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Complications in proximal humeral fractures

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ABSTRACT

Necrosis of the humeral head, infections and non-unions are among the most dangerous and difficult-to-treat complications of proximal humeral fractures. The aim of this work was to analyse in detail non-unions and post-traumatic bone defects and to suggest an algorithm of care. Treatment options are based not only on the radiological frame, but also according to a detailed analysis of the patient, who is classified using a risk factor analysis. This method enables the surgeon to choose the most suitable treatment for the patient, thereby facilitating return of function in the shortest possible time. The treatment of such serious complications requires the surgeon to be knowledgeable about the following possible solutions: increased mechanical stability; biological stimulation; and reconstructive techniques in two steps, with application of biotechnologies and prosthetic substitution.

Introduction

Fractures of the proximal part of the humerus represent almost 5% of all fractures, with the incidence increasing in patients aged over 50 years, in whom these fractures are the third most common osteoporosis-related fractures. Proximal humerus fractures are around two to three times more common in women than in men. Mortality one year after surgery increases from 1% to 10% in patients aged over 65 years [1].

Several studies have been conducted to evaluate whether surgical timing influences the outcome of surgical treatment of these fractures. Evidence from the literature indicates that long-term consequences are worse and more common in patients who had surgery more than 2 days after trauma, even if there are no valid differences between intraoperative death rate and complication rate [2].

Complications

Fracture classification is necessary for the evaluation of possible complications that could occur before, during or after surgery.

Early complications may include nervous or vascular lesions that occur during trauma as a result of dislocation of bony fragments, and concomitant rotator cuff lesions. Non-union is another possible complication that could evolve into late complications if it is not treated or does not resolve spontaneously.

Late complications, which are generally the most serious, include three main clinical conditions:

- avascular necrosis of the humeral head: the frequency of this complication is 7%, and there are no obvious differences in outcome between surgical and non-surgical treatment [3];
- sepsis: the incidence of infection is really variable in the literature, ranging from just above 0% to 10%;
- non-union: the incidence of non-union in proximal humeral fractures is 1.1%, although it increases to 8% in those cases with metaphyseal comminution and to 10% if more than one-third of the surgical neck is involved [4].

Our work is focused on non-union and post-traumatic bone loss.

Risk factors

There are various predisposing factors for the onset of complications, including general factors and fracture-site-specific factors.

The general risk factors for the onset of complications during healing include: old age (particularly in females because of hormonal imbalances after menopause); uncontrolled diabetes; certain vascular and neurotrophic problems (some of these have been observed to decrease the formation of collagen and cells

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involved in formation and maturation of bone callus); osteoporosis; muscle atrophy; living habits (diet, smoking, alcohol); and drugs, such as non-steroidal anti-inflammatory drugs (NSAIDs) taken for pain control after surgery.

Local risk factors are related to the trauma. High-energy traumas are associated with more comminution and dislocation of bone fragments and significant soft tissue and vascular system involvement, which impacts greatly on blood support at the fracture site. Experimental studies have shown how the healing process is guided, with a peak at 2 weeks after the traumatic event, with blood support from the cortical bone. Consequently, a wide soft tissue lesion and a large haematoma that limits blood flow to the cortical bone itself reduce the flow of nutrients to the fracture site. This condition can determine a higher risk of necrosis and non-union, with possible evolution to atrophic pseudoarthrosis or avascular necrosis of the humeral head [5].

A patient at low risk who receives suitable treatment for their proximal humeral fracture could also evolve towards non-union; this outcome may be attributed to genetic predisposition.

Classification: NUSS

Numerous classifications of non-union have been proposed over the years. Currently, the most commonly used in the scientific community is the Weber-Cech classification, which defines non-union in relation to bone reaction to treatment and is divided as follows: atrophic, oligotrophic and hypertrophic [6].

This classification is limited in that it evaluates only the radiological aspect of the fracture, and does not consider all the biological and environmental characteristics of the patient; such fundamental information is necessary to help the surgeon choose the most effective treatment. Therapeutic strategy should take into account all potential risk factors.

We propose a new classification system, the Non-Union Scoring System (NUSS), which considers all these variables and provides a final score from 0 to 100 points [7,8].

The true advantage of the NUSS is that it enables the surgeon to homogenise different kinds of non-union using an evaluation system that establishes a numerical score to guide the surgeon through the most suitable treatment options. The score identifies four treatment groups with increasing complexity.

1.° Group (Score 0/25)

The problem is mainly mechanical; the only treatment indication is the stabilisation of the non-union site, changing the inadequate osteosynthesis.

2.° Group (Score 26/50)

There are both biological and mechanical problems; the treatment needs revision of the osteosynthesis and biological stimulation of the non-union site, which is achieved by physical means (electro-pulsated magnetic fields, extracorporeal shock waves) or the application of Biotechnologies (bone growth factors, mesenchymal stem cells, scaffold) in Monotherapy [9] (Fig. 1).

3.° Group (Score 51/75)

The problem is complex and is characterised by severe biological and mechanical conditions. It almost always requires resection of the non-union site and there is bone loss that has to be restored. This is the field with more indication to use Biotechnologies in Polytherapy [10,11]. In most of the difficult cases, and in all of the septic cases, it is advisable to operate in two different surgical steps, as in the Masquelet technique, following the principle of the Biological Chamber (*Chamber Induction Technique*) [12,13] (Figs. 2 and 3).

4.° Group (Score 76/100)

These problems are so complex that the non-union could be considered quite unsolvable and, therefore, could require shoulder disarticulation or mega-prosthesis implantation [14] (Fig. 4).

Discussion

The treatment of proximal humeral fractures can be associated with complications and reduced functional capacity [15–24]. One of them is the development of non union.

There are numerous different treatment approaches in the literature for proximal humerus non-union, including intramedullary nails, osteosynthesis plates, bone grafts, biotechnology and prosthetic implants. As shown in the literature, all these therapeutic strategies are associated with problems. For example, the use of osteosynthesis plates is particularly ineffective in patients with inadequate bone stock at the humeral head, in patients with big cavitation or when bone graft from the iliac crest is expected. The disadvantages of this surgical option include the need for wide soft tissue dissection, inadequate fixation of the screws on the humeral head in some cases, and the fearsome complication of necrosis of the humeral head or possible acromial impingement. Intramedullary nails require only minimal soft tissue dissection for positioning, but even they could cause impingement, and in more proximal cases they may be difficult

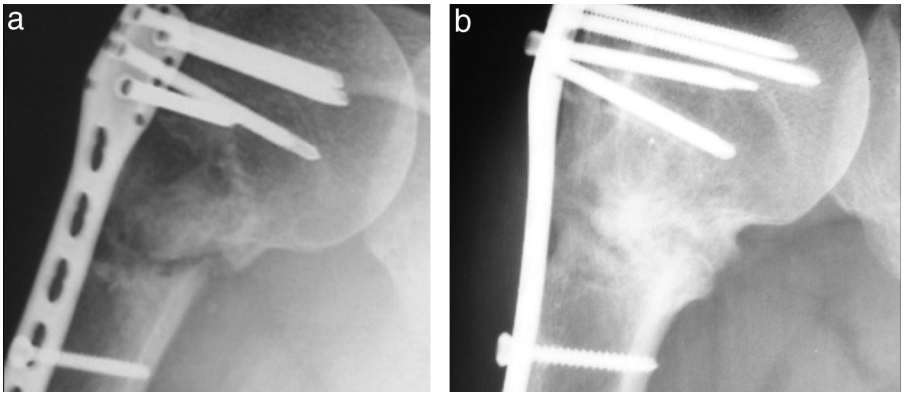

Fig. 1. Radiographic images (female, aged 65 years, NUSS 40) showing non-union at the humeral neck before (1a) and 6 months after (1b) the application of growth factors in monotherapy (rh-BMP-7) without changing osteosynthesis.