ORIGINAL ARTICLE

Fixation of Fractures of the Humerus in Adults Using Intramedullary Elastic Nails

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ABSTRACT

Keywords: fractures of the humerus, intramedullary elastic nails.

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Background: Humerus is the most mobile long bone of the upper extremity. Humeral shaft fractures comprise about 3-5% of all fractures involving body. **Objective:** the aim of the work was to evaluate the results of use of elastic intramedullary nails in treatment of humeral shaft fractures. **Patients and Methods:** the study included 30 patients presented to Aswan University Hospitals suffering from humeral shaft fracture. There were 22 males and 8 females. There were 29 closed fractures and 1 open type I clean fracture. A full workup including history taking, clinical examination and radiograph as well as laboratory investigations were performed for all patients on admission. **Results**: the results obtained after a mean follow up time of 32 weeks. According to Stewart Handly's score, it was excellent in 18 patients (60%), good in 9 patients (30%), fair in 2 patient (6.66%), and poor in 1 patient (3.33%). The difference between excellent and good groups was statistically significant, that the younger the patient the more rapid the fracture heals. **Conclusion:** elastic intramedullary nailing is a simple, easy semi-rigid and quick technique for treatment of humeral shaft fractures in different age groups.

INTRODUCTION

Fractures of the humeral shaft are representing 3- 5% of all fractures [1]. These fractures occur with a bimodal age distribution; the 1st peak occurs in the third decade, and consists mostly of high-energy male trauma patients, and a 2nd peak occurs in the eighth decade, and consists mostly of low-energy females sustaining a simple falling on ground [3, 4]. Fractures of the humeral shaft could be managed by both conservative methods or surgically. The goals of treatment are to achieve union with acceptable humeral alignment [5, 6]. Surgical options include external fixation, open reduction and internal fixation, minimally invasive percutaneous osteosynthesis, and antegrade or retrograde intramedullary nailing. Each of these techniques has advantages and disadvantages, and the rate of fracture union may vary based on the technique used. A relatively high incidence of radial nerve injury has been associated with surgical management of humeral shaft fractures. However, good surgical outcomes can be achieved with proper patient

selection [7]. Elastic stable intramedullary nails (ESIN), also referred to as titanium elastic nails or Nancy nails, is a device that has low modular of elasticity [2]. ESIN are subjected to smaller bending loads and are less likely to fail due to fatigue. They act as load sharing and stress shielding devices [1,23]. The ESIN was developed by Küntscher and the principle was three point fixation when introduced in the medullary canal of long bones and was first used in the fracture of long bones of lower extremities and soon became very popular method for fracture fixation of long bone and later used for fractures of humeral shaft [8]. This study reported the results of using the ESIN in treatment of humeral shaft fractures.

PATIENTS AND METHODS

The study included 30 patients presented to Aswan University Hospitals, were suffering from humeral shaft fracture. A full workup including history taking, clinical examination and radiograph also laboratory investigations were performed for all patients on admission. Written informed consent: An approval of the study was obtained from Aswan University Academic and Ethical Committee. All patients signed an informed written consent for acceptance of the operation. Inclusion criteria: age more than 15 years old, recent injuries (less than 2 weeks), closed fractures and open Gastilo type I fractures. Exclusion criteria: age less than 15 years old, Old injuries (more than 2 weeks), Open Gastilo type II and III fractures, neurovascular injury and intra-articular fractures. Data was collected according to the following sheet: history, clinical assessment and radiograph (x-rays). The fractured limb was splinted by U-shaped slab or high above elbow slab. Analgesic and anti-edematous measurements were prescribed. Patients were kept under observation in the hospital till time of surgery with management of any associated injuries and other medical conditions. Routine laboratory investigations were done.Patients were kept under observation in the hospital till time of surgery with management of any associated injuries and other medical conditions. Routine laboratory investigations were done.

Surgical technique:

Under general anesthesia, Patient was placed in supine position on radiolucent orthopedic table. Closed manipulations were performed until an accepted reduction was obtained and confirmed by image intensifier. The diameter of the each nail was chosen by an equation (nail diameter = minimum diameter of medullary canal x 0.4) to avoid varus or valgus angulation [22]. Each nail was pre-bent at the same point manually by hands to an angle of 30° (nail contoured into a bow with nail tip pointing to the concave side of the bowed nail), and the apex of curvature lies at the level of the fracture site. In order to achieve optimum reduction, stabilization and alignment of the fracture and prevent rotation, the curvature at the fracture site had to be identical in both nails. Regarding the entry point; a 5 cm skin incision over the lateral supracondylar ridge was made. Starting usually on the lateral side because it is easier (figure 1).These holes were performed by a drill and it had been widened by bone awl (figure 2). The awl was directed diagonally at an angle of 45° towards the far cortex to make the hole accommodating the direction of a progressing nail. In 12 patients the medial and lateral holes was performed by a 3.2 drilling bit. In 16 patients lateral entry holes were done. In 2 patients lateral ascending and lateral descending entry were done. The nail was held in a cannulated T- handle inserter with the horizontal bar of the T-handle and the curved tip of the nail aligned in the same plane (this allowed identification of the curved tip as it passed along the medullary canal). The nail was passed through the entry hole with the curved tip pointing distally. Once it goes in the medullary canal, the nail was rotated to point to the direction in which it should be passed. The nail was driven up the canal by rotating the T-handle back with jerky movement and pushing. With a mallet, the nail was gently tapped to cross the fracture site. The nail was advanced towards the metaphysis to anchor into the cancellous bone.

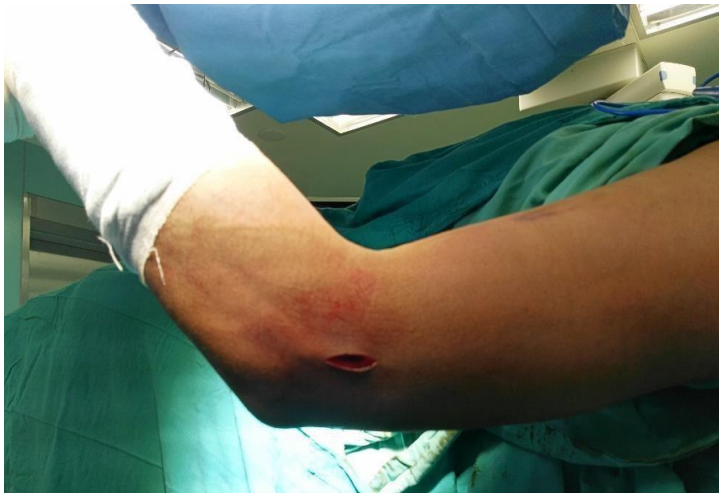

Figure (1): lateral humeral approach.

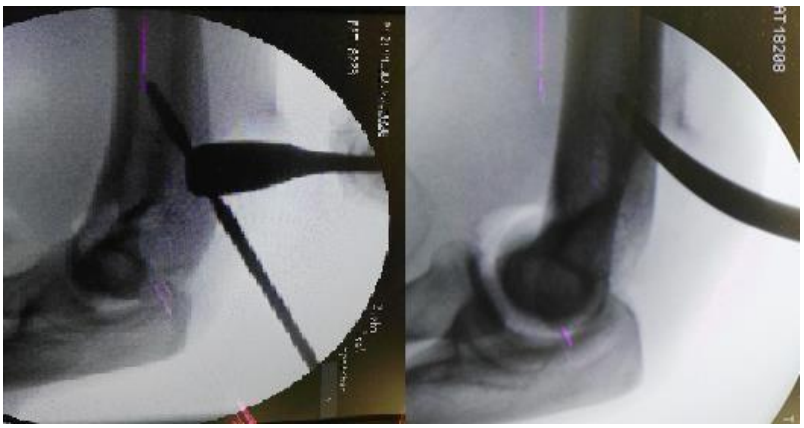

Figure (2): Using of Drill and Awl to make the entry hole.

The second nail was advanced either from a lateral entry or from a medial entry using the same rotating movements and light taps. However, it was never rotated on its own axis through a full 360° to avoid wrapping itself around the first nail. Both nails were advanced and impacted at their final proximal points. We used 3 nails in only one patient. The nail entering the lateral cortex of the humerus ended just distal to greater tuberosity, while the second nail introduced either through the lateral entry or a medial entry ended at the same level but pointing towards the glenoid. Reduction of the fracture and position of the nails were confirmed with the image intensifier. The ends of both nails were cut, ensuring that $\geq$ one cm of each nail remains outside the bone. Wound irrigation, closure in routine manner and sterile dressing was applied. To compress the fracture, manual pressure was applied at the elbow. All patients were immobilized using humeral brace, U-shaped slab or above elbow slab in addition to broad arm sling.

Postoperative care:

All patients were examined for neurovascular status. X-rays (AP and lateral views) were obtained to assess the reduction and the position of nails. Analgesics and anti-edematous medications were prescribed. Patients were encouraged to move the elbow (flexion and extension) from the first day postoperatively.

Follow up:

Wound care and dressing and follow up of neurovascular status. Sutures were removed after 2 weeks. In twenty-four patients, the arm sling was removed after 3 weeks and active shoulder exercises were allowed.

In the six patients the U-shaped slab was removed after 3 weeks and replaced by an humeral brace for 2 further weeks, during which active shoulder exercises were allowed.

Check X-rays (AP and lateral views) were obtained after 2, 6, and 12 weeks, then monthly till radiological union, then at the end of follow up.

According to Stewart and Hundley's [14] scoring system, the results were obtained after a mean follow up time of 32 weeks.

Statistical analysis:

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Chi-square (x2) test of significance was used in order to compare proportions between two qualitative parameters. The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following:

Pvalue <0.05 was considered insignificant. P-value <0.001 was considered as highly significant. P-value >0.05 was considered insignificant.

RESULTS

Age of the patient was significantly ($p \leq 0.05$) different we it was excellent with younger age group (Table 1)

According Stewart and Hundley's scoring system; excellent in 18 (60%), good in 9 (30%), fair in 2 (6.66%), and poor in 1 (3.33%) patient. Excellent results were reported with younger age and transverse midshaft fractures groups (Tables 1, 2 and 3)

Age	Result							
	Excellent		Good		Fair		Poor	
	No.	%	No.	%	No.	%	No.	%
<30	12	40.0%	3	10.0%	0	0.0%	0	0.0%
30-39	2	6.66%	0	0.0%	0	0.0%	0	0.0%
40-49	2	6.66%	2	6.66%	2	6.66%	0	0.0%
50+	2	6.66%	4	13.33%	0	0.0%	1	3.33%
MCp	0.014							
Range	14.00-65.00		35.00-65.00		33.00-33.00		31.00-31.00	
Mean	31.27		43.11		45		51	
^{2} (p)	10.585* (0.014)							

Table 1: Relationship between result and age: MCp: p for Monte Carlo test. Chi square for Kruskal Wallis test, *: Statistically significant at $p \leq 0.05$

Full range of shoulder motion in 27 patients (90%) in all directions. Three patients (10%) had loss of 30 of shoulder abduction and were associated with proximal migration of the nails through the greater tuberosity. After the nails were removed, the abduction range improved by about 15 . Twenty-four patients (80%) had full elbow range of motion, four patients (13.33%) had elbow extension loss about 15 after the nails had removed, and two patients (6.66%) had elbow extension loss about 60 , but it improved gradually to 30 after physiotherapy. One (3.33%) patient suffered from skin irritation due to prominent nail ends. three patients had their nails removed. One of them due to pain at insertion sites, other one due to protrusion of proximal ends of the rods, last patient due to irritation at nail insertion site. It was performed as a day case procedure under general anaesthesia, after an average period of six (range from 5 to 8) months postoperatively.

Level of fracture	Result							
	Excellent		Good		Fair		Poor	
	No.	%	No.	%	No.	%	No.	%
Proximal 1/3	2	6.66%	1	3.33%	1	3.33%	0	0.0%
Mid shaft	10	33.33%	7	23.33%	1	3.33%	1	3.33%
Distal 1/3	6	20.0%	1	3.33%	0	0.0%	0	0.0%
MCp	0.887							

Table 2: Relationship between result and level of fracture: MCp: p for Monte Carlo test

Shape of fracture	Result							
	Excellent		Good		Fair		Poor	
	No.	%	No.	%	No.	%	No.	%
Transverse	7	23.33 %	3	10.0 %	1	3.33 %	1	3.33 %
Oblique	5	16.66 %	5	16.66 %	1	3.33 %	0	0.0%
Spiral	2	6.66 %	0	0.0%	0	0.0 %	0	0.0%

Minimally comminuted	3	10.0 %	1	3.33 %	0	0.0 %	0	0.0%
Comminuted	1	3.33 %	0	0.0%	0	0.0 %	0	0.0%
MCp	0.811							

Table 3: Relationship between result and shape of fracture: MCp: p for Monte Carlo test

CASE PRESENTATION:

Figures (3 - 6): A 44-year-old male, transverse fracture of the middle third of his left humerus. Fixed with retrograde titanium ESIN (diameter: 3 mm) through the lateral humeral condyle. Pre and postoperative x-ray. Shoulder abduction, elbow flexion and extension.

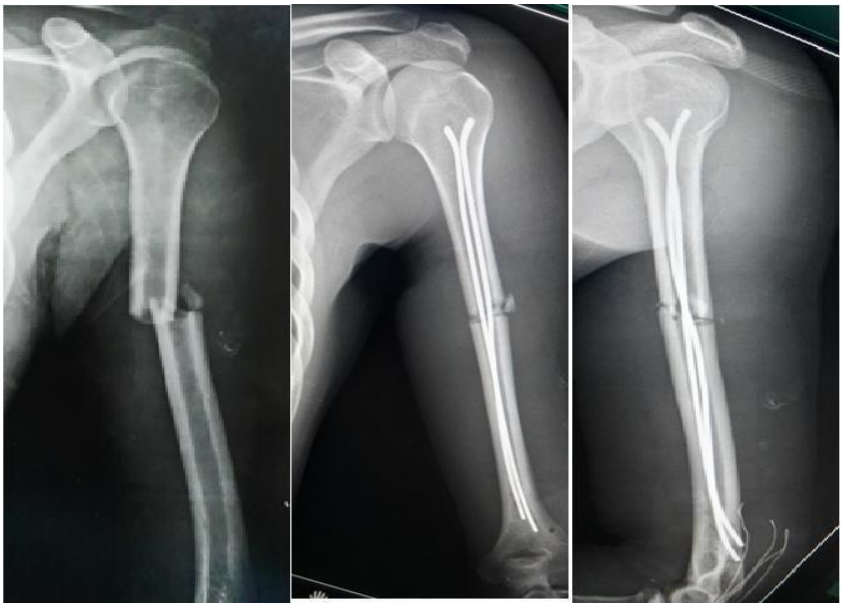

Figure (3): Pre and postoperative x-rays

Figure (4): 3 months follow

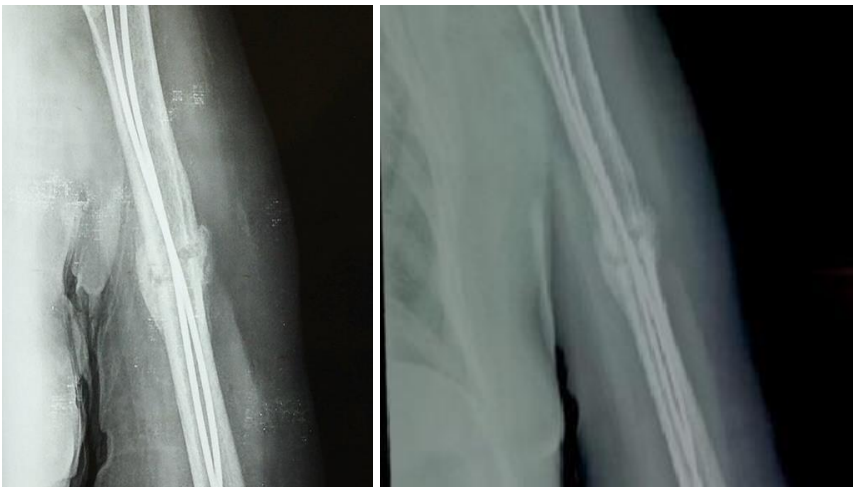

Figure (5): 4 (left) and 6 (right) months follow up x-ray

Figure (6): Shoulder abduction and elbow flexion and extension.

DISCUSSION

The humerus is the most mobile long bone of the upper limb. Humeral shaft fractures comprise about 3 to 5% of all body fractures [1].

The aim of the present work was to evaluate the results of using the ESIN for management of humeral shaft fractures in different ages.

ESIN functions as an internal splint, maintains the fracture hematoma and provides biological fixation. It is usually performed through a closed technique. Even when open reduction is required, a minimal approach is usually adequate to facilitate reduction, with minimal periosteal stripping. Furthermore, fixation fulfils the three points principle for each nail. Both elasticity and stress distribution of the titanium elastic nails facilitate callus formation. [10, 11, 12]

In this study, prebent elastic stable nails were used to treat humeral shaft fractures. This method of treatment was applied for 29 closed fractures and one open fracture were treated at Aswan University Hospitals.

These nails were introduced through the lateral humeral condyle alone in sixteen patients with proximal and middle third fractures using a C and S-shaped pre-bent elastic stable nails. While in middle to distal and distal one third humeral shaft fracturs both medial and lateral condyles were used in twelve patients using two C-shaped nails to avoid valgus angulation that may occurred if a lateral entry only was utilized. [11, 13] Two patients with proximal and middle one third humeral fractures were treated using lateral ascending & superior descending technique. According to Stewart and Hundley's scoring system, the results obtained after a mean follow up time of 32 weeks, were excellent in eighteen patients (60%), good in nine patients (30%), fair in two patients (6.66%), and poor in one patient (3.33%). The results obtained were found comparable to the results of other studies that used different methods for humeral fixation. [14,15].

The average age of these patients was 36.4 years, which was less than the average age reported in most of the studies published on such injury, a fact that can be explained by increased number of high velocity injuries included in this study. [9, 16].

In the present study, the mean age of patients achieved excellent outcome was 31.27years, whereas the mean age of patients achieved good outcome was 43.11 years. While for fair results it was 45 years, and for poor results it was 51 years. The difference between excellent and good groups was statistically significant, that the younger the patient the more rapid the fracture healing occurs.

This was similar to that reported by Osman et al, in 1998, [14] they found that the age of the patient had a great effect on the duration needed for fracture healing, with better results in younger patients. Osman et al compared the different methods of fixation of humeral shaft fractures in 104 diaphyseal fractures of the adult humerus. 32 patients were treated non-operatively, 28 fractures were treated using plates and screws, 22 fractures were treated using multiple flexible intramedullary nails and 22 fractures were treated using an intramedullary antegrade Seidel nail. [19] Similar observations were reported by Naill et al. in 2004 on 49 patients with humeral shaft fractures fixed with plate and screws. [18].

In the present series, we obtained a full range of shoulder motion in twenty-seven patients (90%) in all directions. Three patients (10%) had loss of 30 of shoulder abduction. In 2001 Ajmal et al, [10] reported poor shoulder motion (41%) in 22 patients treated with antegrade locked intramedullary nailing with Russell-Taylor nail. In 2004 Martinez et al, [19] who used retrograde nailing, observed excellent shoulder range of motion in 66.5% of patients, good in 30% of patients, and poor in 3.5%.
In the present work, at the end of follow up,24 patients (80%) had full elbow range of motion, 4 patients (13.33%) had loss 15 of elbow extension, and 2 patients (6.66%) had loss 60 of elbow extension, In 2004, Martinez et al, [19] reported an excellent elbow function in 39.1% of patients, good in 62% of patients, fair in 12.6% of patients, and poor in 4.9% of patients. In 1998, Osman et al, [14] observed low percentage of excellent elbow results (42.8%) in patients treated with multiple flexible nails via a supracondylar entry point; this was explained by reduced mobility of the elbow due to protruded nails under the skin.

The mean operative time in this study was shorter than reported by Hall et al, [12] in 1987, using ender nails (76 minutes), and Niall et al, [18] in 2004 using plate and screws (115 minutes) and by Chao et al, [20] in 2005, using ender nails (52 minutes), antegrade interlocking nail (102 minutes) and plate and screws (110 minutes).
In this study, there were no neurological complications, the same result occurred with Radwan et al, [26] who used multiple Titanium Elastic nails. However, Hall et al, [12] reported two patients (2%) with post-operative radial nerve injury. In 1998 Osman et al, [14] reported a radial nerve palsy with plate and screws (7%), with the flexible nails (3.5%) and with Seidel nail (21%).

LIMITATIONS

In this study, the sample size was small number of patients and short duration of follow up. There is no comparison between other methods of humerus fractures fixation as plate osteosythesis, IM interlocking nail or external fixators.

Conflict of interest; there is no conflict of interest.

CONCLUSION

ESIN is a good alternative for treatment of diaphyseal fractures of humerus in adult age group, as it requires minimum invasive approach, can achieve union without disturbing the biology of fracture site, and reduce the chances to almost none of iatrogenic radial nerve injury. Technique of ESIN is easy and can be done by junior surgeons.

REFERANCES

1. Garvanos C (2015): Humeral shaft fractures. In Court-Brown CM, Heckman JD, McQueen MM, Ricci WM, Tornetta PIII, eds. Rockwood and Green's Fractures in adults. 8th ed. Philadelphia: Wolters Kluwer Health, 2015:1287-336.
2. Fricka, K. B., Mahar, A. T., Lee, S. S., & Newton, P. O. (2004). Biomechanical analysis of antegrade and retrograde flexible intramedullary nail fixation of pediatric femoral fractures using a synthetic bone model. Journal of Pediatric Orthopaedics, 24(2), 167-171.

3. Ekholm, R., Adami, J., Tidermark, J., Hansson, K., Törnkvist, H., & Ponzer, S. (2006). Fractures of the shaft of the humerus: an epidemiological study of 401 fractures. The Journal of bone and joint surgery. British volume, 88(11), 1469-1473.
4. Tytherleigh-Strong, G., Walls, N., & McQueen, M. M. (1998). The epidemiology of humeral shaft fractures. The Journal of bone and joint surgery. British volume, 80(2), 249-253.
5. Sharma, V., Awasthi, B., Mehta, S. M., Yadav, R. S., & Babhulkar, S. (2014). Evaluation of Results of Different Treatment Modalities in Management of Diaphyseal Fractures of Humerus.
6. Clement, N. D. (2015). Management of humeral shaft fractures; non-operative versus operative. Archives of trauma research, 4(2).
7. Carroll, E. A., Schweppe, M., Langfitt, M., Miller, A. N., & Halvorson, J. J. (2012). Management of humeral shaft fractures. JAAOS-Journal of the American Academy of Orthopaedic Surgeons, 20(7), 423-433.
8. Bong MR, Koval KJ, Egol KA (2006): The history of intramedullary nailing. Bulletin of the NYU Hospital for Joint Diseases, 64(3and4):94-97.
9. Stewart, M. J., & Hundley, J. M. (1955). Fractures of the humerus: a comparative study in methods of treatment. JBJS, 37(4), 681-692.
10. Ajmal, M., O'sullivan, M., McCabe, J., & Curtin, W. (2001). Antegrade locked intramedullary nailing in humeral shaft fractures. Injury, 32(9), 692-694.
11. Ligier, J. N., Metaizeau, J. P., Prévot, J., & Lascombes, P. (1988). Elastic stable intramedullary nailing of femoral shaft fractures in children. The Journal of bone and joint surgery. British volume, 70(1), 74-77.
12. Hall Jr, R. F., & Pankovich, A. M. (1987). Ender nailing of acute fractures of the humerus. A study of closed fixation by intramedullary nails without reaming. The Journal of bone and joint surgery. American volume, 69(4), 558-567.
13. Knorr, P., Joeris, A., Lieber, J., Schalamon, J., & Dietz, H. G. (2005). The use of ESIN in humerus fractures. European Journal of Trauma, 31(1), 12-18.
14. Osman, N., Touam, C., Masmejean, E., Asfazadourian, H., & Alnot, J. Y. (1998, January). Results of non-operative and operative treatment of humeral shaft fractures A series of 104 cases. In Annales de Chirurgie de la Main et du Membre Supérieur (Vol. 17, No. 3, pp. 195-206). Elsevier Masson.

15. Uhthoff, H. K., Poitras, P., & Backman, D. S. (2006). Internal plate fixation of fractures: short history and recent developments. Journal of Orthopaedic Science, 11(2), 118-126.
16. Tome, J. L., Carsi, B., García-Fernández, C., Marco, F., & Lopez-Duran Stern, L. (1998). Treatment of pathologic fractures of the humerus with Seidel nailing. Clinical orthopaedics and related research, 350, 51-55.
17. Balfour, G. W., & Marrero, C. E. (1995). Fracture brace for the treatment of humerus shaft fractures caused by gunshot wounds. The Orthopedic clinics of North America, 26(1), 55-63.
18. Niall, D. M., O'Mahony, J., & McElwain, J. P. (2004). Plating of humeral shaft fractures—has the pendulum swung back?. Injury, 35(6), 580-586.
19. Martínez, A. A., Malillos, M., Cuenca, J., & Herrera, A. (2004). Marchetti nailing of closed fresh humeral shaft fractures. Chirurgie de la main, 23(5), 237-242.
20. Chao, T. C., Chou, W. Y., Chung, J. C., & Hsu, C. J. (2005). Humeral shaft fractures treated by dynamic compression plates, Ender nails and interlocking nails. International orthopaedics, 29(2), 88-91.
21. Radwan, Y. A. F., Elfeky, A., & Nassar, Y. (2008). Titanium elastic nail fixation of diaphyseal humeral fracture in multiply traumatized adolescent and young adults, Pan Arab J. Orthop. Trauma, 12(1), 67-74.
22. Eladawy, A. M., Megahed, R. M., Yosef, A. E. M., & Salama, M. I. (2021). Management of Open Tibial Shaft Fractures in Children with Intramedullary Elastic Nail. The Egyptian Journal of Hospital Medicine, 84(1), 1984-1988.

23. Langer P, Born CT. (2011). Intramedullary fixation of humeral shaft fractures. In: InTornetta P III, Williams GR, Ramsey MLHunt TR III, eds, editors. Operative Techniques in Orthopaedic Trauma Surgery. Philadelphia, PA: Lippincott Williams & Wilkins;. pp. 197–205.