REVIEW ARTICLE

Shoulder hemiarthroplasty: review of basic concepts

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The aim of this publication is to offer a complete, easy-to-understand and comprehensive overview on shoulder hemiarthroplasty focusing on the different design types, prosthetic generations, fixation techniques, indications and results.
Nowadays, shoulder hemiarthroplasty has led to satisfactory, reproducible and lasting results in addressing conditions like glenohumeral arthritis, avascular necrosis and rheumatoid arthritis. In rotator cuff pathology and in proximal humeral fractures and their sequelae, results have been less predictable. Reproducing the patient's anatomy, improving stem fixation techniques and the size and orientation characteristics of the head component and preserving the tuberosities and the rotator cuff are essential for a good clinical outcome. Resurfacing could be a valid and more bone-preserving option. The advantages of bipolar arthroplasty are still to be demonstrated.

Key words: *hemiarthroplasty, shoulder, glenohumeral arthritis, shoulder prosthesis.*

Prótesis parcial de hombro: revisión de conceptos básicos

El objetivo de este trabajo es ofrecer una visión clara, completa y asequible sobre la artroplastia parcial de hombro, revisando los tipos de diseño y generaciones protésicas, técnicas de fijación, indicaciones y resultados.
Actualmente, la artroplastia parcial de hombro ha demostrado resultados satisfactorios, reproducibles y duraderos en la resolución de cuadros clínicos como la artrosis glenohumeral, la necrosis avascular y la artritis reumatoide. En patología del manguito rotador y fracturas de húmero proximal y sus secuelas, los resultados son menos reproducibles. La imitación de la anatomía, la mejora en técnicas de fijación de vástagos, las características del tamaño y orientación del segmento cefálico, y la preservación de las tuberosidades y el manguito rotador son fundamentales para la obtención de buenos resultados clínicos. La prótesis de superficialización puede ser una opción válida y más conservadora. La artroplastia bipolar todavía debe demostrar sus ventajas teóricas.

Palabras clave: *artroplastia parcial, hombro, omartrosis, prótesis de hombro.*

INTRODUCTION

In the last few decades, important steps have been taken in the design of prosthetic components for partial shoulder arthroplasty. A more in-depth knowledge of the anatomy, gained through studies that harness the latest digital techniques, has made it possible to identify the main morphological features as well as inter-individual variability as regards the substituted structures, thus making more anatomical implants a reality. The possibility of selecting the orientation and size of the head components, using different stem fixation techniques, and implanting stem-free designs and nonanatomical prostheses make available to the surgeon a wide range of options to address the different indications of partial shoulder arthroplasty. As in other areas of orthopedics, in partial shoulder arthroplasty it is also necessary to take into account the basic design features of the prostheses and to be familiar with the main clinical studies that warrant their use, always remembering that manufacturing techniques tend to evolve faster than scientific-clinical knowledge.

This paper lays out the basic principles that lie behind the use of partial shoulder arthroplasty in different indications, outlining its advantages over total shoulder replacement.

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HISTORY AND DESIGN

Historical background1

The first partial shoulder prosthesis was implanted in Paris by the French surgeon Jules-Émiles Pean in 1893. The implant, made of rubber and platinum, had to be removed two years later further to a chronic infection. The second attempt was made by F. Koenig in 1914. This prosthesis was made of ivory. After this no further attempts were made until almost 40 years later.

Between 1951 and 1952 resin (Boron, Kevin, Judet) and vitallium (Krueger) prostheses were manufactured. At the same time, Charles S. Neer II developed the modern monoblock prosthesis, indicated for proximal humerus fractures. Both in Europe (Scales and Lettin in 1969, Reeves and Jobbins in 1971, Zippel in 1972, Kölbel in 1972 and Kessel in 1973) and in the United States (Neer and others), different shoulder prosthetic designs were developed. In those days, there was no great interest in this type of implant given the high rates of loosening detected (higher than 50%).

Hemiarthroplasty: prosthetic generations

Shoulder prostheses started to gain greater popularity when Dr. Neer started to used unconstrained designs. Neer believed that results would be better if the prostheses imitated the bone's natural anatomy, even if his own model only offered a limited range of sizes. Some centers still use the Mark II prosthesis, a model that Dr. Neer developed at the beginning of the 60's.

Second-generation implants were brought onto the market at the end of the 80's (the Biomet, Cofield and Global models). Their main feature was modularity and their goal was to recreate the different sizes of humeral Canals — but they came across two serious problems[1]. In the first place, the head was poorly placed both on the vertical and the horizontal plane. This was a result of the fixed geometry of implants; most of them were uncemented press-fit prostheses, which means that the position of the stem determined the final position of the head, leading to a shift in its center of rotation. In the second place, the head component tended to be oversized owing, on the one hand, to a discrepancy between the depth to which the prosthesis was implanted and the latter's diameter, and to de width of the gap remaining between the osteotomy and the prosthetic head.

In spite of their modularity, second generation prostheses still failed to recreate natural anatomy, leading to problems that had not occurred even with Neer's model[1]; particularly, oversizing the prosthetic head caused early glenoid erosion and increased tension at the joint, which could bring about rotator cuff rupture and anterior instability. Furthermore, upward displacement of the center of rotation provoked a change in the function of the infraspinatus and subscapularis muscles, which became adductor muscles and placed excessive load son the supraspinatus. On the other hand, excessive retroversion led to significant wear at the back of the glenoid, which caused considerable pain.

The first third generation prosthesis was designed by Boileau and Walch in France at the beginning of the 90's. This type of prosthesis is characterized by recreating the features and tridimensional measurements of the bone, studied by several authors on the basis of cadaver bone analyses conducted with computer-assisted tridimensional surface identification techniques[2-4]. Thus the development of the «anatomical reconstruction of the proximal humerus» concept, which lays specific emphasis on each patient's anatomical characteristics. Its main advantage is the possibility to adapt the prosthesis to different parameters reproducing the anatomical features of natural bone (fig. 1):

1) Posterior offset: the center of the joint surface is displaced posteriorly with respect to the axis of the shaft.

2) Medial offset: the center of the joint surface is displaced medially with respect to the axis of the shaft.

3) Variability in the orientation of the joint surface on the horizontal (retroversion between 9 and 30° - average 20°) and vertical (angle formed by the axis of the humeral shaft and the orientation axis of the joint surface, also known as the inclination angle, which ranges between 123 and 135° - average 130°) planes.

Hemiarthroplasty: stem fixation

Most prosthetic designs offer a cemented and an uncemented version. Cemented fixation is related to a lower incidence of radiolucent lines between bone and cement[5,6];

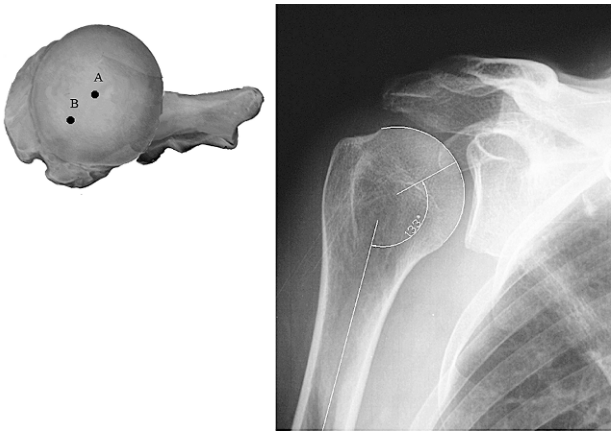

Figure 1. *(A) Superior view of the proximal humerus, where point A represents the center of the joint surface and point B represents the projection of the axis of the humeral shaft. Note that the center of the joint surface is placed posteriorly (posterior offset) and medially (medial offset) to the axis of the shaft. Note that the joint surface is oriented posteriorly with respect to the interepicondylar axis (retroversion). (B) Anteroposterior x-ray that shows the head-shaft inclination angle which, in this case, is 133°*

this rate is even lower in partial prostheses than in total ones[5]. However, revision of cemented humeral components is technically very hard, being associated with a considerable risk of diaphyseal fracture during extraction given the fact that the cortex is rather thin in this anatomical region.

There are three ways of fixating uncemented stems: diaphyseal press-fit fixation[6], metaphyseal press-fit fixation[7] and the use of porous prostheses to favor bone incorporation and facilitate stem fixation[8]. The progressive development of radiolucent lines in uncemented stems has not as yet been shown to have any clinical significance, although follow-up of the series is still short and revision of these kinds of components is technically simpler. Following the criteria developed by the Mayo Clinic, the stem is considered to be at risk of coming loose when a 2 mm-wide radiolucent line is observed in 3 or more of 8 zones, or if subsidence or inclination of the stem is identified in consecutive x-ray series by at least 2 of 3 observers. On the basis of these criteria, table 1 shows the radiographic analysis of different kinds of component fixation[5,6,8].

As regards metaphyseal press-fit fixation, Matsen et al[7] carried out a prospective study of 127 patients followed up for a mean of 3 years during which the appearance of radiolucent lines was evaluated. They found that 50 prostheses showed no sign of loosening, 2 had radiolucent lines in the metaphyseal area and 75 had them at the tip of the implant. Only 11 cases showed radiolucencies that were over 11 mm wide. This study included both partial and total prostheses, although no differences were found between the 2 groups.

The current trend is to use uncemented porous metaphyseally fixated designs, with cemented fixation being reserved for cases with poor bone quality.

Resurfacing prostheses

These prostheses were designed for patients with avascular necrosis, osteoarthritis and rheumatoid arthritis[1], although they have also been used for other indications[9].

Their advantages are the preservation of bone stock, the straightforwardness of revision surgery, the removal of all stress risers and the lower risk of periprosthetic fractures. Moreover, this type of implant makes it possible to accurately recreate the natural anatomy as far as offset[10], retroversion and inclination angle are concerned[1].

The implant that surgeons have most experience with, and the one with the longest follow-up, is the one designed by Copeland, which is on its third generation. It comprises a particular shell with a small stabilizing cylinder. The clinical results that can be expected with this type of implant are similar to those of stem-based arthroplasty, with a reoperation rate of 8% for the Mark-29 type prosthesis. Currently, the new Mark-3 designs include a hydroxyapatite coat on the internal aspect of the shell and a stabilizing cylinder.

Bipolar prostheses

The theoretical advantages of this design are as follows:

1) Glenoid wear is reduced since the design has two bearing surfaces instead of one (although the greater head diameter could also promote wear). This has not yet been demonstrated by a comparative clinical study.

2) There is a mechanical improvement in shoulder function. The greater size of the head would in theory provide the deltoid muscle with a greater lever arm, laterally displacing the center of rotation of the implant (although this benefit could be overshadowed by the potential detrimental effects related to the enlargement of the prosthetic head that were mentioned above). Two studies set about finding out whether movement between the two head components still occurs with the passage of time. One of these studies analyzed 11 prostheses with a minimum of 2 years' follow-up and concluded that the movement occurs basically at the level of the scapulo-thoracic joint, with the prosthesis behaving almost as a monopolar implant[11]. The other study assessed 25 shoulders in patients with rheumatoid arthritis treated by means of a partial bipolar replacement. Initially, the authors found no differences between mobility inside and outside the implant, but in 12 patients that were evaluated 3 years post-op it was observed that mobility inside the implant was far common, with some of these patients showing a pattern of paradoxical movement that was independent of the mobility between the outer head and the glenoid. As regards the clinical results, the authors report that mobility was maintained 8 years postoperatively[12].

INDICATIONS AND RESULTS

Partial shoulder arthroplasty is currently used to treat avascular necrosis, osteoarthritis and rheumatoid arthritis with good and reproducible results[1,13-16]. Nevertheless, in the case of complex proximal humerus fracture reconstruction,

Table 1. Percentage of prostheses at risk of becoming loose, following the Mayo Clinic criteria. The different types of fixation are considered

Author, year	Implant	Fixation	N/follow-up	% at risk
Sánchez Sotelo, 2001	Neer II Total Shoulder	Diaphyseal press-fit	72/4.1 years	55,6
Sánchez Sotelo, 2001	Neer II Total Shoulder	Cemented	43/6.6 years	2
Sperling, 2000	Total shoulder	Porous	62/4.6 years	10

Table 2. Results obtained with a partial shoulder prosthesis in various indications

Diagnosis	Author	Sample	Pain relief (patient %))	Active elevation (degrees)	Follow-up (months)
Sequela of fracture	Tanner	28	89	112	38
	Boileau	71	81	102	19
	Mansat	20	85	107	47
	Antuña	25	84	88	72
	Antuña	50	78	102	108
Acute fracture	Hawkins	20	90	72	40
	Goldman	22	73	107	30
	Zyto	27	66	70	39
	Boileau	66	87	101	27
	Kralinger	167	79	ND	29
	Robinson	138	75	ND	75
	Miguell	72	93	128	36
	Antuña	57	84	100	123
Bone necrosis	Hattrup	52	77	126	107
	Parsch	13	70	ND	30
	Mansat	14	95	107	84
	Rutherford	11	88	161	48
Osteoarthritis	Neer	28	100	ND	ND
	Zuckerman	36	83	132	39
	Levine	10	76	139	29
Reumathoid arthritis	Zuckerman	36	89	106	39
	Koorevaar	19	63	65	ND
	Trail	65	ND	79	58
	Collins	36	ND	89	39
Cuff arthropathy	Arntz	18	83	112	33
	Field	16	81	108	39
	Zuckerman	15	87	86	28
	Sánchez-Sotelo	33	73	91	60

Pain relief is shown as a percentage of patients that reported significant relief of pre-op pain. NA: not available.

results have been less predictable[1,17-19]; although more often than not adequate pain relief is achieved, most patients end up with limited range of motion and difficulties to carry out their activities of daily living. These poor results have led to the development of specific implants to address these problems: specific prostheses for fractures and a semiconstrained reverse prosthesis for cuff arthropaty[1]. Table 2 shows a summary of the results obtained by unconstrained partial prostheses in several indications[20,21].

Hemiarthroplasty in primary glenohumeral arthritis

Primary glenohumeral arthritis was the most usual diagnosis in patients subjected to shoulder arthroplasty at the Mayo Clinic in the 90's[22].

As is the case in other locations, the indication of performing an arthroplasty in cases diagnosed with shoulder arthritis is based upon the intensity of the pain and the decrease in function and life quality brought about by the condition, after less aggressive therapy has failed.

Clinical series with reproducible good and excellent results are myriad[22], with the debate currently focusing on preoperative poor prognostic factors and the need (or lack thereof) of replacing the glenoid surface[23].

Gartsman et al[24] report an ASES (American Shoulder and Elbow Surgeons) score[25] after hemiarthroplasty of 62 over 100 points, with clear improvements in terms of pain relief and function. Norris et al[13] performed 43 hemiarthroplasties for this indication and reported dramatic changes in pain relief, function and patient satisfaction, with intraoperative complications having an incidence of 5.4% and postoperative ones of 7.8%. The most common intraoperative complication was fracture and the most common postoperative one implant subluxation.

Preoperative prognostic factures were described by Iannotti et al[23] further to a multi-center study including 128 cases of both total shoulder hemiarthroplasty and arthroplasty. Patients with less than 10° passive external rotation before surgery experienced only a slight improvement in this parameter alter arthroplasty. The presence of full-thickness rotator cuff tears did not influence results on the ASES score[25] in terms of pain relief or patient satisfaction, regardless of the type of prosthetic replacement employed. Patients that presented with eccentric glenoid erosion obtained better results with total arthroplasty than with hemiarthroplasty, with better passive elevation and active external rotation, and also tended to show improved levels of shoulder flexion. Patients who presented with an initial posterior sub-

luxation had lower ASES scores, more pain and showed a reduction in active external rotation, regardless of the type of surgery performed.

A previous study had been conducted on the influence of a massive irreparable rotator cuff tear on 33 hemiarthroplasties with a mean follow-up of 5 years, with satisfactory results in 67% of patients, mean elevation improving from 71° to 91°. However, 27% of the subjects had moderate pain and 20% showed anterosuperior instability, significantly related to the fact that an acromioplasty had been carried out previously[26].

Most current studies focus on the debate of whether the glenoid articular surface should be replaced or not. Bryant et al[27] recently Publisher a systematic review of the literature and a metaanalysis on the subject, which included 112 patients, They came to the conclusion that total shoulder arthroplasty achieved better short-term results than hemiarthroplasty as regards function and elevation, and saw that outcomes were also more encouraging in terms of pain relief. It remains to be seen whether these results can be maintained over time, taking into account the risk of glenoid erosion in hemiarthroplasty and glenoid component loosening in total arthroplasty. Edwards et al[28] evaluated 601 total arthroplasties and 89 hemiarthroplasties in a multi-center study with a minimum 2-year follow-up. A the end of follow-up, mean elevation in hemiarthroplasties was 130°, active external rotation 36° and the age-adjusted Constant score 86%. For total replacements, results were 145°, 42° and 96%, respectively, with significant differences in all parameters. 56% of glenoid components had radiolucent lines at the end of follow-up.

Hemiarthroplasty in inflammatory arthritis

In cases of inflammatory arthritis, shoulder hemiarthroplasty can relieve pain and reproducibly improve function and mobility. The main problem facing the surgeon in these cases is the difficulties related to the soft tissues and the significant degree of bone loss usually present[29]: Thus, preoperative planning becomes particularly important in these cases.

As regards the type of implant to be used, Collins et al[16] carried out a prospective multi-center study in 2004 where they analyzed the results obtained with 36 partial and 25 total prostheses. After a mean follow-up of 39 months, they found that with both prosthetic types surgery significantly improved scores on both the visual analog scale and the Simple Shoulder Test[30]. Nonetheless, active mobility was significantly better in total than in partial prostheses. The presence of an extremely serious disease did not influence the postoperative outcome. Adaptation of the prosthesis to the patients' anatomy and the restoration of glenohumeral alignment tended to lead to better results in terms of mobility, quality of life and use of the shoulder for occupational and leisure activities. In 4 cases of hemiarthroplasty glenoid erosion was found. The glenoid component came loose in 2 total arthroplasties.

Stem fixation was assessed in a prospective randomized study[31] that compared diaphyseal press-fit fixation with fixation by means of pressurized cement and distal sealing after lavage of the canal in 26 shoulders afflicted with rheumatoid arthritis. Alter 2 years' follow-up, no differences were found between the 2 types of fixation for this indication.

Hemiarthroplasty in bone necrosis

Necrosis of the humeral head usually occurs further to the use of corticoids or as a sequela of a fracture caused either by a direct vascular lesion from the fracture itself or by a iatrogenic intraoperative lesion[32]. In other cases it may be idiopathic or caused by less common conditions such as Gaucher's disease, sickle cell anemia or bone necrosis induced by radiation therapy. The need to carry out an arthroplasty will be determined by the extent and stage of disease and its etiology, traumatic necrosis being the condition that most frequently requires a surgical procedure[33] (fig. 2).

In general, better results are obtained at early stages, when pain is moderate and the range of motion preserved[14]. When the disease is not yet at an advanced stage, it tends to affect only the humeral head and does not in theory involve the glenoid surface. In these cases it would seem that total arthroplasty would not seem necessary and that replacement of just the humeral head would be sufficient. To answer this question, Hattrup and Cofield[34] carried out a study that included 127 cases treated with 71 hemiarthroplasties and 56 total prostheses, with a mean follow-up of 9 years for the 88 cases that completed the follow-up. 79% of patients reported a subjective improvement, and 77% reported either absence or occasional presence of pain. Mean ASES store was 63 points. No differences were found between partial and total arthroplasty for the parameters studied. The most important prognostic factor was the post-traumatic origin of bone necrosis, which led to poorer results in terms of mobility and the ASES score. The most usual postoperative complication was a rotator cuff tear, which occurred in 18% of cases. This was more frequent when patients had been subjected to some previous surgery.

HHemiarthroplasty in proximal humerus fractures

In acute fractures, prosthetic replacement of the humeral head is reserved for elderly patients with poor bone quality, for fractures where fixation or head preservation are very difficult and for cases in which there is a high risk of necrosis (fig. 3). In general, arthroplasty should be avoided in patients under 60 years of age[35].

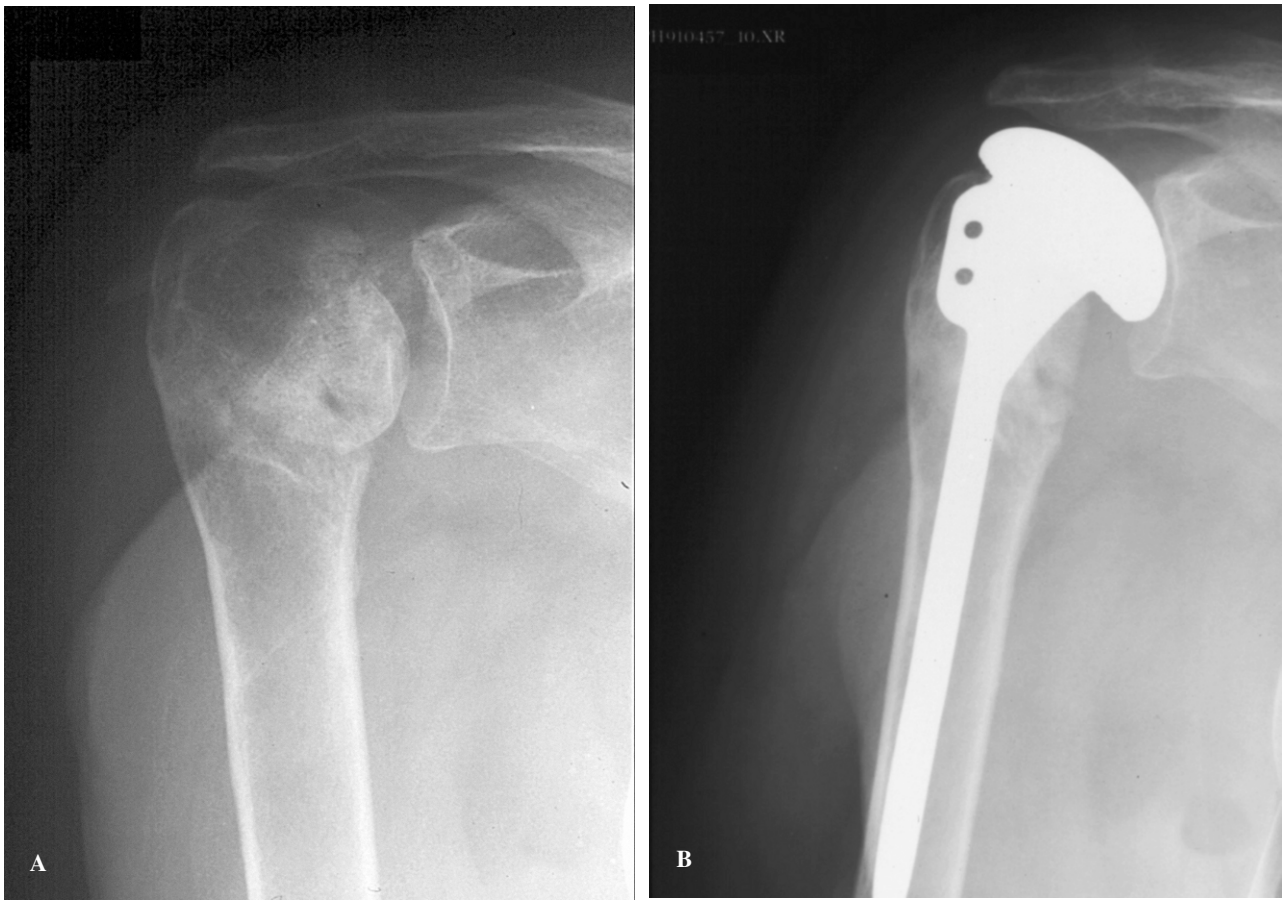

Figure 2. *(A) Avascular humeral head necrosis; note the increased density of the head segment and the collapse of the articular surface. (B) Radiological result further to the implantation of an uncemented unconstrained prosthesis, with satisfactory clinical results.*

The main indications for shoulder replacement in cases of acute fracture are as follows[35,36]:

1) Fractures believed to be associated with a high risk of avascular humeral head necrosis, i.e. those that isolate the articular surface from the tuberosities thereby restricting its blood supply (for example, fractures and Neer 4-fragment fracture-dislocations, anatomical neck fractures). In this connection, the integrity of the medial periosteal hinge between head and shaft, and the greater extension of the posteromedial metaphyseal segment joined to the articular surface have been suggested as protective factors against head segment ischemia[37].

2) Fractures involving the articular surface, such as head-splitting fractures, or fractures secondary to the impaction of the articular surface where destruction is usually greater than 40%.

3) Displaced fractures which, given their significant comminution or poor bone quality, are very hard to fixate, and where conservative treatment does not seem appropriate.

When there is no compromise of the glenoid articular surface, a partial prosthesis is to be employed. These prostheses vary in terms of their design rationale. As far as the surgical technique is concerned, a stable and lasting reduction of the greater tuberosity is fundamental to achieve an appropriate functional outcome[18], healing disruptions of the greater tuberosity being the most frequent complication[19].

Some of the designs available (for example, the fracture-specific prosthesis designed by Pascal Boileau) allow the possibility to apply a bone graft to the tuberosity bed in the metaphyseal region of the prosthesis. Others, such as the new design by Popp Gerber, involve the use of a large metaphyseal module with a porous surface on which the tuberosity can be anchored with sutures through the prosthesis in an attempt to facilitate coalescence between the prosthesis and the greater tuberosity. In this connection, a very recent study[38] compared anatomical prostheses with fracture-specific ones and, in spite of finding a higher rate of complete healing of the greater tuberosity in fracture-specific prostheses, similar rates of incomplete healing in anatomical prostheses and similar degrees of resorption (around 45%) of the greater tuberosity in both, did not find differences in terms of the Constant score or patient satisfaction, which calls into question the alleged clinical advantages of the specific designs for this indication.

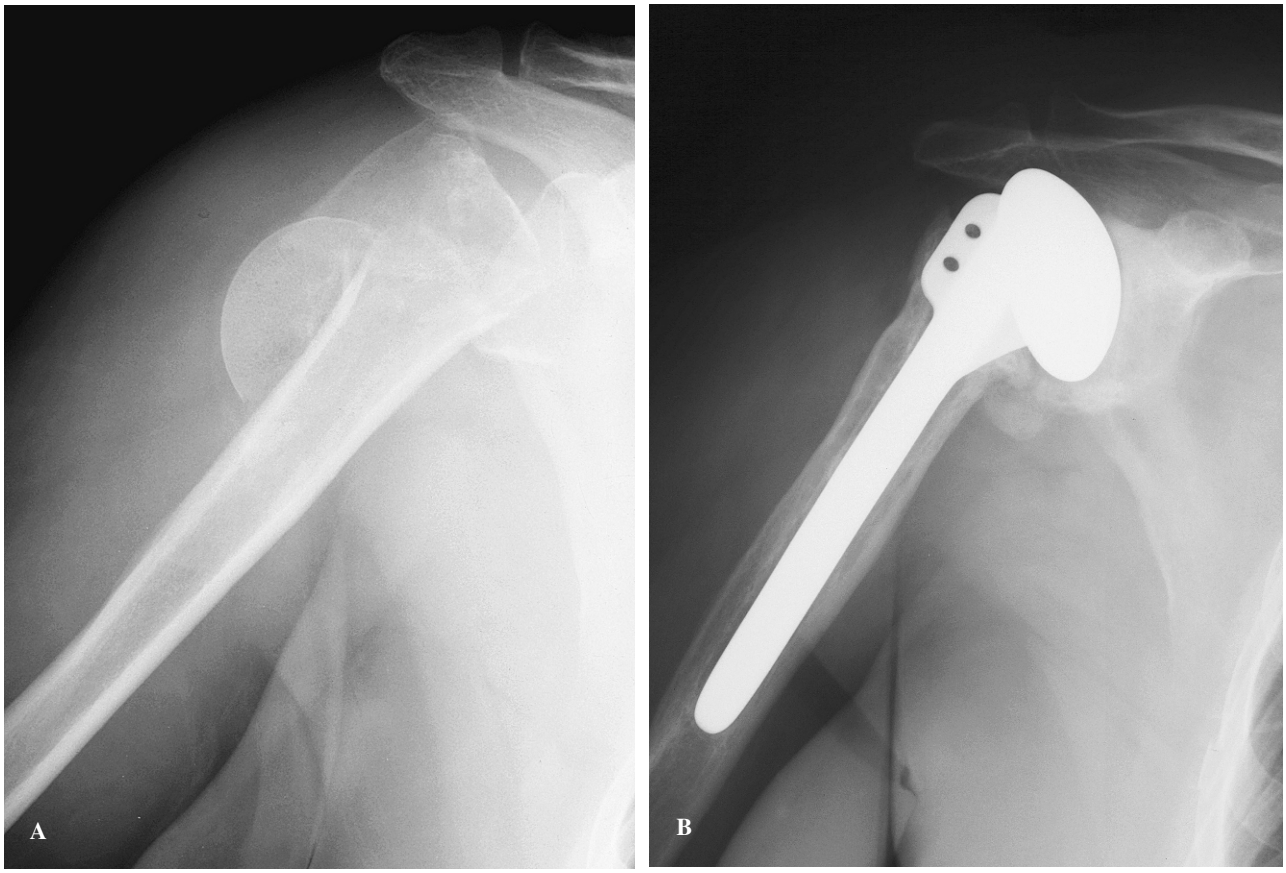

Figure 3. *(A) Four-fragment proximal humerus fracture with significant displacement of the articular segment, which appears turned over and placed lateral to the shaft. (B) Resolution of the case by means of a cemented unconstrained partial shoulder arthroplasty. X-ray performed five years into follow-up showing glenoid osteoarthritis with a reduction in the articular space and osteophytes in the lower region.*

Reverse designs are currently being used for cases in which an adequate reduction of the tuberosities is not feasible in order to counteract the ineffectiveness of the rotator cuff[39].

Other important points as regards implant selection and placement are: the head has to be of the same size or smaller than the natural one; retroversion must not exceed 20° in order to reduce tension on the sutures of the greater tuberosity; and appropriate height of the prostheses must be ensured. This last goal could be difficult to achieve given the disappearance of bone landmarks caused by the fracture. A useful reference is that in 95% of cases the tip of the greater tuberosity is 5.5 ± 0.5 cm away from the upper edge of the pectoralis major tendon[40].

Long-term follow-up studies have shown a general survivorship rate of partial prostheses in this indication of up to 94% at 10 years[18]. Results regarding pain relief are fairly satisfactory and reproducible. However, this is not the case for functional ability, for which results are unpredictable[18]. In a study, Stableforth[41] includes a retrospective historical series of 32 four-fragment fractures treated conservatively and a prospective series of 49 patients, of whom 32 had displaced 4-fragment fractures, half of them treated with hemiarthroplasty and the other half conservatively; he found better results in terms of pain relief and function in the hemiarthroplasty group. Bosch et al[42] evaluated 39 three and 4-fragment fractures treated with hemiarthroplasty and stated that this procedure affords better results when it is performed early, i.e. within 4 weeks. The best results are seen in younger patients, with no preoperative neurological problems and with a satisfactory x-ray after 6 weeks' follow-up.

Hemiarthroplasty to address sequelae of proximal humerus fractures

As regards the treatment of the sequelae of proximal humerus fractures (fig. 4), Antuña et al[43] obtained satisfactory results in terms of pain relief, but nearly 50% of poor global results according to Neer's scale as modified by Cofield for the treatment of pseudoarthrosis using different models of partial and total arthroplasty (mean follow-up: 9 years). The same authors[44] published a study where 50 cases of malunion were treated with hemiarthroplasty. They found that the patients who experienced most severe pain at the

end of follow-up (9 years on average) were those that had been subjected to previous surgeries, had bone necrosis, or were operated less than two years further to sustaining the fracture. Overall, 50% of patients had unsatisfactory results.

In a very recent paper, Boileau et al[45] provided the validation of their classification as well as a proposal for the treatment of these sequelae based upon the analysis of the results obtained in 203 patients treated with adaptable unconstrained modular prostheses. Authors classify sequelae into 4 groups:

1) Type 1 sequelae are characterized by a collapse of the head segment or avascular necrosis.

2) Type 2 sequelae present with an inveterate dislocation or a fracture-dislocation.

3) Type 3 sequelae consist of a nonunion of the surgical neck. Since in these cases results tend to be poor with unconstrained prostheses, the literature recommends osteosynthesis with bone grafting when the head segment is well preserved, or the use of a low-profile prosthesis with grafting of the metaphyseal region to facilitate the healing of the tuberosities, in cases of glenohumeral arthritis o cavitary defects of the humeral head.

4) Type 4 sequelae correspond to malunions of the tuberosities, where results with unconstrained prosthesis have been poor. In these cases, the use of a reverse prosthesis is recommended.

In type 1 and 2 sequelae predictable satisfactory results are achieved with the use of unconstrained modular prostheses, with better outcomes with the use of total rather than partial prostheses. The author attributes the success of these implants to the fact that an osteotomy of the greater tuberosity is not necessary. In type 3 and 4 sequelae the need to perform an osteotomy of the greater tuberosity is related to the poor results obtained with modular unconstrained prostheses.

Hemiarthroplasty in rotator cuff pathologies

In this section, two clinical scenarios could be considered: the need to carry out an arthroplasty for different reasons, for example, osteoarthritis or rheumatoid arthritis in a patient with an irreparable rotator cuff injury, or final-stage rotator cuff degeneration, i.e. rotator cuff arthropathy[46] (fig. 5). Until recently, the treatment of choice for both condi-

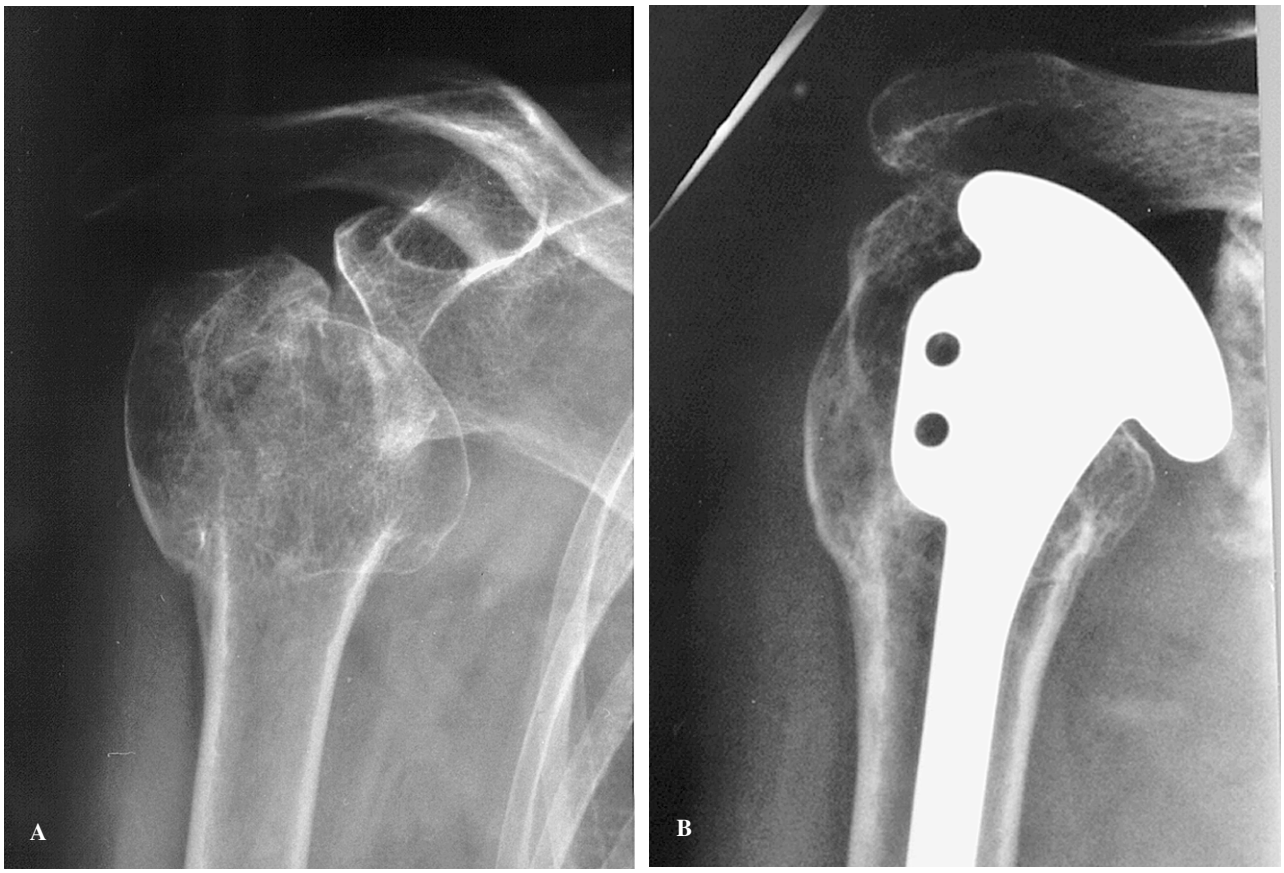

Figure 4. *(A) Malunion where the articular surface shows valgus deformity and a superimposed greater tuberosity. (B) Case resolved with an uncemented hemiarthroplasty. Note the preservation of the greater tuberosity in the follow-up radiograph.*

Figure 5. *Rotator cuff arthropathy in an elderly patient. Note the roundedness of the humeral head, which is subluxated superiorly resting on the acromion and forming a new «joint» at this location.*

tions was hemiarthroplasty with preservation of the coracoacromial arch, which leads to significant benefits in terms of pain relief, but to a slight improvement as regards mobility[17]. Zuckerman et al[47] published a retrospective study of 15 patients diagnosed with cuff arthropathy, with a mean follow-up of 28 months. Mean elevation went from 69° to 86°, and external rotation from 15° to 29°. 87% were satisfied with the results and pain levels decreased significantly in 95% of cases. In addition, an increase in strength was observed in the 6 cases in which this parameter was evaluated.

Given the poor functional results obtained in these pathologies, a different implant design is now being used, i.e. the reverse prosthesis. This design seems to improve results in terms of elevation, exceeding 100° according to different studies, but does not seem too effective in terms of increasing external or internal rotation[48]. On the other hand, survivorship curves for these implants, although satisfactory when the indication is cuff arthropathy, are generally rather discouraging since early implant loosening occurs at 3 years and function starts deteriorating at 6 years, with a Constant score of 58% at 10 years[49]. All of this means that these implants are recommended for patients over 70 years of age with low functional demands who have osteoarthritis and an irreparable cuff tear.

As can be noted, this problem remains a significant challenge with no clearly advantageous solution having been found as yet.

COMPLICATIONS OF SHOULDER HEMIARTHROPLASTY

The main complications associated with hemiarthroplasties are as follows:

1) Prosthesis loosening. This occurrence was discussed in the section on stem fixation options above.

2) Prosthesis migration. It occurs mainly in situations where there the soft tissues, particularly the rotator cuff, do not provide sufficient stabilization. In order to prevent migration, it has been suggested that the coraco-acromial arch should be left intact so that it can block superior migration[17].

3) Periprosthetic fractures[50,51]. These have an incidence between 0.5 and 3%. Most of them occur intraoperatively, involve the shaft and are often provoked by torsion forces. Risk factors are female sex, poor bone quality, old age and a history of rheumatoid arthritis. Existing classifications are based on the anatomical relation between fracture and stem: type A periprosthetic fractures occur at the tip of the stem and extend proximally; type B are circumscribed to the tip of the stem; and type C occur distally to the stem. In fractures that occur postoperatively, therapeutic decisions must be made considering the stability of the fracture and the stability of the implant; the achievement of early shoulder mobilization and the preservation of function should be the main priorities. Fractures considered stable can be treated conservatively. Unstable fractures with loose components require a prosthetic replacement with long stems that reach the inferior-most end of the fracture. Fixation with plates and locking screws in a therapeutic option for stable implants. Mean time to healing for these injuries can be of up to 280 days.

4) Instability of the arthroplasty[52]. The causes of instability are inadequate capsular tension, dysfunction or absence of the rotator cuff and component malpositioning. Surgery must attempt to resolve these problems. In the series published by Sánchez-Sotelo et al[52], which included 7 hemiarthroplasties and 26 total arthroplasties, stability was restored in only 9 cases. A second surgery only succeeded in stabilizing 5 additional cases. Anterior instability proved more refractory to treatment than posterior instability. According to Neer's classification as modified by Cofield, there were 4 excellent, 6 satisfactory and 23 unsatisfactory results (70%).

CONCLUSIONS

These are multiple designs and prosthetic generations for partial shoulder arthroplasty. Currently, the use of implants designed to imitate the natural anatomy, together with a suitable appropriate surgical technique and appropriate component selection, offers satisfactory and lasting results in indications such as osteoarthritis, rheumatoid arthritis and avascular necrosis. There are also specific designs for cuff pathology and proximal humerus fractures, although results are less reproducible.

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Conflict of interests

The authors have declared that they have no conflict of interests.