Stemless Humeral Prosthesis in Shoulder Arthroplasty: Systematic Review

Prótese Umeral Sem Haste em Artroplastia de Ombro: Revisão Sistemática

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ABSTRACT

Introduction: Stemless shoulder prostheses were introduced as a new shoulder replacement system designed to reduce the potential risks associated with the humeral component and achieve better functional results by lowering the surgical complication rates. This systematic review aims to assess the latest available published findings regarding stemless shoulder replacement.

Methods: A search in PubMed, Scopus, and Clarivate Web of Science databases was performed, selecting publications that reported the constant score for functional assessment in patients submitted to shoulder arthroplasty with a stemless prosthesis.

Results: Three types of shoulder arthroplasties were identified, with a constant score average between 63.4% and 73.3% and with a revision rate average between 2.8% and 3.4%. These results were similar among studies with different follow-up duration: 6 months to 9 years.

Conclusion: Shoulder arthroplasty with stemless prosthesis is very promising with favourable results in the short and medium-terms regarding improvement in the shoulder function, pain relief and patient satisfaction and low rates of complications.

Keywords: Arthroplasty, Replacement Shoulder; Shoulder Joint/surgery; Shoulder Prosthesis

RESUMO

Introdução: As próteses de ombro sem haste foram introduzidas como um novo sistema de substituição do ombro concebido para reduzir os potenciais riscos associados ao componente umeral e alcançar melhores resultados

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funcionais através da redução das taxas de complicações cirúrgicas. Esta revisão sistemática tem como objetivo avaliar os últimos resultados publicados sobre a substituição do ombro sem haste.
Métodos: Foi realizada uma pesquisa nas bases de dados PubMed, Scopus e Clarivate Web of Science, selecionando publicações que relatassem o *constant score* de avaliação funcional em pacientes submetidos à artroplastia de ombro com prótese *stemless*.
Resultados: Foram identificados três tipos de artroplastias de ombro, com uma média de *constant score* entre 63,4% e 73,3% e com uma média de taxa de revisão entre 2,8% e 3,4%. Estes resultados foram semelhantes entre estudos com diferentes durações de seguimento: 6 meses a 9 anos.
Conclusão: A artroplastia do ombro com prótese *stemless* é muito promissora com resultados favoráveis a curto e médio prazo no que respeita à melhoria da função do ombro, alívio da dor e satisfação do doente e baixas taxas de complicações.

Palavras-chave: Articulação do Ombro/cirurgia; Artroplastia do Ombro; Prótese do Ombro

INTRODUCTION

Shoulder replacement surgery was first described by Neer, in 1955.[1] Indications to this intervention have expanded over the last years, including not only proximal humerus fractures, but also osteoarthritis[2] and other painful conditions of the shoulder,[3,4] resulting in an exponential growth of shoulder arthroplasties performed around the world.[5]

Although the results of most arthroplasties are acceptable and predictable, many factors should be evaluated, including the primary indication, reports of previous surgeries, soft tissue stiffness, rotator cuff status, preoperative range of motion, and post-surgery rehabilitation program compliance.[3,6,7]

Problems related to the humeral stem in shoulder replacements are not uncommon,[8-12] and range from intraoperative humeral fractures during preparation and introduction of the stems to loosening of the implant, mainly in elderly patients. The eventual need for stem removal in case of revision surgery is associated with considerable morbidity and bone loss, sometimes requiring the use of long massive stems.[4,13-16]

Stemless shoulder prosthesis was introduced as a modern replacement system, designed to reduce the risks associated with the implantation of a humeral stem while enabling an anatomic reconstruction of the humeral head independently of the shaft axis.[17,18] In fact, by being anchored on the metaphysis, its use may also preclude the need for an osteotomy of the greater tuberosity in the cases of post-traumatic deformities.[17]

This study aims to evaluate the population being submitted to shoulder arthroplasty, in particular the stemless prosthesis, while comparing both types in terms of function, bone stock, radiographical and revision results.

METHODS

A search was performed in November 2018, that followed the PRISMA guidelines[46] using the following queries for PubMed, Scopus and Clarivate Web of Science electronic databases, respectively: *shoulder AND ((“Arthroplasty, Replacement, Shoulder”[MeSH] OR arthroplasty* OR replacement) AND (stemless OR “short stem”))* and shoulder *AND* ((arthroplasty *OR* arthroplasties *OR* replacement) *AND* (stemless *OR* short *AND* stem)). All articles published from January 2010 to October 2018 were included.

In the selection process, all duplicates were discarded, and all titles and abstracts were read initially. Subsequently, the full texts of the selected articles were analyzed, and further data extraction was performed for analysis. The literature databases were probed independently by two authors who identified studies for inclusion based on title and abstract, according to the eligibility criteria. When a study could not be excluded on this basis or in case of disagreement, the full text was revised, and two independent reviewers discussed it until a consensus was attained.

A research paper was qualified for inclusion if it considered experimental settings aiming to evaluate functional results and complications of shoulder arthroplasty with stemless prosthesis or short stems. There are reports in the literature of a wide diversity of stemless. The stemless system is considered when a description of its advantages is presented. Techniques as hemiarthroplasty (HA), total shoulder arthroplasty (TSA) or reverse shoulder arthroplasty (RSA) were considered.

Review studies, non-shoulder arthroplasty, stemmed/long-stem prosthesis, previous shoulder arthroplasty or non-related studies were excluded. Non-English studies were

excluded. If articles did not mention the use of constant score, they were also excluded.[19]

The revision rate reflects the percentage of patients submitted to a secondary intervention after prosthesis insertion. When provided by the study authors, this information was used in the analysis; if not, it was assessed through the number of complications implying a further intervention after prosthesis insertion, regardless of the reason that justified surgery. In such cases, patients who refused secondary interventions, even though indicated, were not considered. Since the number of studies was limited, the statistical analysis was based on groupings of studies as described in the results. Sample sizes were not uniform, ranging between 9 and 149 patients, and most included less than one hundred surgical procedures. Also, the type of stemless prosthesis used was highly heterogeneous among regarding brands and specific designs, further complicating the study and requiring data sub analysis.

RESULTS

The database search resulted identified 360 articles. We excluded duplicates (n=169) and articles before January 2010 (n=24). With title and abstract screening, 125 articles were excluded, most of them because of references to stemmed/long-stem prosthesis. By full text review (n=42) articles without constant score (n=7), previous shoulder arthroplasty (n=3) and Non-English (n=1) were excluded. From the selection process, a final number of 31 articles were eligible for the analysis (Fig.1).

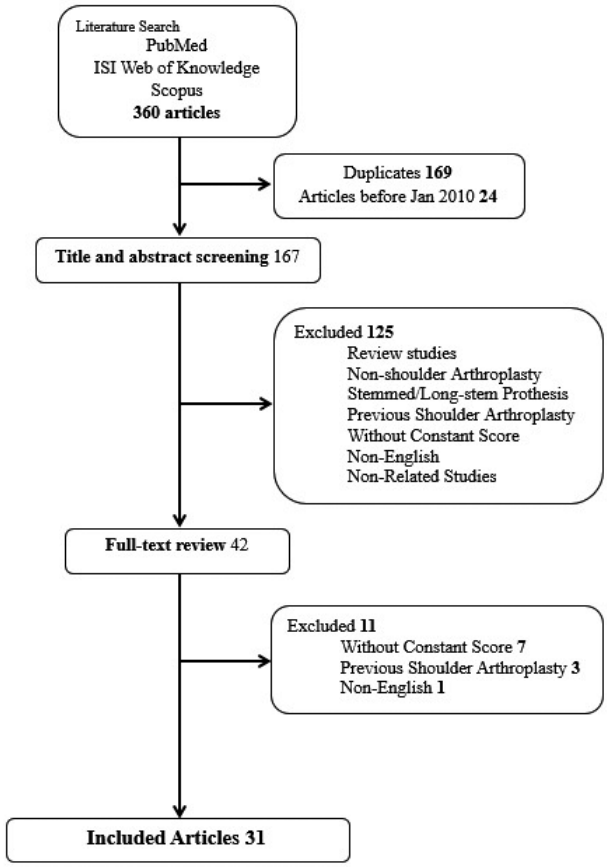

Figure 1. Flow diagram of the database search, exclusion, and inclusion of articles.

Data retrieved is summarised in Table 1.

Tabela 1. Characteristics of the studies included in the analysis, including descriptive analysis of complications reported in each article, including the cases assigned for revision procedures

AUTHOR	SAMPLE SIZE	IMPLANT	FOLLOW-UP (YEARS)	CONSTANT SCORE	REVISION RATE	STUDY DESIGN	COMPLICATION
HA							
Verstraelen *et al*, 2018[34]	33	Copeland Mark-III	7.2	56.4	3%	Retrospective multicenter cohort	Periprosthetic fracture (revision). Superior glenohumeral subluxation and progression of the glenoid erosion.
Krukenberg *et al*, 2018[28]	32	Sidus Stem-Free Shoulder System	2	59	0%	Prospective multicenter cohort	Intraoperative fracture. Temporary axillary nerve palsy. Temporary irritation of the plexus brachialis. Insufficiency of the pectoralis major. Deep vein thrombosis.
Davidson *et al*, 2018[8]	22	Hemi-CAP	5	82.1	3 (excluded from analysis)	Prospective cohort	Metastatic cancer to the humerus. Nerve and vascular traumatic injury. Ongoing and progressive pain. (all revised)
Hawi *et al*, 2017[17]	32	Eclipse	9	62	7%	Prospective cohort	Infection (revision). Rotator cuff deficiency (revision). Resorption of a greater tuberosity. Proximal humeral traumatic fracture.
Ballas *et al*, 2016[21]	10	Biomet TESS	3.6	55	3.7%	Retrospective case series study	Lysis under the humeral anatomic head. Rotator cuff failure (revision)

AUTHOR	SAMPLE SIZE	IMPLANT	FOLLOW-UP (YEARS)	CONSTANT SCORE	REVISION RATE	STUDY DESIGN	COMPLICATION
TSA							
Schnetzke *et al*, 2018[32]	67	Aequalis Ascend Monolithic	2.6 5.3	75.5 76.6	3%	Prospective cohort	Secondary rotator cuff insufficiency (revision). Aseptic loosening of the glenoid.
Krukenberg *et al*, 2018[28]	73	Sidus Stem-Free Shoulder System	2	74.7	0%	Retrospective case study	Intraoperative fracture. Temporary axillary nerve palsy. Temporary irritation of the plexus brachialis. Insufficiency of the pectoralis major. Deep vein thrombosis.
Beck *et al*, 2018[35]	31	Biomet TESS	8	68.8	9.7%	Retrospective case study	Secondary rotator cuff failure with displacement of the humeral head (revision). Slight superior displacement of the humeral component. Glenoid loosening with clinical symptoms. Traumatic periprosthetic fracture (revision).
Von Engelhardt *et al*, 2017[31]	21	Biomet TESS	1.5	75	9.5%	Prospective cohort	Posttraumatic humeral head necrosis (revision). Partial brachial plexus lesion. Cuff failure (revision).
Uschok *et al*,2017[18]	15 14	Eclipse	2 5	65.5 72.8	7,1%	Randomized Trial	Traumatic loosening of the glenoid component. Rotator cuff deficiency (revision).
Spranz *et al*, 2017[38]	12	Biomet TESS	4.3	67.9	Not reported	Restropective case study	Not reported
Hawi *et al*, 2017[17]	17	Eclipse	9	63	7%	Prospective cohort	Infection (revision). Rotator cuff deficiency (revision). Resorption of a greater tuberosity. Proximal humeral traumatic fracture.
Glanzmann *et al*, 2017[26]	37	Promos	2	70.6	2.3%	Retrospective case study	Subscapularis tear with decentering of the humeral head (revision)
Collin *et al*, 2017[23]	47	Simpliciti	3	69	4.3%	Prospective multicenter cohort	Residual pain and radiographic signs of periprosthetic osteolysis (revision). Massive anterosuperior tear of the rotator cuff with pseudoparalysis of the shoulder (revision).
Churchill *et al*, 2016[24]	149	Simpliciti	2	80.7	2%	Prospective multicenter cohort	Subscapularis failure. Infection. Glenoid loosening. (all revised)
Ballas *et al*, 2016[21]	17	Biomet TESS	3,6	64	3.7%	Retrospective case series study	Lysis under the humeral anatomic head. Rotator cuff failure (revision)
Schnetzke *et al*, 2015[37]	82	Aequalis Ascend	2.6	70.8	1.2%	Prospective multicenter	Secondary rotator cuff insufficiency. Posterior dislocation after falling over the operated shoulder (revision).
Maier *et al*, 2015[40]	12	Biomet TESS	0.5	48	0%	Randomized trial	
Habermeyer *et al*, 2015[13]	78	Eclipse	6.1	65	9%	Retrospective case series study	Rotator cuff tears. Loosening of the cementless metal backed glenoid component. Secondary glenoid wear. Infection. Proximal humeral fracture.
Mariotti *et al*, 2014[41]	9	Aequalis Ascend	2	88	0%	Randomized trial	Not reported
Bell *et al*, 2014[22]	38 12	Affinis	1 2	76.1 85.8	2.6%	Prospective cohort	Inadequate supraspinatus power and gross fatty atrophy of the supraspinatus muscle (revision). Acromioclavicular joint pain. Transient partial musculocutaneous nerve palsies. Olecranon bursitis. Skin reactions to the dressings
Berth *et al*, 2013[3]	41	Biomet TESS	2.5	54.7	0%	Randomized trial	Intraoperative fissure of the glenoid. Temporary incomplete brachial plexus neuropathy.

AUTHOR	SAMPLE SIZE	IMPLANT	FOLLOW-UP (YEARS)	CONSTANT SCORE	REVISION RATE	STUDY DESIGN	COMPLICATION
Jost *et al*, 2011[27]	49	Mini-stem humeral component	2.4	91	2%	Retrospective case series study	Acute postoperative subscapularis tendon rupture (revision). Nonfatal pulmonary embolism
Huguet *et al*, 2010[15]	63	Biomet TESS	3	75	1.6%	Retrospective case series study	Intraoperatively small crack. Large hematoma. Persistent stiffness (revision).
RSA							
Moroder *et al*, 2016[30]	24	Biomet TESS	2.9	65.4	8.3%	Prospective case control study	Traumatic dislocation (revision). Acromial spine fracture. Symptomatic mesacromion (revision). Slight post-operative stiffness
Levy *et al*, 2016[42]	98	Verso	4.1	59	6.1%	Retrospective case series study	Undisplaced intraoperative fracture of the humeral metaphysis. Cracked glenoid rim during preparation. Early dislocations (revision). Glenoid head disengaged from the baseplate (revision). Pathologic fracture of the acromion (revision). Late traumatic periprosthetic fractures (revision).
Von Engelhardt *et al*, 2015[43]	52	Biomet TESS	1.5	56.1	11.5%	Prospective case series study	Loosening of the glenoid component (revision). Infection (revision). Glenoid fracture (revision). Instability with luxation of the prosthesis (revision). Unstable and symptomatic os acromiale (revision). Incomplete lesion of the brachial plexus. Intraoperative malpositioning of the humeral and glenoid components.
Teissier *et al*, 2015[33]	91	Biomet TESS	3.4	68	1.1%	Prospective case series study	Recurrent dislocations (revision). Stress fracture of the spine of the scapula. Traumatic clavicle fracture
Atoun *et al*, 2014[25]	31	Verso	3	56.2	9.7%	Retrospective case series study	Intraoperative crack of the humeral metaphysis during bone graft impaction. Glenoid rim was cracked during preparation. Early dislocations (revison). Stress fracture of acromion. Late traumatic periprosthetic fractures after falls (revision).
Ballas *et al*, 2013[44]	56	Biomet TESS	4.9	62	7.1%	Prospective case series study	Intraoperative partial humeral metaphyseal crack. Superficial infection. Hematoma (revision). Rupture of the subscapularis. Stress fracture of the acromion. Lysis of the greater tuberosity. Dissociation of the glenoid components (revision). Displacement of the humeral corolla (revision).

Three types of shoulder arthroplasties were identified: HA (n=5), TSA (n=22), and RSA (n=8). In some studies, only a single type of shoulder arthroplasty was considered, whereas, in other studies, a combination of techniques was adopted.

The follow-up time ranged from 6 months to 9 years.

For functional assessment, articles reported a statistically significant improvement in the post-operative constant score. Studies with no data for constant score and Revision Rate were excluded from the quantitative analysis.

The minimal constant score found was 55 in a study with just 10 cases. The average was 63.4 (SD 20.2). TSA obtained a minimum constant score of 48 in a study with a sample size of 12 and 6 months of follow-up, a maximum of 91 and an average of 64.6 (SD 14.5). In RSA, the average of the constant score was 73.3 (SD 15.3), with a range between 56.1 and 71.0 in the most recent study. The results aggregation by follow-up (considering two timings, up to and after 3 years) are illustrated in Fig. 2. TSA shows a constant score slightly higher than the other techniques in the short- and medium-term, although this difference is not statistically significant (p>0.05).

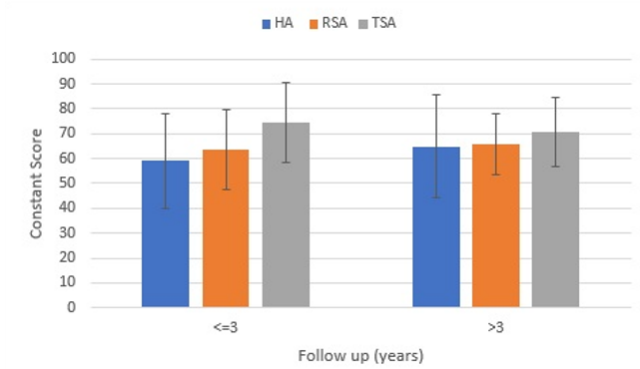

Figure 2. Results of constant score means of three arthroplasty techniques by short- and medium-term follow-up.

Concerning secondary interventions, the details were not fully disclosed by all the authors. Revision rate for HA ranged between 0% and 7%, with an average of 3.4%. Regarding TSA, it differed between 0% and 9.7%, with an average of 5.3%. This maximum value was obtained from a study with an 8-year follow-up and the minimum seems related to a short period of follow-up (about 2 years). Revision rate in RSA had an average of 2.8%, with a variation between 0% and 11.5%. Fig. 3 illustrates the revision rate distribution when short- and medium-term follow-up is considered. For all techniques, the proportion of patients that need another intervention after the first surgery did not appear to surpass the expectations before and after 3 years.

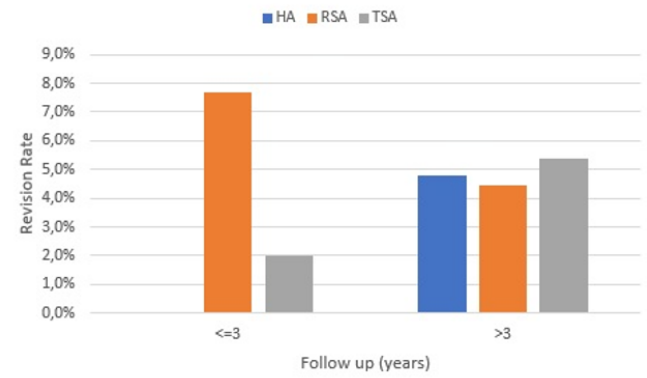

Figure 3. Results of revision rate means of three arthroplasty techniques by short- and medium-term follow-up.

Table 1 includes, when mentioned by the authors, the complications reported in each article, including the cases assigned for revision procedures.

DISCUSSION

This systematic review aims to evaluate and compare the most recent and available findings in the literature regarding stemless prosthesis systems used in shoulder arthroplasty.

Long-stem shoulder arthroplasty still remains the gold-standard with proven results in long-term follow-up, but with the progressive aging of the population and subsequent increase in the number of revisions, which are considered a challenge in the stemmed designs, regarding technical difficulties, bone loss, substantial weaker fixation of the revision implants, the stemless components are now being looked upon as a pre-emptive solution.

Stemless approaches are the new trend in shoulder arthroplasty with reports of satisfactory functional results, excellent bone fixation and absence of significant radiographic changes.[20] It provides a reconstruction of the proximal humerus anatomy, using a simpler surgical technique without the need of osteotomy of the major tuberosity in cases of severe deformity.[13,15,17,21]

Berth *et al* asserts that these modern systems combined with glenoid resurfacing provide significant pain relief with functional improvement, comparable to stemmed methods.[3]

In medium follow-ups, results have shown maintained stability of the shoulder function, which is similar to the stemmed systems.[13,18,21-32,33] Regarding a long-term follow-up, Hawi *et al* has shown optimal results using stemless implants in shoulder arthroplasties with a 9-year follow-up,[17] clinically comparable to the stemmed prosthesis of third and fourth generations.[34, 35]

Regarding various subtypes of shoulder arthroplasty (TSA, HA, or RSA), findings were similar to the stemmed approach. Patients that underwent stemless TSA have demonstrated clinical improvement, showing similar results to the traditional TSA methods.[15,26,36-41] Levy *et al* and von Engelhardt *et al* have concluded that RSA offers encouraging results with excellent pain relief and shoulder function, good range of motion, and patients' satisfaction.[42-44]

Concerns using stemless humeral components might include prosthesis misalignment and a slightly higher incidence of loosening when compared to the conventional implants. Szerlip *et al* described the appearance of radiolucent lines around the humeral component at 2 years follow-up 5.9% patients, but without evidence for loosening.[36]

Stemless prosthesis' most beneficial characteristic is the humeral fixation without the need of diaphyseal preparation, thus retaining bone stock and, potentially, better conditions in case of subsequent revision surgery. The theoretical benefits of stemless are, as summarized by Athwal: less surgical time, less blood loss, bone preservation, and lower risk

of intra-, and potentially, post-operatory peri-prosthetic fractures.[3,17,36,45]

Furthermore, revision surgery, if needed, is easier as stemless can be replaced by a primary stemmed prosthesis without an increase of complications.[13,15,21,23,26,34]

The incidence of intra-operatory humeral fractures in RSA, both primary and revision, is low. However, the risk is higher during the preparation and enlargement of the humeral canal to accommodate the stem. This potential complication is possibly averted by the stemless hardware, since there is no need to approach the humeral diaphysis.[4,42] There are some limitations to the use of stemless prosthesis in RSA surgeries, namely, patients with acute and comminuted fractures, or revision cases of a stemmed prosthesis. For these patients, a traditional prosthesis with a stem should be used.[42]

Levy *et al* reported that a good initial fixation was achieved regardless of osteoporosis or bone quality, together with an impacted technique with bone graft, reporting that consistent bone graft integration on the metaphysis involving the prosthesis was achieved within 3 weeks post-procedure.[42] In cases where the primary stability is not achieved, the stemmed prosthesis is always an intra-operative alternative.[3]

Regarding bone remodelling, related to the tension distribution around an arthroplasty, it has been mentioned that the shorter the stem, the greater the benefit on bone stock, considering proximal stress distribution in the bone-prosthesis interface.[18] Consequently, the use of stemless prosthesis can reduce the risk of stress shielding and peri-prosthetic fractures. Even in case of fracture, it will more likely occur in the metaphysis, which has better results with conservative treatment than those involving the lower levels of the humerus.[25, 42]

Complications were shown to be similar when comparing stemless to 3rd generation stemmed approaches.[13] Recent literature reviews for stemmed prosthesis report complications rates from 4.2% to 15.2%, which are similar to the results found for stemless.[31] Another study reported that stemless prosthesis had a significantly lower surgical time and blood loss when compared to stemmed ones, thus underlining more advantages of the approach.[3]

One of the main limitations of this systematic review is the diversity of the available studies. Sample sizes were less than one hundred cases in most articles, along with different methods regarding inclusion/exclusion criteria and further diversity of pathologies requiring surgery. Inability to follow-up cases justified some small sample sizes of the studies. Studies involving a larger sample size should be undertaken to strengthen the results mentioned above for short and medium follow-ups.

It ought to be considered a bias that some of the studies were done by the designer or co-developer of the implants. Conflicts of interest often arise. Although the concept of short stem with bone stock preservation is universal, the option for each system was not specified, and characteristics of the different brands might influence the result.

Additionally, the presence or not of a control group strongly conditions any comparison. When present and statistically analysed, there was wariness for having two similar groups. On the other hand, some articles were not using any control group or had used data from the literature, which does not allow estimation of any differences between the populations.

Reported complications were often scare and poorly described. Recognizing what is proposed, considered criteria for complications directly related to surgery or prosthesis, and what might have led to revision surgery are not completely clear for most of the works. The admitted comparisons are other studies and there is no consensus regarding expected incidence of complications or revision rates for each type of prosthesis or shoulder arthroplasty. Additional studies are necessary to determine expected rates of adverse outcomes in these shoulder arthroplasties.

CONCLUSION

It is possible to assert that shoulder arthroplasty with stemless prosthesis is very promising. Results in the short- or the medium-term demonstrated good functional results, with pain relief and satisfaction, along with low rates of complications. It is crucial to sustain the research in this field aiming to reinforce the recognized good outcomes and to predict the durability of these stemless prostheses.

Responsabilidades Éticas

Conflitos de Interesse: Os autores declaram não possuir conflitos de interesse.
Suporte Financeiro: O presente trabalho não foi suportado por nenhum subsidio o bolsa ou bolsa.
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Declaração de Contribuição

RS e GA: Responsável pelo conteúdo intelectual, conceção e desenho do estudo, interpretação dos dados e redação do artigo, recolha e análise dos dados e pela revisão crítica do conteúdo.
FF e MG: Responsável pela conceção e desenho do estudo, interpretação dos dados e pela revisão crítica do conteúdo.
AB: Gestão estatística.
Todos os autores aprovaram a versão final a ser publicada.

Contributorship Statement

RS and GA: Responsible for the intellectual content, conception and design of the study, interpretation of the data and writing of the article, collection and analysis of the data and critical revision of the content.
FF and MG: Responsible for the conception and design of the study, interpretation of the data and critical revision of the content.
AB: Statistical management.
All authors have approved the final version to be published.

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