Introduction

There is a vast literature on the treatment of humeral fractures, with most studies being divided into fractures of proximal humerus, diaphyseal fractures and fractures of the distal third of the humerus. Nonetheless, bifocal and multifocal fractures of the humerus are infrequent (1,2) and there is a paucity in literature concerning its classification and treatment.

The aim of the present paper is to introduce the cases of three female patients; aged 68, 74 and 78 years old, which underwent long-stemmed reverse shoulder arthroplasty surgery at our department due to bifocal right humerus fractures, and the functional outcomes obtained in an average follow-up of 3.6 years.

Patients and Methods

From 2010 to 2014, three right-handed female patients aged 68, 74 and 78 years old were treated surgically at our department due to bifocal right humerus fractures affecting proximal humerus and diaphyseal regions.

Upon arrival, none of the patients presented any neurological or vascular impairment. Diagnosis was performed through plain antero-posterior and lateral x-ray projections which included the whole humerus, as well as computerized tomography with three-dimensional reconstruction of the proximal humerus (Figures 1A, 1B). Fracture patterns were classified according to Neer’s (3) and AO (4) classifications for proximal and diaphyseal regions respectively (Table 1).

All three patients were treated using long-stemmed reverse shoulder arthroplasty. Surgery was performed in a...
beach-chair position under general anesthesia, using deltopectoral approach in one of the cases and a combination of delto-pectoral and antero-lateral approach on the two others. The same implant was used in all the patients; the Long-Stemmed SMR Shoulder System designed by Lima Corporate Orthopedics. We performed a cemented fixation for humeral stem with 30° retroversion. Implant specifications are shown in Table I. In all the patients we performed a reconstruction of the humeral tuberosities using a non-resorbable suture (Ethibond nº5) as well as humeral head autograft was used to fill the bone defects. Exeresis of the remanent supraspinatus muscle was also performed. In two cases, cerclage wires were added in order to improve the stability of the diaphyseal fracture (Figures 2A, 2B). Mean surgical time was 102 minutes.

After the surgery, the humerus was immobilised with an abduction brace orthosis for 3 weeks, after this period pendular, passive abduction and forward flexion exercises up
to 90 degrees were allowed. Active range of motion exercises were allowed after six weeks.

Patients were followed ambulatory after the surgery and clinical and radiological assessments were programmed at the 3rd, 6th, 12th weeks and eventually once a year. The standard assessment included the Constant Abbreviated Scale (5) (which skips the strength evaluation, with a maximum possible result of 75 points), patient's satisfaction level and presence of pain in daily activities.

Results

The three patients were reviewed with a mean follow-up of 3.6 years (range, 1.8 to 4.2 years). There were no intraoperative or post-operative complications reported and any re-interventions of the patients were required. The mean time of consolidation was 3.8 months (range, 3 to 5 months).

All the patients were able to use their right dominant arm with none or mild pain, and had an acceptable range of motion with an average forward flexion of 122 degrees, 91 degrees of abduction, external rotation of 12 degrees, and internal rotation up to fifth lumbar vertebra (Figures 3A, 3B). The average score obtained with the Constant Abbreviated Scale was 48.7 points. In two patients tuberosities consolidated in anatomical position. In the third patient a migration of the major tuberosity occurred, however no functional manifestations of this radiological finding were reported during the follow-up.

All three patients showed a high or very-high level of satisfaction with the outcomes of the surgical intervention and they said that will be willing to undergo the same procedure in the event of suffering a similar fracture on the other arm.

Discussion

Bi-focal and multi-focal humeral fractures are an infrequent entity and are poorly described on medical literature, without existing defined criteria for its classification or treatment. Broadbent et al., carried-out an epidemiological study through a period of 8 years. During this period, only 7 cases of bi-focal humeral fractures were reported in a series of 13,560 patients with an upper limb fracture (2). Within

| Case 1 | 68 | F | 3 part | 12-A1 | 13 x 150mm 36mm | 3.5 months | anatomic | 48 |
| Case 2 | 74 | F | 3 part | 12-B3 | 15 x 150mm 36mm | 3 months | migration | 52 |
| Case 3 | 78 | F | 4 part | 12-A2 | 13x210mm 36mm | 5 months | reabsorption | 46 |

Figures 3A, 3B. 1 year follow-up of one of the patients showing anterior flexion and abduction functional outcomes.
these 7 patients, only four of them had fractures affecting proximal humerus and ipsilateral humeral shaft concomitantly.

Differently from multi-focal lower-limb fractures, which maximum incidence is found associated with high-energy trauma in middle-aged male patients (6), the majority of the multi-focal humeral fractures are found associated with falls from standing height in middle-aged female patients (2,7). These findings correspond with the presentation form in the patients of our study, three women aged between 68 and 78 years old.

In our series we used Neer’s (3) and AO classifications (4) in an independent way in order to classify proximal humerus fractures and humeral shaft fractures respectively. These classifications were used not only because they are widely found in literature but also, specially in the case of Neer’s classification for having a prognostic value and being of aid in order to assess the treatment (8,9). Maresca et al. proposed a new classification system for multi-focal humeral fractures (1) classifying as type A those affecting proximal humerus and humeral shaft, type B those affecting exclusively humeral shaft; and type C those diaphyseal fractures associated with distal humerus fractures.

There are few reports of concomitant ipsilateral proximal humerus and shaft fractures treated with prosthetic replacement (7,10,11). Unlike our series, in all these studies patients were treated using proximal humerus hemiarthroplasty with ORIF of the diaphyseal humeral fracture. Chun et al. reported two cases of ipsilateral proximal humerus fracture dislocation and shaft fracture in young adults treated with hemiarthroplasty and dynamic compression plate (10). The authors used a thin humeral stem allowing screw fixation around the stem. In contrast, Ando et al. reported one case of ipsilateral comminuted humeral neck fracture and concomitant humeral shaft fracture in an 85-years-old woman, treated with hemiarthroplasty and locking compression plate with a cable-plating system and periprosthetic screws (7). They obtained acceptable functional results and proposed that in elderly osteoporotic patient, a thickest humeral stem prosthesis should be used in order to obtain adequate initial fixation and prevent prosthesis loosening. Pater et al. reported a case of unrecognized posterior shoulder dislocation and nonunion of a humeral shaft fracture treated with long-stemmed cemented hemiarthroplasty and fixation of the humeral shaft with structural strut allograft bone by means of a cable-plating technique (11).

In general terms, hemiarthroplasty grants a complete or almost complete recovery from pain in 60% to 90% of patients which undergo surgery due to an acute fracture. However, the recovery of range of motion and strength is less predictable given its dependence, in a great extent, to an anatomical consolidation of tuberosities (12, 13). In the only published study that evaluates the long-term outcomes of hemiarthroplasty for the treatment of acute humeral fractures Antuña et al. reviewed 57 patients with an average follow-up of 10.3 years reporting that 53% of patients were unsatisfied due to pain or limited range of motion. The main factor accounting with poor functional outcomes was nonunion or reabsorption of the tuberosities.

In our series, all patients were treated using RSA associated in two cases with cerclage wires for the humeral shaft. The main advantage found on RSA over the hemiarthroplasty in the treatment of fractures is given by its design, that allows the abduction of the arm in absence of a functional rotator cuff (15,16). Therefore, restitution of active elevation in patients treated with RSA will not be influenced by the anatomical or non-anatomical consolidation of humeral tuberosities. Villodre et al. in a study conducted at our department, including 30 patients with a mean age of 74.9 years old, treated with RSA due to proximal humerus fractures, found no statistically significant differences between Constant, QuickDASH and articular range of motion depending on humeral tuberosities consolidation (17). Mata-Fink et al. performed a systematic review comparing 377 patients treated with RSA and 504 patients treated with hemiarthroplasty. The group of patients that were treated with the RSA reached a higher active forward flexion and also performed better in functional assessment tests (18). For these reasons we think that RSA should be considered in those patients that suffered a bi-focal humeral fracture (affecting proximal humerus and humeral shaft) that present risk factors that could threaten the results of the treatment with osteosynthesis or hemiarthroplasty: four-fragment fractures that could not be reconstructed, high risk of osteonecrosis, severe osteoporosis, comminution of tuberosities or previous dysfunction of the rotator cuff. Moreover, the use of long stems for the fixation of bi-focal fractures allows the stabilization of the diaphyseal fracture acting as an intramedullary nailing system and decreases dissection and bone exposure beyond the fracture, reducing the risk of neurovascular iatrogenic lesions as radial nerve palsy.

Nevertheless, all that glitters is not gold. On one side, the complication rate of RSA in the treatment of proximal humerus fractures ranges between 5% and 40% according to literature (19). On the other side, its survival time is being questioned; according to a study published including 36 patients treated with RSA due to proximal humerus fracture with an average follow-up of 6.6 years, Cazeneuve et al. observed that the functional outcomes declined through the time and up to 63% of patients presented radiological signs.
of loosening of the glenoid component (20). For both reasons, RSA should be considered to be used only in patients above 65-70 years old or in those cases on which no other treatment option could be found.

**Conclusion**

We consider long stemmed RSA is a convenient option in those patients over 65 years-old that suffered a bi-focal humeral fracture (affecting proximal humerus and humeral shaft) that present risk factors that could threaten the results of the treatment with osteosynthesis or hemiarthroplasty. Due to the fact that available literature regarding the use of RSA is limited to series of cases, we consider that more studies including larger number of patients and longer follow-up times are required in order to establish the potential uses of the RSA.

**References**


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The authors certify that they have no affiliations with or involvement in any organisation or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

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