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A COMPARATIVE STUDY OF TENS NAILING & PLATING IN FRACTURE SHAFT CLAVICLE

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ABSTRACT

Background: Clavicle fractures are common, with midshaft fractures comprising a significant portion. Treatment options include both conservative measures and surgical interventions, with advancements in surgical techniques improving outcomes. This study aims to compare titanium elastic nails (TENs) with Locking Compression Plate (LCP) fixation in the management of displaced midshaft clavicle fractures.

Methods: A cross-sectional study was conducted on 60 patients with displaced midshaft clavicle fractures. Patients were divided into two groups: TENS and LCP. Demographic data, mode of injury, associated injuries, type of fracture, time to surgery, duration of surgery, duration of hospital stay, blood loss, complications, and functional outcomes were assessed.

Results: The majority of patients in both groups were males with a mean age of approximately 35 years. Road traffic accidents were the most common cause of injury in both groups. TENS group had shorter operative time and less blood loss compared to the LCP group. Both groups achieved union within a similar timeframe, with comparable functional outcomes as assessed by DASH and Constant Murley scores. Complications varied between the groups, with TENS group experiencing hardware migration and non-union, while LCP group had cases of infection, malunion, and skin irritation.

Conclusion: Both TENS and LCP fixation methods provide effective treatment for displaced midshaft clavicle fractures, with similar functional outcomes. TENS offers advantages such as minimal invasiveness and reduced blood loss, while LCP provides increased stability but may result in stress shielding. Individual patient factors and preferences should guide treatment selection, with consideration for desired return to physical activity and cosmetic outcomes.

Keywords: *Clavicle fractures, Outcome, Locking Compression Plate (LCP),Titanium Elastic Nail(TENs)*

Introduction

The clavicle is prone to fracturing when impacted at the shoulder joint. It represents 44% of shoulder injuries and 2.6-10% of all forms of fractures [1,2]. Additionally, about 50% of clavicle fractures are displaced, with individuals under 40 and over 70 being the primary demographic affected by clavicle fractures resulting from traffic accidents, unexpected falls, and shoulder injuries.[1,3]

The clavicle functions as a strut to enable correct upper limb movement at the shoulder. Moreover, it mechanically transfers stresses from the upper limb to the trunk. The clavicle's shallow position near the shoulder, together with its naturally slender midsection, increases its vulnerability to injury when subjected to forces during falls with the arm at the side. Clavicle fractures are often classified as Type I (fracture at the center third), Type II (fracture at the lateral third), and Type III (fracture at the medial third) based on the location of the fracture on the clavicle. When there is an impact at the shoulder joint, the narrowed area of the clavicular midshaft undergoes increased compressive stress, leading to a potential fracture. Most clavicular fractures (80-85%) occur at the midshaft.[1]

A clavicle fracture results in discomfort and swelling at the location of the fracture. The inability to lift or use the arm can greatly impact an individual's ability to perform their activities of daily living (ADL). Non-invasive treatments for clavicle fractures involve utilizing a shoulder arm pouch, triangular sling, clavicle brace, and figure-of-eight bandages. Minimally displaced fractures are still best treated with conservative care. Yet,[4] conservative treatments may prove inadequate for intricate fractures, such as significantly displaced or comminuted ones, leading to potential malunion/non-union, distortion, and cosmesis [5-6]. Elderly individuals and patients with comminuted fractures without bone connections or displacement are at a higher risk [7]. Advancements in operating procedures, metallurgy, and medical imaging have improved the effectiveness of surgical intervention for treating complicated fractures. Various methods of treatment such as K-wire fixation, Austin Moore pins, Steinmann pins, titanium elastic nails (TENs), and fixation plates are commonly used. Furthermore, research has shown that surgical procedures led to better functional outcomes and higher rates of union compared to conservative approaches [8-9].

The typical surgical procedure for a complicated midshaft clavicular fracture includes open reduction and internal fixation (ORIF) with plates or intramedullary fixation utilizing TENs. TENS are commonly used as a substitute for plate or screw fixation [10-12]. TENs have been tried as closed reduction and internal fixation (CRIF). The procedure has been proven to be safe and minimally invasive, providing main stability and achieving functional and cosmetic objectives. Tension band wiring (TENs) promote quick healing with less issues when compared to plate osteosynthesis. Furthermore, the stress distribution of titanium elastic nails (TENs) closely resembles that of an undamaged clavicle [13]. Fixation with reconstruction plates increased stress shielding and provided greater stability for early recovery to perform activities of daily living. The superiority of plate fixation over TENs was attributed to its greater resilience to bending and torsional forces [14]. Plate fixation is recommended for treating displaced midshaft clavicle fractures as it decreases the likelihood of non-union and symptomatic malunion rates.[15] When selecting a treatment for complex midshaft clavicle fractures, it is important to evaluate factors such as fracture features, patient comorbidities, and functional outcome expectations, even if both intramedullary fixation

(TENs) and plate fixation are potential options.[16] The study is to determine an appropriate therapy for midshaft clavicle fractures by comparing TENs with locking plates.

MATERIAL AND METHODS

The current cross-sectional study was carried out on 60 patients with clavicle fractures who visited the Orthopaedics Outpatient Department and Emergency Department at a tertiary care center in Central India over a one-year period. The inclusion criteria were individuals aged over 18 and under 70 years old, with closed fractures classified as Robinson 2B1 and 2B2 (displaced fractures), and no medical contraindications to general anesthesia. The exclusion criteria included pathological fractures, many injured patients, concomitant head injury, neurovascular damage, acromioclavicular joint dislocation, any medical contradiction to surgery or general anesthesia, and those unwilling to participate in the study.

Demographic data was documented. Patients were placed into two groups, each consisting of 16 individuals. The first group was the TENS group, and the second group was the plating group. Following standardized surgical procedures, all patients were provided with a sling for comfort. The wound was examined on the third day following the procedure, and the stitches were taken out on the tenth day. The patient was discharged with a sling and instructed to perform exercises to improve the range of motion in the elbow, wrist, and fingers. Assessment involves systematic clinical evaluation and the completion of the Constant Shoulder Score and Disability of the Arm, Shoulder, and Hand (DASH) score. Each patient underwent both an antero-posterior and a 200 cephalad radiograph. Patients are monitored periodically for a duration of 1 year at intervals of 3 weeks, 6 weeks, 3 months, 6 months, and 12 months. The results were calculated and analyzed using statistical methods. A P value below 0.05 was deemed significant.

RESULTS

Table 1 illustrates the distribution of patients across age groups in the TENS and plating groups, as well as the total population. Each age category, ranging from 20-30 to 51-60 years, displays the number of patients along with the corresponding percentage within their respective treatment groups and the total sample. The total number of patients in each treatment group and overall is provided, alongside the mean age ± standard deviation for both groups. These findings offer a comprehensive overview of the age distribution among patients undergoing TENS and plating procedures, facilitating comparisons between the groups and providing insight into the demographics of the studied population.

Table 1: Distribution of patients

Age in Years	TENS GROUP	PLATING GROUP	Total
20-30	12(40%)	10(33.3%)	**22(36.7%)**
31-40	12(40%)	12(40%)	**24(40%)**
41-50	2(6.7%)	8(26.7%)	**10(16.7%)**
51-60	4(13.3%)	0(0%)	**4(6.7%)**
Total	30(100%)	30(100%)	**60(100%)**
Mean ± SD	**33.33±11.43**	**35.53±8.55**	**34.43±9.98**

Table 2 presents the gender distribution within the TENS and plating groups, as well as the total sample. The table outlines the number of female and male patients along with their corresponding percentages within each treatment group and the total population. In both the TENS and plating groups, 26.7% of patients were female, while 73.3% were male. The total number of patients in each treatment group and overall is also provided, ensuring a clear representation of gender distribution across the studied population.

Table 2: Gender distribution

Gender	TENS GROUP	PLATING GROUP	Total
Female	8(26.7%)	8(26.7%)	**16(26.7%)**
Male	22(73.3%)	22(73.3%)	**44(73.3%)**
Total	**30(100%)**	**30(100%)**	**60(100%)**

Table 3 presents the frequency distribution of modes of injury within the TENS and plating groups, as well as the total sample. The table categorizes injuries into different modes such as assault, fall from height, fall on outstretched hand (FOOSH), road traffic accident (RTA), and sports-related injuries. The number of patients and their corresponding percentages within each treatment group and across both groups are provided. In the TENS group, the most common mode of injury was RTA, accounting for 60% of cases, followed by fall from height and sports injuries, each at 26.7%. In contrast, the plating group had RTA as the most prevalent mode of injury as well, constituting 46.7% of cases, followed by fall from height at 13.3%. Notably, FOOSH injuries were only observed in the plating group, comprising 20% of cases. This table offers insight into the distribution of injury mechanisms among patients undergoing different treatment modalities, aiding in understanding the patterns of trauma in the studied population.

Table 3: Mode of Injury- frequency distribution in two groups

Mode of Injury	TENS GROUP	PLATING GROUP	Total
ASSULT	2(6.7%)	2(6.7%)	**4(6.7%)**
FALL FROM HEIGHT	8(26.7%)	4(13.3%)	**12(20%)**
FOOSH	0(0%)	6(20%)	**6(10%)**
RTA	18(60%)	14(46.7%)	**32(53.3%)**
SPORTS	2(6.7%)	4(13.3%)	**6(10%)**
Total	**30(100%)**	**30(100%)**	**60(100%)**

Table 4 presents the frequency distribution of the side of injury within the TENS and plating groups, as well as the total sample. The table categorizes injuries based on whether they occurred on the dominant or non-dominant side. For each treatment group and overall, the number of patients and their corresponding percentages are provided. In the TENS group, 60% of injuries were on the dominant side, while 40% were on the non-dominant side. In contrast, the plating group had a higher proportion of injuries on the dominant side, accounting for 80% of cases, with only 20% occurring on the non-dominant side. Overall, the majority of injuries across both groups were on the dominant side, constituting 70% of cases, while 30% occurred on the non-dominant side. This table offers

insights into the distribution of injuries based on the dominant and non-dominant sides, providing valuable information for understanding injury patterns within the studied population.

Table 4: Side of Injury- frequency distribution in two groups

Side of Injury	TENS GROUP	PLATING GROUP	Total
Dominant	18(60%)	24(80%)	**42(70%)**
Non dominant	12(40%)	6(20%)	**18(30%)**
Total	**30(100%)**	**30(100%)**	**60(100%)**

Table 5 displays the frequency distribution of associated injuries within the plating and TENS groups, as well as the overall sample. The table categorizes associated injuries into three groups: nil (no associated injury), yes (presence of associated injury), and specific types of associated injuries. For each treatment group and overall, the number of patients and their corresponding percentages are provided. In both the plating and TENS groups, the majority of patients had no associated injuries, accounting for 86.7% and 93.3% of cases, respectively. However, in the plating group, 13.3% of patients had associated injuries, compared to only 6.7% in the TENS group. Specific associated injuries observed in the plating group included Colles' fracture of the right wrist (6.7%) and fractures of both bones in the right leg (6.7%), while the TENS group had Jones fracture of the left foot (6.7%). Overall, 10% of patients across both groups had associated injuries. This table provides valuable insights into the prevalence and types of associated injuries in patients undergoing different treatment modalities for their primary injury, aiding in understanding the overall clinical picture and treatment outcomes.

Table 5: Associated Injury-frequency distribution in two groups

Associated Injury	PLATING GROUP	TENS GROUP	Total
Nil	26(86.7%)	28(93.3%)	**54(90%)**
Yes	4(13.3%)	2(6.7%)	**6(10%)**
Colles' fracture right	2(6.7%)	0(0%)	**2(3.3%)**
Fracture both bone right leg	0(0%)	2(6.7%)	**2(3.3%)**
Jones fracture left foot	2(6.7%)	0(0%)	**2(3.3%)**
Total	**30(100%)**	**30(100%)**	**60(100%)**

Table 6 compares various parameters between the TENS and plating groups in terms of type of fracture, time to surgery, duration of surgery, duration of hospital stay, blood loss, complications, DASH score at 6 months, and Constant Murley score. It illustrates the distribution of patients based on these parameters and their corresponding percentages within each treatment group. For instance, in the TENS group, 86.7% of fractures were classified as 2B1, whereas in the plating group, 73.3% were 2B1 fractures. Regarding time to surgery, the majority of patients in the TENS group underwent surgery within 2-4 days (66.7%), while in the plating group, surgery was mostly performed between 5-7 days (60%). The duration of surgery, duration of hospital stay, blood loss, and occurrence of complications are also outlined, along with the distribution of DASH scores and Constant Murley scores at 6 months post-operation. This comprehensive comparison provides

insights into the differences in treatment outcomes and complications between the two surgical techniques, aiding in clinical decision-making and patient management.

Table 6: Comparison of parameters

Parameters	Variables	TENS GROUP	PLATING GROUP
Type of Fracture	2B1	26(86.7%)	**22(73.3%)**
	2B2	4(13.3%)	**8(26.7%)**
Time to Surgery (days)	2-4	20(66.7%)	**6(20%)**
	5-7	4(13.3%)	**18(60%)**
	8-10	6(20%)	**6(20%)**
Duration of surgery (minutes)	<50	18(60%)	**4(13.3%)**
	>50	12(40%)	**26(86.7%)**
Duration of Hospital Stay	2-3	20(66.7%)	**0(0%)**
	4-5	10(33.3%)	**22(73.3%)**
	6-7	0(0%)	**8(26.7%)**
Blood loss (ml)	60-90	30(100%)	**0(0%)**
	91-120	0(0%)	**10(33.3%)**
	120-150	0(0%)	**20(66.7%)**
Complication	Hardware migration	2(6.7%)	**0(0%)**
	Infection	0(0%)	**2(6.7%)**
	Mal union	0(0%)	**2(6.7%)**
	Non union	2(6.7%)	**0(0%)**
	Skin Infection	2(6.7%)	**0(0%)**
	Skin Irritation	4(13.3%)	**4(13.3%)**
DASH at 6 months	<10	20(66.7%)	**18(60%)**
	10-15	8(26.7%)	**10(33.3%)**
	>15	2(6.7%)	**2(6.7%)**
Constant Murley Score	<10	20(66.7%)	**8(26.7%)**
	10-15	6(20%)	**20(66.7%)**
	>15	**4(13.3%)**	**2(6.7%)**

DISCUSSION

The study was conducted on patients with displaced midshaft clavicle fractures at the Department of Orthopaedics, tertiary care hospital in central India. Patients were randomly assigned to two groups: Group 1 and Group 2. Group 1 patients received treatment with Transcutaneous Electrical Nerve Stimulation (TENS), while Group 2 patients received treatment with Locking Compression Plate. The data were analyzed through a comparison of the 2 groups. During the follow-up, the clinical and functional result was evaluated using measures such as union time, DASH score, and Constant Murley score. We also attempted to evaluate post-operative complications such as skin irritation, malunion, non-union, hardware migration, and infection.

The age range of patients in the TENS group in our study was 20 to 60 years, with a mean of 33.33±11.43. In the LCP group, the age range was 20 to 50 years, with a mean of 35.53±8.55. In this study, the average age was 40±11.2 years for the LCP group and 38.9±9.1 years for the TENS group, similar to the work by Narsaria N *et al*. In our study, there were 22 males (73.3%) and 8 females (26.7%) in both the TENS group and LCP group, resulting in a male to female ratio of 2.7:1 for each group. The majority of participants in both groups were males, consistent with a study conducted by Zehir S *et al*.[17] In the TENS group, 58.3% were males and 41.7% were females, while in the LCP group, 57.1% were males and 42.9% were girls. Road Traffic Accident was the most frequent cause of injury in both groups, occurring in 18 cases (60%) for the TENS group and 14 cases (46.7%) for the LCP group in our study. Four instances in the TENS group involved falls from height near to road traffic accidents, while three cases involved falls on outstretched hands next to road traffic accidents. In a study by Sahu AK *et al*, [18]it was found that road traffic accidents (RTA) were the most common cause of injury for both groups, with 48% of patients in the TENS group and 64% in the LCP group.

The clavicle of the dominant limb was usually affected in 60% of the TENS group and 80% of the LCP group, similar to the findings of Sahu AK *et al*., [18]where the dominant side was involved in 76% of the TENS group and 52% of the LCP group. Most patients in both groups did not have any injuries related to the clavicle fracture in the current investigation. In our study, the majority of patients were classified under type 2B1 according to Robinson's classification. Specifically, 86.7% of patients were operated on using TENS and 73.3% using LCP. This aligns with a study by Kumar M *et al*,[19] where 78.3% of patients operated on with plating were of AO type 2B1 and 89.47% of patients operated on with TENS. The majority of patients in the TENS group underwent surgery within 2 to 4 days of injury, totalling 20 patients (66.7%). In contrast, the majority of patients in the LCP group were operated on between 5 to 7 days of injury, totaling 18 patients (60%), with a range of 2-10 days. In a research by Zehir S *et al*,[10], the average time to surgery for the TENS group was 5.7 days, but for the LCP group, it was 6.2 days.

Our study revealed that patients treated by TENS had an operative time of less than 50 minutes, accounting for 60% of the cases, whereas patients operated by LCP had an operative time over 50 minutes, accounting for 86.7% of the cases. In a study by Chen YF *et al*,[20], the average operative time for TENS was 48.25 ± 19.76 minutes, while for plating it was 66.49 ± 22.47 minutes.

In our study, patients who underwent TENS surgery experienced blood loss ranging from 60-90 ml, while the majority of patients in the LCP group had blood loss between 120-150 ml. In a research by Liu HH *et al*,[21] blood loss in TENS was 67±37 ml while in LCP was 128±49 ml. Most patients in both the TENS and LCP groups achieved union within 10-15 weeks. However, 4 patients (13.3%) in the LCP group achieved union in less than 10 weeks. In a study by Sahu AK *et al*,[18], the union time for the TENS group was 11.4±2.12 weeks, while it was 13.4±3.46 weeks for the LCP group.

At 6 months, the DASH score was below 10 for 20 patients (66.7%) in the TENS group and for 18 patients (60%) in the LCP group. The study found that the majority of patients in the TENS group (66.7%) had a Constant Murley Score below 10, with a mean score of 11.13±8.46. In comparison,

most patients in the LCP group (66.7%) had a Constant Murley Score between 10 and 15, with a mean score of 11.07±2.37 for the TENS group.

After comparing both groups in the study, the TENS group had 2 instance of hardware migration, 2 case of non-union, and 2 case of skin infection. In contrast, the LCP group had 2 case of infection, 2 case of malunion, and 4 cases of skin irritation. In a study conducted by Chen YF *et al*, the TENS group had 2 case of infection, 8 cases of skin irritation, and 34 cases of hardware migration. In the LCP group, there were 6 cases of infection and 14 cases of skin irritation.

CONCLUSION

Authors discovered that both internal fixation methods using TENS and plating have their own pros and cons. However, the ultimate functional results, as measured by DASH and Constant Murley scores, are not affected by the surgical treatment method for displaced mid-shaft clavicle fractures. TENS is effective for treating uncomplicated displaced fractures of the mid-shaft clavicle due to its ability to distribute stress similarly to an intact clavicle using a minimally invasive approach, resulting in minimum blood loss, little to no periosteal stripping, and improved cosmetic results. TENS offers lower stability than plate fixation, hence it is advisable to refrain from intense exercise and weight bearing during the initial post-operative phase. Fixation of comminuted mid-shaft clavicle fractures using open reduction and internal fixation with LCP is a successful treatment. Plating for mid-shaft clavicular fractures provided increased stability, although resulted in noticeable stress shielding. Thus, patients desiring a prompt return to exercise may benefit from plating.

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