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Original Article

Preliminary results from osteosynthesis using Ender nails by means of a percutaneous technique, in humeral diaphysis fractures in adults☆

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ABSTRACT

Objective: To demonstrate the clinical and functional results from treatment of humeral diaphysis fractures using Ender nails.
Methods: Eighteen patients who underwent osteosynthesis of humeral diaphysis fractures using Ender nails were evaluated. In addition to the clinical and radiographic evaluations, patients with a minimum of one year of follow-up were assessed by means of the Constant, American Shoulder and Elbow Surgeons (ASES), Mayo Clinic and Simple Shoulder Value (SSV) functional scores, and in relation to the degree of satisfaction with the final result. The fixation technique used was by means of an anterograde percutaneous route.
Results: All the patients achieved fracture consolidation, after a mean of 2.9 months (ranging from 2 to 4 months). The mean Constant score was 85.7 (ranging from 54 to 100) and the mean ASES score was 95.9 (ranging from 76 to 100). All the patients achieved the maximum score on the Mayo Clinic scale.
Conclusion: Fixation of humeral diaphysis fractures using Ender nails by means of a percutaneous technique was shown to be a method with promising preliminary results.

☆ Work performed at the Belo Horizonte, Lifecenter and Belvedere Hospitals, Belo Horizonte, MG, Brazil.

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Resultados preliminares da osteossíntese com haste de Ender, por meio da técnica percutânea nas fraturas diafisárias do úmero nos adultos

Palavras-chave:
Fraturas do úmero
Fixação intramedular de fraturas
Fixação interna de fraturas

RESUMO

Objetivo: Demonstrar os resultados clínicos e funcionais do tratamento da fratura diafisária de úmero com uso das hastes de Ender.
Métodos: Foram avaliados 18 pacientes submetidos à osteossíntese da fratura diafisária de úmero com uso da haste de Ender. Além das avaliações clínicas e radiográficas, os pacientes com no mínimo um ano de seguimento foram avaliados pelos escores funcionais de Constant, American Shoulder and Elbow Surgeons (Ases), Mayo Clinic, Simple Shoulder Value (SSV) e quanto ao grau de satisfação com o resultado final. A técnica de fixação usada foi por via anterógrada e percutânea.
Resultados: Todos os pacientes obtiveram consolidação da fratura, com média de 2,9 meses (variação de dois a quatro). A média do Score de Constant foi de 85,7 (variação de 54-100) e a do ASES de 95,9 (variação de 76-100) e todos obtiveram pontuação máxima pelo escore Mayo Clinic.
Conclusão: A fixação das fraturas diafisárias do úmero com o uso da haste de Ender pela técnica percutânea demonstrou ser um método com resultados preliminares promissores.

Introduction

The Ender nail, which is thin, flexible and premolded, was first described by Ender for treating intertrochanteric hip fractures.[1] The first study to evaluate the results from using Ender nails for treating closed humeral diaphysis fractures was published in 1987. In that study, osteosynthesis was performed using an Ender nail after closed reduction of fractures with angular displacements greater than 20 degrees.[2]

The majority of humeral diaphysis fractures can be treated conservatively with good clinical and functional results.[3–5] Surgical treatment is reserved for exposed segmental fractures, multiple trauma patients, cases of floating shoulder or elbow and failure of conservative treatment.[6–8]

Currently, the two types of implant for which there is the greatest amount of evidence regarding surgical treatment of humeral diaphysis fractures are dynamic compression plates and rigid intramedullary nails.

Anatomical reduction of the fragments, which is the objective when plates are used, tends to reduce the risks of poor consolidation. However, this requires greater perioperative exposure, with greater damage to the soft tissues and periosteal vascularization, which possibly can be correlated with a higher infection rate and pseudarthrosis.[6–8] On the other hand, rigid intramedullary nails give rise to less soft-tissue aggression. However, their use has been correlated with postoperative shoulder pain and high numbers of second interventions.[7,9–11]

Fixation using flexible intramedullary nails has been criticized because of the deficit of rotational control and instability during the fixation,[7,10] along with the possibility that the rotator cuff might be affected in cases of anterograde entry.[2,12] With modification to the technique originally described for introducing the nail, good results are expected.

The objective of the present study was to demonstrate the clinical and functional results from treating humeral diaphysis fractures using Ender nails and compare the financial costs of this implant in relation to those from other surgical techniques.

Materials and methods

Twenty-six patients with closed humeral diaphysis fractures that had been treated surgically using Ender nails as the fixation method were selected. The operations were performed in our institution between July 1998 and August 2011. All of the patients were retrospectively evaluated regarding the neurological functioning of affected limb before the surgical procedure, and possible associated lesions were investigated. In addition, by means of orthogonal preoperative radiographs of the humerus, in anteroposterior (AP) and lateral views, the fractures were classified in accordance with the AO system.

The inclusion criteria were that the cases should comprise closed fractures that occurred not more than 7 days before the surgical procedure, in which the fracture displacement was more than 20 degrees in the sagittal or coronal plane, with shortening between the segments greater than 2 cm, classified as 12A, 12B, 12C1 or 12C2 fractures.

Cases were excluded if a minimum of one year of outpatient follow-up had not been concluded, including reviews conducted 1 week, 15 days and 1, 2, 3 and 6 months after the operation. Fractures of the type 12C3 were also excluded, as were pathological and exposed fractures. None of the patients presented a fracture of type 12B3. Among the 26 patients selected, eight were lost from the follow-up: one due to death and seven because it was impossible to contact them. Eighteen patients (12 women and 8 men) remained, and were all evaluated. Their mean age was 48 years (range: 24–72), and the

mean duration of the postoperative follow-up was 3.2 years (range: 1–13).

The most common type of fracture was A (66%), followed by B (27%), and only one case presented a segmental fracture (type C2).

During the follow-up, the patients were evaluated using the Constant, American Shoulder and Elbow Surgeons (ASES), Mayo Clinic and Simple Shoulder Value (SSV) functional scales, including a comparison with the contralateral side regarding range of motion (ROM) of the shoulder and elbow. Neurological tests were also used and possible complications inherent to the surgical procedure, such as infection of the surgical site and systemic complications, were investigated. The SSV was used to subjectively evaluate the shoulder, given that this procedure may indirectly influence the functioning of this joint. Subsequently, the patients were asked about their satisfaction relating to the treatment of the humeral fracture and whether they were satisfied or dissatisfied with it.

The postoperative radiographs furnished information regarding the time taken for the fracture to consolidate and the alignment between the segments, along with information regarding the positioning and migration of the nails.

Satisfactory union of the fragments was defined according to the following criteria: viewing of a bone bridge between the fragments or obliteration of the fracture site, with union of the cortical bone in both views. Consolidation was considered to be delayed when the parameters established above were absent 4 months after implementation of osteosynthesis and a situation of pseudarthrosis was defined if consolidation remained absent 9 months after the operation.

Skewed consolidation was taken to be radiographic consolidation showing an angle greater than 20 degrees to the anatomical axis of the diaphysis.

All the patients used a Velpeau sling during the immediate postoperative period. They performed flexion and extension exercises for the elbow and pendulum exercises for the ipsilateral shoulder on the day following the procedure.

Surgical technique

The surgery was performed with the patient in the deckchair position, under general anesthesia or sedation, with regional block of the brachial plexus. All the patients were administered 2 g of first-generation cephalosporin intravenously, 30 min before the procedure and this was followed by 1 g every 6 h for 24 h.

The entry point was viewed under fluoroscopy, approximately 2 cm distally to the footprint of the supraspinatus tendon. At this point, a longitudinal incision of around 2 cm was made. An entry orifice in the bone was made using a manual starter (Fig. 1). Two or three Ender nails were inserted (Fig. 2) after reduction of the fracture, performed while viewing using an image intensifier (Fig. 3), and it was sought to diverge the distal extremities of the nails. It was decided to insert three nails when instability was observed at the focus after arm

Fig. 1 – Using the manual starter to make the entry orifice in the bone.

Fig. 2 – Insertion of the Ender nail through the bone orifice.

Fig. 3 – Reduction of the fracture and passage of the nail, using an image intensifier.

Fig. 4 – Radiograph demonstrating the consolidation process 1 month after the operation.

rotation tests during the operation. The size of the nails was chosen by means of preoperative radiographic examinations in AP and lateral views, taking the normal contralateral arm as the standard. At the end of the operation, the positions of the nails were checked by means of radiographic examinations in AP and lateral views.

Results

The mean Constant score was 85.7 (range: 54–100) and the mean ASES was 95.9 (range: 76–100). All the patients obtained 100 points in the evaluation using the Mayo Clinic scale. The mean score from the subjective evaluation using the SSV was 96 points.

Two patients presented Constant scores of 54 and 58, corresponding to ASES scores of 76 and 79, respectively.

When the patients were asked about their degree of satisfaction, all of them said that they were satisfied.

The migration rate among the nails was 33.3% and all the migrations were upwards.

The mean time taken to reach fracture consolidation was 2.9 months (range: 2–4) and none of the patients evolved with delayed consolidation or pseudarthrosis (Fig. 4).

Two patients (11%) presented lesions of the radial nerve before the operation, but showed complete recovery during the postoperative follow-up (without any intervention during the operation).

None of the patients evolved with infection, neuropraxia, wound dehiscence or any other type of complication.

Postoperative radiographic evaluations (patients invited to return) were performed on 16 of the 18 patients. None of them presented skewed consolidation or any other alteration.

Discussion

The implant options most used today for treating humeral diaphysis fractures are plates and rigid intramedullary nails.

In a meta-analysis, Ouyang et al.[9] sought to objectively evaluate the functional and clinical results and the complications from these two types of implant (plates and locked intramedullary nails) for treating humeral diaphysis fractures.

In the present study, 100% of the fractures treated using Ender nails reached consolidation, without presenting any delay. In the meta-analysis of Ouyang et al.,[9] 8.3% if the fractures treated using locked intramedullary nails evolved to pseudarthrosis and 17% to delayed consolidation. Likewise, 6.75% of the fractures treated using plates evolved to pseudarthrosis and 5% to delayed consolidation.

Chiu et al.[6] showed a pseudarthrosis rate of 9.4% among fractures treated using Ender nails and attributed the cause of this to excessive dislocation at the focus of the fracture. In all the cases, the gap between the main fragments during the postoperative clinical follow-up was greater than 0.5 cm, even though fragment impaction had been performed during the operation so as to produce a gap of less than 3 mm at that time.

Among the patients of our sample, all of them were encouraged to perform active flexion and extension of the elbow. It is believed that this movement helps to maintain the impaction of the fragments through the strength of the biceps.

In a study on 86 patients who were treated using Ender nails, Hall and Pankovich[2] only observed one case of pseudarthrosis and the mean time taken to reach consolidation was 7.2 weeks.believe that our high fracture consolidation rate and low complication rate arose from the basis of the

Table 1 – Average costs of humeral implants on the metropolitan region of Belo Horizonte.

	Ender nail[a]	DCP plate[b]	Locked plate	Locked plate[c]
Amounts (reais)	195.62	389.36	1572.00	1520.00

[a] Two nails (minimum number of nails used).
[b] Dynamic compression plate of 4.5 mm and eight cortical screws.
[c] Locked plate and locking screws.

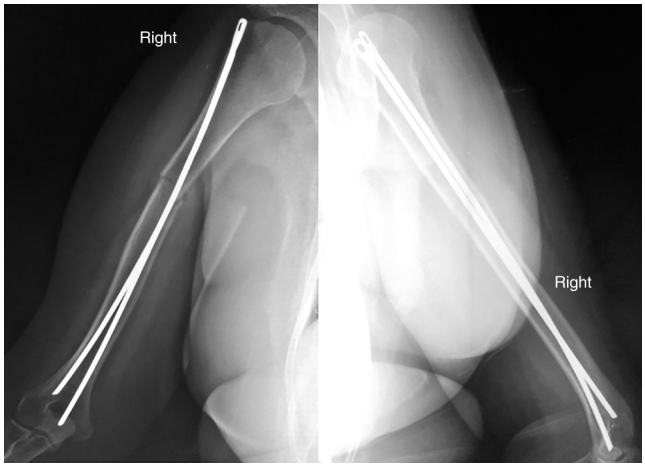

Fig. 5 – Radiographs in anteroposterior and lateral view of the right arm after removal of the nail, with the fracture consolidated.

principle of biological internal fixation, as described by Gerber et al.,[13] who emphasized maintenance of the integrity of the soft tissues surrounding the fracture, through indirect reduction of the focus. Another technique that has produced good results using this principle was described by Livani and Belangero[14] and consisted of using a bridge plate. No cases of postoperative infection (superficial or deep) were observed during the follow-up among our patients. We believe that this lack of infection was due to the minimally invasive approach. This argument is validated by the findings of Ouyang et al.,[9] who observed infection in 2% of the cases dealt with using nails and in 6.3% of the procedures with plates. Two cases of neurological lesions due to preoperative paralysis of the radial nerve were identified, both caused by trauma, with complete recovery during the postoperative follow-up without any intervention during the operation. No cases of postoperative neurological were observed. The data of Ouyang et al.[9] showed that among the patients treated with rigid intramedullary nails, the radial paralysis rate was 2.5%, while among those treated with plates, it was 4.8%. Hall and Pankovich[2] reported two cases of paralysis of the radial nerve after fixation of the humeral fracture using a retrograde Ender nail and achieved spontaneous improvement without exploration of the nerve affected.

Among the 18 cases treated with Ender nails, the nail was removed in 6 cases because upward migration was observed after consolidation (Fig. 5). This represents a reworking rate of 33%, but it should be noted that in half of these cases, the nail was removed as an outpatient procedure, using local anesthetic, after obtaining radiographic confirmation of consolidation, without subsequent complication. The authors of the present study believe that this migration is due to insufficient impaction of the nails in the medullary canal. Burial of the nails is avoided as a way of facilitating their removal if this becomes necessary. In a sample of 21 patients who underwent intramedullary fixation using rigid nails, McCormack et al.[11] presented two cases in which removal of the nail was necessary because of the severe impact that the nail had had. In the meta-analysis study by Ouyang et al.,[9] a reoperation rate of 16.1% among cases using locked intramedullary nails and 8.5% among cases with plates.

We did not observe any limitation regarding passive ROM (i.e. this was symmetrical to the contralateral side). Two patients presented limitation regarding active anterior elevation and these patients had the lowest functional scores (one patient aged 67 years and the other, 71 years). These two patients presented significant deficits of rotator cuff strength. Since these patients were oligosymptomatic, we believe that their deficit was due to a previous pathological condition of the rotator cuff that had not been caused by introduction of the nails, given that these were inserted below the insertion of the supraspinatus tendon. However, it should be emphasized that both of these patients said that they were satisfied with the result from the surgery.

Surgery to implant Ender nails for treating humeral diaphysis fractures is a rapid minimally invasive procedure with lower costs than those of other implants. In a randomized study on 91 fractures that were treated surgically using dynamic compression plates and Ender nails, Chiu et al.[6] showed that the blood loss was smaller and the duration of the operation was shorter in the procedure with Ender nails, which corroborates the findings of the present study. These data clearly present reductions in costs and morbidity for the patient and for the healthcare system.

A survey of costs conducted in the purchasing department of the Lifecenter Hospital, relating to the prices charged by the largest healthcare plan provider in the Metropolitan Region of Minas Gerais, showed the values displayed in Table 1.

The present study had the following limitations: (1) it was a retrospective study; (2) it was a case series study with a limited sample, which made statistical analysis impossible.

Conclusion

Fixation of the humeral diaphysis fractures using Ender intramedullary nails was shown to be a safe procedure, with promising preliminary clinical and functional results. New studies with higher levels of evidence need to be conducted in order to improve the basis of these results.

Conflicts of interest

The authors declare no conflicts of interest.

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