

Original Research Article

Diaphyseal fractures of the clavicle in adults, comparative study of LCP(Locking Compression Plate) versus intramedullary nailing with TENS (Titanium Elastic Nailing System)

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Abstract

Background: Fractures of clavicle are one of the most common fractures in traumatic injury around shoulder girdle as the bone is sub cutaneous throughout. Open reduction and internal fixation with locking compression plate have become the mainstay of treatment for most of the midshaft fractures, as these operative methods restores the anatomy, biomechanics and contact loading characteristics of the clavicle. Intramedullary nailing with TENS(Titanium elastic nailing system) has also proved to be effective with better cosmetic effect, faster union, and less operating time. **Objectives:** To determine the functional outcome using constant scoring system following both plating and nailing technique and also to observe the various complications arising with both procedures.**Methodology:**This study is a prospective study of 80 cases that were admitted and operated in the dept. of orthopedics attached to R. L. Jalappa hospital from June 2016 - December 2018. 40 patients included in the LCP were operated from June 2016 to October 2017 and the rest 40 in TENS group were operated from October 2017 to December 2018. Skeletally mature patients with age group > 18 years, closed displaced mid shaft fracture of clavicle, polytrauma patients were included. Patients with open fractures, pathological fractures, non-union, ipsilateral limb pathology and with ipsilateral neuro-vascular injury were excluded. The functional outcome was assessed using CONSTANT scoring system during follow-up after LCP and intramedullary nailing for clavicle fractures at 6weeks, 3months and 6months. Student t test and chi square test was used as the test of significance. P value <0.05 was considered as statistically significant. **Results:** Length of incision, operation time and duration of hospital stay were less for the TENS group. There was no significant difference between the two groups regarding radiological outcome but Constant Shoulder scores were significantly higher (p<0.0001) in the TENS group than the LCP group by the end of 6 month follow-up. Infection and revision surgery rates were also higher in the plate group.

Conclusion:We can conclude from our study that Titanium elastic intramedullary nailing TENS is a safe, minimally invasive surgical technique with a lower complication rate, faster return to daily activities, excellent cosmetic and comparable functional results, and can be used as a better alternative for surgical fixation of displaced midshaft clavicular fractures in place of current trend of locking compression plating.

Keywords: locking compression plate, titanium elastic nailing system.

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Introduction

Clavicle fractures account approximately 2.6% of all fractures and are the commonest injuries in active individuals who participate in activities like sports and high-speed falls or violent collisions[1]. Midshaft fractures forms majority of clavicle fractures (80% to 85%), where a combination of typical compressive forces to the shoulder and the narrow cross section of the bone results in bony failure[2]. Studies conducted to analyze the results of conservative treatment found poor results following conservative treatment of displaced middle third clavicle fracture. Various methods of fixation methods gained attention and broadly can be divided into two mainly plating and intramedullary nailing techniques but the indication for both for a particular type of fracture is still in debate. Currently Locking compression plating is the main stay of treatment among surgical management. Disadvantages of plating include- need for increased soft tissue stripping and exposure, supraclavicular nerve damage, slightly higher infection rates along with risk of re-fracture after plate removal[3]. The newest intramedullary device showing similar biomechanical properties to a clavicle is an elastic nail made of titanium and is showing promising results in many studies, although

it has its own disadvantages like medial entry site irritation, nail migration, entry point infection[4-6]. Thus the effectiveness of both the implants for midshaft clavicle fracture needed to be analysed in terms of functional outcome, and complications. Two different surgical approaches for clavicle plating have been described, in which the position of plate is either on the anteroinferior or superior surface of clavicle[7]. The advantages of using intramedullary nail include smaller incision, less soft tissue dissection, and load-sharing fixation with relative stability that encourages copious callus formation[8]. In contrast, technique-specific complications like medial implant protrusion and irritation are reported in several studies[4,9]. The goal of this study was to determine the functional outcome using constant scoring system following both plating and nailing technique and also to observe the various complications arising with both procedures.

Materials & methods

This study is a prospective study of 80 cases that were admitted and operated in the dept. of orthopedics attached to R. L. Jalappa hospital from June 2016 - December 2018. Our institutional ethics committee approved the study & informed consent was obtained from all patients when called for follow-up. 40 patients included in the LCP were operated from June 2016 to October 2017 and the rest 40 in TENS group were operated from October 2017 to December 2018. All surgeries were conducted at our institute. Skeletally mature patients with age group > 18 years, closed displaced mid shaft fracture of clavicle, polytrauma patients were included. Open

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fractures, pathological fractures, non-union, ipsilateral limb pathology and with ipsilateral neuro-vascular injury were excluded. The functional outcome was assessed using CONSTANT scoring system during follow-up after LCP and intramedullary nailing for clavicle fractures at 6weeks, 3months and 6months. All the quantitative measures, categorical variables like functional outcome, sex, age, side of fracture and fracture type was compared using percentages. Student t test and chi square test was used as the test of significance. P value <0.05 was considered as statistically significant. Statistical analysis was carried out using softwares- SPSS version 22(IBM, Chicago, USA).

Operative procedure

After general anesthesia, the patient was positioned in supine position with a folded sheet under the affected shoulder. A transverse incision was made over the fracture site and dissection was carried out down to the fracture site, followed by careful subperiosteal dissection. The fracture was reduced and held temporarily with bone clamps, and the plate was positioned on the anterior superior surface of the clavicle and fixed with screws. Elastic intramedullary nailing was done using the technique described first by Jubel et al[10]. A small skin incision was made approximately 1 cm lateral to the sternoclavicular joint. The medullary cavity of the clavicle was opened using an awl and single elastic nails of different diameters varying from 2 to 3 mm, were used, depending on the width of the bone. Closed reduction was done under an image intensifier after provisionally reducing the fragments with two percutaneously pointed reduction clamps. If closed reduction of the fracture site could be done, an additional small incision was made above the fracture site and fragments reduced under direct visualization and nail introduced into the lateral fragment. Care was taken to avoid perforation of the dorsolateral cortex of the lateral clavicle. The TENS was cut as short as possible at the medial end and buried under soft tissue.

Post Operative Regimen

Among Tens group rehabilitation of the affected limb was started immediately according to patient tolerance except for those with comminuted fracture for whom we started by second week. For LCP cases patients were protected with a sling immediately after the

operation instructed to perform early gentle and passive shoulder motion cautiously under sling protection for a period of 2-4 weeks. At 4 to 6 weeks gentle active range of motion of the shoulder was allowed but abduction was limited below 90 degrees. At 6 to 8 weeks active range of motion in all planes were allowed, but not allowed to lift weight or do exertional activities with the affected arm. Clinical and plain radiographic postoperative follow up was performed at 2 weeks, 6 weeks, and then monthly. At 6 months post-surgery, we checked: (1) status of fracture healing; (2) length and condition of the surgical wound; (3) functional status of the injured shoulder and (4) complications like implant migration, loosening, or failure. The functional outcome of the injured shoulder was measured using the Constant and Murley shoulder scores[11].

Result

Majority of the injury occurred in male patients in both group - 32 cases (80%) in TENS and 29(72.5%) in LCP group, whereas a total of 8 cases (20%) in TENS and 11 cases(27.5%) in LCP were females. The distribution of age reveals that majority of cases lie between 18-30years (42.5% in TENS and 47.5% in LCP group), followed by 31-40years(32.5% in TENS and 25% in LCP), 12.5% in TENS and 20% in LCP lie between 41-50 years and 12.5 % in TENS and 7.5% in LCP were 50 and above age group. In this study, there were a total of 21 cases (52.1%) of right sided fracture, and left side was affected in 19 cases (47.9%) among TENS group and 23 cases(57.5%)of right sided fracture, and left side was affected in 17 cases(42.5%) among LCP. Complications encountered in TENS group include: 3 cases (7.5%) each of delayed union and infection at nail entry site. 2 cases (5%) each of nail loosening and lateral protrusion of nail, 4 cases (10%) of medial protrusion of nail. 9(22.5%) cases complained of medial entry site skin irritation. There were no complications of malunion, non-union, nail breakage, hypertrophic scar or shoulder stiffness. Whereas in LCP group, 2 cases (5%) had superficial infection, 6(15%) cases had delayed union, 5(12.5%) cases formation of skin scar, 2 cases(5%) there was restriction of shoulder motion. 3 cases(7.5%) showed plate prominence and 1 cases (2.5%)plate breakage. There were no complications of plate loosening and malunion. Majority of patients 11(27.5%) were unhappy with the scar acquired following surgery.



Fig 1: showing plain radiograph of both shoulder anteroposterior view showing right mid shaft clavicle fracture fixed with TENS



Fig 2: showing plain radiograph of left shoulder anteroposterior view showing left mid shaft clavicle fracture fixed with LCP

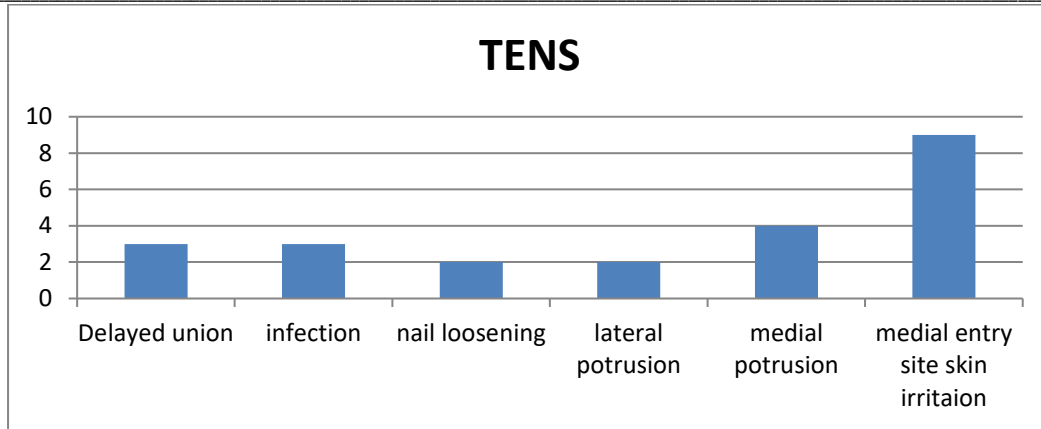


Fig 3 : Bar diagram showing complications encountered in TENS Group

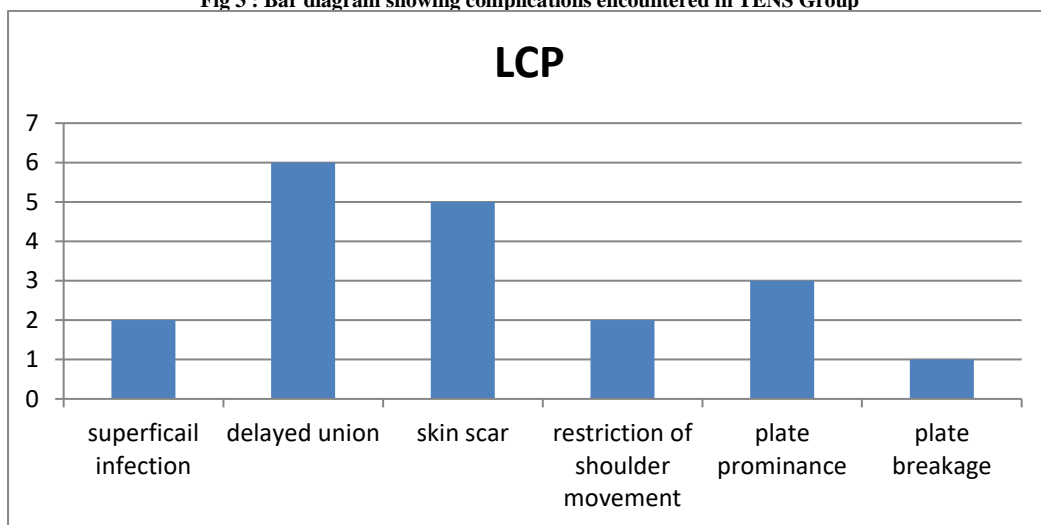


Fig 4 : Bar diagram showing complications encountered in LCP group

Discussion

Management of acute mid-shaft clavicular fractures in patients has been undergoing controversy on which fixation pattern was preferable when making a clinic decision[12,20-22]. LCP is the most commonly used, although complications reported include wound infection, wound dehiscence, skin irritation or numbness, implant failure, and poor cosmetic results[13,18,19]. Intramedullary devices which utilize minimally invasive surgical techniques were developed to treat displaced midshaft clavicle fractures. Intramedullary devices may also preserve the soft tissue envelope, periosteum, and vascular integrity around the fracture region, potentially enhancing fracture site callus formation[14]. Eventhough application of intramedullary devices seem to have more advantages than plate fixation for treatment of displaced midshaft clavicular fractures complications like medial migration of the nail tip and clavicle length shortening after fracture healing, especially in comminuted fractures due to the telescope effect after TEN fixation is seen[15,16]. Mueller et al also supports such an observation and suggested that patients with lower extremity injuries were able to use crutches after intramedullary splinting, enabling early mobilization. This was effective as costs associated with long-term immobilization were reduced. On the other hand, treatment of additional injuries including intensive care of those with multiple injuries and usage of crutches did not affect

clavicular healing[17]. In this study all patients with midshaft clavicle fractures were of closed type. Robinson Type-2 B1 were more common as they constituted 55% patients in the study. Rest 22.5% under 2B2, 15% under 2A2 and 7.5% under 2A1. This indicates TENS nailing is successful not only in simple fractures but also in segmental fractures and fractures with mild to moderate comminution. Surgery time in our study ranged from 30 min to 80 min in TENS group and 40 min to 90 min in LCP group over all mean time came as 50 min for TENS and 60 min for LCP group. Time increased with severity of comminution. Among TENS group majority of surgery needed open reduction. That is in 31(77.7%) of cases, rest of 9 cases (22.5%) was able to do closed reduction. This shows that achieving closed reduction is difficult and majority requires minimal opening to aid in reductions and is mainly attributed to varied comminution and the S shaped curve of the bone which demands technical expertise. All cases which underwent closed reduction were operated within 3 days post trauma and operative time increased with increase in delay for surgery. In this study, We used 2.5mm in majority of cases (52.5%) and 2mm in those in who had narrower canal(42.5%). It is suggested that nail diameter should be between one third and 40% of the medullary space diameter[23]. In LCP group 7 hole plates were used in 26(65%)cases, 8 in 7(17.5%)cases and rest with 9 hole plates,

depending upon type of fracture. Plate length depended upon the amount of comminution. In our study there was no incidence of nail breakage like many others. But 1 case of plate breakage was noted. In this study among TENS group, 11(27.5%) cases united by 6 weeks and majority cases that is 20(50%) united by end of 12weeks, 6(15%) cases took till 16 weeks, 4 (10%) cases took longer than 16 weeks. In LCP fixation, 11 cases(27.5%) each united by 6 weeks and 12 weeks, 10 cases(25%) united by 16 weeks and in 8(20%) cases the union took longer than 12 weeks. In 1 patient (2.5%) union occurred after

18 weeks as there was implant failure (breakage) after 1 month for which replating was done. Time of union was not statistically significant ($P < 0.234$). Functional outcome assessed using Constant and Murley, showed that in TENS group by end of 6 months, 34(85%) cases showed excellent result and rest 6(15%) cases showed good result whereas. Locking compression plate and screws showed excellent outcome in 29(72.5%)cases, 8 cases (20%) had good outcome and 3 case(7.5%) had a fair outcome. Overall the functional outcome was significantly higher ($P < 0.0001$) in TENS group.

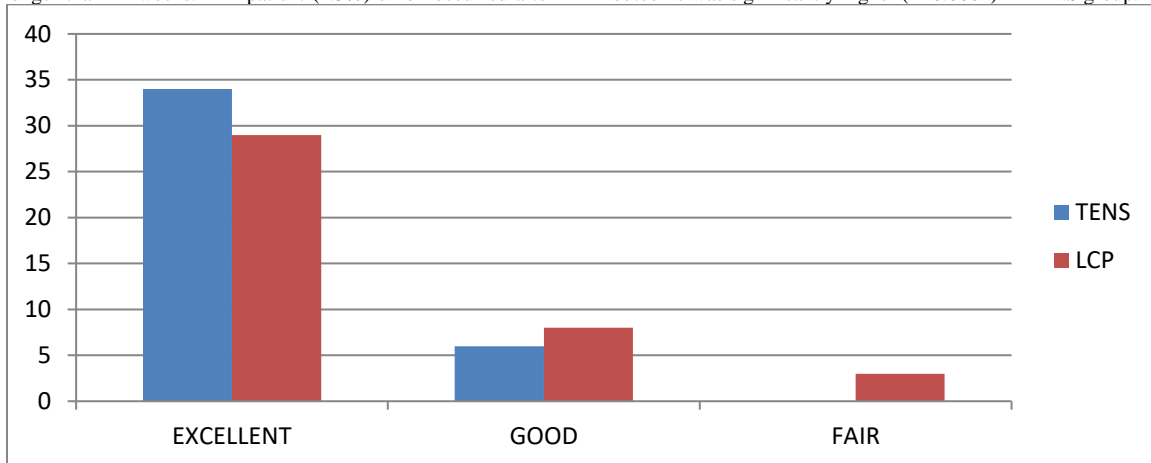


Fig 6 : bar diagram showing functional outcome assessed using constant and murley in both TENS and LCP Group

Conclusion

We can conclude from our study that Titanium elastic intramedullary nailing TENS is a safe, minimally invasive surgical technique with a lower complication rate, faster return to daily activities, excellent cosmetic and comparable functional results, and can be used as a better alternative for surgical fixation of displaced midshaft clavicular fractures in place of current trend of locking compression plating.

Limitation in study

The primary limitation of our study was that it was a small prospective comparative study including a small number of patients and done at a single center. Larger randomized controlled trials are needed to further evaluate outcomes and complications of precontoured plates and TENS in displaced midshaft clavicle fractures.

References

- Zlowodzki M, Zelle BA, Cole PA. Treatment of acute midshaft clavicle fractures: Systematic review of 2144 fractures: On behalf of the Evidence-Based Orthopaedic Trauma Working Group. *J Orthop Trauma*. 2005; 19:504-507.
- Michael D, Mckee. Clavicle fractures. In: Chapter 36, Robert W. Bucholz, James D. Heckman, Charles M. Court-Brown, and PaulTornetta (eds). *Rockwood and Greens' fractures in adults*, 7th edition, II, Philadelphia: Lippincott Williams and Wilkins. 2010; 1106-1141.
- Suhail AB, Khurshed AB, Sanjeev G, Mohd SL, Abedullah B, Nadeem A. Changing Trends In Management Of Adult clavicular Fractures. *IJAR*. 2014;6:843-849.
- Andrade-Silva FB, Kojima KE, Joeris A, Santos Silva J, MattarR, Jr. Single, superiorly placed reconstruction plate compared with flexible intramedullary nailing for midshaft clavicular fractures: A prospective, randomized controlled trial. *J Bone Joint Surg Am*. 2015; 97(8):620-626.
- Ethiraj P, Prathap P, Arun HS, Nagakumar JS. Functional outcome in surgical management of midshaft clavicle fractures fixed with precontoured plate in adults. *IJOS*. 2016; 2(4): 458-462.
- Meier C, Grueninger P, PlatzA. Elastic stable intramedullary nailing for midclavicular fractures in athletes: Indications, technical pitfalls and early results. *Acta Orthop. Belg.*, 2006; 72: 269-275.
- Robinson CM, Goudie EB, Murray IR, Jenkins PJ, Ahktar MA, Read EO et al. Open Reduction and Plate Fixation Versus Non operative Treatment for Displaced Midshaft Clavicular Fractures. *J Bone Joint Surg Am*. 2013;95:1576-84.
- Smekal V, Irenberger A, Struve P, Wambacher M, Krappinger D, Kralinger FS. Elastic stable intramedullary nailing versus nonoperative treatment of displaced midshaft clavicular fractures-a randomized, controlled, clinical trial. *J Orthop Trauma*. 2009; 23(2):106-112.
- Wijdicks FJ, Houwert RM, Millett PJ, Verleisdonk EJ, Van der Meijden OA. Systematic review of complications after intramedullary fixation for displaced midshaft clavicle fractures. *Can J Surg*. 2013; 56:58-64.
- Jubel A, Andermahr J, Schiffer G, Tsironis K, Rehm KE. Elastic stable intramedullary nailing of midclavicular fractures with a titanium nail. *Clin Orthop Relat Res*. 2003; 408:279-285.
- Constant CR, Murley AHG. A clinical method of functional assessment of the shoulder. *Clinical Orthopaedics and Related Research*. 1987; 214: 160-164.
- Zhang B, Zhu Y, Zhang F, Chen W, Tian Y, Zhang Y. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2015;23:27.
- Duncan SF, Sperling JW, Steinmann S. Infection after clavicle fractures. *Clin Orthop Relat Res* 2005;439:74e8.
- Liu PC, Chien SH, Chen JC, Hsieh CH, Chou PH, Lu CC. Minimally invasive fixation of displaced midclavicular fractures with titanium elastic nails. *J Orthop Trauma* 2010;24:217e23.
- Smekal V, Irenberger A, Struve P, Wambacher M, Krappinger D, Kralinger FS. Elastic stable intramedullary nailing versus nonoperative treatment of displaced midshaft clavicular fracturesa randomized, controlled, clinical trial. *J Orthop Trauma* 2009;23:106e12.

16. Frigg A, Rillmann P, Perren T, Gerber M, Ryf C. Intramedullary nailing of clavicular midshaft fractures with the titanium elastic nail: problems and complications. *Am J Sports Med* 2009;37:352e9.
17. Mueller M, Rangger C, Striepens N, Burger C. Minimally Invasive Intramedullary Nailing of Midshaft Clavicular Fractures Using Titanium Elastic Nails. *J Trauma*. 2008; 64:1528–1534.
18. Liu PC, Hsieh CH, Chen JC, Lu CC, Chuo CY, Chien SH. Infection after surgical reconstruction of a clavicle fracture using a reconstruction plate: a report of seven cases. *Kaohsiung J Med Sci* 2008;24:45e9.
19. Bostman O, Manninen M, Pihlajama`ki H. Complications of plate fixation in fresh displaced midclavicular fractures. *J Trauma* 1997;43:778e83.
20. Zhu Y, Tian Y, Dong T, Chen W, Zhang F, Zhang Y. Management of the mid-shaft clavicle fractures using plate fixation versus intramedullary fixation: an updated meta-analysis. *Int Orthop* 2015;39:319e28.
21. Zeng L, Wei H, Liu Y, Zhang W, Pan Y, Zhang W, et al. Titanium Elastic Nail (TEN) versus Reconstruction Plate Repair of Midshaft Clavicular Fractures: A Finite Element Study. *PLoS ONE*.2015; 10: e0126131.
22. Houwert RM, Smeeing DP, Ahmed Ali U, Hietbrink F, Kruyt MC, van der Meijden OA. Plate fixation or intramedullary fixation for midshaft clavicle fractures: A systematic review and meta-analysis of randomized controlled trials and observational studies. *J Shoulder Elbow Surg*. 2016; 25:1195-1203.
23. Slongo TF. Complications and failures of the ESIN technique. *Injury*.2005; 36:78–85.

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