



REVIEW ARTICLE

OPEN ACCESS

REVERSE TOTAL SHOULDER ARTHROPLASTY EFFICACY IN PROXIMAL HUMERAL FRACTURES TREATMENT: A SYSTEMATIC REVIEW

*¹Brauner de Souza Cavalcanti, ²Vinícius Gueiros Buenos Aires, ¹Francisco Cabral de Oliveira Neto, ¹Bruno Candido Monteiro Da Silva, ¹Raphael Burlamanqui de Queiroz and ³Epitácio leite Rolim Filho

¹Orthopedics fellow at Getúlio Vargas Hospital

²Medical Student at Federal University of Pernambuco

³Orthopedics teacher at Federal University of Pernambuco

ARTICLE INFO

Article History:

Received 14th February, 2019
Received in revised form
21st March, 2019
Accepted 19th April, 2019
Published online 30th May, 2019

Key Words:

Fractures; Proximal humerus;
Total reverse arthroplasty;
Treatment; Efficiency.

ABSTRACT

Introduction: Currently there are many controversies in several aspects of surgical management of proximal humeral fractures, such as the optimal surgical approach and the role of reverse shoulder arthroplasty. For all these reasons, the main objective of the present study is to evaluate, through a systematic review of, the role of reverse total shoulder arthroplasty (RTSA) in proximal humeral fractures. **Methods:** Two reviewers independently searched through the Pubmed, Medline and Embase databases for studies published up to August 22, 2018. The following descriptors were used: "reverse total shoulder arthroplasty"; "total shoulder prostheses"; "fractures"; "fracture of the proximal humerus." Treatment"; "Efficacy". The following filters were used to arrive at the expected final result: "Clinical Trial"; "Randomized Controlled Trial," "Randomized Clinical Trial," "Meta-Analysis," "Systematic Reviews." **Results:** There was a strong correlation between the two researchers' search results ($k = 0.853$). In this review, a total of 589 patients with proximal humeral fracture treated with RTSA were included. There were 60 men (10.8%) and 529 women (89.2%). The mean age was 75.5 ± 2.2 years. RTSA was associated with a number of clinical complications, such as infection (10.4%) as well as a lower revision rate (1.02%). Average patient satisfaction rate was 86% **Conclusion:** Through the literature, it is possible to report that for complex fractures of the proximal humerus, where reconstruction is not feasible, RTSA may be the most appropriate treatment option, especially in older patients requiring less of the joint. However, new studies with level of evidence I and II are fundamental to answer this question definitively.

Copyright © 2019, Brauner de Souza Cavalcanti et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: Brauner de Souza Cavalcanti, Vinícius Gueiros Buenos Aires, Francisco Cabral de Oliveira Neto, et al. 2019. "Reverse total shoulder arthroplasty efficacy in proximal humeral fractures treatment: a systematic review", *International Journal of Development Research*, 09, (05), 27821-27825.

INTRODUCTION

Proximal humeral fractures (PHF), are relatively common lesions in adults, accounting for 4-5% of all fractures presenting to the emergency room and about 5% of the fractures of the appendicular skeleton (Foroohar, 2011; Bruinsma, 2013 and Court-Brown, 2006). PHFs account for 10% of all fractures in people 65 years of age or older (Foroohar, 2011; Bruinsma, 2013; Court-Brown, 2006; Lind, 1989 and Court-Brown, 2001), being The third most frequent fracture in patients ≥ 65 years. Some studies have found higher

mortality in PHFs than in other types of fractures (Court-Brown, 2002; Court-Brown, 2004 and Robinson, 2010). PHFs have a higher incidence among women (Court-Brown, 2004; Robinson, 2010; Austin, 2018; Gallinet, 2018; 13. Holton, 2007; Holton, 2017 and Smith, 2017). Risk factors associated with this type of fracture, such as comorbidities, osteoporosis, advanced age and falls, are found in more than 75% of these fractures (Robinson, 2003 and Austin, 2008). These may occur alone or be associated with the concomitant shoulder joint dislocations. Additional injuries to the shoulder girdle, such as coexisting scapular fractures, may also be present. As such, a wide range of fracture patterns has been described (Roux, 2012; Robinson, 2003; Court-Brown, 2002; Court-Brown, 2004 and Robinson, 2010), making it difficult and

*Corresponding author: Brauner de Souza Cavalcanti,
Orthopedics fellow at Getúlio Vargas Hospital

reproducible to classify complex and difficult prognostic value. Despite significant advances in surgical technique and a plethora of reconstructive options, adequate fixation in osteoporotic bone remains a problem (Austin, 2018; Gallinet, 2018 and Holton, 2017). Joint replacement options for proximal humeral fractures include shoulder hemiarthroplasty, total arthroplasty, RTSA. The latter two may be used primarily in elderly patients with complex displaced fractures, fractured luxations and fractures that split the head with a high risk of avascular necrosis, or as salvage procedures after reconstruction failure. Primary replacement surgery, however, is less attractive in young and active patients, given the expected longevity of the prosthesis and the potential need for multiple revision operations (Smith, 2017; Villodre-Jiménez, 2017 and Long, 2016). Management of proximal humeral fractures in adults encompasses a constantly increasing range of non-surgical, reconstructive, and prosthetic replacement options. Good outcomes are highly dependent on appropriate management decisions, which should be based on a complete and multifactorial assessment of fracture, patient and treatment center factors (Austin, 2018; Gallinet, 2018; Holton, 2017; Smith, 2017; Villodre-Jiménez, 2017 and Long, 2016). For all these reasons, the main objective of the present study was to evaluate, through a systematic review, the use of RTSA in fractures of the proximal humerus.

METHODS

Research strategy: Two reviewers independently conducted a search using the same descriptors and Pubmed, Medline and Embase databases for studies published up to August 20, 2018. The following descriptors were used: "reverse total shoulder arthroplasty"; "total total shoulder prostheses"; "fractures"; "fracture of the proximal humerus." Treatment; Efficacy. The following filters were used to arrive at the expected final result: "Randomized Controlled Trial"; "Randomized Clinical Trial" "Meta-Analysis" "Systematic Reviews" "Clinical Trial".

Eligibility and selection criteria

The studies found were submitted to the following inclusion criteria:

- Studies related to the proposed theme;
- Studies with level of evidence I and II;
- Studies published in indexed journals;
- Articles in languages: English, Spanish and Portuguese;
- Human research;
- Articles available in full version.

The exclusion criteria were:

- Simple case report studies or methodology with low reliability.

Investigated variables and extracted data: Two independent investigators were part of the search. Those who followed the same criteria in the selected studies, collecting the following data: Study design; Purpose and outcome of the study.

RESULTS

Identification of the studies and characteristics: According to the search strategy, 103 studies with the abovementioned descriptors were found, which were again evaluated according to their design and relevance according to the type of study filters and inclusion criteria. There was a very strong

correlation between the two researchers' searches ($k = 0.853$). At the end, 21 studies remained, of which 16 were complete and included (Table 1) (Austin, 2018; Gallinet, 2018; Holton, 2017; Smith, 2017; Villodre-Jiménez, 2017; Long, 2016; Savin, ?; Wang, 2016; Ferrel, 2015; Grادل, 2014; Anakwenze, 2014; Mata-Fink, 2013; Brorson, 2013; Ockert, 2013; Gomberawalla, 2013 and Farmer, 2010). As general characteristics, a total of 589 patients with proximal humeral fractures treated with RTSA were included in this review. There were 60 men (10.8%) and 529 women (89.2%). The mean age of the patients was 75.5 ± 2.2 years (range 70-78 years). The mean follow-up period was 27.8 ± 21.8 months (6-86 months). RTSA was associated with a median rate of clinical complications, such as infection (6.4%) and dislocation (9.7%), but with a low revision rate (1.02%). The average satisfaction rate was 86%. In the general functional analysis, among the studies that used instruments of evaluation, the average *Constant score* was 56.7 ± 7.6 points (variation of 44-67.8 points), the mean score *Disability of the Arm, Shoulder and Hand (DASH)* was 39.9 ± 6 points (range 31.5-46.8 points), and the *American Shoulder and Elbow Surgeons Shoulder Score (ASES)* averaged 70.3 ± 6.8 points (range 65-78 points). Regarding the range of motion, patients treated with RTSA demonstrated mean flexion of 118 degrees, and mean external rotation of 20 degrees. We observed heterogeneity in relation to the study design (Figure 1). The results were positive in 90% (14) of the included articles (Figure 2). The selected articles had the following characteristics: randomized clinical trial, meta-analysis, and systematic review. The predominance in the literature was the absence of a gold standard in the treatment of proximal humeral fractures, even with positive results presented with ATOR, however the indications for this technique are more expressive in elderly patients. The collected studies can be observed in Table 1, below.

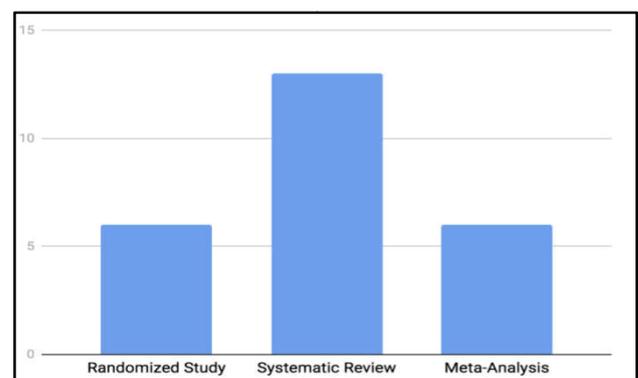


Figure 1. Number of articles according to study design

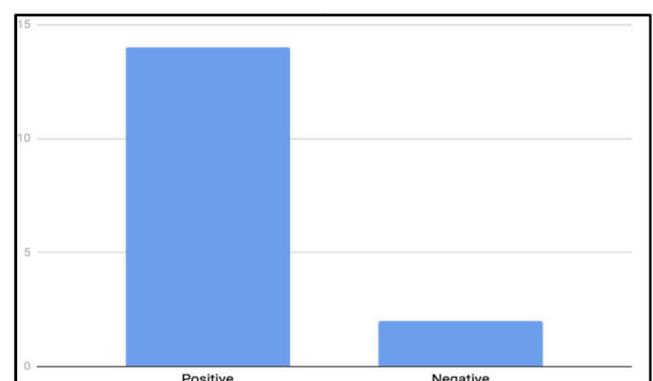


Figure 2. Representation of the number of articles that reported positive and negative results using RTSA in the treatment of proximal humeral fractures

Table 1. Articles listed in the study

STUDY	METHODS	OBJECTIVE	CLINICAL OUTCOME
Austin et al (2018)	Systematic review and meta-analysis	compare clinical outcomes and complications after with hemiarthroplasty (HA) in geriatric patients with proximal humerus fractures.	RTSA results in improved range of motion, better clinical scores when compared to HA, especially in elderly patients. Future work should evaluate long-term results to see if the benefits of RTSA persist.
Gallinet et al (2018)	Meta-analysis and randomized clinical trial.	To determine clinical outcomes, complications, reoperations and revisions Of RTSA and to compare them with those of HA.	Compared to HA, RTSA provides a more reproducible function with better recovery from flexion and active abduction. On the other hand, the rate of complications in RTSA is higher, but with fewer revisions when compared with HAD.
Holton et al (2016)	Meta-analysis of randomized clinical trial.	The role of reverse shoulder arthroplasty in the management of proximal humeral fractures with sequelae.	RTSA-better range of motion and function after proximal humerus fractures. However, there is a risk of Significant complications, such as dislocation and infection.
Smith et al (2017)	Randomized Clinical Trial.	The primary endpoint was to compare pain and function 12 months after FPU in patients 70 years of age or older.	Study in progress.
Villodre-Jiménez et al (2017)	Systematic review and meta-analysis.	To evaluate the clinical, radiological and functional results in patients over 65 years of age with complex proximal humeral fractures treated with total reverse arthroplasty of the shoulder.	Reverse arthroplasty is a valid option for treating proximal humerus fractures of 3 and 4 parts in elderly patients. The surgical objectives should include the anatomical reconstruction of the tuberosities, avoiding an increase of the operated arm larger than 2cm.
Longo et al (2016)	Systematic review	ATOR for the management of proximal humeral fractures.	RTSA restores function and relieves pain in patients with proximal humeral fractures. However, no randomized clinical trial is available to support RTSAx Osteosynthesis, anatomical prostheses or HA. Further studies are needed to evaluate the effectiveness of the RTSA in the management of proximal humeral fractures.
Savin et al (2016)	Review	Deepen and define the standard of care, evaluating the preference and the treatment of the surgeon for the management of the FPU.	There is consensus in our studies that RTSA is the preferred treatment for four-part proximal humeral fractures for elderly patients.
Wang et al. (2016)	Meta-analysis and systematic review	Critically compare the outcome of the reverse shoulder arthroplasty versus hemiarthroplasty for the treatment of complex proximal humeral fracture.	This meta-analysis suggests that RTSA is a better option than hemiarthroplasty in the elderly.
Ferrel et al (2015)	Systematic review and randomized clinical trial	Report and compare the clinical and radiographic results of patients treated with RTSA or hemiarthroplasty for complex FPU.	ATOR was associated with an increased rate of clinical complications and a lower revision rate in the short and medium term follow-up. However, RTSA offers an acceptable surgical option for patients after acute and complex proximal humeral fractures.
Gladl et al (2014)	Systematic review	Describe the incidence and clinical features of proximal humeral geriatric fractures, a description of therapeutic options and treatment recommendations.	Most fractures of the proximal humerus requiring surgical treatment are amenable to reconstruction. Primary arthroplasty is usually reserved for comminuted fractures with late presentation, head fracture or those in which the head of the humerus is devoid of soft tissue attachments. Decision making depends on the fracture pattern, as well as factors related to the patient and the surgeon.
Anakwenze et al (2014)	Systematic review	Detail the demographics, and complications of patients undergoing reverse arthroplasty of the shoulder for complex proximal humeral fractures.	Grouped data and frequency-weighted mean outcomes showed that older women are more affected, and that preferential treatment is ATOR. Greater tuberosity repair allows a better range of motion in these patients.
Mata-Fink et al (2013)	Systematic review	Evaluate the RTSA for treatment of proximal humeral fractures in the elderly.	The RTSA results in better flexural scores and functional results compared to hemiarthroplasty in the elderly with proximal humeral fractures.
Brorson et al (2013)	Systematic	review Review clinical studies reporting benefits and damage of RTSA in acute fractures.	Based on the available evidence, the use of RTSA in acute fractures is questionable. The complication rate was high and the clinical implications of the long-term scapular notch are worrisome. Randomized studies with long-term follow-up, using the latest techniques of tuberculin re-insertion in RTSA for HA should be encouraged.
Ockert et al (2013)	Randomized Clinical Trial	Examine the functional results of the RTSA and compare them with results after reconstruction and block plate osteosynthesis, 1-year follow-up.	RTSA should be considered as an appropriate alternative for the treatment of comminuted fractures of three and four parts of the proximal humerus with ruptured head, or large ruptures of the rotator cuff in elderly patients. Although RTSA may provide immediate shoulder stability for the elderly, primary RTSA needs to be investigated for long-term outcome.
Gomberawalla et al (2011)	Meta-analysis	Joint-preservation meta-analysis versus ACOR for the treatment of displaced fractures of 3 and 4 parts of the proximal humerus.	In the existing literature, displaced proximal humeral fractures demonstrate better scores when treated with joint preservation options. Age, fracture pattern, and complication rate are significant predictors of score <i>constant</i> regardless of the treatment selected. In this sense, more comparative studies are needed to definitively recommend reconstructive techniques versus reverse and total arthroplasties for specific fracture patterns.
Farmer et al (2010)	Randomized controlled clinical trial.	To compare the clinical and functional results of open reduction and internal fixation versus total arthroplasty, in the treatment of fractures of the distal humerus.	Total arthroplasty presents promising results in elderly patients and in extensive fractures with difficulty of internal fixation.

DISCUSSION

In this review it was evidenced that complex fractures of the proximal humerus should be evaluated, mainly, by the reliability with which they can be reconstructed. When reconstruction is not feasible or after primary surgical failures, especially in patients who are physiologically older and less active, RTSA may be considered the most appropriate option. Our study reveals important observations. First, there is a lack of high quality evidence on the treatment for proximal humerus fractures with RTSA. We note that although there are many types of approaches, none is gold standard, there is little scientific evidence to guide the surgeon about which approach is best. We found only four randomized clinical trials finalized, however with a reduced sample and design with average reliability. There are many systematic reviews and meta-analyses, based, for the most part, on prospective and retrospective studies, which maintains the theme with no definitive answer. RTSA was originally designed to treat glenohumeral arthritis with rotator cuff arthropathy (Anakwenze, 2014). Currently, it is also used in the treatment of proximal humerus fractures, where tuberosity repair for hemiarthroplasty is impossible (Mata-Fink, 2013; Brorson, 2013 and Ockert, 2013). RTSA can be seen as a first or as a secondary “rescue” for hemiarthroplasty failure (Holton, 2017; Smith, 2017; Villodre-Jiménez, 2017; Long, 2016; Savin, ?).

Ferrel et al (2015) compared primary hemiarthroplasty to primary RTSA and observed improvement in flexion after total shoulder arthroplasty, with similar complication rates between the two groups. In another comparison by Gomberawalla et al (Gomberawalla, 2013). RTSA was associated with better functional results compared to hemiarthroplasty, with similar review and mortality rates at one year. Previous studies failed to demonstrate statistically significant differences between the functional outcomes of hemiarthroplasty and total reverse arthroplasty (Gomberawalla, 2013 and Farmer, 2010). A high rate of complications with RTSA has been reported by Brorson et al (Brorson, 2013) in a recent systematic review of the literature. These included dislocation, infection, hematoma, instability, neurological injury, intraoperative and periprosthetic fracture, insufficiency of the base plate, reflex sympathetic dystrophy and scapular notch, which in the long term has been associated with loss of component and loss of glenoid bone. However, total reverse shoulder arthroplasty remains a good option for elderly patients with non-reconstructive fractures and cuff deficiency, as well as a valuable salvage solution for the management of reconstructive or prosthetic replacement after primary failure. Several case series in the literature have documented degenerative diseases as the main etiologic indication for shoulder arthroplasties (Bruinsma, 2013; Court-Brown, 2006; Lind, 1989; Court-Brown, 2001; Roux, 2012; Robinson, 2003; Court-Brown, 2002; Court-Brown, 2004 and Robinson, 2010).

These studies presented as an etiologic diagnosis to indicate RTSA, in 57% of the cases with diagnosis of primary degenerative disease, 13% of the cases with rheumatoid arthritis, 25% with acute trauma of the proximal humerus and 5% with musculoskeletal tumor. In addition to rheumatoid arthritis, followed by acute trauma, osteoarthritis and osteonecrosis. Management of proximal humeral fractures in adults is a challenging and demanding task. Good results depend on detailed fracture assessment, careful patient selection, detailed consideration of individual patient

characteristics, comorbidities and functional expectations, as well as advanced surgical experience on a wide range of reconstructive and joint replacement options. A multidisciplinary team approach should be used with experienced musculoskeletal radiologists, geriatricians, and specialized physiotherapists for optimized rehabilitation. The treatment of these complex lesions requires careful planning and therefore should be provided in centers with appropriate resources and expertise in their management and rehabilitation. Currently, there is insufficient evidence to suggest superiority of one treatment option over the others. The study by Smith et al, is a multicenter randomized controlled trial, which aims to compare the efficacy and cost-effectiveness of currently indicated surgical treatments for FPU in adults, its methodology and objectives are promising, but research is still ongoing (Smith, 2017). However, currently available evidence suggests that RTSA should be considered as an appropriate alternative for the treatment of comminuted three- and four-part proximal humeral fractures with humeral head rupture or large rotator cuff tears in elderly patients.

Conclusion

In this review it was evidenced that complex fractures of the proximal humerus should be evaluated, and the individualized treatment adapted to specific factors related to fracture, to the patient and to the treatment center. When reconstruction is not feasible or after primary surgical failures, especially in patients who are physiologically older and require less of the joint, RTSA may be considered the most appropriate option. However, there are no elements to determine RTSA as a gold standard recommendation.

REFERENCES

- Anakwenze OA, Zoller S, Ahmad CS, Levine WN. Reverse shoulder arthroplasty for acute proximal humerus fractures: a systematic review. *J Shoulder Elbow Surg.* 2014 Apr; 23 (4): e73-80.
- Austin DC, Torchia MT, Cozzolino NH, Jacobowitz LE, Bell JE. Decreased Reoperations and Improved Outcomes with Reverse Total Shoulder Arthroplasty in Comparison to Hemiarthroplasty for Geriatric Proximal Humerus Fractures: A Systematic Review and Meta-Analysis. *J Orthop Trauma.* 2018 Aug 23.
- Brorson S, Rasmussen JV, Olsen BS, Frich LH, Jensen SL, Hróbjartsson A. Reverse shoulder arthroplasty in acute fractures of the proximal humerus: A systematic review. *Int J Shoulder Surg.* 2013 Apr; 7 (2): 70-8.
- Bruinsma WE, Guitton TG, Warner JJ, Ring D. Interobserver reliability of classification and characterization of proximal humeral fractures: a comparison of two and three-dimensional CT. *J Bone Joint Surg Am.* 2013; 95: 1600-1604.
- Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury.* 2006; 37: 691-697.
- Court-Brown CM, Cattermole H, McQueen MM. Impacted valgus fractures (B1.1) of the proximal humerus. The results of non-operative treatment. *J Bone Joint Surg Br.* 2002; 84: 504-508.
- Court-Brown CM, Garg A, McQueen MM. The epidemiology of proximal humeral fractures. *Acta Orthop Scand.* 2001; 72: 365-371.
- Court-Brown CM, McQueen MM. The impacted varus (A2.2) proximal humeral fracture: prediction of outcome and

- outcomes of nonoperative treatment in 99 patients. *Acta Orthop Scand*. 2004; 75: 736-740.
- Farmer KW, Wright TW. Three- and four-part proximal humerus fractures: open reduction and internal fixation versus arthroplasty. *J Hand Surg Am*. 2010 Nov; 35 (11): 1881-4; quiz 1884.
- Ferrel JR, Trinh TQ, Fischer RA. Reverse total shoulder arthroplasty versus hemiarthroplasty for proximal humeral fractures: a systematic review. *J Orthop Trauma*. 2015 Jan; 29 (1): 60-8.
- Foroohar A, Tosti R, Richmond JM, Gaughan JP, Ilyas AM. Classification and treatment of proximal humerus fractures: inter-observer reliability and agreement across imaging modalities and experience. *J Orthop Surg Res*. 2011; 6: 38.
- Gallinet D, Ohl X, Decroocq L, Dib C, Valenti P, Boileau P; French Society for Orthopedic Surgery (SOFOT). Is reverse total shoulder arthroplasty more effective than hemiarthroplasty for proximal displacement humerus fractures in older adults? A systematic review and meta-analysis. *Orthop Traumatol Surg Res*. 2018 Oct; 104 (6): 759-766.
- Gomberawalla MM, Miller BS, Coale RM, Bedi A, Gagnier JJ. Meta-analysis of joint preservation versus arthroplasty for the treatment of displaced 3- and 4-part fractures of the proximal humerus. *Injury*. 2013 Nov; 44 (11): 1532-9.
- Gradl G, Pape HC, Tingart M, Arbab D. [Fractures of the proximal humerus in the elderly: Osteosynthesis versus joint replacement]. *Orthopade*. 2014 Apr; 43 (4): 339-46.
- Holton J, Yousri T, Arealis G, Levy O. The Role of Reverse Shoulder Arthroplasty in Management of Proximal Humerus Fractures with Fracture Sequelae: A Systematic Review of the Literature. *Orthop Rev (Pavia)*. 2017 Feb 24; 9 (1): 6977.
- Lind T, Krøner K, Jensen J. The epidemiology of fractures of the proximal humerus. *Arch Orthop Trauma Surg*. 1989; 108: 285-287.
- Long UG, Petrillo S, Berton A, Denaro V. Reverse total shoulder arthroplasty for the management of fractures of the proximal humerus: a systematic review. *Musculoskelet Surg*. 2016 Aug; 100 (2): 83-91.
- Mata-Fink A, Meinke M, Jones C, Kim B, Bell JE. Reverse shoulder arthroplasty for treatment of proximal humeral fractures in older adults: a systematic review. *J Shoulder Elbow Surg*. 2013 Dec; 22 (12): 1737-48.
- Ockert B, Biermann N, Haasters F, Mutschler W, Braunstein V. [Reverse shoulder arthroplasty for primary fracture treatment. Displaced three and four fractures of the proximal humerus in the elderly patient]. *Unfallchirurg*. 2013 Aug; 116 (8): 684-90.
- Robinson CM, Page RS. Severely impacted proximal valgus humeral fractures. Results of operative treatment. *J Bone Joint Surg Am*. 2003; 85-A: 1647-1655.
- Robinson CM, Wylie JR, Ray AG, Dempster NJ, Olabi B, Seah KT, Akhtar MA. Proximal humeral fractures with a severe varus deformity treated by fixation with a locking plate. *J Bone Joint Surg Br*. 2010; 92: 672-678.
- Roux A, Decroocq L, El Batti S, Bonneville N, Moineau G, Trojani C, Boileau P, Peretti F. Epidemiology of proximal humerus fractures managed in a trauma center. *Orthop Traumatol Surg Res*. 2012; 98: 715-719.
- Savin DD, Zamfirova I, Iannotti J, Goldberg BA, Youderian AR. Survey study suggests that reverse total shoulder arthroplasty is becoming the treatment of choice for four-part fractures of the humeral head in the elderly. *Int Orthop*. The results are consistent with the results obtained by
- Smith GC, Bateman E, Cass B, Damiani M, Harper W, Jones H, Lieu D, Petchell J, Petrelis M, Piper K, Sher D, Smithers CJ, Trantalís J, Vrancic S, Harris IA. Reverse Shoulder Arthroplasty for the treatment of Proximal humeral fractures in the Elderly (ReShAPE trial): study protocol for a multicentre combined randomized controlled and observational trial. *Trials*. 2017 Feb 28; 18 (1): 91.
- Villodre-Jiménez J, Estrems-Díaz V, Diranzo-García J, Bru-Pomer A. Reverse shoulder arthroplasty in 3 and 4 part proximal humeral fractures in patients aged over 65 years: Results and complications. *Rev Esp Cir Ortop Traumatol*. 2017 Jan-Feb; 61 (1): 43-50.
- Wang J, Zhu Y, Zhang F, Chen W, Tian Y, Zhang Y, et al., Meta-analysis suggests that reverse shoulder arthroplasty in proximal humerus fractures is a better option than hemiarthroplasty in the elderly. *Int Orthop*. 2016 Mar; 40 (3): 531-9.
