

Epidemiology of Shoulder Arthroplasty in a Southern-Italy Region: A Three-Year Registry Study

Alfonso Maria Romano¹, Emanuela Marsilio², Francesco Cuzzo², Francesco Ascione^{1,3}, Stefano Lepore⁴, Pasquale Casillo¹, Guglielmo Nastrucci¹, Nicola Maffulli^{2,5,6}, Francesco Oliva²

¹ Department of Shoulder Surgery, Campolongo Hospital, Salerno, Italy

² Department of Medicine, Surgery and Dentistry, University of Salerno, Baronissi, Salerno, Italy

³ Department of Orthopaedic and Traumatology Surgery, Ospedale Buon Consiglio Fatebenefratelli, Naples, Italy

⁴ Department of Orthopaedic and Trauma Surgery, "A. Cardarelli" Hospital, Naples, Italy

⁵ Faculty of Medicine, School of Pharmacy and Bioengineering, Guy Hilton Research Centre, Keele University, Stoke-on-Trent, U.K.

⁶ Queen Mary University of London, Barts and the London School of Medicine and Dentistry, Centre for Sports and Exercise Medicine, Mile End Hospital, London, U.K.

CORRESPONDING AUTHOR:

Emanuela Marsilio
Department of Medicine, Surgery and
Dentistry
University of Salerno
via Salvador Allende 43
84081 Baronissi
Salerno, Italy
E-mail: emanuelamarsilio16@gmail.com

DOI:

10.32098/mltj.01.2023.03

LEVEL OF EVIDENCE: 3

SUMMARY

Background. Shoulder pathologies are increasingly common in the worldwide population. Total shoulder replacement procedures grew significantly in the last ten years. Based on the diagnosis, shoulder conditions can be treated with different surgical implants, such as shoulder hemiarthroplasty (HA), total anatomic shoulder arthroplasty (TSA), and reverse shoulder arthroplasty (RSA).

Materials and methods. Data from Italian Register of Arthroplasty (RIAP) from 2018 to 2020 of the Campania region were collected to perform this investigation.

Results. Between 2018 and 2019 an increase of 18.3% in shoulder replacement surgeries was reported by a total of 35 different hospitals in Campania. However, in 2020 the number of shoulder arthroplasty decreased of 21.3%. Proximal humeral fractures and their sequelae were reported as an indication for shoulder arthroplasty with an increasing rate of +10.3%. While the indication most frequently reported was rotator cuff arthropathy with an increasing of +15.4% between 2018 and 2019.

Conclusions. Shoulder interventions are becoming increasingly common. Reverse shoulder arthroplasty has been the most performed in Campania during the last three years in patients with rotator cuff arthropathy.

KEY WORDS

Shoulder arthroplasty; total; reverse; anatomical; hemiarthroplasty; revision surgery.

INTRODUCTION

Shoulder pathologies are increasingly common in the worldwide population (1). Osteoarthritis (OA) of the glenohumeral joint represents the first cause of joint replacement. Indeed, shoulder arthroplasty is usually performed in patients with OA, complex fractures of the proximal humerus, osteonecrosis, and massive and irreparable tears of the rotator cuff associated with a severe arthropathy (2-5). The

incidence of these diseases is exponentially higher in patients older than 50 years, with greater prevalence in women (2, 6). Several epidemiological studies have been published during the last twenty years. From 2002 to 2011 the Nationwide Inpatient Sample database of the United States reported an incidence of shoulder arthroplasty with an increase of 267% (7). Although shoulder arthroplasty is less commonly performed than hip and knee arthroplasty, total shoul-

der replacement procedures grew significantly in the last ten years (8, 9). Based on the diagnosis, shoulder conditions can be treated with different surgical implants, such as shoulder hemiarthroplasty (HA), total anatomic shoulder arthroplasty (TSA), and reverse shoulder arthroplasty (RSA) (10-12). The aim of the current study is to retrospectively report the incidence of different types of shoulder arthroplasty, such as HA, TSA, RSA, and revision arthroplasty in a southern Italy region population. Furthermore, we investigated the relationship among the choice of implant and the diagnosis in more than twenty different hospitals.

MATERIALS AND METHODS

Recently, some regions organized data and collected them individually in a common project called RIAP, producing a single annual report. The collected data are anonymous, no demographic or personal information is retrievable from the registry. One of the authors (SL) was allowed to access and investigate the regional report and anonymously performed the data analysis. Data from Italian register of arthroplasty (RIAP) from 2018 to 2020 of the Campania region were collected to perform this investigation. The anonymous data included the number of shoulder arthroplasty performed, type of shoulder arthroplasty (reverse, total anatomical arthroplasty, hemiarthroplasty, revision arthroplasty), diagnosis and surgical approaches. The indications for primary shoulder arthroplasty were acute fractures, concentric osteoarthritis, eccentric osteoarthritis, inflammatory arthritis, anterior shoulder instability, osteonecrosis, rotator cuff arthropathy, dislocation, revision. In some cases, the indication was unknown and was marked as other in a column. The primary outcome variable of this study was the incidence of shoulder arthroplasty performed in the population of the Campania region for the years 2018, 2019, 2020. The second outcome was to evaluate the commonest indications to treatment and the preferred surgical approach. Incidence of the surgeries per 100,000 person-years was calculated by dividing the annual number of interventions by the size of the population aged ≥ 18 years in the end of the year in question, multiplied by 100,000. The population ranging from 5.740.291 (year 2018), to 5.712.143 (year 2019), to 5.624.260 (year 2020).

RESULTS

The number of all the procedures during the 3-year study period was 1653. Out of 1653, 531 procedures (32%) were performed in 2018, 628 (38%) were performed in 2019, and 494 (30%) procedures in 2020. Incidence rates were calculated using the annual adult population size during the study period.

The choices of implants and diagnosis through the studied period were reported in **tables I** and **II**. In more than 90% of the reported cases, the surgeons chose a deltoid-pectoral approach. However, different results arose regarding the management of the subscapularis tendon. These results have been reported in **table III**.

During the 2018-2020 period, the number of RSA increased and for this reason the difference between the choice of an on-lay or in-lay device was studied and reported in **table IV**.

Table I. Shoulder replacement performed in 2018, 2019, and 2020 in Campania. Baseline description of the choice of implants.

	Implants		
	2018	2019	2020
Hospitals (n)	35	35	35
Shoulder procedures	531	628	494
Reverse Shoulder Arthroplasty RSA (%)	396 (74.6)	457 (73)	448 (90)
RSA cemented (%)	64 (16)	13 (3)	4 (1)
RSA non cemented (%)	332 (84)	444 (97)	444 (99)
Total Anatomic Shoulder Arthroplasty TSA (%)	23 (4.3)	18 (3)	14 (3)
TSA cemented (%)	7 (30.5)	0	0
TSA non cemented (%)	16 (69.5)	18 (100)	14 (100)
Hemiarthroplasty HA (%)	34 (6.4)	35 (6)	19 (4)
HA cemented (%)	6 (17.7)	11 (31)	0
Ha non cemented (%)	28 (82.3)	24 (69)	19 (100)
Revision (RSA to RSA) (%)		3 (43)	5 (55)
Revision (TSA to RSA) (%)		1 (14.5)	1 (11)
Revision (HA to RSA) (%)	7 (87.5)	2 (28)	2 (22)
Revision (RSA to HA) (%)	1 (12.5)	1 (14.5)	1 (11)

Table II. Diagnosis and indications for shoulder arthroplasty.

	Diagnosis		
	2018	2019	2020
Acute fractures (%)	136 (39)	153 (24)	150 (30)
Fracture sequelae (%)	18 (4)	22 (3)	25 (5)
Primary OA (%)	22 (4)	24 (4)	10 (2)
Rotator cuff arthropathy (%)	231 (43.5)	232 (37)	227 (46)
Osteonecrosis (%)	2 (0.4)	2 (0.3)	6 (1)
Dislocation (%)	1 (0.2)	1 (0.1)	4 (0.8)

Table III. Management of the subscapularis tendon after deltoid-pectoral approach.

	2018		2019		2020			
	Tenodesis	Tenotomy	Tenodesis	Tenotomy	Tenodesis	Tenotomy		
RSA (%)	218 (55)	90 (23)	RSA (%)	154 (34)	130 (28)	RSA (%)	165 (37)	144 (32)
TSA (%)	12 (52)	0	TSA (%)	10 (55)	0	TSA (%)	4 (29)	0
HA (%)	7 (21)	4 (12)	HA (%)	18 (51)	8 (23)	HA (%)	6 (32)	5 (26)
Revision (%)	0	2 (25)	Revision (%)	0	6 (85)	Revision (%)	0	9 (100)

Table IV. Comparison between two different prostheses designs used for RSA.

	Reverse shoulder arthroplasty (RSA)		
	2018	2019	2020
Inlay (%)	253 (64)	295 (65)	292 (65)
Onlay (%)	143 (36)	162 (35)	156 (35)

DISCUSSION

This registry study results show an increasing incidence of shoulder replacements from 2018 to 2019 in the Italian region of Campania, where the number of reverse shoulder arthroplasty significantly rose while the hemiarthroplasties and anatomical shoulder arthroplasties incidence decreased. However, this growing trend stopped in 2020 when the number of shoulder surgeries significantly decreased. These findings confirm the international trend changes in the choice of implant for shoulder replacement expected from previous studies when considering the 2018-2019 period (11, 13, 14). In these two years, an increase of 18.3% in shoulder replacement surgeries was reported by a total of 35 different hospitals in Campania. Unfortunately, in 2020 the increasing trend stopped probably due to the COVID-19 pandemic. In Italy and Europe, since March 2020 elective surgeries were postponed because of the spread of SARS-CoV-2 virus (15). Clement *et al.* investigated the rate of patients deferral of elective surgeries in April, June, August and September 2020 in UK finding a 5% deferral rate from patients waiting for elective arthroplasties. The main reason for postponing surgeries was the perceived risk of contracting the disease, given the older age of patients that usually go through joint arthroplasty (16). In the current study a decreasing rate of 21.3% of all the shoulder arthroplasties performed in 2020 in the whole Campania region was reported, compared to the surgeries performed in 2019.

According to our retrospective study, in 2018 the incidence of shoulder replacements was 9.25 per 100.000 per person-years, while in 2019 the incidence was 11 per 100.000 person-years, with a growing rate of 18.26% compared to 2018. Consistently with previous studies, 74.6% (396 shoulders) of the performed surgeries were RSA with an increasing rate of 15.4% from 2018 to 2019, while the rate of hemiarthroplasties significantly decreased (-44%) between the years 2018 and 2020 (figure 1).

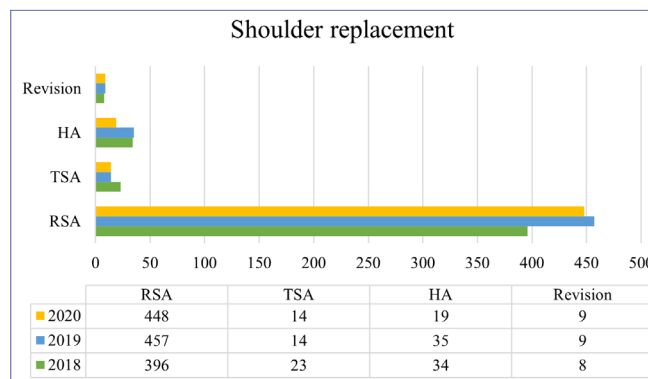


Figure 1. Changes in the choice of implants for shoulder replacement in a 3-year period in Campania.

Previously, Harjula *et al.* analyzed data from the Finnish Arthroplasty Register (FAR) from 2004 to 2015 to investigate the incidence of primary shoulder arthroplasty, finding that in an eleven-year period the rate of RSA increased of 4,500% among the Finnish population (14). This study results were consistent with other national registers studies. Indeed, Lubbeke *et al.* examined shoulder arthroplasty trends of 9 different countries using their national registers, finding that the rate of total shoulder arthroplasty was tripled in the first decade of the 2000s with a growing use of RSA, in particular in Norway (from 12% to 52%) and New Zealand (from 2% to 54%) (17). However, few evidence regarding shoulder replacement in the Italian population is currently available. In only one study, the authors reported data from

the Emilia-Romagna shoulder registry, reporting RSA as the most frequently performed (59%) between 2008 and 2013 (17). Recently, Longo *et al.* investigated the rate of hospitalization for shoulder replacements in a 10-years period using the National Hospital Discharge Reports (S.D.O.) evaluating the costs of these procedures in the past ten years and for the next decade. Interestingly, the frequency of Italian shoulder replacements tripled in the last ten years assessing an overall cost of €625,638,990 for the Italian Health System to reimburse. Furthermore, in the following decade the predicted costs were doubled as well as the number of the expected shoulder replacement procedures (18). During the last decade, the indications for shoulder arthroplasty have been changing throughout the world (19-21). Consistently with the current evidence, during the three years period analyzed proximal humeral fractures and their sequelae were more frequently reported as an indication for shoulder arthroplasty (+10.3%). Ferrel *et al.* conducted a systematic review comparing HA and RSA outcomes in patients who suffered from acute proximal humerus fractures, finding an improved forward flexion in patients treated with RSA (22). RSA has become the most frequently used implant after trauma to avoid the risks of poor outcomes after HA, such as tuberosity healing failure due to advanced age, poor bone quality, and compromised vascularization (23-28). However, the raising use of RSA is closely associated with the increasing rate of irreparable rotator cuff tears and rotator cuff arthropathy diagnosis in the middle age population (29-32). In 2018, Sellers *et al.* discussed the indication for RSA in patients with massive irreparable rotator cuff tears, showing that, thanks to its design, the reverse prosthesis can solve the glenohumeral joint pathology and the rotator cuff deficiency (33). While performing RSA, surgeons usually must choose whether to repair or not the subscapularis tendon. In our results, surgeons performed a subscapularis tendon tenodesis during RSA in most cases. However, this trend has resulted to be decreasing through the 2018-2020 period. We found a 24% decrease rate in the tenodesis group, while 44% higher rate of subscapularis tendon tenotomy between 2018 and 2019, that further increased of 11% between 2019 and 2020 (**figure 2**). Recently, this topic has been largely discussed in literature (34-36). Corona *et al.* performed a meta-analysis evaluating the role of subscapularis tendon repair in lateralized RSAs, finding reasonable to perform a tenodesis only when dealing with acceptable tissue and without evidence of tendon fatty degeneration (12). Indeed, the prosthetic design of RSA can guide through the management of subscapularis tendon. As stated by Jawa *et al.*, subscapularis repair can play a crucial role in shoulder stability in medialized RSA, while in lateralized design prosthesis stability is provided by the tensioned deltoid, and subscapularis repair could worsen that tension

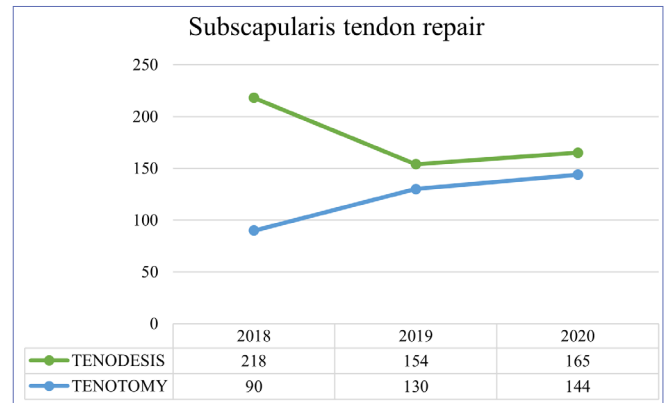


Figure 2. Subscapularis tendon management in RSA during the 2018-2020 period in Campania.

causing alterations in shoulder biomechanics (37). Nowadays, several prosthesis designs are available and can be classified as Grammont-style prosthesis, a non-anatomical design, that improves the deltoid lever arm by medializing the center of rotation of the shoulder and giving stability to the implant (38). Onlay designed prosthesis are relatively new models that cause less humeral distalization and provide more lateralization, thanks to a shorter neck shaft angle (26). More than 60% of the RSA performed in Campania between 2018 and 2020 were Grammont-style designs (**table IV**). However, Beltrame *et al.* conducted a prospective study comparing inlay and onlay design prosthesis in 46 patients treated with RSA, finding similar results except for better active external rotation, adduction and extension provided by onlay models (39). Previously, Merolla *et al.* retrospectively evaluated the functional outcomes of these two models, finding comparable results in terms of range of motion and pain relief. However, the onlay configuration prosthesis revealed higher external rotation delta scores compared to the Grammont-style RSA, probably due to the additional contribution of the glenoid bone grafting to external mobility of the shoulder (21). This study represents the first attempt to evaluate the changing trend in shoulder replacement in a southern Italy region during a prolonged period of time, based on a National Arthroplasty Register. Clearly this work has some limitations. First, the Italian registry did not report demographic data of the patients, and for this reason statistical comparison about age or gender could not be carried out. Furthermore, no additional information was given about patients comorbidities and past medical history, leading to a paucity of information about the diagnosis that lead to shoulder arthroplasty. This lack of demographic data could limit the understanding of a changing trend in the surgeons choice of implant. For these reasons further studies are needed to analyze and better comprehend the changing trends in shoulder arthroplasty.

CONCLUSIONS

Shoulder replacements are becoming increasingly common. Reverse shoulder arthroplasty has been the most performed in Campania during the last three years, particularly in patients with rotator cuff arthropathy.

FUNDINGS

None.

DATA AVAILABILITY

This study was conducted within the rules of the project of the Italian Arthroplasty Registry.

REFERENCES

1. Buck FM, Jost B, Hodler J. Shoulder arthroplasty. *Eur Radiol*. 2008;18(12):2937-48. doi: 10.1007/s00330-008-1093-8.
2. Macias-Hernandez SI, Morones-Alba JD, Miranda-Duarte A, et al. Glenohumeral osteoarthritis: overview, therapy, and rehabilitation. *Disabil Rehabil*. 2017;39(16):1674-82. doi: 10.1080/09638288.2016.1207206.
3. Davey MS, Hurley ET, Anil U, et al. Management options for proximal humerus fractures - A systematic review & network meta-analysis of randomized control trials. *Injury*. 2022;53(2):244-9. doi: 10.1016/j.injury.2021.12.022.
4. McLaughlin R, Tams C, Werthel JD, et al. Reverse Shoulder Arthroplasty yields similar results to Anatomic Total Shoulder Arthroplasty for the treatment of Humeral Head Avascular Necrosis. *J Shoulder Elbow Surg*. 2022;31(6S):S94-S102. doi: 10.1016/j.jse.2021.11.011.
5. Vervaecke AJ, Carbone AD, Zubizarreta N, et al. Reverse shoulder arthroplasty for rotator cuff tears with and without prior failed rotator cuff repair: A large-scale comparative analysis. *J Orthop*. 2022;31:1-5. doi: 10.1016/j.jor.2022.03.002.
6. Millett PJ, Gobeze R, Boykin RE. Shoulder osteoarthritis: diagnosis and management. *Am Fam Physician*. 2008;78(5):605-11. Available at: https://www.aafp.org/link_out?pmid=18788237.
7. Padegimas EM, Maltenfort M, Lazarus MD, Ramsey ML, Williams GR, Namdari S. Future patient demand for shoulder arthroplasty by younger patients: national projections. *Clin Orthop Relat Res*. 2015;473(6):1860-7. doi: 10.1007/s11999-015-4231-z.
8. Bullock GS, Garrigues GE, Ledbetter L, Kennedy J. A Systematic Review of Proposed Rehabilitation Guidelines Following Anatomic and Reverse Shoulder Arthroplasty. *J Orthop Sports Phys Ther*. 2019;49(5):337-46. doi: 10.2519/jospt.2019.8616.
9. Guarrella V, Chelli M, Domos P, Ascione F, Boileau P, Walch G. Risk factors for instability after reverse shoulder arthroplasty. *Shoulder Elbow*. 2021;13(1):51-7. doi: 10.1177/1758573219864266.
10. Boileau P, Watkinson DJ, Hatzidakis AM, Balg F. Grammont reverse prosthesis: design, rationale, and biomechanics. *J Shoulder Elbow Surg*. 2005;14(1 Suppl S):147S-61S. doi: 10.1016/j.jse.2004.10.006.

CONTRIBUTIONS

AMR, FA, FO: conceptualization. SL: database providing, data investigation. FC, EM: writing. FO, GN, PC: visualization. NM: supervision.

CONFLICT OF INTERESTS

AMR and FA receive fees for consulting from Exactech Inc. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. The other authors declare no conflict of interests.

11. Rasmussen JV, Hole R, Metlie T, et al. Anatomical total shoulder arthroplasty used for glenohumeral osteoarthritis has higher survival rates than hemiarthroplasty: a Nordic registry-based study. *Osteoarthritis Cartilage*. 2018;26(5):659-65. doi: 10.1016/j.joca.2018.02.896.
12. Corona K, Cerciello S, Ciolli G, et al. Clinical Outcomes and Joint Stability after Lateralized Reverse Total Shoulder Arthroplasty with and without Subscapularis Repair: A Meta-Analysis. *J Clin Med*. 2021;10(14):3014. doi: 10.3390/jcm10143014.
13. Best MJ, Aziz KT, Wilckens JH, McFarland EG, Srikanth U. Increasing incidence of primary reverse and anatomic total shoulder arthroplasty in the United States. *J Shoulder Elbow Surg*. 2021;30(5):1159-66. doi: 10.1016/j.jse.2020.08.010.
14. Harjula JNE, Paloneva J, Haapakoski J, Kukkonen J, Aarimaa V, Finnish Shoulder Arthroplasty Registry G. Increasing incidence of primary shoulder arthroplasty in Finland - a nationwide registry study. *BMC Musculoskelet Disord*. 2018;19(1):245. doi: 10.1186/s12891-018-2150-3.
15. Giorgi PD, Gallazzi E, Capitani P, et al. How we managed elective, urgent, and emergency orthopedic surgery during the COVID-19 pandemic: The Milan metropolitan area experience. *Bone Jt Open*. 2020;1(5):93-7. doi: 10.1302/2633-1462.15.BJO-2020-0016.
16. Clement ND, Oussedik S, Raza KI, Patton RFL, Smith K, Deehan DJ. The rate of patient deferral and barriers to going forward with elective orthopaedic surgery during the COVID-19 pandemic. *Bone Jt Open*. 2020;1(10):663-8. doi: 10.1302/2633-1462.110.BJO-2020-0135.R1.
17. Lubbeke A, Rees JL, Barea C, Combescure C, Carr AJ, Silman AJ. International variation in shoulder arthroplasty. *Acta Orthop*. 2017;88(6):592-9. doi: 10.1080/17453674.2017.1368884.
18. Longo UG, Papalia R, Castagna A, et al. Shoulder replacement: an epidemiological nationwide study from 2009 to 2019. *BMC Musculoskelet Disord*. 2022;23(1):889. doi: 10.1186/s12891-022-05849-x.
19. Westermann RW, Pugely AJ, Martin CT, Gao Y, Wolf BR, Hettrich CM. Reverse Shoulder Arthroplasty in the United States: A Comparison of National Volume, Patient Demo-

- graphics, Complications, and Surgical Indications. *Iowa Orthop J.* 2015;35:1-7. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC26361437/>.
20. Day JS, Lau E, Ong KL, Williams GR, Ramsey ML, Kurtz SM. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. *J Shoulder Elbow Surg.* 2010;19(8):1115-20. doi: 10.1016/j.jse.2010.02.009.
 21. Merolla G, Walch G, Ascione F, et al. Grammont humeral design versus onlay curved-stem reverse shoulder arthroplasty: comparison of clinical and radiographic outcomes with minimum 2-year follow-up. *J Shoulder Elbow Surg.* 2018;27(4):701-10. doi: 10.1016/j.jse.2017.10.016.
 22. Ferrel JR, Trinh TQ, Fischer RA. Reverse total shoulder arthroplasty versus hemiarthroplasty for proximal humeral fractures: a systematic review. *J Orthop Trauma.* 2015;29(1):60-8. doi: 10.1097/BOT.0000000000000224.
 23. Boileau P, Krishnan SG, Tinsi L, Walch G, Coste JS, Mole D. Tuberosity malposition and migration: reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. *J Shoulder Elbow Surg.* 2002;11(5):401-12. doi: 10.1067/mse.2002.124527.
 24. Reitman RD, Kerzhner E. Reverse shoulder arthroplasty as treatment for comminuted proximal humeral fractures in elderly patients. *Am J Orthop (Belle Mead NJ).* 2011;40(9):458-61. Available at: <https://pubmed.ncbi.nlm.nih.gov/22022675/>.
 25. Kralinger F, Schwaiger R, Wambacher M, et al. Outcome after primary hemiarthroplasty for fracture of the head of the humerus. A retrospective multicentre study of 167 patients. *J Bone Joint Surg Br.* 2004;86(2):217-9. doi: 10.1302/0301-620x.86b2.14553.
 26. Romano AM, Braile A, Casillo P, et al. Onlay Uncemented Lateralized Reverse Shoulder Arthroplasty for Fracture Sequelae Type 1 with Valgus/Varus Malunion: Deltoid Lengthening and Outcomes. *J Clin Med.* 2020;9(10):3190. doi: 10.3390/jcm9103190.
 27. Ascione F, Damos P, Guarrella V, Chelli M, Boileau P, Walch G. Long-term humeral complications after Grammont-style reverse shoulder arthroplasty. *J Shoulder Elbow Surg.* 2018;27(6):1065-71. doi: 10.1016/j.jse.2017.11.028.
 28. Giardella A, Ascione F, Mocchi M, et al. Reverse total shoulder versus angular stable plate treatment for proximal humeral fractures in over 65 years old patients. *Muscles Ligaments Tendons J.* 2017;7(2):271-8. doi: 10.11138/mltj/2017.7.2.271.
 29. Sevivas N, Ferreira N, Andrade R, et al. Reverse shoulder arthroplasty for irreparable massive rotator cuff tears: a systematic review with meta-analysis and meta-regression. *J Shoulder Elbow Surg.* 2017;26(9):e265-e77. doi: 10.1016/j.jse.2017.03.039.
 30. Hartzler RU, Steen BM, Hussey MM, et al. Reverse shoulder arthroplasty for massive rotator cuff tear: risk factors for poor functional improvement. *J Shoulder Elbow Surg.* 2015;24(11):1698-706. doi: 10.1016/j.jse.2015.04.015.
 31. Romano AM, Oliva F, Nastrucci G, et al. Reverse shoulder arthroplasty patient personalized rehabilitation protocol. Preliminary results according to prognostic groups. *Muscles Ligaments Tendons J.* 2017;7(2):263-70. doi: 10.11138/mltj/2017.7.2.263.
 32. Oliva F, Piccirilli E, Bossa M, et al. I.S.Mu.L.T - Rotator Cuff Tears Guidelines. *Muscles Ligaments Tendons J.* 2015;5(4):227-63. doi: 10.11138/mltj/2015.5.4.227.
 33. Sellers TR, Abdelfattah A, Frankle MA. Massive Rotator Cuff Tear: When to Consider Reverse Shoulder Arthroplasty. *Curr Rev Musculoskelet Med.* 2018;11(1):131-40. doi: 10.1007/s12178-018-9467-2.
 34. Godin JA, Pogorzelski J, Horan MP, et al. Impact of Age and Subscapularis Tendon Reparability on Return to Recreational Sports Activities and 2-Year Outcomes After Reverse Total Shoulder Arthroplasty. *Orthop J Sports Med.* 2019;7(10):2325967119875461. doi: 10.1177/2325967119875461.
 35. Lachance AD, Peebles AM, McBride T, Eble SK, Provencher MT. Subscapularis repair techniques for reverse total shoulder arthroplasty: A systematic review. *J ISAKOS.* 2022;7(6):181-8. doi: 10.1016/j.jisako.2022.05.001.
 36. Franceschetti E, de Sanctis EG, Ranieri R, Palumbo A, Paciotti M, Franceschi F. The role of the subscapularis tendon in a lateralized reverse total shoulder arthroplasty: repair versus nonrepair. *Int Orthop.* 2019;43(11):2579-86. doi: 10.1007/s00264-018-4275-2.
 37. Jawa A, Colliton EM. Role of Subscapularis Tendon Repair in Reverse Total Shoulder Arthroplasty. *J Am Acad Orthop Surg.* 2021;29(14):604-8. doi: 10.5435/JAAOS-D-20-01151.
 38. Berliner JL, Regalado-Magdos A, Ma CB, Feeley BT. Biomechanics of reverse total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2015;24(1):150-60. doi: 10.1016/j.jse.2014.08.003.
 39. Beltrame A, Di Benedetto P, Cicuto C, Cainero V, Chisoni R, Causero A. Onlay versus Inlay humeral stem in Reverse Shoulder Arthroplasty (RSA): clinical and biomechanical study. *Acta Biomed.* 2019;90(12-S):54-63. doi: 10.23750/abm.v90i12-S.8983.