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Assessment of elastic nail for fracture treatment among the Nigerian Patients

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Abstract

Clavicle fractures are commonly treated through conservative methods. However, due to a higher likelihood of complications such as delayed union, non-union, symptomatic malunion, cosmetic deformities, and other issues, surgical intervention has become more widely used. Plating and intramedullary nailing are among the most frequently employed surgical techniques. Recent prospective randomized studies have shown that operative treatment often yields better outcomes than traditional methods. This study aims to compare clinical outcomes, surgical techniques, and associated complications. A total of 50 patients with OTA type B displaced midshaft clavicle fractures (DMCFs) underwent surgical fixation using either antegrade Titanium Elastic Nails (TENS) or a one-third tubular plate. The patients were divided into two groups based on the fixation method. Their outcomes were assessed using the Constant-Murley shoulder score and DASH score at 6 weeks, 12 weeks, 3 months, 6 months, and 12 months postoperatively. Findings indicated that the TENS group experienced easier implant removal, minimal complications, reduced blood loss, and shorter operating time. The primary complication observed in this group was slight shortening (approximately 0.5 cm) in a few cases. In contrast, the plate fixation group did not exhibit major complications, though minor issues such as deep and superficial infections, hypertrophic scarring (without pain), and mild shoulder motion restriction were noted. However, no cases of shortening were reported in this group. Both fixation methods demonstrated similar outcomes in terms of bone union and stability. However, TENS appeared to be the preferred choice due to its lower morbidity, improved cosmetic results, and ease of implant removal. Plate fixation, on the other hand, offered slightly greater stability and was preferred in cases of comminuted fractures.

Keywords: Titanium Elastic Nail, Tubular Plate, Displaced Midclavicular Fracture.

INTRODUCTION

A large number of shoulder injuries involve clavicle fractures, which are primarily caused by falls on an outstretched hand or direct trauma (Robinson, 1998). These fractures are commonly observed in individuals participating in sports activities or those involved in traffic accidents (O'Neill, Hirpara, & O'Briain, 2011). Most clavicle fractures occur at the midshaft, with more than half being displaced. This is due to the compressive forces acting on the shoulder combined with the narrow cross-section of the bone, leading to structural failure (Postacchini, Gumina, & Santis, 2002). Traditionally, non-operative treatment was the primary approach for managing these fractures. However, there is now a growing preference for surgical intervention due to its advantages, including lower rates of symptomatic malunion and nonunion (McKee, Whelan, & Schemitsch, 2012; Virtanen, Remes, & Pajarinen, 2012; Robinson, Goudie, & Murray, 2013). With advancements in anatomically pre-shaped plates, the debate has shifted from whether to perform surgery to determining the most suitable implant for midshaft clavicle fractures (VanBeek, Boselli, & Cadet, 2011).

The two primary surgical methods for treating displaced midshaft clavicle fractures are intramedullary fixation and internal plate fixation. Intramedullary fixation is known to improve functional outcomes and reduce the risk of nonunion, while plate fixation generally provides superior results across various parameters and remains the most commonly used surgical technique. In current study, we investigated this issue in the context of a Nigerian teaching hospital. Accordingly, we made a comparison between the two groups and compared the post-treatment results.

MATERIALS AND METHOD

This prospective study was conducted on patients with displaced midshaft clavicle fractures who underwent treatment with Titanium Elastic Nailing System (TENS) or a one-third tubular plate at a teaching hospital in Lagos, Nigeria. The patients were randomly assigned to two groups for comparison. Inclusion criteria included patients aged between 16 and 65 years with displaced midshaft clavicle fractures, fractures with shortening of 2 cm or more, skin tenting, or compromised skin. Patients were excluded if they had fractures older than two weeks, open fractures, nonunion or malunion of previous fractures, or pathological fractures.

Operative Technique

General anesthesia was administered with the patient positioned supine on the operating table. The sternoclavicular joint was identified through palpation and marked. A skin incision approximately 1.2 cm in length was made lateral to the sternoclavicular joint. A pointed awl was then used to create the entry point on the anterior cortex. A titanium elastic nail (1.75 mm in size, depending on the canal diameter and the patient's stature) attached to a T-handle was inserted through the entry point. The tip of the nail was slightly straightened before insertion to facilitate smoother gliding within the medullary canal. The nail was advanced using a corkscrew motion until it reached the fracture site. Closed reduction was performed under fluoroscopic guidance with the assistance of percutaneously introduced towel clips. If closed reduction was unsuccessful, an alternative accessory incision of approximately 3 to 4 cm was made to allow for manual manipulation. The nail was then advanced until it reached the medial aspect of the acromioclavicular joint, while ensuring that the thin dorsal cortex was not penetrated. Once the nail was fully inserted, it was cut and slightly bent at the medial end to prevent soft tissue irritation while leaving sufficient length for easier removal in the future. The procedure was completed by closing the fascia and skin in layers.

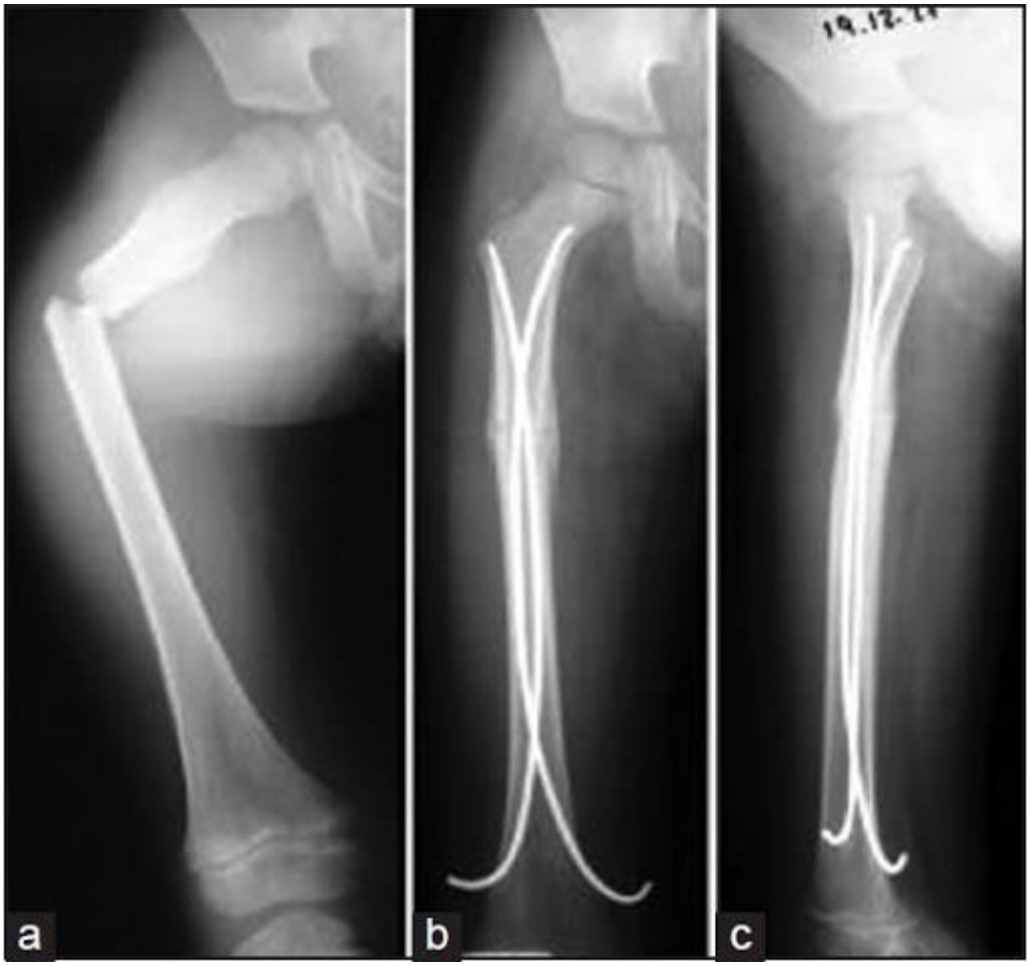

Figure 1: A Titanium Elastic Nail Fixed

Operative Procedure

A transverse skin incision was made along the anterior border of the clavicle under either general anesthesia or brachial block. After achieving reduction with minimal periosteal stripping, fixation was performed. Each plate was carefully contoured to match the natural shape of the clavicle. To ensure optimal fixation strength, at least three screws were inserted on both the proximal and distal ends. In cases where fracture reduction was challenging due to severe comminution with 23 or more bone fragments, additional support was provided using a cerclage wire and a lag screw. For fractures involving extensive comminution on the inferior surface of the clavicle, autogenous iliac bone grafting was performed to prevent nonunion, fixation failure, or metal breakage caused by tension. Bone grafting was conducted in five cases using autogenous grafts from the ipsilateral iliac crest. Postoperatively, patients were placed in an arm sling for approximately two weeks and were instructed to perform pendulum exercises and active range-of-motion exercises.

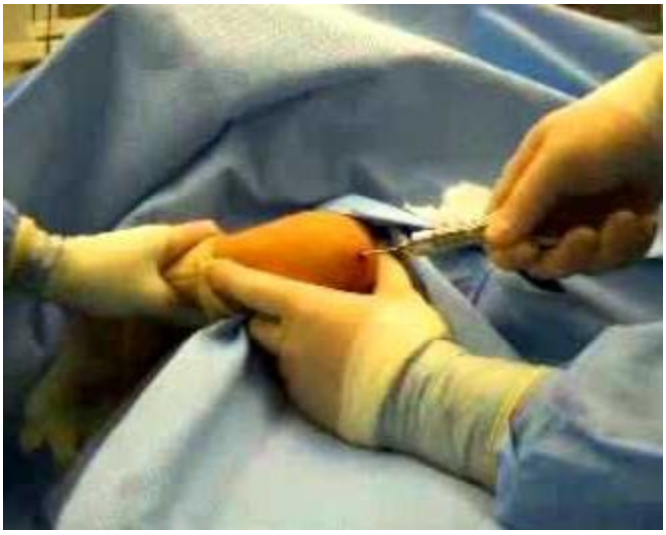

Figure 2: Clinical Picture

Assessment of Treatment Outcomes

Patients were provided with an arm sling but were encouraged to begin mobilization within their tolerance level, including pendulum exercises. Active range-of-motion exercises commenced after seven days. Daily activities were gradually resumed following this period, except for lifting heavy objects, which was restricted until fracture union was confirmed. Patients attended regular follow-up visits at the hospital for clinical evaluation. Clinical assessments were conducted to measure both primary and secondary outcomes. Functional outcomes were evaluated using the Constant score. Radiographic union was defined by the presence of bridging callus or the disappearance of fracture lines, while clinical union was determined by the absence of tenderness at the fracture site. The time required to achieve union was recorded. Once union was achieved, clavicle shortening was measured clinically by comparing the linear distance from the sternal end to the acromial end between the operated and the unaffected side.

Perioperative data, including blood loss, operative time, surgical wound size, and complications such as wound infection, malunion, nonunion, implant failure, and neurovascular injury, were documented as secondary outcomes. Additionally, the time taken for patients to return to normal activities following fracture union was recorded.

Statistical analysis

Only patients who attended at least four follow-up sessions after surgery were included in the study. The differences between the two groups concerning primary and secondary outcomes at the end of the follow-up period were measured and analyzed using the *t*-test for independent group means comparison.

RESULTS AND DISCUSSION

A total of 50 patients participated in the study. Out of total patients, 25 patients were in Plate group and 25 patients were in TENS group. Based on gender, there were 13 male and 12 female in Plate group, and 14 male and 11 female in the TENS group. In terms of age, the biggest age group in Plate group was 16 to 30 followed by 31 to 40. In TENS group, the biggest age group was 41 to 50, followed by 51 to 60. The 12 patients in Plate group had Left side treatment and 13 right side, while in TENS group, 9 patients were left side, and 16 had right side treatment. Based on Fracture type, in Plate group, 7 patients had B1, 7 patients had B2, and 11 patients had B3 fracture type. In TENS group, 13 patients had B1, 6 patients had B2, and 6 patients had B3 fracture type. In terms of model of injury, the biggest cause was RTA and others both having frequency of 7 in Plate group. In TENS group, it was RTA which was the biggest mode of injury.

Table 1
Study Group Characteristics

		Plate Group N=25	TENS Group N=25
Gender	Male	13	14
	Female	12	11
Age	16 to 30	8	4
	31 to 40	6	5
	41 to 50	3	7
	51 to 60	5	6
	Above 60	3	3
Side	Left, %	12	9
	Right, %	13	16
Fracture Type	B1, %	7	13
	B2, %	7	6
	B3, %	11	6
Mode of Injury	RTA, %	7	15
	Fall, %	6	3
	Assault, %	5	3
	Others, %	7	4

The age range in the TENS group was 15 to 55 years, with a mean age of 34.5 years, whereas the Plate group had an age range of 15 to 57 years, with a mean age of 33.9 years. The average delay before trauma surgery was 5.98 days in the Plate group, ranging from 4 to 27 days, and 5.43 days in the TENS group, with a range of 2 to 10 days. In the TENS group, 28 patients (82%) had AO class B1 fractures, 3 patients (9%) had AO class B2 fractures, and 3 patients (9%) had AO class B3 fractures. In the Plate group, 23 patients (71.9%) had AO class B1 fractures, 5 patients (15.6%) had AO class B2 fractures, and 4 patients (12.5%) had AO class B3 fractures.

Table 2
Parameters Analyzed

	Results	
Parameters Analyzed	TENS	Plate
Duration of injury, Days (Mean ± SD)	6.1 ± 2.98	6.23±2.19
Union, n	100 %	100 %
Union time, weeks (Mean ± SD)	9.43±1.53	9.76 ± 1.82

In the TENS group, a nail diameter of 2 mm was used in 9 patients, 2.5 mm in 15 patients, and 3 mm in 1 patient. Closed reduction and nailing were successfully performed in 20 patients, while the remaining 5 cases required open reduction using a mini-open technique. The mean follow-up period was 26.23 ± 3.43 months (range: 18–30 months) for the Plate group and 25.53 ± 2.39 months (range: 18–30 months) for the TENS group.

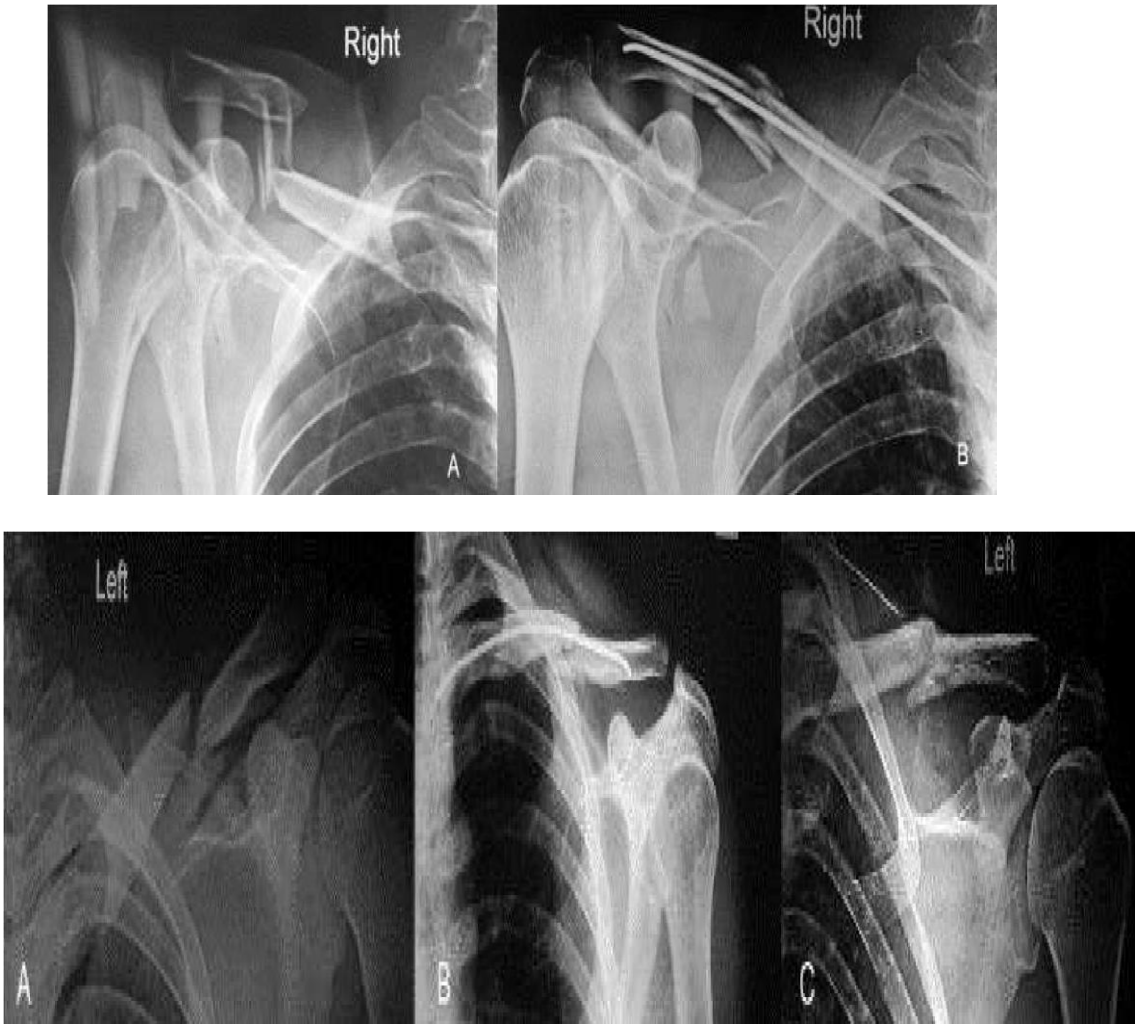

Figure 3: Comminuted Fracture of Clavicle with Significant Shortening.

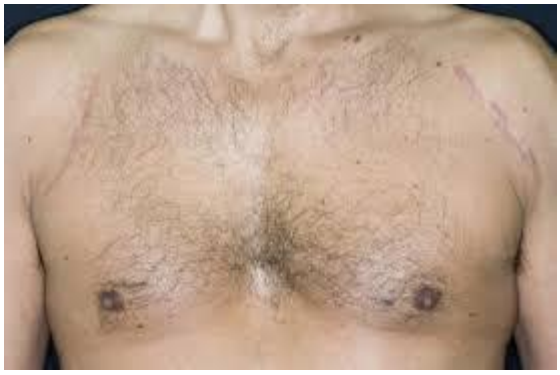

Figure 4: Cosmetically Acceptable Small Surgical Scar

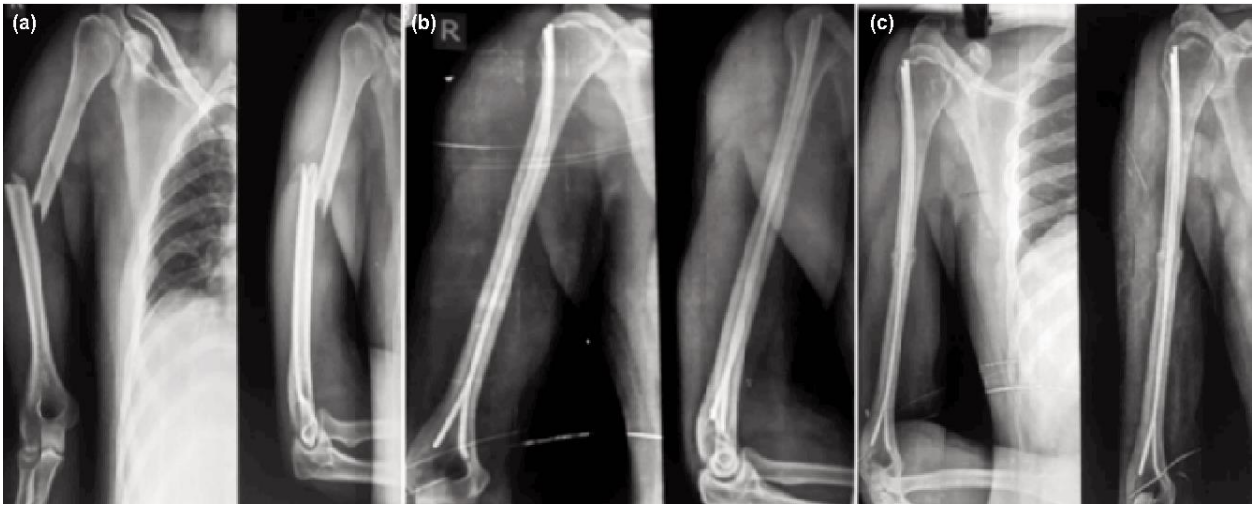

Figure 5: X-Ray of Titanium Elastic

Table 3

Comparison

	Constant Score (Mean±SD)		**DASH Score (Mean±SD)**	
	Tens	**Plate**	**Tens**	**Plate**
4 Weeks	59.5±3.47	58.7±4.57	12.31±4.97	12.96±3.93
3 Months	71.36±5.95	61.62±5.63	5.87±1.98	5.91± 2.13
6 Months	93.47±1.57	91.27±2.32	6.23±1.21	6.57±1.93
12 Months	91.57±2.67	90.87 ± 208\	5.37±1.47	5.87± 1.12
P value	p > 0.05	p > 0.05	p > 0.05	p > 0.05

A comparison of scores at 6 weeks, 3 months, 6 months, and 12 months follow-up revealed no significant difference between the TENS and Plate groups. In other words, the outcomes for both groups were comparable with no statistically significant variation.

Table 4

Complications

Complications	TENS (No.)	Plate (No.)
Superficial infection	1	-
Hypertrophied scar	-	1
Limited shoulder motion	-	2
Painful shoulder	-	3
Neither pain nor functional disability	1	1
Medial TEN protrusion	6	-
Shortening >0.5 cm	3	1

Discussion & Conclusion

Currently, the treatment approach for midshaft clavicular fractures is shifting from nonoperative methods to operative techniques due to their associated benefits, such as reduced rates of nonunion and malunion, decreased pain, and improved functional outcomes (Narsaria, Singh, & Arun, 2014). Various surgical treatment options are available, including nailing, plating, and external fixation. Among these, plating is the most commonly used procedure and is considered biomechanically superior because it provides better resistance to bending and torsional forces (Poigenfurst, Rappold, & Fischer, 1992). Historically, the prevailing belief among medical professionals was that clavicular fractures could be effectively managed through nonoperative treatment (Canadian Orthopaedic Trauma Society, 2007; Robinson, Goudie, & Murray, 2013). However, recent trends indicate a growing preference for surgical intervention (Chen, Zeng, & Chen, 2010). Despite its advantages, surgical treatment—particularly plating—is associated with certain complications. These include hardware

prominence, compromised blood supply that may delay fracture healing, dysesthesia, and unsightly scars due to the need for a long incision and extensive periosteal stripping. Additionally, plating involves more extensive surgical exposure and a longer operative duration (Chen, Zeng, & Chen, 2010). The use of rigid plates may also lead to stress shielding, which increases the risk of re-fracture after implant removal (Jubel, Andermahr, & Bergmann, 2003).

Intramedullary nailing using TENS has been successfully employed for the fixation of displaced midshaft clavicular fractures (DMCFs), delivering excellent outcomes with minimal complications (Assobhi, 2011). Due to its elastic nature and titanium alloy composition, the nail conforms to the natural curvature of the clavicle without compromising its structural integrity. The medial cortex entry point, tight fit within the curved medullary canal, and lateral anchoring provided by the curved tip offer a stable three-point bony fixation (Jubel, Andermahr, & Bergmann, 2003). This technique involves a smaller incision, resulting in better cosmetic outcomes, and in most cases, biological fixation can be achieved without directly exposing the fracture site, leading to higher union rates (Jubel, Andermahr, & Bergmann, 2003). Additionally, micromotion at the fracture site encourages secondary bone healing through callus formation. Since the nail is positioned intramedullary, it reduces stress shielding, thereby lowering the risk of refracture compared to plate fixation.

In the present study, we compared the outcomes of anterior and antero-inferior plating with antegrade intramedullary (IM) fixation using TENS. Patients were divided into two groups: the TEN group and the Plate group. Our post-surgery follow-up revealed no unsatisfactory outcomes among all patients, which aligns with the findings of other studies (Hartmann, Hessmann, Gercekm, & Rommensm, 2008). The average time to achieve union was similar in both groups, with no statistically significant differences observed. However, there were minor variations, as clavicular length was better maintained in the Plate group compared to the TEN group, particularly in AO type B2 fractures. These findings are consistent with those of previous studies (Lazarides & Zafiropoulos, 2006). Despite these small differences, they were not statistically significant. Additionally, there were no cases of clavicular shortening greater than 0.5 cm in the TEN group and none in the Plate group. These results were considered satisfactory, as only differences greater than 18 mm in males and 14 mm in females are classified as unsatisfactory (Canadian Orthopaedic Trauma Society, 2007).

In our study, clavicular lengths were significantly better maintained by plate fixation than by TENS, especially in AO type-B2 fractures (Lazarides & Zafiropoulos, 2006). We observed three cases (8.82%) of clavicular shortening greater than 0.5 cm in the TENS group, while no cases of shortening were found in the plate group. However, this degree of clavicular shortening did not significantly affect functional outcomes. According to Lazarides and Zafiropoulos, only final clavicular shortening exceeding 18 mm in males and 14 mm in females is significantly associated with unsatisfactory results (Canadian Orthopaedic Trauma Society, 2007).

Ultimately, in cases of comminuted DMCF or fractures with large butterfly fragments, plate fixation remains the preferred operative method due to its superior maintenance of clavicular length. No major complications were encountered during the study. Minor complications in the plate group included superficial infection (n = 2), hypertrophied scar (n = 2), limited shoulder motion (n = 2), and screw loosening (n = 1), which did not cause pain or functional disability.

In our study, the incidence of superficial infection following plate fixation was 10.81%, which falls within the range reported in the literature, varying from 0% to 18% (Assobhi, 2011; Smekal, Irenberger, Struve, Wambacher, Krappinger, & Kralinger, 2009).

A notable, though minor, complication observed in the TEN group was medial hardware prominence, which led to skin irritation or, in some cases, skin perforation. The incidence of

this complication is reported in the literature to range from 5.2% to 38.8% (Jubel, Andermahr, Schiffer, Tsironis, & Rehm, 2003; Frigg, Rillmann, Perren, Gerber, & Ryf, 2009; Wijdicks, Houwert, Dijkgraaf, de Lange, Oosterhuis, & Clevers, 2012). Two primary causes for this issue are discussed in the literature (Canadian Orthopaedic Trauma Society, 2007). The first is inadequate trimming of the medial nail end during the initial surgery, which is a surgeon-related factor and can be addressed by ensuring the nail is cut properly. The second cause is nail displacement resulting from secondary clavicle shortening or telescoping, which is more challenging to prevent. However, it can be minimized through accurate anatomical reduction, intraoperative compression, and by avoiding shoulder abduction beyond 90° during the first two weeks postoperatively. Another approach to reducing medial nail protrusion is the use of medial end caps, as suggested by Wijdicks, Houwert, Dijkgraaf, de Lange, Oosterhuis, and Clevers (2012).

Our conclusion is that there were no significant differences between the Plate and TENS groups regarding union, including both clinical and radiological outcomes, as well as stability. However, our findings suggest that TENS is preferable for treating simple displaced fractures of DMCFs due to its association with reduced morbidity, easier implant removal, and better cosmetic results.

Limitations

Our limitations included a small sample size, which was drawn from a single teaching hospital in one city, and a short follow-up period.

Conflict of Interest

The authors declare no conflict of interest.

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