Percutaneous Fixation of Mid Shaft Clavicle Fractures

Kareem Hamdy Ebada [1], Ahmed Afifi [2], Ashraf Anbar [3], and Ali El Zawahry [4]

Abstract

Background: Clavicle fractures account for 5–10% of all fractures and almost half of all shoulder girdle injuries. About 80% of these fractures affect the middle third of the clavicle. The management of clavicle fractures still remains controversial. Historically, the orthopedic literature reported high union rates with conservative measures however; patient satisfaction and outcome measures were not gauged. In the past decade, surgical treatment has gained increasing popularity due to McKee's work and advances in surgical implants.

Aim: To investigate the effectiveness of percutaneous fixation of midshaft fracture clavicle regarding union and shoulder function.

Subjects and Methods: This prospective study was done to evaluate the effectiveness of titanium elastic intramedullary nail in treatment of displaced midshaft clavicular fractures. Forty patients between 18 and 60 years of age were included in this study. They were treated with elastic intramedullary nail (EIN). Clinical and radiological assessments were performed at regular intervals to assess union and Constant Shoulder Score and DASH score were done to assess the function outcome.

Results: All fractures united and the mean duration of radiological union was 11.60 ± 4.76 (range, 5-20 weeks). There were no cases of malunion or non-union. The mean value of constant score in comminuted type (84.88 ± 8.81) was less than that of simple and wedge (94.00 ± 5.39) (93.89 ± 6.38) respectively. The mean DASH score in comminuted type 12.19 ± 7.88(10- 20) was higher than that of simple and wedge 1.7 ± 2.29 (0.8 – 4.3), 5.29 ± 2.29(0.8– 7.5) respectively. Constant score has a statistically significant relation with medial migration and shortening (P = 0.018, 0.037 respectively). DASH score has a statistically high significant relation with medial migration and shortening (P = 0.007, 0.004 respectively).

Conclusion: The present intramedullary titanium elastic nails technique is simple, quick and safe. It is minimally invasive with less soft tissue injury, involves less blood loss, requires a short operating time, leads to fast bone union with 100% union rate, and produces an excellent cosmetic outcome. The technique has good functional outcomes, is facile to perform, and results in a higher constant score with a lower complication rate in simple and wedge fractures compared to comminuted fracture. Therefore, surgical stabilization by plating is to be considered for comminuted fractures.

Keywords: Titanium Elastic nail, md shaft clavicle, fractures

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Introduction

Fracture of the clavicle is common in occurrence with the incidence of approximately 5% of all fractures seen in hospital emergency admission. *(1)*

Midshaft clavicular fractures are clearly the mostcommon with a reported variable incidence of 70 to 80%. About 3/4 of the midshaft fractures are displaced. *(2,3)*

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These fractures are more common in men (68%) than women (32%). Road traffic accidents were the most common cause of the injury.[4]

Standard treatment for this fracture pattern was nonoperative, using an arm sling or figure-of-eight bandage for external fixation. [4]

Good outcome was reported with a non-union rate of 0.1% with conservative treatment. [5]

Other authors have failed to demonstrate similar good results with conservative treatment.

This may be due to the fact that the initial series included children and adolescents and their enormous potential for bone healing may have skewed the results, and that patient-based scoring systems were not used in the initial series to record the outcome. [7]

Reduced patient satisfaction noted due to asymmetry and cosmetic following malunion in patients with more than 20 mm shortening. [6]

Furthermore, decreased shoulder function due to clavicular shortening of more than 1–2 cm after nonoperative fracture management has been reported. [8]

Surgery has been indicated for completely displaced fractures, potential skin perforation, shortening of clavicle by more than 20 mm, neurovascular injury, and floating injury. [9]

The gold standard for the surgical treatment has been open reduction and plate fixation through a large incision. Plating is the most commonly used surgical treatment; however, plating requires relatively extensive soft tissue dissection and periosteal stripping, which may jeopardize the blood supply at the fracture site, thus adversely affecting fracture healing. Stress shielding produced by rigid plates can lead to an 8% refracture rate after plate removal. [9]

Other surgical options include intramedullary pinning with Kirschner wire, Rush pins, Knolwes pin, Steinman pin, Haige pin, ESIN (elastic stable intramedullary nailing), and external fixation. [10]

Intramedullary fixation for clavicular fractures was first described by Peroni in 1950. [11]

Intramedullary devices behave as internal splints that maintain alignment without rigid fixation. Intramedullary device has advantages of a smaller incision, less dissection, and load sharing fixation with relative stability that helps in callus formation. [12]

Due to flexibility of titanium nails is that it can manage itself in the bone and provide a 3-point fixation within the S-shaped clavicle. [12]

However, some studies have shown a relatively high complication rate and technical difficulties with intramedullary nailing. [7]

This study was undertaken to evaluate the results of displaced mid shaft clavicle fracture treated by titanium elastic nail.

Patients and Methods

Between January 2017 and January 2019, 40 consecutive patients with simple A1, wedge B2 or comminuted C1 mid-shaft clavicular fractures were treated with elastic intra-medullary nail at 6 October University Hospital and Kasr-Al Ainy Hospital hand prospectively evaluated.

1. **Inclusion criteria:**
    - Isolated, displaced mid-shaft clavicular fractures with no cortical contact between the main fragments.
    - Patient's age from 18 to 60 years.

Exclusion criteria:

- fractures of the medial or lateral third of the clavicle.
- pathological or open fractures.
- neurovascular injury and
- additional shoulder girdle fractures.

Pre-procedure assessment & preparation:

Clinical history, general physical examination, and local examination were performed. Patients were accordingly investigated for operative and anesthetic complications. The supportive and prophylactic therapy in the form of analgesics, antibiotics, antiedematous medications, were given to the patient. Thereafter, radiographs of injured part were done to confirm bony injury and fracture geometry.

Fractures were classified according to the Orthopaedic Trauma Association system (OTA). Simple shaft fractures were coded as 15A1, wedge fractures as 15B2 and complex fractures as 15C1.

An informed written consent from the patient was obtained before inclusion in the study.

Clavicular shortening was determined after trauma and after osseous consolidation in millimeters.

The fractured limb was splinted by sling. Patients were kept under observation in the hospital till time of surgery with management of any associated injuries and other medical conditions.

3.Technique:

Surgery was performed within 3-7 days after trauma under general anesthesia with muscle relaxant to facilitate fracture reduction.

Patient position

The patient lied supine on a radiolucent operation table. The trunk was brought to the edge of the table on the operative side. A small rolled towel was placed between the scapulae posteriorly. This promotes reduction of the fracture particularly when shortening is noted. Fluoroscopic images were obtained before draping. Fluoroscopy was brought in at an angle from the top of the bed on the operative side. Figure (1)

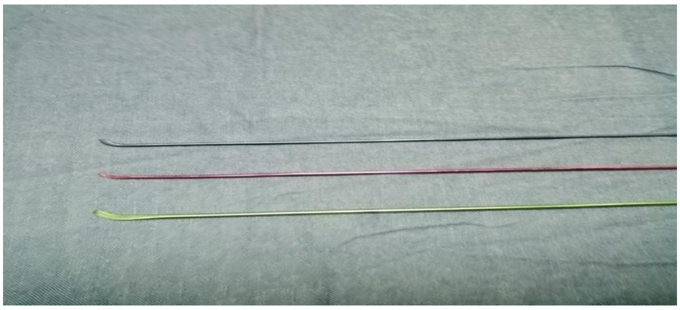
Figure (1): Position of the patient.

The fluoroscopy unit was positioned to obtain near orthogonal images without moving the base of the machine. Images include a cephalic and caudal tilt view.

The nail diameters are about two thirds of the medullary canal measured on the x-ray image. (The diameter of the nail should be 60 – 80% of the narrowest diameter of the medullary canal).

The nail diameter is varying from 2 to 3.5 mm, depending on the width of the bone. Choose nails with identical diameter (indicated by the color).

This study used titanium elastic nails system by (Synthes® and Biomet®) (Fig. 2)



2.0 mm green 2.5 mm pink 3.0 mm gold

Figure (2): Titanium elastic nails.

The skin prepped by sterilely (betadine) and draped free from the elbow to include the shoulder, neck and. Up to opposite mid chest.

A small incision of 1–1.5 cm was made near the sternal end of the clavicle parallel to the clavicle. Starting at the planned entry point, and extend medially.

The insertion points on the anterior cortex of the clavicle about 1.5 cm lateral to the sternoclavicular joint (this is about one finger breadth). If necessary, check the intended insertion points under the image intensifier. (Fig 3)

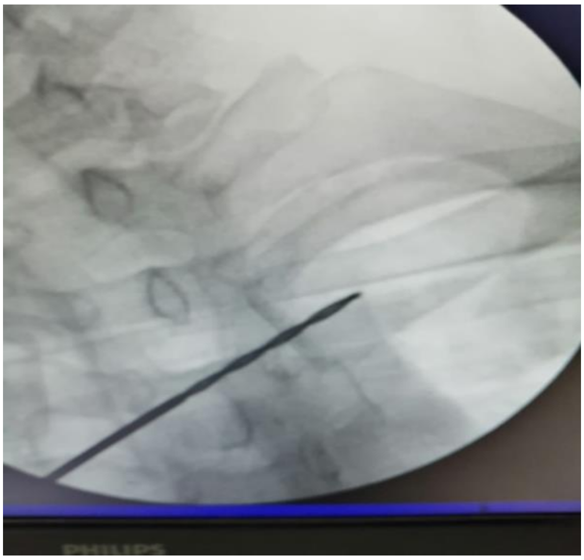


Figure (3): A, Fluoroscopy is used to localize the point of entrance into the clavicle is 1.5 cm lateral to the sternoclavicular joint on the ventral aspect of the clavicle.

The anterior cortex was opened with an awl about 1.5 cm lateral to the sternoclavicular joint, a titanium nail (average diameter 2.0 mm) which was mounted over a T-handle was inserted and advanced manually up to the fracture site, using oscillating movements or with gentle blows of a hammer to drive the nail to the level of the fracture.

If it is very difficult to advance the nail with repeated hammer blows, consider the following options:

1. Ensure that the nail is properly oriented or aligned.
2. Increase the bending of the anterior part of the nail.
3. Change to the next smaller nail diameter.

Fracture alignment and Closed reduction could be achieved by traction and manipulation of the proximal fragment by the nail (joystick technique).

If these maneuvers did not result in an acceptable reduction, intraoperative closed reduction can be facilitated by the use of the 2 towel clamps for reduction.

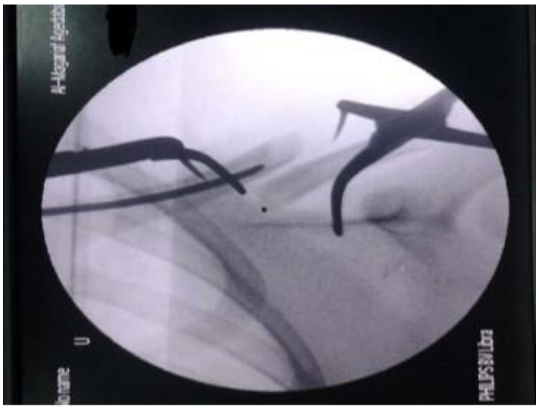
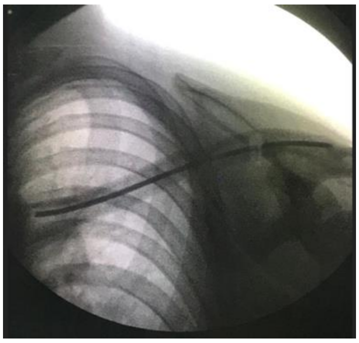


Figure (4): The nail is advanced to the level of the fracture. In this case, towel clips are used to manipulate the fracture fragments while longitudinal traction is applied to the arm. The nail is then advanced beyond the fracture.

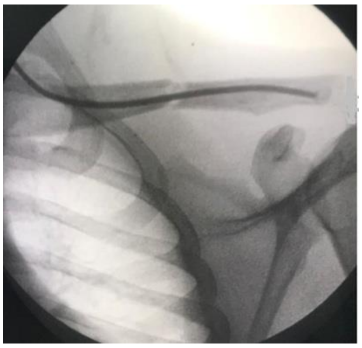
If a closed reduction is not possible within 20 – 30 min or after several attempts, a short incision (1-2 cm) at the level of the fracture site was made for open fracture reduction.

When the cavities were aligned correctly, advance the nails alternately with gentle hammer blows or oscillating movements far enough across the fracture zone. The fracture will be reduced by the nail acting as an internal splint.

The nail came to rest in the posterior aspect of the lateral clavicle just medial to the acromioclavicular joint (Fig. 5). The nail should not be allowed to penetrate the posterior cortex of the distal clavicle.



A



B

Figure (5): The fracture will reduce as the nail is advanced within the distal fragment. The nail should come to rest 2 to 3 cm medial to the lateral end of the clavicle. Final fluoroscopic images. A, Caudal tilt. B, Cranial tilt.

If the nail tip in the lateral fragment was correctly located, then the nail was shortened to the required length with the cutter for TEN or bolt cutter, which allows the nails to be cut medially leaving 5 to 10 mm of nail outside the cortical bone. It is important that long nail ends result in pseudo bursa formation they can also perforate the skin and cause infections.

Leaving the medial tip of the nail outside the bone facilitates removal of the implant at a later date if needed. The small entrance wound was closed in a single layer. (fig. 6)

Figure (6): Post-operative wound.

If second incision over fracture site was done during reduction, wound was closed with subcutaneous suturing and skin suturing.

Long-acting local anesthetic may be injected to help manage postoperative pain, then applied sterile dressing.

Postoperative care

Aseptic dressing was done and arm pouch was applied and appropriate postoperative antibiotics and analgesics were given for few days.

The first postoperative dressing was done on the 3rd day. Stitches were removed on 14th day. Patient was called for follow up every 3–4 weeks, till complete union achieved.

At 4 weeks, if radiographs show no loss of reduction, full active and passive motion was initiated and the patient was weaned from the sling. Overhead abduction or flexion was restrained for 6 weeks since increasing rotational loads on the clavicle could result in proximal migration of the nail. Resistance and strengthening activities were allowed when radiographs revealed union, typically at 6 to 8 weeks post injury. Complete shoulder rehabilitation was recommended before the patient resumes any sports activity.

Radiographic union was assessed every 4 weeks. Radiographic union was defined as complete cortical bridging between the medial and lateral fragments.

Clavicular shortening was determined after osseous consolidation.

At 6 months postoperatively all patients were assessed using constant shoulder score system and DASH score.

Results:

Table (1): Patient characters in the study.

		Total no. = 40
Age	Mean ± SD Range	33.43 ± 13.61 18 – 60
Gender	Female	14 (35.0%)

	Male	26 (65.0%)
Fracture side	Right Left	22 (55.0%) 18 (45.0%)
Dominant side affection	Dominant Non-dominant	23 (57.5%) 17 (42.5%.)
Mechanism of injury	Sports injury Road accident Fall	8 (20.0%) 20 (50.0%) 12 (30.0%)

Table (2): Operative technique.

		Total no. = 40
Open- closed	Open	18 (45.0%)
	Closed	22 (55.0%)
Average size of nail	Mean ± SD	2.55 ± 0.48
	Range	2 – 3
Operative time	Mean ± SD	54.63 ± 17.81
	Range	25 – 90

Table (3): Post operative outcome.

		Total no. = 40
Time of union	Mean ± SD Range	11.60 ± 4.76 5 – 20
Complications	Negative Positive	33 (82.5%) 7(17.5%)
Type of complications	Skin irritation Medial migration Nonunion Malunion Superficial Infection Lateral protrusion Shortening	4(10.0%) 2 (5.0%) 0(0%) 0(0%) 2 (5.0%) 1 (2.5%) 2(5.0%)
Constant score	Mean ± SD Range	91.62 ± 6.93 78 – 98
DASH score	Mean ± SD Range	6.43± 5.88 0.8 - 20

(DASH) Score: The Disabilities of the Arm, Shoulder and Hand

Table (4): Comparison between fracture types regarding patients characters.

		Fracture type			Test value	P-value	Sig.
		Simple No. = 23	Wedge No. = 13	Comminuted No. = 4			
Age	Mean ± SD Range	27.79 ± 13.19 18 – 55	36.33 ± 12.72 19 – 57	36.75 ± 14.74 18 – 60	1.942•	0.158	NS
Gender	Female Male	6 (42.9%) 8 (57.1%)	7 (38.9%) 11 (61.1%)	1 (12.5%) 7 (87.5%)	2.280*	0.320	NS
Fracture side	Right	7 (50.0%)	11 (61.1%)	4 (50.0%)	0.494*	0.781	NS

	Left	7 (50.0%)	7 (38.9%)	4 (50.0%)			
Mechanism of injury	Sports injury	5 (35.7%)	3 (16.7%)	0 (0.0%)	8.360*	0.079	aa
	Road vehicle accident	3 (21.4%)	11 (61.1%)	6 (75.0%)			
	Fall	6 (42.9%)	4 (22.2%)	2 (25.0%)			

P-value > 0.05: non-Significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant

*: Chi-square test; •: One Way ANOVA test

Table (5): Comparison studies between the fracture types regarding operative technique.

		Fracture type			Test value•	P-value	Sig.
		Simple	**Wedge**	**Comminuted**			
		No. = 23	**No. = 13**	**No. = 4**			
Open- closed	Open Closed	10(43.5%) 13 (56.5%)	6 (46.1%) 7 (53.9%)	2(50.0%) 2 (50.0%)	8.089	0.06	NS
Operative time	Mean ± SD Range	45.71 ± 14.39 30 – 75	50.22 ± 14.68 25 – 85	52.73 ± 14.67 30 – 85	11.508•	0.051	NS
Nail size	Mean ± SD Range	2.25 ± 0.38 2 – 3	2.64 ± 0.38 2 – 3	2.88 ± 0.12 2 – 3	2.069	0.141	NS

P-value > 0.05: non -Significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant

•: One Way ANOVA test

Table (6): Comparison between the fracture types regarding post-operative outcome.

		Fracture type			Test value*	P-value	Sig.
		Simple A1	**WedgeB2**	**Comminuted C1**			
		No. = 23	**No. = 13**	**No. = 4**			
Time of union	Mean ± SD Range	10.43 ± 4.80 5 – 20	11.00 ± 4.13 6 – 20	15.00 ± 5.01 6 – 20	2.856	0.070	NS
Complications	Negative Positive	22 (95.6%) 1 (4.3%)	11 (84.6%) 2 (15.4%)	0(0.0%) 4 (100%)	6.005	0.02	S
Type of complications	Skin irritation	1 (4.3%)	1 (7.7%)	2 (50.0%)	5.675	0.059	NS
	Medial migration	0 (0.0%)	0(0.0%)	2(50.0%)	8.831	0.012	S
	Malunion	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA	NA	NA
	Superficial Infection	0 (0.0%)	1 (7.6%)	1 (25%)	2.573	0.276	NS
	Shortening	0 (0.0%)	0 (0.0%)	2(50%)	8.831	0.012	S
	Lateral protrusion	0 (0.0%)	1 (7.6%)	0 (0.0%)	1.254	0.534	NS
Constant score	Mean ± SD Range	94.00 ± 5.39[a] 90 – 99	93.89 ± 6.38[a] 89-98	84.88 ± 8.81[b] 78– 90	6.024••	0.005	HS
DASH score	Mean ± SD Range	1.7± 2.29 0.8 – 4.3	5..29 ±2.29 0.8– 7.5	12.19 ±7.88 10 – 20	4.136*	0.03	S

Table (7): Correlation between constant score and age of patients.

	Constant score t	
	r	**P-value**
Age	**-0.765****	**0.000**

Table (8): Relation between constant score and patient characters.

		Constant score t		Test value	P-value	Sig.
		Mean ± SD	Range			
Gender	Female Male	90.50 ± 6.80 92.23 ± 7.06	78 – 98 78 – 99	-0.749•	0.458	NS
Fracture side	Right Left	91.23 ± 7.32 92.11 ± 6.60	78 – 99 78 – 99	-0.397•	0.694	NS
Mechanism of injury	Sports injury Road accident Fall	95.75 ± 4.68 90.85 ± 7.36 90.17 ± 6.85	85 – 99 78 – 99 78 – 97	1.980••	0.165	NS

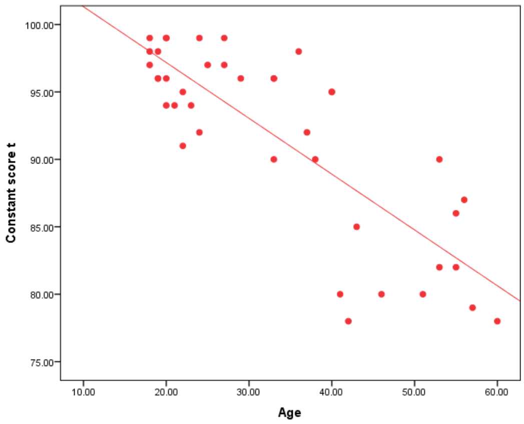


Figure (7): Correlation between constant score and age of patients.

Table (9): Correlation between DASH score and age of patients

	DASH score	
	R	**P-value**
Age	**0.826****	**0.000**

Table (10): Relation between DASH score and patients characters

		DASH score		Test value	P-value	Sig.
		Mean ± SD	**Range**			
Gender	Female Male	7.14±**6** 6.04±**5.9**	0.8 – 19.2 0.8 – 20	-0.560*	0.579	NS
Fracture side	Right side Left side	6.62±**6.53** 6.19±**5.14**	0.8 – 15 0.8 – 20	-0.229*	0.820	NS
Mechanism of injury	Sports injury Road accident Fall	2.7± 2.32 6.98±**6.51** 7.99 ± **5.71**	0.8 – 7.5 0.8 – 20 1.7 – 19.2	0.330**	1.109	NS

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
≠: Mann-Whitney test; ≠≠: Kruskal-Wallis test

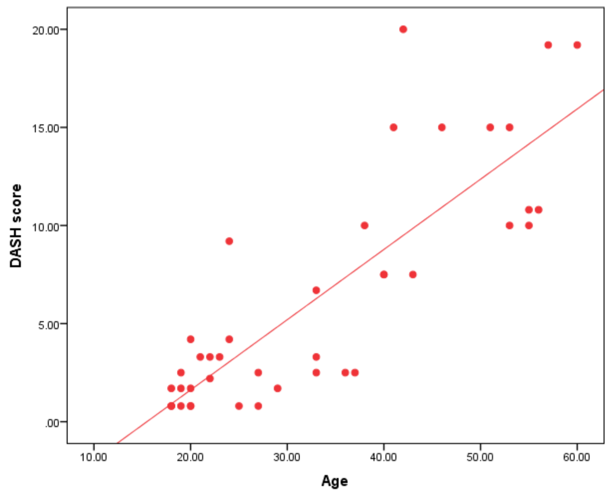


Figure (8): Correlation between DASH score and age of patients.

Table (11): Relation between constant score and fracture type

		Constant score t		Test value	P-value	Sig.
		Mean ± SD	Range			
Fracture type	Simple	94.00 ± 5.39[a]	90 – 98	6.024••	0.005	HS
	Wedge	93.89 ± 6.38[a]	89 – 98			
	Comminuted	84.88 ± 8.81[b]	78 – 90			

The same supra-script letters indicate non-significant difference.

Table (12): Relation between DASH score and fracture type

		DASH score		Test value	P-value	Sig.
		Mean ± SD	Range			
Fracture type	Simple	1.7± 2.29	00.8 – 4.3	3.136*	0.03	S
	Wedge	5..29 ±2.29	0.8– 7.5			
	Comminuted	12.19 ±7.88	10 – 20			

Table (13): Correlation between constant score and operative time and nail size.

	Constant score t	
	r	P-value
Operative time	-0.199	0.054
Nail size	-0.193	0.232

Table (14): Relation between constant score and type of reduction

		Constant score t		Test value	P-value	Sig.
		Mean ± SD	Range			
Open-closed	Open	91.50 ± 6.72	78 – 98	-0.092•	0.927	NS
	Closed	91.71 ± 5.52	78 – 98			

Table (15): Correlation between DASH score and operative time and nail size.

	DASH score	
	r	P-value
Operative time	0.291	0.065
Nail size	0.280	0.080

Table (16): Relation between DASH score and type of reduction

		DASH score		Test value	P-value	Sig.
		Mean ± SD	Range			
Open- closed	Open	7.27±6.79	0.8 – 20	-0.125≠	0.901	NS
	Closed	5.86± 5.26	0.8 – 19.2			

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
≠: Mann-Whitney test; ≠≠: Kruskal-Wallis test

Table (17): Correlation between constant score and time of union.

	Constant score t	
	r	P-value
Time of union	**-0.189**	**0.070**

Table (18): Relation between constant score and complications.

		Constant score t		Test value	P-value	Sig.
		Mean ± SD	Range			
Complications	Negative	91.88 ± 6.79	78 – 99	0.276•	0.784	NS
	Positive	91.25 ± 7.34	78 – 99			
Skin irritation	Negative	91.75 ± 6.76	78 – 99	0.225•	0.823	NS
	Positive	91.13 ± 8.04	78 – 99			
infection	Negative	91.85 ± 6.70	78 – 99	0.438•	0.664	NS
	Positive	90.57 ± 8.44	78 – 99			
Medial migration	Negative	92.21 ± 6.59	78 – 99	2.478•	0.018	S
	Positive	80.50 ± 2.12	79 – 82			
Lateral protrusion	Negative	91.54 ± 7.00	78 – 99	-0.488•	0.628	NS
	Positive	95.00 ± 0	95 – 95			
Shortening	Negative	92.27 ± 6.40	79 – 99	2.163•	0.037	S
	Shortening 2 cm	83.67 ± 9.81	78 – 95			

Table (19): Correlation between DASH score and time of union.

	DASH score	
	r	**P-value**
Time of union	0.268	0.067

Table (20): Relation between DASH score and complications.

		DASH score		Test value	P-value	Sig.
		Mean± SD	**Range**			
Complications	Negative Positive	5.83±**5.54** 7.33±**6.43**	0.8 – 20 0.8 – 19.2	-0.68≠	0.496	NS
Skin irritation	Negative Positive	6.3±**5.72** 6.95±**6.85**	0.8 – 20 0.8 – 19.2	-0.187≠	0.852	NS
Infection	Negative Positive	3.3 (1.7 – 10) 4.2 (2.2 – 15)	0.8 – 20 0.8 – 19.2	-0.591≠	0.555	NS
Medial migration	Negative Positive	5.87±**5.45** 17.1±**2.97**	0.8 – 20 15 – 19.2	-2.868*	0.007	**HS**
Lateral protrusion	Negative Positive	6.4±**5.95** 7.5 ± **0**	0.8 – 20 7.5 – 7.5	-0.479≠	0.632	NS
Shortening	Negative Shortening 2 cm	5.69±**5.21** 15.57±**7**	0.8 – 19.2 7.5 – 20	-3.092*	0.004	**HS**

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
≠: Mann-Whitney test; ≠≠: Kruskal-Wallis test

Table (21): Correlation between DASH score and constant score

	DASH score	
	r	**P-value**
Constant score t	**-0.895****	**0.000**

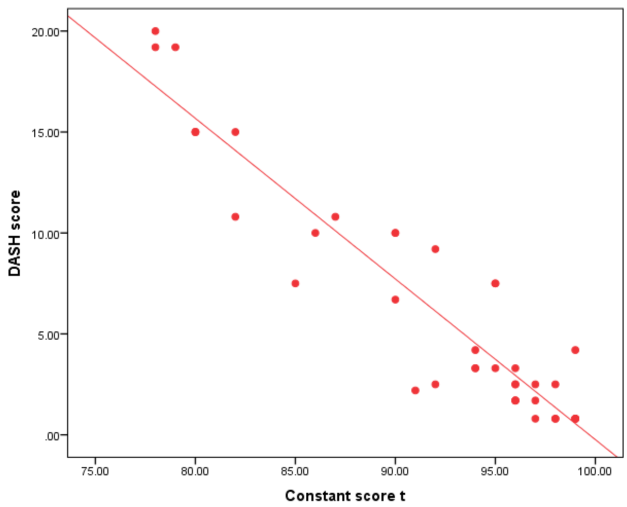


Figure (9): Correlation between DASH score and constant score.

Discussion

This study was done with objective to study the outcome of operative treatment of mid shaft clavicle fracture with flexible intramedullary nail (FIN).

In this study, displaced mid shaft fracture clavicle seen predominantly in males comprised of 26 males (65%) and 14 females (35%). The sex distribution in our study come in accordance with the percentage reported by ***Nowak et al. (2000)*** [(13)] (70% male and 30% female). Hence, the incidence in present study closely correlates with the previous studies. This is probably due to type of society in which outdoor activities are predominantly preferred by males which predispose them to traffic accidents.

The mean age of our patients was 33.4 years. This come in agreement with Chen et al. (2010) (91 and Kettler et al. (93) showing the mean age of fracture clavicle 38 years. Mueller et al 2008 (12) reported the highest mean age of 40 years while Meier et al. (92) reported the lowest mean age of 28 years. This highest incidence in young age group is seen because they are most commonly involved in traveling, driving, sports activities, and also are victims of assault.

In this study, the right side was involved more commonly in 22 cases (55%) and the left side in 18 cases (45%). ***Postacchini et al. (2002)***[(4)] also reported similar incidence of the right side involvement 58.8% right and 41.2% left. Force of trauma having been borne by the right side as being the dominant side.

Mechanism of injuries classified mainly as roadside accident, fall, and sports injuries. The present study showed mechanism of injuries were road accident in 20 cases (50%), fall in 12 cases (30%) and sports injury in 8 case (20%). our results are consistent with ***Hartmann et al. (2008)*** [(14)] who Reported roadside accident in 46%, fall in 20%, 34% sports injuries. ***Chen et al. (2010)*** [(15)] reported roadside accident in 62%, fall in 15%, sports injuries in 15%, and assault in 8% cases.

Mid shaft clavicle fractures in our study were classified into simple in 23 cases (57.5%), wedge in 13 cases (32.5%) and comminuted (C1) in 4 cases (10%). Our results are different from ***Chen et al. (2010)*** [(15)] who reported percentage of 23%,73%and 14 % in simple, wedge and comminuted fracture, respectively.

In this study, closed reduction succeeds in 22 cases (55%) and open reduction needed in 18 cases (45%). Our results are consistent with ***Jubel et al. (2003)*** [(16)] who reported that closed and open reduction percentages were 58% and 42% respectively. ***Jubel et al. (2003)*** [(16)] our results are also in agreement with ***Meier et al.*** [(17)] (50% closed and 50%open).

These data showed that flexible intramedullary nailing is a technically demanding procedure. Reasons to failure of closed reduction were as follows:

1. Fractures situated in lateral part of midshaft.
2. Comminuted fractures.
3. Soft-tissue interposition.
4. Failure of maintenance of reduction during engagement of distal fragment of fracture.
5. Excessive time between injury to surgery.
6. Inadequate straightening of tip of the flexible nail.
7. Ill-defined medullary cavity of clavicle.

The size and location of the smallest diameter of the IM canal is of important as it is the limiting region for IM device design and must be understood for proper implant fit. [(18)]

In the current study, nail size ranged from 2 to 3 mm, according to the patient's body stature and clavicular diameter. No nail breakage occurred in patients. **Mueller et al 2008** [(12)] reported 2 cases with nail breakage.

The mean time of surgery was 54.6 min ranging minimum 25 min to maximum 90 min. It is in accordance with data given by ***Meier et al.*** [(17)] having mean time of surgery 62 min with mean time for close reduction group was 39 min and for open reduction was 85min. *(15)*

In the present study, mean duration of union was 11.6 weeks ranging from minimum 5 to maximum 20 weeks. This duration is longer than the duration periods reported by ***Chen et al. (2010)*** ***(15)*** ***and Meier et al.*** ***(17)*** which were 2.2 month ***Chen et al. (2010)*** ***(15)*** and 7.7 weeks respectively ***(Meier et al., 2006)*** ***(17)*.**

In the present study, all 40 cases (100%) had fracture union. Our results are in agreement with ***Hartmann et al.*** ***(14)*** who showed union in 100% cases. however, our result are different from ***Kettler et al.*** ***(19)*** who showed union in 98% cases ***(Hartmann et al., 2008(14); Kettler et al., 2007 (19))***

Skin irritation at entry point in 4 patients (10%), superficial infection in 2 patients (5%). This come in agreement with Kettler et al., 2007 (93 who reported 6 cases with skin irritation.

Regarding implant migration, proximal(medial) migration of nail occurred in two patients (5%) with comminuted fracture, while latertal protrusion occurred in only one patient (2.5%) with wedge fracture. The rate of hardware migration of elastic intramedullary nail (EIN) in previous literature was between 4.5 and 26.6% ***(Jubel et al., 2003 (16); Meier et al 2006(17); Kettler et al., 2007 (19)).***

The reasons to decreased hardware migration in our study are:

1- The titanium elastic nail is flexible with a curved tip that is fixed in the cancellous bone of the lateral clavicle. This helps it to accommodate the S-shaped contour of the clavicle and adhere tightly to the cortex.
2- The three-point stabilization of EIN provide a better anti-bending and anti-torsion load. *(15)*
3- We restricted the range of motion to 90 ° for the first 4 weeks.

Shortening after clavicle fractures may have an effect on shoulder function. This might be a specific problem with the use of intramedullary nailing with telescoping and nail protrusion***.*** ***(9)*** In our study, shortening of 2 cm occurred in only 2 cases (5%) with comminuted fracture. This shortening is higher than the shortening reported by Mueller et al 2008 (12), Meier et al., 2006 (92) , Kettler et al., 2007 (93) which were 0.5 cm , 1.7 cm. and 1 cm respectively.

Wick et al reported that clavicle fractures with greater than **20 mm** of shortening were highly predisposed to develop a nonunion. Of middle third clavicle nonunions in their series, 91% (30/33) were shortened by at least 2 cm***.*** ***(20)***

Overall, it can be stated that in this study, there was no any major complication regarding management and healing leading to reoperation. Minor complications were seen and that were managed on outdoor basis.

The Constant Score calculated on scale 0-100 where 0 is worst and 100 best. The minimum Constant score was 78(worst) to maximum of 98 (best). The mean Constant Score was 91.4 in older literature of flexible intramedullary nail fixation of displaced midshaft clavicular fractures, the values calculated were 98.3, ***(16),*** 98 ranging 93–100, ***(17),*** 95.3 ± 3.9 ***(14),*** 95.2 ranging 86.5–97.0 ***(15),*** and 81 ranging 46–100 ***(21).***

In the current study, there was a negative correlation between Constant score and age of the patients as (r= -0.765, P < 0.01). The poor healing outcome in elderly could be explained by the impaired vascularization, angiogenesis, inflammatory response and osteochondral activity***.*** ***(22)***

Moreover, we have found that constant score was significantly decreased in cases of medial migration and shortening as (P = 0.018, 0.037 respectively). The significant relation between the constant score and both of shortening and medial migration may be due to that the clavicular shortening leads to static changes in the shoulder girdle. The sternoclavicular joint angle increases, and the resting position of the scapula and the preload of the muscles of the shoulder girdle change. This might lead to limitations in the overhead motion and symptoms such as pain, weakness and easy fatigability. *[23]*

We have found a statistically highly significant relation between constant score and fracture types as it was significantly decreased in comminuted type than simple and wedge fractures (P= 0.005).

Considering that comminuted fractures are typically caused by high energy trauma and are associated with a higher degree of soft tissue damage, shortening and medial implant migration, we agree with ***Jubel et al. (2003)*** *[16]* that surgical stabilization plating is to be considered in comminuted fractures to provide stability and maintain clavicular length.

We did not find a significant correlation between constant score and any of operative time, time of union, average size of nail, gender of patient, fracture side, mechanism of injury and type of reduction.

The disabilities of the Arm, Shoulder and Hand (DASH) score was calculated on scale 0-100, considering score 0 best and 100 worst. In this study, minimum DASH score was 0.8 (best), and the maximum was 20 (worst). The mean DASH score was 6.43± 5.88 (0.8- 20). In earlier studies, it was 6.8 (0–43),) ***Kettler et al., 2007*** *[19]* which was in accordance with this study. 2.5 (0.5–8.0), ***(Chen et al., 2010)*** *[15]*. and 3.4 (±* 4.8) ***(Zhang et al., 2012)*** *[21]*.

We have found a statistically significant relation between DASH score and fracture types as it was significantly decreased in comminuted type than simple and wedge fractures (P= 0.005).

We also found a statistically significant relation between DASH score and both of medial migration and shortening (P = 0.007, 0.004) respectively

There are some limitations of the study that should be considered. The number of patients is relatively small (40 patients), and the mean follow-up time is only 6 months. We realize that a larger and a long-term study would appropriately address these issues.

Conclusion:

The present intramedullary titanium elastic nails technique is simple, quick and safe. It is minimally invasive with less soft tissue injury, involves less blood loss, requires a short operating time, leads to fast bone union with 100% union rate, and produces an excellent cosmetic outcome. The technique has good functional outcomes, is facile to perform, and results in a higher constant score with a lower complication rate in simple and wedge fractures compared to comminuted fracture. Therefore, surgical stabilization by plating is to be considered for comminuted fractures.

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