HUMERAL SHAFT FRACTURES

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ABSTRACT

Humeral shaft fractures (HSFs) represent 3% of the fractures of the locomotor apparatus, and the middle third of the shaft is the section most affected. In the majority of cases, it is treated using nonsurgical methods, but surgical indications in HSF cases are increasingly being adopted. The diversity of opinions makes it difficult to reach a consensus regarding the types of osteosynthesis, surgical technique and quantity and quality of synthesis materials that should be used. It would appear that specialists are far from reaching a consensus regarding the best method for surgical treatment of HSFs. We believe that less invasive methods, which favor relative stability, are the most appropriate methods, since the most feared complications are less frequent.

Keywords – *Humeral fractures; Classification; Treatment; Orthopedic surgery; Fractures fixation, internal*

INTRODUCTION

Humeral shaft fractures (HSFs) represent 3% of the fractures of the locomotor apparatus(1). It has been estimated that around 60 new cases of HSF in adults are treated per year, for every group of 600,000 inhabitants(2).

With regard to location, the middle third of the right shaft is the region most affected, and type A of the AO classification occurs most frequently(3), while type C is rarest(4,5).

Exposed fractures of the humeral shaft are rare(2,6).

In the majority of cases, HSFs are treated using nonsurgical methods, with good functional results(4,7,8). However, there are situations and certain types of HSF for which conservative treatment has not been found to be effective. Supported by notable progress in surgery for trauma of the locomotor apparatus over recent decades, with better techniques and osteosynthesis materials, surgical indications for HSFs are being adopted increasingly frequently, such as in situations of multiple trauma, exposed fractures, bilateral fractures, pathological fractures, etc(9).

In surgical treatment for HSFs, the surgical technique and the quantity and quality of the synthesis materials used are still sources of controversy, and these factors will be covered in this review.

CLASSIFICATION

These fractures can be classified according to the type of fracture line, its location and whether it is open or closed, and according to the bone condition (normal or diseased).

One of the classifications most used is the system of Zuckerman and Koval(9), who analyzed the biomechanics of deviations of HSFs. They stated that when the fracture line occurred above the insertion of the pectoralis major muscle, the proximal fragment would be deviated towards abduction and external rotation, due to the action of the rotator cuff muscles. When the focus of the fracture was between the insertions of the pectoralis major and deltoid muscles, the proximal fragment would present adduction, due to traction by the pectoralis major muscle, and the distal fragment would

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present insertion of the deltoid muscle, the proximal fragment would be abducted due to traction by the deltoid muscle, while the distal fragment would present proximal deviation.

The classification by Müller *et al*[3] and the group that they founded (known as the AO group) is more complete, with division of HSFs as shown in Figure 1.

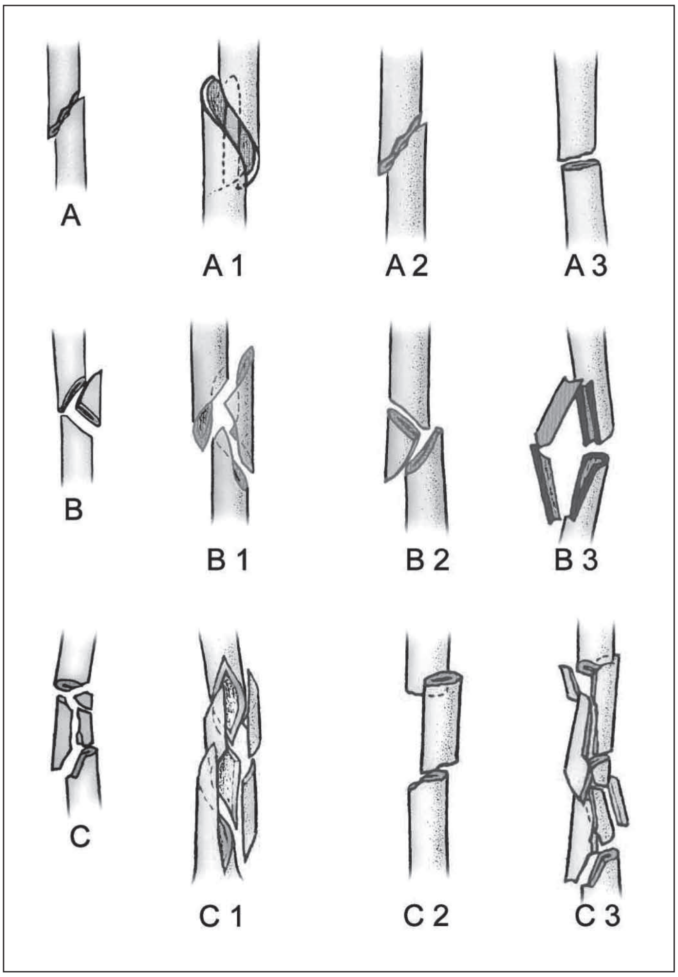

Figure 1 – AO classification of HSFs

DIAGNOSIS

Radiographic examination using anterior and lateral views is sufficient for diagnosing and classifying HSFs.

Bone scintigraphy, magnetic resonance and computed tomography are used in special situations, such as for diagnosing and staging pathological fractures.

Electroneuromyography is only useful for diagnosing neurological lesions from the third week after the trauma. Therefore, adequate clinical examination is essential.

TREATMENT

Because the humerus is a well vascularized bone that is surrounded by several muscles, the consolidation process is made easier. Deviations (anterior angling greater than 20º, varus deviation greater than 30º or shortening greater than three centimeters[4,10]) without changing upper-limb function or esthetics also become possible.

These characteristics explain the almost unanimous opinion that nonsurgical treatment leads to high consolidation rates and good functional results[4,5,79,1114].

Among the various nonsurgical treatment methods (confectioners' clamp, hanging plaster cast, thoracobrachial plaster cast and Velpeau immobilization), the use of brachial orthoses is the nonsurgical method most used today[5,8]. This enables contraction of the adjacent muscle groups and stimulates consolidation. However, certain aspects of HSFs and patient characteristics make it difficult to carry out treatment using external immobilization. With increasing incidence of HSFs due to multiple trauma, exposed fractures and deviation caused by muscle action[9], along with other factors such as obesity, which lead to poor results from nonsurgical treatment, many investigators have been seeking new treatment methods, such as the use of pins[15], intramedullary nails[16] or screwed plates[17,18]. Thus, although most HSFs can be treated nonsurgically, the fracture characteristics and patient requirements should be fundamental with regard to indicating surgery[14].

Based on such needs, Zuckerman and Koval[9] indicated surgical treatment in cases of exposed fracture, associated vascular injuries, floating elbow, segmental fracture, pathological fracture, bilateral humeral fracture, humeral fracture in multiple trauma patients, radial nerve injury following closed manipulation of the HSF, nerve injury following stab wounds, HSF with unacceptable deviation, or extension of the fracture line to joints. Modabber and Jupiter[13] used the surgical procedure only in cases of loss or if fracture reduction is impossible, cases of joint involvement in the fracture line with deviation, fractures associated with vascular or nerve injury, other fractures in the same limb, segmental fractures, pathological fractures, exposed fractures, pseudarthrosis, multiple trauma, bilateral humeral fracture or skin injuries that impede conservative treatment. Rommens *et al*[18] defined the absolute indications for osteosynthesis as multiple trauma, exposed fractures, bilateral humeral fractures, pathological fractures, floating elbow, associated vascular or nerve injury, paralysis of the radial nerve following closed reduction, and pseudarthrosis. They defined the relative indications as long spiral fractures, transverse fractures, associated lesions of the brachial plexus, primary nerve paralysis, incapability to maintain the reduction, neurological diseases, lack of cooperation because of alcohol or drug abuse, and obesity.

After establishing an indication for surgical treatment, the diversity of opinions makes it difficult to reach a consensus regarding the type of osteosynthesis to use.

Authors who have advocated treatment with plates and 4.5 mm screws by means of an open route[14,19-23] believed that this method led to a lower rate of complications such as iatrogenic nerve injury, pseudarthrosis, impact syndrome, fracturing while introducing nails by means of a retrograde route, adhesive capsulitis. They also believed that it would lead to a better functional result, with shorter duration of postoperative immobilization, faster return to shoulder and elbow joint function and better alignment of the humeral shaft.

The experience acquired within the traumatology sector of IOT-HCFMUSP makes us believe that the muscle envelope and vascularization around the fracture focus should be preserved and that the lower the degree of soft-tissue dissection is, the lower the rate of complications such as infection, nerve injury and pseudarthrosis will be.

In the same way as believed by Ingman and Waters[17] and Habernek and Orthner[24], we prefer intramedullary locked nails over intramedullary pins, since they ensure better fixation. This enables early mobilization of the shoulder and elbow joints.

We also agree with Robinson *et al*[25], who reported that distal fixation of the nail developed by Seidel[16] is insufficient. Thus, we prefer locked nails with proximal screws and one distal screw.

Contrary to Lin *et al*[26] and Ingman and Waters[17], and in the same way as Habernek and Orthner[24], Modabber and Jupiter[13] and Flinkkilä *et al*[27], we believe that anterograde introduction of the locked intramedullary nail, with careful dissection of the rotator cuff and deepening to the proximal cortex of the greater tubercle, minimizes the risk of residual shoulder pain.

We agree with Modabber and Jupiter[13] that, in using intramedullary nails, it is preferable not to ream the medullary canal because this is less damaging to the circulation of the endosteum. We also agree with the use of non-reamed nails, given that because the humerus is an upper-limb bone, it is not subject to axial loads, thereby making it unnecessary to use reaming to widen the medullary canal. Another argument for using non-reamed nails was advocated by Verbruggen *et al*[28], who stated that both reamed and non-reamed nails were capable of resisting the deforming forces of HSFs.

Although we believe that osteosynthesis for HSFs using external fixators is a good method for treating exposed fractures or for damage control among individuals with multiple trauma, we agree with Rommens *et al*[18] that prolonged use of such fixators for definitive treatment of these fractures causes complications such as infection and loosening of the fixation screws.

Livani and Belangero[29,30] published a scientific paper on an original technique in which they treated HSFs by means of bridge plates. This has become established for treating other long bones but, until then, it had not been used for the humerus because of fear of causing iatrogenic lesions of the radial nerve. Encouraged by the good results published by Livani and Belangero[29,30] and by the advantages of the relative stability method, in which the rotator cuff is not dissected (thereby protecting the muscle envelope and vascularization around the fracture focus and avoiding iatrogenic lesions of the radial nerve), we planned a randomized prospective study to compare locked intramedullary nails and bridge plates for surgical treatment of HSFs (Figures 2 and 3).

Consolidation occurred in 100% of the bridge plate group and in 94.7% of the locked intramedullary nail group, and these numbers were very close to the findings of Sarmiento *et al*[8] (98%), from nonsurgical treatment of HSFs. Other consolidation rates from the use of intramedullary nails have been reported in the studies of Ingman and Waters[17] (97.6%), Rommens *et al*[18] (94.8%) and Scheerlinck and Handelberg[31] (93%).

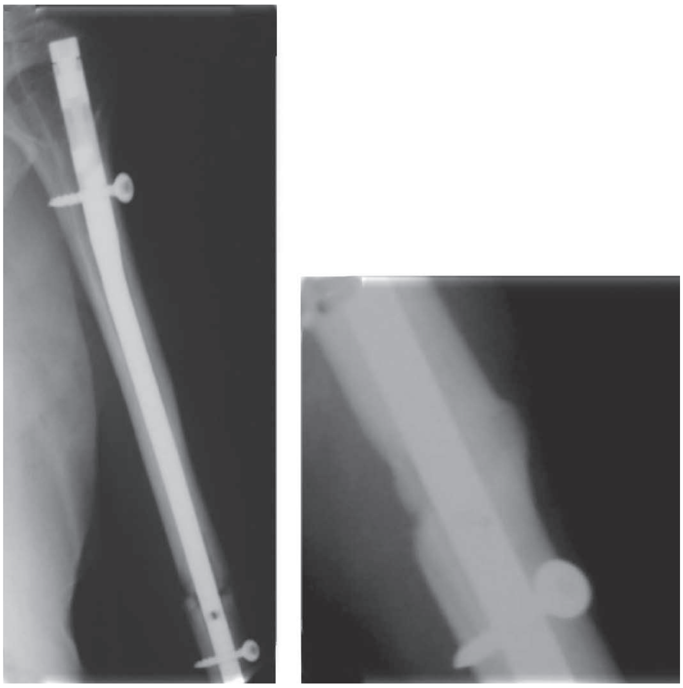

Figure 2 – Locked intramedullary nail

Figure 3 – Bridge plate

We proved that, with the techniques used, the duration of radioscopy use was greater when using locked intramedullary nails.

Although we used radioscopy for longer times in the locked intramedullary nail group, the duration of the operation did not present any statistically significant difference.

The final functional results from the bridge plate and locked intramedullary nail methods were similar to those obtained by authors such as Mast *et al*(7) and Sarmiento(8), through nonsurgical treatment; Rommens *et al*(18), through using intramedullary nails; and Changulani *et al*(32), through using plates and screws via an open route, with around 85% of the results satisfactory.

It needs to be borne in mind that, in the same way as in the study by Gadegone and Salphale(33), HSFs associated with previous lesions of the radial nerve were not included in our study, in order not to influence the final comparative result between the two treatment methods. According to Shao *et al*(34), such lesions occur in 11.8% of the cases and regress spontaneously in 70.7% of the occurrences, starting in the seventh week: this time point was also found by Ring *et al*(35). Pollock *et al*(36) found that only 6% of radial nerve lesions were associated with HSFs, and 92% of the cases presented spontaneous regression of symptoms. Thus, they recommended waiting for three and a half to four months before undertaking surgical exploration.

CONCLUSION

At the end of this study, the impression that remains is that the specialists studying HSFs are far from reaching a consensus regarding the best method of surgical treatment for such fractures, since each method has its particular advantages, disadvantages and complications. We believe that less invasive methods that favor relative stability, such as locked intramedullary nails or bridge plates are the most appropriate methods because the most feared complications (which in our opinion are infections, neurovascular lesions and pseudarthrosis of the humerus) are the least frequent ones. Between these two methods for relative stability, i.e. locked intramedullary nails and bridge plates, the latter seems to us to be more recommendable, since it not only provides high consolidation rates and satisfactory results, but also gives rise to lower exposure to X-rays both for patients and for the surgeon, than does the locked intramedullary nail technique.

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