Analysis of Displaced Middle Third Clavicular Fractures Treated By Plate Osteosynthesis

Authors
Dr S. Kumar MS Ortho¹, Dr T. M. Manohar MS Ortho², Dr C. Pradobh MS Ortho³,
Dr C. Kamalanathan Ms Ortho⁴

¹Assistant Professor, Department of Orthopaedics,
²Associate Professor of Department of Orthopaedics
³Resident Department of Orthopaedics
⁴Professor and HOD Department of Orthopaedics

Government Mohan Kumaramangalam Medical College Hospital, Salem, Tamilnadu, India 636301
Telephone 0427 2210674

University: The Tamilnadu Dr. MGR Medical University, Chennai, Tamilnadu.
Email: kumars75dr@gmail.com, 9894310608

Abstract

Introduction: Fracture of the clavicle is common, accounting for 5 to 12% of all fractures. Displaced mid shaft clavicle fractures are common and are generally treated non-operatively. Open reduction and internal fixation with plating provides rigid fixation, early functional recovery and low rates of non union, mal union.

Materials and Methods: The study conducted was time bound, hospital based, prospective study In this study we analyze the functional outcome of 40 cases of displaced middle third clavicular fractures, internally fixed by plate osteosynthesis which was undertaken at the department of orthopaedics and traumatology at Government Mohan Kumaramangalam Medical College and Hospital, Salem from November 2011 to September 2013

Results: Out of 40 cases 18 cases united in 8 weeks and by 12 weeks all cases united except one. In one case there was delayed union followed by implant failure. In our study 24 patients returned to day today activities after 2-3 weeks and 30 patients returned to work within 2½ months

Conclusions: In our study Open reduction and rigid internal fixation of displaced midshaft clavicular fractures have given fracture union and excellent functional outcome.

Introduction
Fracture of the clavicle is common, accounting for 5 to 12% of all fractures. About 80 to 85% of these fractures are in the middle third of the bone, where the typical compressive forces applied to the shoulder and the narrow cross section of the bone combines and result in bony failure. Displaced mid shaft clavicle fractures are common and are generally treated non-operatively. Non-operative treatment of these fractures with axial shortening is associated with non union, delayed union, and symptomatic malunion. Other complications are severe pain, neurological complications, loss of shoulder.
function and protuberant callus forming swelling and stretching of skin which is cosmetically unacceptable. The proponents of early fixation of fresh clavicular fractures to prevent complications like malunion and nonunion emphasize the value of accurate reduction and rigid fixation in affording quick pain relief and promoting early functional recovery. Persons with high activity level will hesitate to accept prolonged recovery and impaired shoulder function, therefore may require more aggressive treatment of middle third clavicle fractures. Prompt fixation of these clavicle fractures permits increased patient comfort, and early shoulder mobility. If the patients have high physiological demands shortly after surgery, high pain scores, or strong preference for surgery early plate fixation can offer advantages. In cases of associated scapula fractures, fixation of the clavicle provides restoration of shoulder mechanics leading to improvement of function. Operative treatment of displaced mid shaft clavicular fractures can be achieved successfully using plates or intramedullary implants like rush pins, kirshner wires or nails. Open reduction and internal fixation with plating provides rigid fixation, early functional recovery and low rates of non union, mal union.

**Materials and Methods**

The study conducted was time bound, hospital based, prospective study. In this study we analyze the functional outcome of 40 cases of displaced middle third clavicular fractures, internally fixed by plate osteosynthesis which was undertaken at the department of orthopaedics and traumatology at Government Mohan Kumaramangalam Medical College and Hospital, Salem from November 2011 to September 2013. Patients with age between 18 years to 60 years and clavicle fractures with displacement of more than 2cm, shortening of more than 2cm, fractures with comminuted fragments, segmental fractures, open fractures and impending compound fracture with soft tissue compromise are included in our study. Patients with age of less than 18 years, undisplaced or minimally displaced fractures and any medical contraindication to surgery (Heart diseases, renal failure or active chemotherapy) are excluded from our study. On admission resuscitation of the patients in the emergency room was carried out followed by radiographic examination was done which included the three-view trauma series of the shoulder devised by Neer and Rockwood. Radiographs of the chest were done routinely to detect any concomitant fractures of the ribs, pneumothorax or heamotherax.

**Operative Procedure**

Under anesthesia the patient was placed in supine position with sand bag between the scapulae. Keeping the sand bag allows the shoulder girdle to falls backward. It restores the length and increases the exposure to clavicle. We made an incision along the axis of the clavicle, centering the fracture site. Subcutaneous tissue along with platysma incised together and were mobilized. Myofascial layer was incised and elevated from the fracture ends for exposure. After that fracture ends cleared of hematoma, fracture reduced using bone clamps. If there was a comminuted wedge fragment, it was fixed with a lag screw either through the plate or separately. Reconstruction plate or anatomical clavicular plate was used. In case of reconstruction plate the plate was contoured accordingly. The Plate is placed over the superior surface of the clavicle will often restore the correct rotation. Once the fracture alignment, length and rotation were satisfactory the screws were inserted. Minimum of six cortical purchases was attained on either side of the fracture. The myofascial layer followed by skin and subcutaneous tissue sutured and immobilized in a shoulder immobilizer. Rehabilitation of the affected arm was started at the end of 3rd post operative day onwards. Gentle pendulum exercises to the shoulder in the arm...
pouch were allowed. At 2 to 3 weeks gentle active range of motion of the shoulder was allowed but abduction is limited to 80 degrees. At 6 to 8 weeks active range of motion in all planes were allowed.

Results
In our study 40 cases of displaced middle third clavicular fractures were treated with plate osteosynthesis using locking compression plate and reconstruction plate. In our study of 40 cases 35 patients are male and 5 patients are female. Age of the patient varies from 20 years to 50 years and most of them were between 20 years to 30 years. The mean follow up period was 1 year ranges from 22 months to 4 months. Of the 40 patients 28 patients sustained injury to the right side and remaining 12 patients on left side. In the majority of the cases road traffic accidents (30 cases) was the cause for injury followed by accidental fall. Regarding the mechanism of injury the fall on outstretched hand was the common cause of injury (25 cases) followed by direct impact. The direct impact injury was associate with fragmentation at the fracture site. The time of presenting to the hospital ranges from 1 hour to 7 days with average time of 20 hours. The average duration of surgery was 50 minutes. The average blood loss during the surgery was less than 100ml. In our study out of the 40 cases 18 cases were united in 8 weeks and by 12 weeks all the cases united except one case. In one case there was delayed union followed by implant failure. In our study 24 patients returned to day today activities after 2-3 weeks and 30 patients returned to work within $2^{1/2}$ months. We had complications of hardware irritation in four cases, infection in one case and delayed union with hardware failure in one case. No nonunion or refracture in our cases. We removed the plate and screws in 3 cases after fracture union during the study period for hardware irritation patients.

Fig 1. Intra operative picture showing fixation with locking compression plate.

Fig 2. Pre operative x ray showing fracture clavicle right side

Fig 3. Post operative x ray showing fracture clavicle right side fixed with locking plate.

Fig 4. Follow up x ray showing fracture union clavicle right side
Fig. 5. Pre operative post operative x ray showing fracture clavicle left side fixed with reconstruction plate

Fig. 6. Pre operative post operative x ray showing fracture clavicle left side fixed with reconstruction plate and interfragmentary screw.

Fig. 7 Post operative picture showing the prominent and hardware irritation.

Discussion

Clavicle is the bony link from thorax to shoulder girdle and contributes to movements at shoulder girdle. Clavicle fracture is a common traumatic injury around shoulder girdle due to their subcutaneous position. It is caused by either low-energy or high-energy impact. The management on clavicle fracture are first introduced by ancient Egyptians. Evidence on the non operative treatment of clavicle fractures dates back to the Edwin Smith Papyrus, written in the 17th century BC. Hippocrates noted various observations about clavicle fracture at 400 BC. Many non operative methods of treatment for clavicle fractures had been described even though a sling consistently gave good functional results. The different types the conservative treatment of the Clavicle fractures are immobilization with (1) Parham support, (2) Bohler brace,(3) Taylor support,(4) Velpeau wrap,(4) Modified Velpeau wrap,(5) Modified Sayre bandage,(6) Billington yoke (plaster figure-of-eight),(7) Commercial figure-of-eight.

The traditional view that most of the clavicular fractures heal with good functional outcomes following non operative treatment is no longer valid. Recent studies have showed a higher rate of nonunion and shoulder dysfunction in subgroups of patients with clavicle fractures. Because of this, these fractures should therefore be considered as a spectrum of injuries with various functional outcomes, each requiring cautious assessment and individualized care. In the beginning clavicle fracture is given little importance and usually treated conservatively. But in the present fast moving world morbidity caused by calvicle fracture is a point of concern.

In a study by Charles Neer only 3 of 2235 (0.1%) patients with middle third clavicle fracture treated by closed methods failed to heal and C Rowe study in 566 patients concluded that nonunion occurs only in <1% of the patients. But the drawback of these studies is both conducted in children, which usually unite always. In a study by Hill in 66 mid third clavicle fractures treated conservatively, 31 % patients were unsatisfactory with the result, 25 % of patients complained of pain, 54% patients found the end result cosmetically displeasing. Displaced middle third clavicle fracture treated non operatively usually associated with shortening. Hill et al in his study concluded that shortening more than 2 cm is associated with poor outcome. The previous studies of outcome following clavicular fractures did not describe any strength deficits following nonoperative treatment of...
displaced mid shaft clavicular fractures and concentrated on radiographic and surgeon based results. Hill et al were one of the first to use a patient oriented outcome measure and found 31% patients were unhappy after non-operative treatment. This may be attributed to significant residual strength deficits following conservative management of these fractures. In another study which measured an objective strength testing protocol for both maximal effort and endurance found strength deficits ranging from 10 - 35% in patients after an average of 54 months following nonoperative treatment of displaced fractures of the clavicular shaft which showed they had a significant impairment in shoulder functions of an active young person recreationally and occupationally. In a study conducted by Canadian orthopaedic trauma society on 111 patients of fracture clavicle showed not only an overall improvement in shoulder functions (at one year) in operated cases, but also a much rapid return of function and decrease in pain in the operative group.

The most predictable method to maintain anatomic reduction of displaced mid shaft clavicular fractures, including length and rotation is in our opinion a plate and screw fixation. Although there is a learning curve with this form of treatment, once one becomes proficient in fixing two part clavicle fractures, displaced comminuted clavicle fractures become far less intimidating. The choice to proceed with operative intervention for a displaced mid-shaft clavicular fracture will be a decision made between the surgeon and the patient. So there is specific indication like displacement, with or without comminuted middle third clavicle fracture (Robinson Type-2B1,2B2).

The patients treated with early, rigid fixation of their clavicle fractures shared a high postoperative constant score, early pain resolution early return to activity and high patient satisfaction rating. Plating has the advantages of maintaining the length especially in comminuted fractures. There is little chance for hard ware breakdown and migration.

In cases of clavicle fractures with more fragments we can apply the plate as bridge plating otherwise called biological plating which achieve relative stability by splinting. This allows the indirect fracture healing with preservation of blood supply and soft tissue attachments while bridging the fracture zone maintaining the exact length, alignment and rotation. Jerry et al studied on 100 clavicles to find out the clinical applicability of anatomic pre contoured plate. He found out that at the lateral aspect of clavicle bone there is a superior bow. Medial aspect of the superior surface of the clavicle is relatively flat, making it an ideal surface for plating.

Clavicle nailing is an option for mid third clavicle fractures. Intra medullary nailing is difficult in clavicle because of the anatomical shape. Nailing has the advantages of less soft tissue dissection and periosteal disruption. The disadvantages are no static locking is available, hard ware can break, hard ware migration ,migration causes breakdown of skin or infraclavicular structure injury and in comminuted fracture shortening occurs over time. Chaithavat and V. Parkpian studied on 108 mid third clavicle fractures treated with Kirschner wires. They came to a conclusion that operative procedure is associated with low complication such as non union, mal union etc. The complication with this procedure is k-wire migration.

The combination of ipsilateral fracture of the clavicle and scapular neck has traditionally been called the “floating shoulder”. It is considered as an unstable injury and may require operative fixation. This injury is considered as a subgroup of superior shoulder suspensory complex. It includes both bone and soft tissue circle, or ring of the glenoid, corocoid process, coraco clavicular ligament, clavicle, acromio clavicular joint and the acromion. This is important biomechanically and maintains the anatomic relationship between upper extremity and axial skeleton. If operative intervention is chosen, then anatomic reduction.
and internal fixation of the clavicle is performed first and the shoulder is then reimaged. If the fixation result in indirect reduction of the glenoid no further intervention is required. If the glenoid remains in unacceptable position then fixation of glenoid neck is indeed\textsuperscript{27}. In our study the clavicle fracture are more common in male than females. There were 35 male and 5 female patients. This is comparable with other studies by Elidrissi Mohammed et al where out of 34 patients 32 were male and two were females\textsuperscript{17}. In a study by Dhoju et al out of 20 patients 16 were males and 4 were females. From this we can conclude that it is more common in active individuals\textsuperscript{18, 20}. In our study right side clavicle is commonly involved than left side. This is also comparable with the study by Elidrissi Mohammed et al where out of 34 cases 28 were on right side and 6 were left side. From this we can come to conclusion that dominant hand involves usually\textsuperscript{17}. In our study the average age group was 27.5 years. It is also comparable with study by Elidrissi et al\textsuperscript{17}. This again indicates clavicle fracture is more common in active, working age group\textsuperscript{20}. In our study Road Traffic Accident was the most common cause for clavicle fractures. Fall on out stretched hand was the commonest mechanism of injury. We studied the fracture pattern (intra operative finding based on mode of injury and mechanism of injury. From this Robinson type 2b2 (comminuted mid shaft fracture) is associated with high velocity injury and direct impact of the shoulder. In our study the average time taken for surgery was less than one hour. Average blood loss was less than 100ml. The average time of union was 9.2 weeks. It is also comparable with other studies like Elidrissi et al, Dhoju et al. Most of our patients return to work at 2 and a half month time. We assessed the functional outcome using constant score. We got excellent result in all patients except one in which we used 1/3\textsuperscript{rd} tubular plate. The patient came after 6 months for evaluation of pain, fracture found to be malunited after implant breakage. The patient was not willing for implant removal. He treated with analgesics.

| Study                        | Implant failure | Malunion/Nonunion |
|------------------------------|-----------------|-------------------|
| Dhoju et al (Reconstruction plate)\textsuperscript{31} | Nil             | Nil               |
| Elidrissi et al (Reconstruction plate)\textsuperscript{17} | Nil             | Nil               |
| Olivier et al (low contact dynamic compression plate)\textsuperscript{4} | Nil             | 5%                |
| Nathan et al (superior Reconstruction plate)\textsuperscript{15} | 3%              | 20%               |
| Our study (21 Reconstruction plate, 18 Locking plate, one 1/3 tubular plate) | 2.5% (1/3 tubular plate) | 3% (Malunion) |

In our study there are 4 patients complained of hard ware irritation. In these patients functional outcome was good. We removed implant in 3 patients. There is no re fracture. We used high profile reconstruction plate. This complication can be avoided by using low profile plate. One case had superficial infection. This was managed with intravenous antibiotics. In other studies deep infection is treated with early surgical debridement for deep infections.

| Infection                        | Infection |
|----------------------------------|-----------|
| Nathan et al\textsuperscript{15} | Superior plating | Nil    |
|                                  | Antero inferior plating | 2.5%   |
| Elidrissi et al\textsuperscript{7} | 3% (deep infection) |
| Dhoju et al\textsuperscript{2}   | 5% (deep infection) |
| Our study                        | 2.5% (Superficial infection) |

Superior plating has the advantage of plating over the tension surface. Superior plating is the preferred technique when there is inferior cortical comminution\textsuperscript{15}. We considered stability more than cosmesis so our choice was superior plating than anteroinferior plating which has less hard ware irritation\textsuperscript{19}. According to literatures superior plating is associated with neurovascular complications. In order to avoid neurovascular
injury we measured the clavicle size preoperatively and we adjusted the drill bit length. In our study we used both reconstruction plate and locking compression plate. There is no significant difference in terms of union or functional outcome. But patient in which locking compression plate is used showed an early return to day today activities and work compared to the reconstruction plate group. Locking compression plate provides better biomechanical stability than reconstruction plate. So it is preferable implant of choice in fractures with inferior cortical defects. Precontoured anatomical plates allows good reduction to be maintained, theoretically improves the rate of union and allows early return to good function2. Low profile locking plates decrease the chance of soft tissue irritation. In a biomechanical comparative study between LCP and reconstruction plate showed better biomechanical stability is obtained by using Locking compression plate13.

Conclusion
In our study Open reduction and rigid internal fixation of displaced midshaft clavicular fractures have given fracture union and excellent functional outcome. Reconstruction plates can be contoured according to the need and superior placement with six cortical purchases on either side gives stable construct, predictable union and optimum functional outcome. Use of interfragmentary screws can be used wherever possible. Owing to the subcutaneous anatomy of clavicle, superior implantation of implant might cause hardware prominence especially in lean individuals demanding subsequent removal. patient in which locking compression plate is used showed an early return to day today activities and work compared to the reconstruction plate group.

References
1. Woltz, Shrah MD, Nonoperative Treatment Compared with Plate Fixation of Displaced Midshaft Clavicular Fractures: A Multicenter, Randomized Clinical Trial Jbjs Jan 2007volume 99, issue 2 ;106-112
2. Jonathan T. Bravman, MD; Armando F. Vidal, MD Midshaft Clavicle Fractures: Are Surgical Indications Changing? J.Am.Acad Orthop. Dec 2009; volume 32
3. Neer CS II. Nonunion of the clavicle. J Am Med Assoc. 1960; 172:1006-1011.
4. Rowe CR. An atlas of anatomy and treatment of midclavicular fractures. Clin Orthop Relat Res. 1968; 58:29-42.
5. L A Khashif khan Fractures of clavicle : Jbjs April 7 ,2010
6. James m. Hill, michael h. Mcguire, lynn a. Crosby Closed treatment of displaced middle-third fractures of the clavicle gives poor results British Editorial Society of Bone and Joint Surgery vol 79-B July 1997
7. Canadian Orthopaedic Trauma Society. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter, randomized clinical trial. J Bone Joint Surg Am. 2007;89:1-10.
8. Olivier Verborgt, Kathleen Pittoors Plate fixation of middle-third fractures of the clavicle in the semi-professional athlete; Acta Orthop. Belg., 2005, 71, 17-21
9. 9) Kaisa J Virtenan, Ville remes , Sling compared to Plate Osteosynthesis for treatment of Displaced Midshaft Clavicle Fractures ; J Bone Joint Surg Am. 2012Vol 94;1546-1553
10. Robbin C. McKee, Daniel.B.Velan, Operative versus Nonoperative care of displaced midshaft clavicular fractures. A Meta Analysis of randomized clinical trial. J Bone Joint Surg . 2012;94:675-84
11. Chaithavat Ngarmukos, Vinai Parkpian, Adisorn Patradul From Chulalongkorn University, Bangkok, Thailand. J Bone Joint Surg [Br] 1998;80-B:106-8.
12. Yu-Cheng Lai, MD; Yih-Wen Tarng, MD, PhD; Chien-Jen Hsu, MD; Comparison of
1. Dynamic and Locked Compression Plates for Treating Midshaft Clavicle Fractures. *Orthopedics* 35(5);e697-702; 2012

2. Eden L; Doht S; Frey SP. Biomechanical comparison of the Locking Compression plate with reconstruction plates in midshaft clavicle fracture stabilisation; *Int Orthop*; 36(12): 2537-43, 2012 Dec.

3. Chin en chen, Chang Gung University, Taiwan. Antero inferior plating of mid third clavicle fractures; *Acta Orthop Trauma.*, 2010, 130(4), 507-511

4. Nathan Foramaini; Benjamin C T, Colubus, Ohio Superior versus antero inferior plating of clavicle fractures;. *Orthopedics* 36(7);e898-904; 2013

5. Eddie Y. Lo, MD; Jonathan Eastman, MD. Neurovascular Risks of Anteroinferior Clavicular Plating; *Orthopedics* 210 Jan;33(1);21

6. Elidrissi Mohammed, MD, H Mahadane. Functional Outcome of Midclavicular Fracture Fixation Utilising a Reconstruction Plate; *Malays Orthop J* 2013 Nov;6-9

7. Dhoju D, Shrestha D, Parajuli NP, Shrestha R, Sharma V. Operative Fixation of Displaced Middle Third Clavicle (Edinburg Type 2) Fracture with Superior Reconstruction Plate Osteosynthesis; *Kathmandu Univ J(KUMJ)*.2011Oct-Dec ;9(36);286-90

8. Iannotti MR, Crosby LA, Stafford P, Grayson G, Goulet R. Effects of plate location and selection on the stability of midshaftercleivle osteotomies: a biomechanical study. *J Shoulder Elbow Surg* 2002;11:457-62.

9. C. M. Robinson; From the Royal Infirmary of Edinburgh, Scotland; Fractures of the clavicle in the adult epidemiology and classification 1998 *British Editorial Society of Bone and Joint Surgery.*

10. Thomas D. Donnelly*, Robert J. MacFarlane. Fractures of the Clavicle: An Overview; *The Open Orthopaedics Journal*, 2013, 7, (Suppl 3: M6) 329-333

11. Lars Eden & Stefa Doht & Sönk P. Frey ni, Biomechanical comparison of the Locking Compression superior anterior clavicle plate with seven and ten hole reconstruction plates in midshaft clavicle fracture stabilization. *International Orthopedics.* ; (SICOT) (2012) 36:2537–2543

12. Jamal E. H. Assobhi Reconstruction plate versus minimal invasive retrograde titanium elastic nail fixation for displaced midclavicular fractures; *Indian J Orthop.* 2014 ;48(6);587-593

13. Grays anatomy

14. Essentials of human anatomy; A.K. Dutta

15. Stig Brorson, Management of Fractures of the Humerus in Ancient Egypt, Greece, and Rome: An Historical Review; *Clin Orthop Relat Res*.2009 467(7);1907-1914

16. Rockwood and Green’s Fractures in adults sixth edition

17. Charles A. Rockwood Jr., Frederick A. Matsen III, *The Shoulder* vol 1

18. Jerry et al Clavicular anatomy and applicability of precontoured plate; *J Bone Joint Surg:* 89 ;oct 2007; 2260-2265

19. Micchael D Mckee Mid shaft mal unions of clavicle;; *J Bone Joint Surg* may 2013.

20. O/ASIF Instruments and implants Second edition.

21. Partha Saha plate versus titanium elastic nail in the treatment of displaced mid clavicular fractures. Indian J Orthop 2014

22. Allman FL Jr. Fractures and ligamentous injuries of the clavicle and its articulation. *J Bone Joint Surg Am.* 1967;49:774–84

23. Matthew Pecci, MD, and Jeffrey B Kreher Clavicle Fractures; *Am Fm Physician* 2008 jan ;77(1);65-70

24. Jit I, Kulkarni Times of appearance and fusion of epiphysis at the medial end of the clavicle *Indian J Med Res* 1976 may ;64(5);773-82
36. Annee Lisabethl Junggren CLAVICULAR FUNCTION”; Acta orthop. scand. 50, 261-268, 1979
37. Eskola A, Vainionpää S, Myllynen P, Pättälä H, Rokkanen P. Surgery for ununited clavicular fracture. Acta Orthop Scand. 1986
38. Andersen K, Jensen PO, Lauritzen J: Treatment of clavicular fractures. Figure-of eight bandage versus simple sling. Acta Orthop Scand 1987
39. Basom W. C.; Breck, L. W.; and Herz, J. R.: Dual Grafts for Non-Union of the Clavicle. Southern. Med. J. , 40: 898-899
40. Kaisa J Virtanen; Surgical treatment of Rockwood grade-V acromioclavicular joint dislocations. Octa Orthopaedica vol 84,2013 191-195
41. Knudsen FW, Andersen M, Krag C. The arterial supply of the clavicle. Surgical and radiologic anatomy: SRA. 1989;11:211–4
42. Schwarz N, et al; Osteosynthesis of irreducible fractures of the clavicle with 2.7-MM ASIF plates. JTrauma 1992 Aug.
43. Hackenbouch W, RagazzoniP, Schwyzer K. Surgical treatment of lateral clavicular fracture with “clavicular hooked plate”. The shoulder ; Charles A Rockwood
44. Mullaji AB, Jupiter JB Low-contact dynamic compression plating of the clavicle Injury, 25, 41-45, 1994
45. Peter A Cole; what’s new in orthopaedic trauma; J Bone Joint Surg nov 2006 vol 88;2545-2561
46. Peter kleon; bilateral clavicle non unions treated with antero inferior locking compression plate. Acta Orthop. Belg., 2004, 70, 609-611
47. I.R. Murray Risk Factors for Nonunion After Nonoperative Treatment of Displaced Midshaft Fractures of the Clavicle47, J Bone Joint Surg july 2013
48. A.G.Slogan operative treatment of medial clavicle fractures; Injury extra August 2008,Vol.39(8):270-272
49. Nordqvist A, Petersson C. The incidence of fractures of the Clavicle. Clin Orthop 1994; 300: 127.
50. Rowe CR. An atlas of anatomy and treatment of midclavicular fractures. Clin Orthop 1968; 58: 29-42.
51. Dhoju D, Shrestha D, Parajuli N, Shrestha R, Sharma V. Operative Fixation of Displaced Middle Third Clavicle (Edinburg Type 2) Fracture with Superior Reconstruction Plate Osteosynthesis. Kathmandu Univ Med J 2011;36(4):286-91.