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Proximal humerus fractures treatment in adult patients with bone metastasis

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Abstract. – OBJECTIVE: The humerus is the second long bone most affected by pathological fractures. According to Capanna and Campanacci criteria, surgical choice is based on bone metastasis location, on the patient's status and on the residual functional capacity. Metadiaphysis is an area of conflict in the choice between megaprosthesis implant and intramedullary nail osteosynthesis. This study compares these two surgical procedures in terms of reacquired functionality and local control of metastasis.

PATIENTS AND METHODS: Thirty-eight patients (17 males and 21 females; mean age: 66 years old) treated in our institution between January 2010 and December 2020 for pathological humeral metadiaphyseal fractures caused by metastasis, were included in this study. We choose the Musculoskeletal Tumor Society rating system (MSTS) and the Quick Disability of Arm-Shoulder-Hand (QuickDASH) scores for the evaluation of the upper limb function after surgery.

RESULTS: Eighteen (47%) pathological fractures were treated by resection and megaprosthesis implantation, twenty (53%) were treated by medullary nail osteosynthesis. A reduction in pain and greater mechanical stability in the immediate post-operative period was found in all patients. Twenty-two patients died (58%) and sixteen survived (42%). Long-term functional recovery of patients undergoing osteosynthesis is greater than megaprothesis group.

CONCLUSIONS: Both medullary nail osteosynthesis and resection and megaprosthesis implantation guarantee excellent recovery at 72 months after surgery, improvement in quality of life and pain relief. Patients treated with osteosynthesis showed a great short-term functional recovery since the joint portion of the limb is not involved, whereas patients treated with megaprosthesis showed better local oncologic control. It is therefore possible to define the type of treatment not only on the localization of the fracture (diaphysis or epiphysis) but above all on the conditions and characteristics of the patient.

Key Words:
Bone metastases, Pathological humeral fractures, Modular prosthesis, Nail osteosynthesis.

Abbreviations

MSTS: Musculoskeletal Tumor Society rating system; QuickDASH: Quick Disability of Arm-Shoulder.

Introduction

Over the last few years, the average life span for cancer patients has lengthened thanks to oncological treatment improvement, leading in many cases to a higher development of long bones metastases. Long bone metastases may affect load and daily life activities. The humerus, after the femur, is the second most affected long bone, for pathological fractures, with an incidence of 16% to 27%[1-4]. A pathological fracture hinders normal daily living activities and can cause a deterioration in the quality of life and poor prognosis of affected patients. Conservative treatment is not recommended, while surgery may improve the patient's quality of life. Surgical procedures have several purposes including local control of the tumor, lasting stability, pain reduction, regaining limb function and reducing morbidity related to hospitalization[3,5,6]. According to the Capanna and Campanacci[7] criteria, surgical choice is based on bone metastasis location, on the patient's status and on the residual functional capacity. The impending fractures or the pathological fractures must be surgically treated ensuring local control of the disease, pain control, good functional and clinical outcomes[8]. Generally, lesions in the proximal epiphyseal area, with a good prognosis, are

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treated with the modular megaprosthesis implant, while lesions localized in the diaphyseal area are treated with osteosynthesis with an intramedullary nail.

The metadiaphysis is an area of conflict in the choice of these two surgical procedures, for this reason the choice is based on the patient's age, comorbidity and surgical risks. Megaprosthesis may be considered for patients with mid-long-life expectancy, who need a large margin of resection to control the disease, and who can undergo a very invasive operation (considering the comorbidities)[9]. For patients with short life expectancy a minimally invasive intervention, such as osteosynthesis, is usually recommended.

This study compares the two main surgical procedures in terms of reacquired functionality and local control of metastasis, performed for pathological fractures in the metadiaphyseal site.

Patients and Methods

Thirty-eight patients (17 males and 21 females; mean age: 66 years old) treated in our institution were included in this study[10]. Inclusion criteria were: the presence of a pathological humeral metadiaphyseal fracture caused by a metastatic lesion; have undergone surgical procedure of osteosynthesis or modular megaprosthesis to treat the fracture; the surgical procedure took place between January 2010 and December 2020; surgical procedures were performed according to the Capanna and Campanacci[7] criteria adapted through the general Karnofsky state scale[11].

Patients treated with osteosynthesis underwent closed reduction. Fractures were stabilized with an anterograde unreamed locked nail inserted in static mode, through a deltoidal approach, and in some cases the bone was reinforced with cement. In the postoperative period, an external support was applied. Patients treated with this surgical approach began to move their arm in the early post-operative period thanks to physiotherapy support.

In patients who underwent modular megaprosthesis surgery, a large resection was performed through a deltopectoral approach and replaced with a modular silver-coated prosthesis[12]. The deltoid muscle and the rotator cuff tendons were preserved only if untouched by the cancer or *via* preoperative imaging.

The Musculoskeletal Tumor Society rating system (MSTS) and Quick Disability of Arm-Shoulder-Hand (QuickDASH) scores were chosen for the evaluation of the upper limb function after surgery.

Statistical Analysis

Statistical analysis was performed using the Excel program (Microsoft, Red-mond, USA). An independent-samples *t*-test was used to compare means between groups. Statistical significance was set for $p<0.05$.

Results

Thirty-eight patients (seventeen men and twenty-one women), with an average age of 66 years were included in the study through careful research and the use of specific inclusion criteria.

Eighteen (47%) pathological fractures were treated by resection and megaprosthesis implantation, twenty (53%) were treated by medullary nail osteosynthesis. No intraoperative complications were found. Postoperative complications included sensitivity deficit of the operated limb (4 cases), radial nerve stupor (2 cases) and prosthesis infection (2 cases). No patient experienced recurrence of the disease, superficial wound infection or impingement syndrome. A reduction in pain and greater mechanical stability in the immediate post-operative period was found in all patients. Sixteen patients survived (42%) and twenty-two patients died (58%) before the last follow-up; therefore, for reasons of clarity, we decided not to consider the data collected up to that point of these patients. Mortality rate at 72 months of patients treated with megaprothesis implant is 47%, while, while for the other group is 61%.

Considering the survived patients, the primary tumor was in five cases (31.3%) kidney cancer, in four cases (25%) breast cancer, in three cases (18.8%) non-Hodgkin's lymphoma, in two cases (12.5%) lung cancer, in one case (6.3%) uterus cancer and in one case (6.3%) esophageal tumor (Figure 1). The sixteen patients still alive were divided according to the treatment received. Seven were treated with medullary nail osteosynthesis (44%) and nine were treated with megaprosthesis (56%). For the two groups, both the MSTS and the QuickDASH score were used to perform

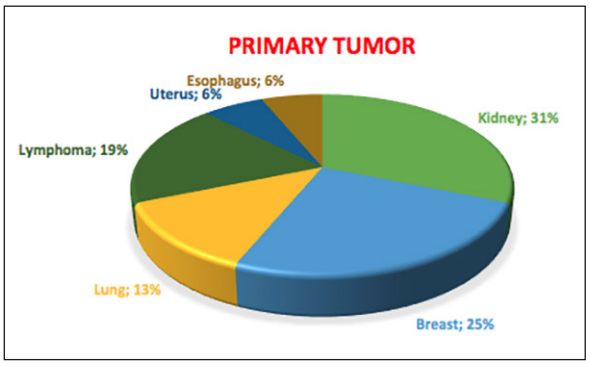

Figure 1. Pie chart of the incidence of primary tumors in the sixteen live patients.

the follow-up at 1 month, 12 months, 24 months and 72 months after surgery, creating an average functional evaluation score of all survived patients for each temporal distance. The seven patients treated with osteosynthesis, had an average age of 61 years. In the short-term follow-up (1 month and 12 months), these seven patients showed a significant reduction of pain and they regained the ability to perform daily activities, but also showed inability to lift heavy loads. At 12 months, the average QuickDASH score was [(21/11) -1] × 25 = 22.7 (Figure 2) and the mean MSTS score was (24/30) % = 80% (excellent) (Figure 3). In this group of patients, the medium and long-term follow-up are comparable in terms of functional results; in fact, the patients had an excellent recovery of limb function reporting no difficulty in carrying out all the actions of daily life with a slight difficulty in heavier jobs. At 72 months, the average QuickDASH score was [(15/11) -1] × 25 = 9.1 (Figure 2), and the mean MSTS score was (25/30) % = 83.3% (excellent result) (Figure 3).

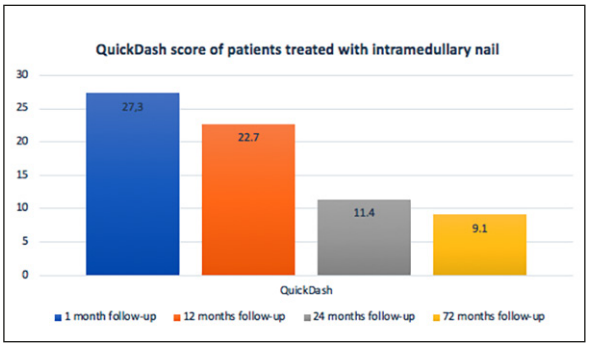

Figure 2. Column chart representing the average QuickDash score of patients treated by osteosynthesis with an intramedullary nail.

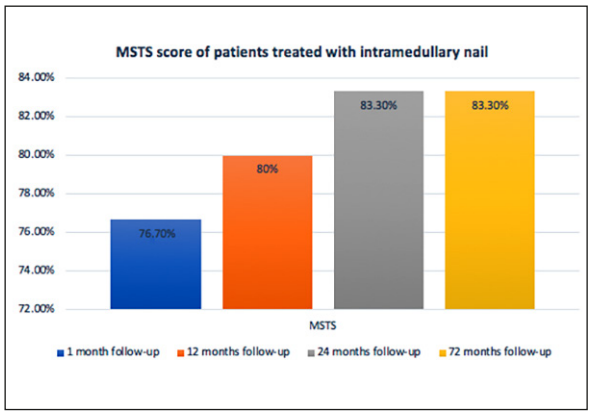

Figure 3. Column chart representing the average MSTS score of patients treated by osteosynthesis with an intramedullary nail.

The nine patients treated with megaprothesis implant, had an average age of 58. In the short-term follow-up (1 month and 12 months), they presented difficulties in carrying out daily activities, and absolute impossibility performing heavy activities; however, they did not report pain or paresthesia. At 12 months, the average QuickDASH score was [(27/11) -1] × 25 = 36.4 (Figure 4) and the mean MSTS score was (18/30) % = 60% (fair result) (Figure 5). In the medium-term follow-up (24 months), patients had medium difficulty in carrying out all daily activities and considerable difficulty in performing heavy activities. Some patients referred mild pain and difficulty sleeping; in fact, the mean QuickDASH score was [(32/11) -1] × 25 = 47.7 (Figure 4), while the mean MSTS score was (19/30) % = 63.3% (fair result) (Figure 5). At 72 months, the results improved markedly, bringing patients back to daily activities, with slight difficulty in carrying out actions that require medium/large strength,

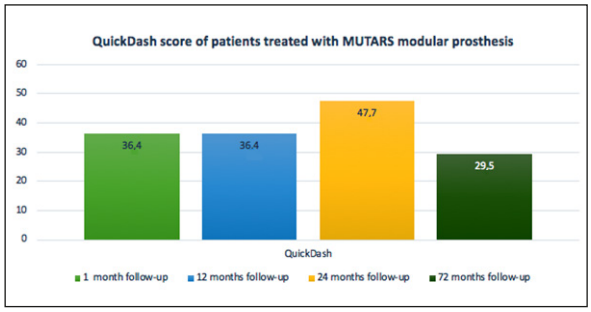

Figure 4. Column chart representing the average QuickDash score of patients treated with modular prosthesis MUTARS.

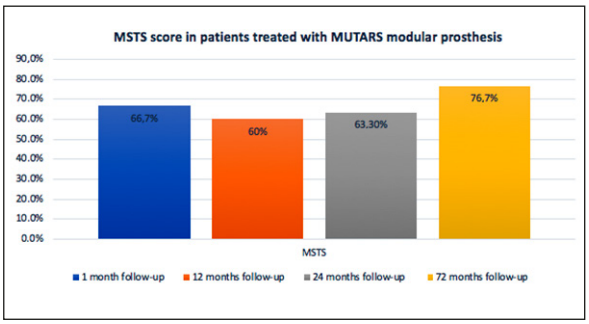

Figure 5. Column chart representing the average MSTS score of patients treated with modular prosthesis MUTARS.

absence of pain and paranesthesia and slight difficulty in sleeping. The results obtained were an average QuickDASH score of [(24/11) -1] × 25 = 29.5 (Figure 4) and a mean MSTS score of (23/30) % = 76.7% (excellent) (Figure 5). No significant differences emerged between two groups regarding the MSTS score (p = 0.966 at 1 month, p = 0.6263 at 12 months, p = 0.105 at 24 months and p = 0.1489 at 72 months) and the QuickDASH score (p = 0.6379 at 1 month, p = 0.327 at 12 months, p = 0.0932 at 24 months and p = 0.1583 at 72 months).

Discussion

Metastatic bone disease leads to deterioration in the quality of life of cancer patients. Impending fractures and pathologic fractures result in the need for ongoing care and intervention for many patients[6,13]. Conservative treatment has been shown to be ineffective in providing complete relief of pain or return to function of the affected limb; therefore, surgical treatment is considered the main treatment for pathologic and impending fractures of the long bones[14,15], although the risk of infection in these patients is very high[16-21]. The goals of surgical treatment are to provide stability to the fracture to facilitate healing, pain relief, and restoration of satisfactory function of the affected limb[1,2]. Improvement in short-term pain and functional status seems particularly desirable for patients with limited life expectancy[5]. Atesoc et al[22] showed relief pain at 6 weeks from surgery in all patients treated with unramed humeral nail. As long as patients have a good life expectancy, the literature points out that surgical treatment may vary based on site; intramedullary nail osteosynthesis find greater indication in diaphyseal fractures, whereas resection and megaprosthesis implantation finds greater indication in epiphyseal and metaphyseal fractures. The biomechanical characteristics of the proximal humerus consist of rotational and bending forces due to the action of the rotator cuff, deltoid, pectoral, and great dorsal muscles. The proximal humeral metaphysis consists primarily of spongy bone with low cortical stiffness; therefore, due to the absence of a strong cortex, metastases can easily spread into the surrounding soft tissues. Taking note of these conditions and characteristics, osteosynthesis is no longer recommended for metastases at this site, while the use of modular prosthesis allows, with adequate resection, good oncological and functional results[23].

In fact, our study showed that the short and long-term functional recovery of patients undergoing osteosynthesis is greater than the other group, with an MSTS score of 76.7%, already in the first month of follow-up, and 83.3% at both 24 and 72 months, whereas patients treated with megaprosthesis implantation showed the same results in terms of recovery only after 72 months with an MSTS score of 76.7% equivalent to the functional recovery at 1 month of patients treated with osteosynthesis. Piccioli et al[24] reported similar results in both group of patients treated with osteosynthesis and megaprothesis, showing a great improvement of function up to 8 months after surgery, with an average score of 68.5% at 3 months improved to 73% at 8 months (p < 0.001) in the group treated with megaprothesis implant, and from 72.7 to 79.2% (p < 0.001) in osteosynthesis group. Furthermore, no patients treated with megaprosthesis experienced a recurrence of the disease, which risk has been hypothesized by Kumar et al[25] related to marginal surgical margins frequently obtained close to neurovascular bundle. They observed 15 local recurrences in a series of 100 patients surgically treated with resection and prothesis implant. Other studies[26-27] related the incidence of local recurrence to the effectiveness of chemotherapy treatment. Furthermore, it is necessary to underline how the pathological fracture negatively affects the prognosis of these patients, because when the fracture occurs it is necessary to operate urgently, interrupting the oncological treatments in an unscheduled manner. The ideal would be to surgically treat patients with an impending fracture[28-31] between one chemotherapy cycle and the following, so that the prognosis is not negatively impacted.

Conclusions

Both medullary nail osteosynthesis and megaprosthesis implantation guarantee an excellent recovery at 72 months after surgery, improvement in quality of life and pain relief. Great short-term functional recovery is seen in patients treated with osteosynthesis, cause the joint portion of the limb is not involved, whereas patients treated with megaprosthesis show better local oncologic control. Therefore, defining the type of treatment, not only on the localization of the fracture (diaphysis or epiphysis) but above all on the conditions and characteristics of the patient, can be possible.

Conflict of Interest
The Authors declare that they have no conflict of interests.

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None.

Authors' Contribution
G.R., A.Z. and P.P; wrote the main manuscript text, C.M, F.M, D.D.M; prepared figures 1-5; A.Z. supervision. All authors reviewed the manuscript.

Consent for Publication
Not applicable.

Ethics Approval
All procedures performed in the current study were in accordance with the 1964 Helsinki Declaration and its later amendments. The study design was approved by the Orthopedic and Traumatology Institute and School Council "Policlinico Universitario Agostino Gemelli IRCCS".

Informed Consent
Written informed consent was obtained from all individual participants included in the study.

Availability of Data and Materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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