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A comparison of intramedullary nailing versus plating in AO type 15.2B and 15.2C clavicle fractures: a prospective study

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ABSTRACT

Background: Midshaft clavicle fractures, particularly AO types 15B and 15C, are common orthopedic injuries. Surgical management is preferred in displaced fractures due to complications associated with conservative treatment. This study compares intramedullary fixation using titanium elastic nailing system (TENS) with conventional plating.
Methods: A prospective cohort study was conducted on 80 patients aged 15-70 years with AO 15B and 15C clavicle fractures. Patients were randomized into two groups: one treated with TENS and the other with plating. Surgical, radiological, and functional outcomes were evaluated at 1, 3, and 6 months postoperatively using Constant-Murley and DASH scores, union time, and complications.
Results: TENS group had significantly shorter union time (7.4 weeks vs. 8.9 weeks, p=10.024), smaller incision size, and shorter hospital stay. Functional scores were superior in the TENS group. TENS group had significantly shorter union time (p=0.024), smaller incision size, and shorter hospital stay. Implant prominence was more common with TENS, but plating had higher rates of infection, non-union, and implant failure.
Conclusions: TENS provides superior functional recovery, better cosmetic results, and fewer complications in AO 15B and 15C clavicle fractures. It is a cost-effective and efficient alternative to plating, especially in resource-limited settings. However, plating may offer more stable fixation in complex fracture patterns.

Keywords: Midshaft clavicle fracture, AO classification 15B and 15C, Titanium elastic nailing system, Plate fixation

INTRODUCTION

The clavicle is the most frequently fractured bone in orthopaedics, typically resulting from a direct blow to the shoulder or a fall on an outstretched hand. These injuries constitute approximately 5-9% of all adult fractures, with the majority occurring at the junction of the medial one-fifth and lateral four-fifths, reported in 12.1-13.1% of cases. Clavicle fractures are more common in men (14%) than in women (15%), and around 16% are displaced.[1,2]

Conservative approach in the management includes bandage in figure of eight, arm sling or combination of both. Conservative approach for displaced fractures has presented various complications that include shoulder discomfort, shoulder dropping, higher nonunion rates, neurological complications, gross cosmetic deformity and limitation of shoulder ROM.[3,4] Surgical indications include >2 cm clavicle shortening, compounding at fracture site or impending skin perforation, severely comminuted fracture and floating shoulder.[3] Operative techniques include open reduction and internal fixation using plates and screws and closed or open reduction with intramedullary fixation using devices such as the TENS.[5] Plating is widely considered the standard method due to its rigid fixation but is associated with disadvantages including a larger surgical scar, longer operative time, higher infection risk, plate prominence, periosteal stripping that may impair blood supply, the need for a second procedure for implant removal, and the potential for refracture after plate removal.[6]

TENS is an intramedullary device that works on the principle of three-point fixation which acts as a load sharing device. Healing occurs through secondary method and without rigid fixation in contrast to the plate where healing occurs through primary intention and absolute stability.[5] Additionally, fixation through TENS has following advantages smaller surgical scar, cosmetically better, reduced operative time, reduced infection rate, early union rate and easy removal procedure that lacks incidence of refracture.[7] Usually, AO 15B and 15C are managed with open reduction and plating, as some surgeons find it difficult to manage the free fragment.[5] Considering the above modalities of treatment and lack of studies, this prospective cohort study was conducted to compare the management of fracture AO classification 15B and 15C through plate fixation and intramedullary nail via medial entry.[8] This study adds evidence to the body of literature already written about the subject and supports it. TENS nailing is a more affordable alternative to plating and a quicker rehabilitation technique than cautious care in the less developed parts of developing countries. In developing countries, cost-effectiveness and expedited rehabilitation facilitate the included demographic group's early return to employment.[5]

METHODS

This prospective study was conducted at Maharani Laxmi Bai Medical College, Jhansi, Uttar Pradesh, India after receiving approval from the institutional ethics committee of the college. The study duration was September 2023 to March 2025.

The study comprises of 80 population between 15-70 years of age group irrespective of gender with shaft clavicle fracture irrespective of side. AO classification system was used to classify the fracture. AO 15B and 15C fracture type were selected for study. Every subject was informed, and written consent was procured before intervention. Open fractures were reduced under direct vision whereas intraoperative image intensifier was used for closed reductions. Patients age <15 years, unfit for surgery, pathological fracture, neurological deficit, floating shoulder, ipsilateral bony injury of upper limb/upper rib fracture, previous non-union, not giving consent were not included in the study. Simple randomization was used to allocate the patient into two groups-one group was managed with plate and screws and the other was managed with TENS. In both groups operative intervention was done under general anaesthesia.

Surgical approach-Clavicle plating

Patient lies supine on OT table. Part was exposed, painted and draped after scrubbing. Under supine position of the patient a bump is placed in between both the scapulas thus causing the shoulder girdle to fall posteriorly thus providing a better exposure and maintaining length of the fractured bone. 6-10 cm skin incision was given, subcutaneous tissue dissected and retracted. 3.5 mm anatomical plate was usually used and 1/3 tubular plate and recon plate were pre-contoured according to the anatomy and fixed over the superior surface after reduction (Figure 1). Suturing was done in layers.

Surgical approach-TENS

Patient lies supine on OT table. Small bolster was placed beneath the scapula. Skin incision of 1-1.5cm over clavicle (sternal end). Awling was done at anteroinferior edge. Appropriate size nail is loaded in the T-handle depending on the size of medullary cavity. Under fluoroscopic guidance, fracture was reduced followed by manual migration of nail and engaging into superolateral cortex of distal end of the clavicle (Figure 3). Fracture site then seen under c arm guidance for cephalic and caudal views. Open reduction was performed by giving 2cm skin incision directly over the fracture and passing the nail under direct vision where close reduction was not possible. Nail was cut very close to the soft tissues to avoid soft tissue impingement (Figure 4).

Post operative care and follow up

Appropriate antibiotics and analgesics were given for both the groups. Arm was immobilized using broad arm pouch or arm sling. Immediate postoperative x-rays were taken after 6-8 hours, and stitch line evaluation was done on day 3 and day 7. Suture removal was done on day 13. Active ROM of shoulder was started as early as possible (Pendulum exercise of the shoulder). Postoperative 4 weeks shoulder ROM were started except overhead abduction and flexion movement. 6 weeks ROM in all planes was allowed. Patients were followed up once every month till complete union was achieved (Figure 2 and 5). Follow up and assessment of the patients were done at 1, 3 and 6 months respectively with X-rays and range of motion (ROM) thus checking the implant position and patient's rehabilitation.

Outcome assessment

We measured the time for union and clavicular shortening following union i.e. comparing the linear difference of length between the normal and the operated side between the acromial end and the sternal end. Clinically union was considered as absence of tenderness on palpation, full ROM, complete strength of the involved extremity and absence of fracture line over X-ray and bridging callus was considered as union radiologically.

Mean Constant-Murley score in plate group was 9.63±4.07 and TENS group 15.80±09.

The therapeutic efficiency was measured by the secondary outcomes-operation time, hospital stay, blood loss, size of surgical scar, non-union, malunion, implant migration/failure, neurovascular injury.

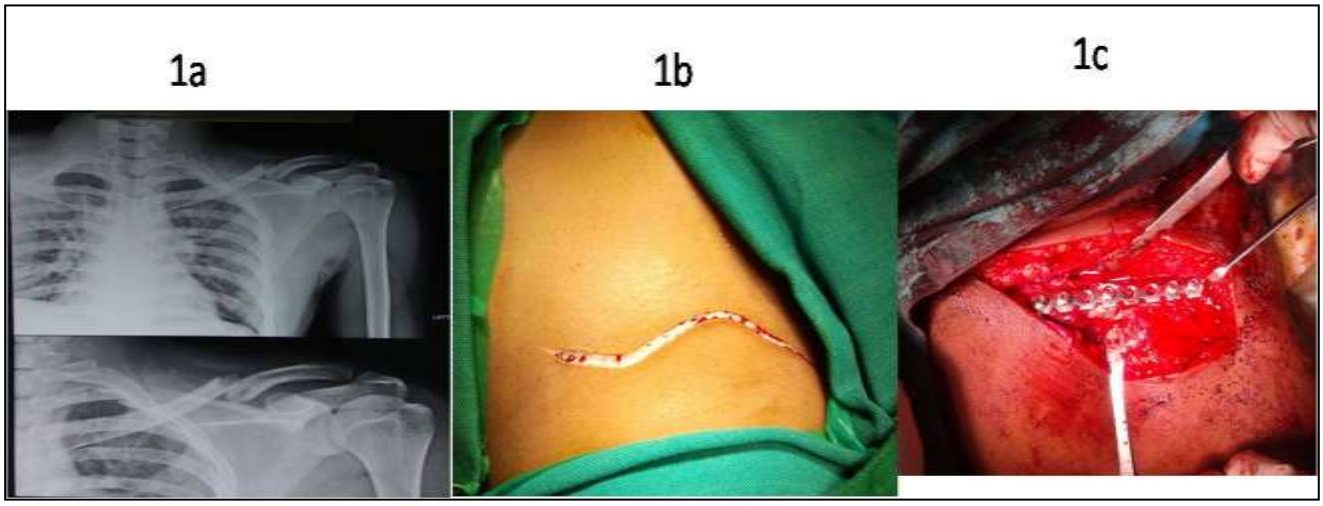

Figure 1 (a-c): Preoperative x-ray, skin incision for clavicle plating, plate fixation of clavicle fractures.

Figure 2: (a) Immediate postoperative Xray and 6 weeks follow up Xray; (b) range of movements following clavicle plating.

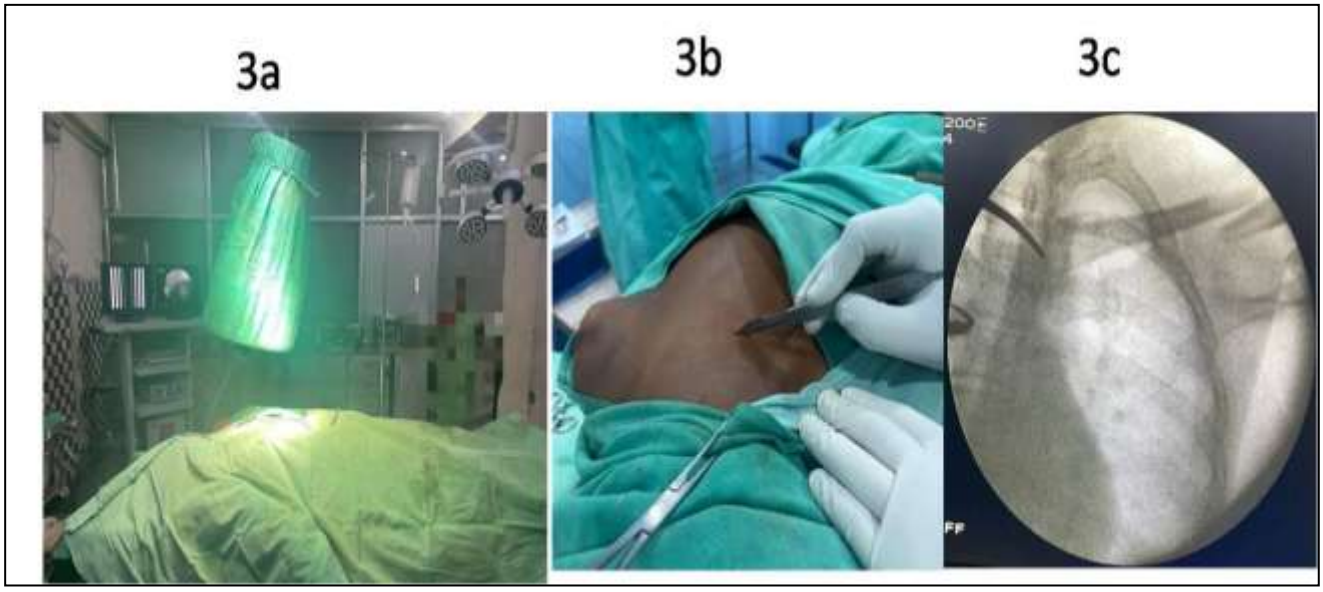

Figure 3 (a-c): (a) Arm positioning during nailing of clavicle, (b) marking skin incision and (c) entry point for TENS.

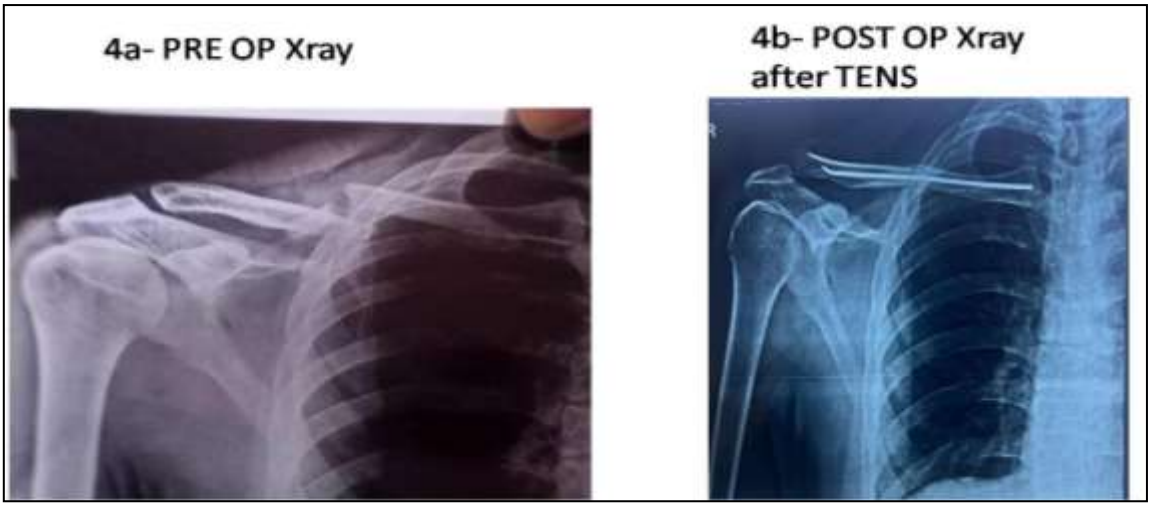

Figure 4 (a and b): Preoperative and post operative x-ray following TENS.

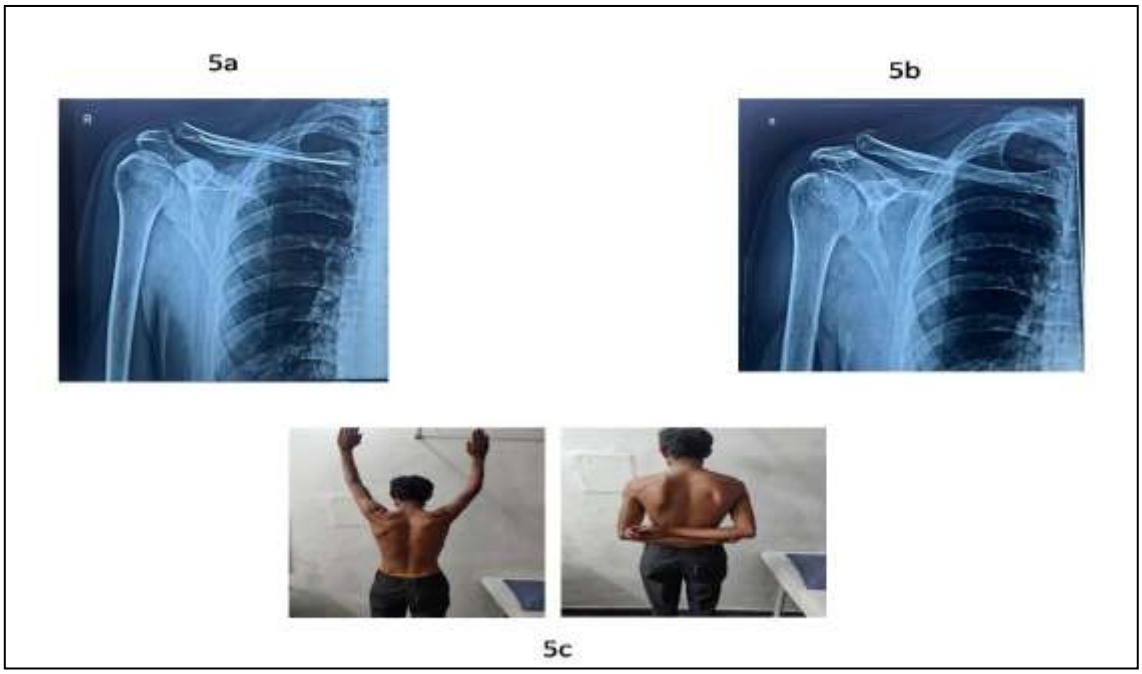

Figure 5: (a) Follow up x-ray at 6 weeks; (b) X-ray after implant removal and (c) range of movements following TENS in clavicle.

Figure 6 (A and B): Complications. (a) Complications following plate-wound dehiscence and plate exposure and (b) complications following TENS-implant prominence and medial migration of TENS.

RESULTS

Study comprises of 80 patients of which 40 were managed with TEN while remaining 40 were managed with plating. The demographic profile showed comparable mean ages between the TEN (34.6±11.4 years) and plating (35.8±12.2 years) groups, with a slight male predominance in both. Road traffic accidents were the leading cause of injury, followed by sports-related trauma, slip and fall, and high-fall injuries, with no marked variation between groups. The dominant limb was more frequently involved in both cohorts (Table 1). Perioperative parameters demonstrated significant advantages with TEN, including shorter operative time (48.3±6.4 min vs. 62.8±5.9 min), reduced hospital stay (2.1±0.5 days vs. 3.4±0.7 days), and markedly smaller incision length (1.8±0.3 cm vs. 9.4±0.5 cm). Postoperative pain scores were consistently lower in the TEN group across the first three days, with statistically significant differences at each time point (Table 2).

Functional assessment revealed smaller wound size but greater clavicular shortening with TEN (1.1 cm vs. 0.2 cm, p<0.002). Functional outcome was accessed through DASH score and constant shoulder score. In TENS group 86% excellent, 7% showed good result. Whereas, in plate group 60% excellent while 15% showed good results. Although the scores favoured TEN numerically, differences were not statistically significant (Table 3).

Fractures managed with TENS showed an average union time of 11.1±3 weeks while in the plating group there was 14.5±2.5 weeks and the difference were significant (p=0.024). Complication analysis showed fewer infections, implant failures, and exposures in TEN, though medial migration was more common; differences did not reach statistical significance (Table 4). Not all medially migrated nails caused implant irritation or exposure. Plate was exposed in 9 patients, 5 of which healed with extended antibiotic coverage and regular dressings. Intramedullary nail was exposed in 2 patients (Figure 6). Proper patient selection and technique refinement are essential to minimize this complication.

Table 1: General variables in TEN and plate group.

Characters	TENS	Plating
Mean age (in years)	34.6±11.4	35.8±12.2
Gender	23-male 17-female	19-male 21-female
Mode of injury		
RTA	21	22
Sports	7	6
Slip and fall	7	7
Fall from height (>10 ft)	5	5
Injured side		
Dominant	35	27
Non-dominant	15	13

Table 2: Comparison of perioperative outcomes between TEN and plate fixation groups.

Parameters	TEN, (n=40)	Plate, (n=40)	P value
Operative time (minutes)	48.3±6.4	62.8±5.9	<0.001
Length of hospital stay (days)	2.1±0.5	3.4±0.7	<0.001
Length of incision (cm)	1.8±0.3	9.4±0.5	<0.001
Pain score			
Post-op day 1	2.1±0.7	3.9±1.0	<0.001
Post-op day 2	1.3±0.4	2.6±0.9	<0.001
Post-op day 3	0.8±0.3	2.0±0.6	<0.001

Table 3: Comparison of wound size, clavicular length shortening, and functional outcomes between both groups.

Parameters	TEN group, (n=40)	Plate group, (n=40)	P value
Wound size (cm)	1.8	9.4	<0.001
Clavicular length shortening (cm)	1.1	0.2	<0.002
Constant score	9.63	15.80	0.188
DASH score	1.85	4.5	0.623

Table 4: Post operative complications in both the groups.

Complications	TEN group, (n=40)	Plate group, (n=40)	P value
Infection	1	8	0.302
Implant failure	0	6	0.423
Implant irritation	7	9	0.323
Medial migration	8	-	
Implant exposed	2	9	0.231
Non-union	2	8	0.142
Restricted shoulder movement	3	7	0.295

DISCUSSION

Fractures of the clavicle, particularly at the midshaft (AO classification 15.2) constitute a significant portion of upper limb injuries, especially in active adults. Although the majority of these fractures have traditionally been managed conservatively, recent shifts toward operative interventions are driven by higher functional demands, increasing rates of non-union, and improved surgical outcomes. This study was conducted to evaluate and compare the clinical, radiological, and functional outcomes of two widely accepted surgical techniques: TENS and plating in midshaft clavicle fractures with wedge or communition. The rationale for the comparison

stemmed from the increasing use of TENS as a minimally invasive alternative to conventional plating, particularly in resource-constrained settings where reduced surgical trauma and cost-effectiveness are highly valued.

Most of the patients in our study were young adults, with a mean age of 24.25 years, consistent with studies by Nordqvist et al which reported similar demographic trends.[9] A predominance of male patients was also observed, reflective of their greater exposure to high-energy trauma such as road traffic accidents, which was the most common mechanism of injury in our cohort. This pattern is similarly reported in studies by Robinson et al.[4]

Radiological union was significantly faster in the TENS group (mean 11.4 weeks) compared to the plating group (mean 14.9 weeks). This is likely due to the biological fixation achieved with intramedullary nailing, which allows for micromotion at the fracture site, promoting secondary healing. These findings are supported by Smekal et al who also demonstrated accelerated union times with intramedullary devices.[5] The relatively higher union rate and shorter healing time in the TENS group are advantageous, especially in terms of early return to work and rehabilitation, which are essential considerations in low-resource and labor-dependent populations.

Functional outcomes assessed using the Constant-Murley score and DASH score favoured TENS over plating. Saha et al and McKee et al also emphasized better shoulder function and patient-reported outcomes following TENS fixation.[10,11] The reduced postoperative pain (as evidenced by lower VAS scores), quicker restoration of ROM, and fewer hardware-related issues likely contributed to the superior functional performance of the TENS group. Fuglesang et al in their study concluded that communited midshaft clavicle fractures fixed with plate gave superior results as compared to intramedullary nail, whereas we have got excellent results with TEN in all such fractures.[12]

The complication rate was markedly lower in the TENS group. Bostman et al and Poigenfurst et al in their study, highlights concern about soft tissue irritation, extensive dissection, and periosteal stripping associated with plating.[13,14] In contrast, TENS patients experienced fewer complications, with only isolated cases of infection and delayed union. The minimally invasive nature of TENS, combined with smaller incisions and less disruption of soft tissue and periosteum, likely accounts for the reduced morbidity.[15] Moreover, cosmetic outcomes were superior in the TENS group, which is particularly relevant in younger individuals who may be concerned about visible scars and hardware prominence.

An often-overlooked but important consideration in surgical decision-making is implant removal. TENS removal is typically simpler, less invasive, and can often be performed under local anaesthesia. Plating, on the other hand, often necessitates a more extensive procedure, with associated risks of refracture or neurovascular compromise.[16] Studies by McKee et al and others have documented refracture rates of 1-2% following plate removal.[11] Our study found 3% refracture rate in the plating group, reinforcing importance of cautious implant removal and postoperative monitoring. Also, 2 cases were found where the plate could not be removed due to driver-screw head mis-engagement due to shape distortion.

The clinical and functional advantages of TENS, combined with reduced surgical time, cost-effectiveness, and quicker rehabilitation, make it a particularly suitable option in developing countries. These regions often have limited access to prolonged hospital care, and patients are more likely to be economically impacted by time away from work. The advantages of TENS thus extend beyond the immediate clinical outcomes to encompass broader socio-economic benefits.

Limitation

Management through TENS is ineffective when the clavicle fracture is towards medial and lateral end as there is minimal purchase of fracture fragment, delayed union, longer activity restriction after the procedure. We have restricted our study for the fracture classification AO 15C, 15B and compared the outcomes with plating group. Patients aged below 15 years, unfit for surgery, pathological fracture, neurological deficit, floating shoulder, ipsilateral bony injury of upper limb/upper rib fracture, previous non-union, not giving consent were not included in the study conducted.

CONCLUSION

Management with TENS for shaft clavicle fracture 15.2 B and 15.2 C as per AO classification system showed better results in terms of functional outcome, better rehabilitation, early return of activities, excellent patient satisfaction and cosmetically more acceptable method of surgical management when compared to the conventional method of plating. Even the implant removal in TENS group can be done through smaller incision. Thus, TENS is superior to plating for management of mid shaft clavicle fracture as per AO classification 15B and 15C compared to plate. TENS nailing is a more affordable alternative to plating and a quicker rehabilitation technique. In developing countries, cost-effectiveness and expedited rehabilitation facilitate the included demographic group's early return to employment.

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