x-ray of right shoulder.

Figure 3: Fixation with Endobutton, immediate post-op x-ray of right shoulder