Chapter 5

Current Outcomes Following Reverse Total Shoulder Arthroplasty: A Composite

Sydney C. Cryder, Samuel E. Perry and
Elizabeth A. Beverly

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.72545

Abstract

Reverse Total Shoulder Arthroplasty (RTSA) is a popular treatment for patients with rotator cuff damage, glenohumeral arthritis, complex fractures, and previously failed total shoulder arthroplasty given its ability to alleviate pain and increase range of motion and function. Although RTSA significantly improves functionality, pain, and satisfaction, patients need to be given realistic expectations for when to expect improvements, peak performance, and plateaus as well as potential risks for negative outcomes. As with any surgical procedure, patients are at risk for intraoperative, perioperative, short-term, and long-term complications. Thus, the purpose of this review is to discuss the short-term and long-term complications, metrics, and length of follow-up for patients who have undergone RTSA. In addition, we provide recommendations for a cut-off point between short-term and long-term outcomes for RTSA.

Keywords: reverse total shoulder arthroplasty, joint prosthesis, shoulder joint surgery, rotator cuff surgery, short-term outcomes, long-term outcomes

1. Introduction

In 1985, Dr. Paul Grammont introduced a new system for reverse total shoulder prosthesis that revolutionized the field by focusing on four key features: (1) the prosthesis must be inherently stable; (2) the lever arm of the deltoid must be effective from the initiation of the movement; (3) the glenosphere must be large and the humeral cup small to create a semi-constrained articulation; (4) the center of rotation must be fixed, medialized and distalized with respect to the glenoid surface [1, 2]. To this day, Grammont's core features are still the mainstay. Of course, modern prosthetics have been modified since 1985 to avoid scapular notching and impingement between the greater tuberosity and the coracoacromial arch and to maximize compressive forces while minimizing shear forces [2, 3].

These advancements contributed directly to the increased utilization of Reverse Total Shoulder Arthroplasty (RTSA) [4]. In fact, in the last ten years, the number of RTSAs nearly tripled in the United States [5]. Reverse Total Shoulder Arthroplasty (RTSA) is a popular treatment for patients with rotator cuff damage, glenohumeral arthritis, complex fractures, and previously failed total shoulder arthroplasty given its ability to alleviate pain and increase range of motion and function. Although RTSA significantly improves functionality, pain, and satisfaction, patients need to be given realistic expectations for when to expect improvements, peak performance, and plateaus as well as potential risks for negative outcomes. As with any surgical procedure, patients are at risk for intraoperative, perioperative, short-term, and long-term complications. Thus, the purpose of this review is to discuss the short-term and long-term complications, metrics, and length of follow-up for patients who have undergone RTSA. In addition, we provide recommendations for a cut-off point between short-term and long-term outcomes for RTSA.

Ease range of motion and function in patients with glenohumeral joint disease, displaced proximal humeral fractures, rotator cuff tear arthropathy, severe irreparable rotator cuff tears, rheumatoid arthritis, and failed shoulder arthroplasty [1–3, 6–8].

2. Surgical approach

The surgical technique for RTSA can be accomplished via two approaches: deltopectorally or superolaterally [3, 9]. The deltopectoral approach is the most common and requires an experienced surgeon [10]. This surgical technique begins with an incision overlying the deltopectoral interval, preserving the cephalic vein, then tenotomizing the biceps tendon and the subscapularis if still intact [3, 11, 12]. Next, the joint capsule is circumferentially released and humeral head exposed to perform a humeral head osteotomy. The humeral head is then reamed and broached. Subsequently, the glenoid is exposed, the labrum excised, and the glenoid prepared. The guidewire for the glenoid reamer is placed inferiorly so that the glenoid baseplate will be flush with the inferior border of the native glenoid rim. This will help decrease the risk of scapular notching. By adding an inferior tilt to the position of the baseplate, the risk of scapular notching can be decreased, which in turn, improves compressive forces and helps avoid shear forces on the glenoid component. The baseplate is impacted in place, and secured with screws to securely fix the baseplate to the patient's native glenoid. The selected glenosphere is then secured to the baseplate with a Morse Taper fixation mechanism. The selection of the appropriately sized glenosphere is multifactorial. It is based on the patient's size (i.e., 42 mm for larger patients, 39 mm for average size patients, 36 mm for smaller patients) and individual patient pathologies. Glenosphere components are available in central, lateral offset, and inferior offset designs.

Next, the humeral stem is prepared by sounding the inner diameter of the humeral shaft and broaching it to the appropriate size. The final implant is tested with the spacer trials in

http://dx.doi.org/10.5772/intechopen.72545

order to gain proper stability and range of motion. Then the real implants are seated and the shoulder is reduced. Lastly, the subscapularis is reattached and the biceps are tenodesed with heavy nonabsorbable sutures that are placed through drill holes in the humeral metaphysis prior to seating of the final implant. However, recent research acknowledges the controversy surrounding the reattachment of the subscapularis due to the potential for increasing the likelihood of dislocation [13]. The deltopectoral-interval is re-approximated and the incision closed. The patient is placed in a shoulder abduction sling for a period of immobilization lasting two to 6 weeks with a home physical therapy program [14]. As with all orthopedic procedures, the rehabilitation protocol is patient specific and additional rehabilitation may be deemed necessary if the patient needs to strengthen external rotation [14].

3. Outcome timeline

What constitutes a short-term versus a long-term outcome? One of the objectives of this review is to address the lack of clarity in the literature regarding the timeline of short-term and long-term outcomes [15]. Bacle and colleagues [15] identified that the majority of mechanical loosening reports occurred outside of the first 2 years following a reverse total shoulder arthroplasty. In contrast, dislocation, infection, and poor seating of the glenoid component were reported within the first 2 years postoperatively; a ratio of 3 to 1 for complications reported before and after the two-year mark [15]. Furthermore, Bacle and colleagues [15] defined medium-term follow-up as a mean of 39 months and long-term follow-up as a mean of 150 months. Similarly, Otto and colleagues [16] argued that a follow-up of period of 24 months was a relatively short time frame to adequately capture long-term complications. Thus, 2 years may be a respectable partition between short-term and long-term outcomes.

4. Outcome quantification

The language of RTSA outcomes is a complex task given the wide range of outcomes metrics. The most common scoring methods include the following: Range of Motion (ROM), Constant-Murley Score (CMS), American Surgeons of Elbow and Shoulder score (ASES), Visual Analogue Score (VAS), and the Simple Shoulder Test (SST). Other methods include but are not limited to the UCLA Shoulder Score and the Shoulder Pain and Disability Index (SPADI) [17–19]. The CMS, first published in 1987, is comprised of four sections: two of which are self-reported by the patient—pain and activities of daily living, the remaining two are reported by the physician—range of motion and strength [20]. Concerns were raised regarding the score's ability to account for age and gender; thus, the modified version adjusts for both [17]. The ASES was created with the goal of developing a universal outcome measure; it too contains patient-reported and physician-reported parts. In addition, the ASES has demonstrated appropriate validity and reliability in assessing operative and non-operative interventions for shoulder pathology [17]. However, it's appraisal of functionality may be somewhat limited among the older adult population; for example, the questions about "do usual sport" and "throw ball overhand" may not be relevant [19]. Patient-reported pain is an outcome that necessitates acknowledgement, which may be quantified by utilizing the VAS [21]. The VAS uses a line measuring 100 mm with pain extremes indicated on either end; no pain and worst pain [21]. The patient marks along the continuum where he/she believes their pain is best described; the score is then represented by a distance in millimeters [22]. Finally, the SST, is used to evaluate patient-reported functionality associated with various shoulder pathology, including rotator cuff arthropathy, osteoarthritis, rheumatoid arthritis, and adhesive capsulitis [17, 18]. This questionnaire consists of 12 questions that ask the patient whether he/she may perform the given activity [18].

5. Short-term outcomes

Table 1 reviews the outcome measures and length of follow-up from numerous surgical studies. Based on these findings, short-term outcomes for RTSA occur postoperatively within the first 24 months. It also addresses the variation in components and metrics used in each study.

RTSA significantly improves functionality, pain, and satisfaction; but when are patients expected to experience peak performance with a new prosthesis? Is there a point in time when a patient should expect a plateau in their improvements over time? In 2015, Simovitch and colleagues [23] demonstrated that at the 6-month follow-up, less than 5% of patients reported decreases in SST, UCLA Shoulder Score, CMS, ASES, SPADI. More importantly, "full improvement" was achieved in the 12–24 month range [23]. Thus, they concluded that the majority of improvement occurred within the first 6 months, as evidenced by the scores for each of the five measures [23]. These findings stress the importance of patient selection, expectations for RTSA, expertise in intraoperative optimization, and strict postoperative physical therapy management. The concept of rapid improvement during the first 6 months with plateau at 12 months was also reported by Muller and colleagues in 2017 [24], in which flexion, abduction, and external rotation in 90 degrees of abduction demonstrated profound increases by 42°, 38° and 33° respectively at 6 months. Additional follow-ups at 12, 24, and 60 months displayed minimal additional improvement [24]. Supplementary evidence of RTSA success was seen by Yoon and colleagues [25] in 2017 with forward flexion increase of 64°, external rotation increase of 13° and pain reduction of (−3) at 12 months postoperatively.

Two factors that have been shown to increase CMS and ROM testing during the short-term period are deltoid volume [25] and glenosphere size [24] respectively. Preoperative deltoid muscle volume was an independent prognostic factor for functional outcomes with CMS ($p = 0.011$), underscoring the importance of patient selection and discussing the potential for negative outcomes such as atrophied deltoid muscle [25]. Likewise, Muller and colleagues [24] conducted a retrospective analysis in 2017, to demonstrate that patients that had received a 44 mm glenosphere had greater external rotation in adduction and abduction strength over the 36 mm glenosphere. Moreover, they found no significant differences in functional scores or complication rates [24].

http://dx.doi.org/10.5772/intechopen.72545

Study	Sample size	Age	Follow up	Complications	Component variability	Risk factors	Scoring Mechanism
Alentorn-Geli et al (2017)	38	77–83 years	3–60 months	Infection Glenoid loosening Revisions Component Dislocation	Comprehensive reverse shoulder system (Biomet) Encore reverse (DJO Global) Delta reverse shoulder System (DePuy)	Tobacco use Diabetes Mellitus Hypertension Increased age	FF ER
Anakwenze et al (2016)	1147	45–84 years	3–36 months	Aseptic revision Mortality Surgical site infection Readmission	-	Increased BMI Diabetes Mellitus Increased age	-
Bacle et al (2017)	186	23–86 years (72.7 mean)	24–150 months	Dislocation Scapular Notching Infection Nerve Palsy Glenoid Loosening Humeral Loosening Glenoid fracture Revisions	164 Delta III (DePuy) 27 Aequalis (Tournier)	Increased age	CMS ROM
Ek et al. (2013)	41	46–64 years	60–171 months	Infection Nerve Palsy Fracture Dislocation Component Wear Glenoid loosening	Glenoid component 36mm, 40mm, or 42 mm Delta III (DePuy) (lateralized humeral polyethylene cup) Anatomical Shoulder System (Zimmer) (6mm medialized humeral cup)	Previous surgery on same shoulder	CMS Validated electronic dynamometer
Feeley et al (2014)	54	53–81 years	30 months	Scapular notching	Zimmer Reverse Trabecular Metal System 36mm glenosphere 3mm lateralized	-	VAS ASES score ROM

Study	Sample size	Age	Follow up	Complications	Component variability	Risk factors	Scoring Mechanism
Friedman et al (2017)	591	50–93 years	24 month minimum (37 month mean)	Component instability Scapular notching	Equinoxe rTSA (Exactech)	-	SST ASES score UCLA score CMS SPADI
Jonusas et al (2017)	27	55–85 years	45 months	Heterotopic ossification Tubercule malposition	Arrow shoulder system with less medialized CoR	-	SST CMS
Mollon et al (2016)	476	53–90 years	22–93 months	Scapular notching Dislocation Infection Component Loosening Humeral fracture Scapular fracture	Equinoxe rTSA (Exactech) 36 mm, 40mm, or 42mm glenosphere lateralized 2.3mm	Increased age Increased BMI	ROM ASES score CMS SST
Muller et al (2017)	68	68–79 years	6–60 months	Glenoid migration Component loosening	SMR reverse shoulder system (Lima Switzerland SA) 36mm or 40mm glenosphere	Increased age	CMS SPADI
Otto et al. (2017)	67	21–54 years	24–144 months	Scapular notching Humeral lucency Glenoid screw lucency Fracture (humeral, scapular) Humeral dissociation Infection Instability Revision	Reverse shoulder system (DJO Surgical)	Prior shoulder surgery	SST ASES score
Randelli et al (2015)	226	64–72 years	3.8 years	Revision Infection Fracture	Delta III	-	Constant Score ASES score

Study	Sample size	Age	Follow up	Complications	Component variability	Risk factors	Scoring Mechanism
Simovitch et al (2015)	912	60–78 years	2 weeks–139 months	-	Equinoxe rTSA system (Exactech)	-	SPADI ASES score UCLA score Constant score
Statz et al (2016)	41	53–83 years	2–7.3 years	Scapular notching Revision Nerve palsy Heterotopic ossification	Encore reverse shoulder Prosthesis (DJO Surgical) Delta III, Delta Xtend (DePuy) Comprehensive prosthesis (Biomet) Aequalis Reversed Shoulder (Tournier)	Increased BMI Previous shoulder surgery Tobacco use Diabetes mellitus	ROM ASES score
Wierks et al (2007)	20	45–88 years	3–21 months	Fracture Poor screw fixation Nerve palsy Infection/ Abscess Dislocation Revision Heterotopic ossification Scapular notching	DePuy reverse shoulder prosthesis Tournier reverse shoulder prosthesis	-	-
Williams et al (2017)	17	45–91 years	10–67.7 months	Dislocation Component migration	Biomet reverse adapter (Bio-Modular to Comprehensive conversion)	-	VAS ASES score
Yoon et al (2017)	35	66–84 years	12–35 months	Scapular notching A/C joint separation Acromial fracture	Aequalis reverse arthroplasty system (Tournier)	Increase BMI Diabetes mellitus Hypertension Decreased BMD	VAS ASES score Constant score SST

ASES = American shoulder and elbow surgeons; SPADI = shoulder pain and disability index; ROM = range of motion; UCLA = University of California Los Angeles score; SST = simple shoulder test; VAS = visual analogue score; FF = forward flexion; ER = external rotation; BMD = bone mineral density.

Table 1. Comparison of outcome measures and length of follow-up for patients undergoing reverse total shoulder arthroplasty.

Complications are a critical component of RTSA. Patients need to be counseled on intraoperative, perioperative, and notably, short-term complications. The most common intraoperative complications are glenoid or humeral fractures along with poor screw fixation [12]. The consequence of poor screw fixation is its lasting impact and conversion to long-term complications such as glenoid screw lucency. Zhou and colleagues [13] discussed the prevention techniques, such as hand reaming the humerus and preserving glenoid bone stock by avoiding reaming beyond subchondral bone margin. Postoperative short-term complications dominate the outcomes of RTSA and range from scapular notching, infection, dislocation, revision, nerve palsy, or even heterotopic ossification.

Scapular notching is by far the most common complication during the first 24 months postoperative. Scapular notching has an incidence of 38%, 57%, 55% and 73% in four recent studies respectively [12, 15, 24, 25]. These findings oblige additional research to review instrumentation and confirm incidence levels on scapular notching in RTSA. In 2014, Feeley and colleagues [12] found that decreasing the neck-shaft angle or a higher inclination angle and 3 mm lateral offset of the glenosphere prosthesis decreased the rate of scapular notching by 16%. Furthermore, Zhou and colleagues [13] assert that continued complication management, by adding inferior placement of the glenosphere, is "the most important factor in the avoidance of inferior impingement." The next step is to investigate whether scapular notching will evolve, both de novo and from early to late stage scapular notching during short-term follow-up. An important question to consider is will the patient be free from scapular notching for the remainder of the prosthesis? [12] Feeley and colleagues [12] observed that of all the patients who did not experience scapular notching during the first 12 months (84% of patients), showed no new evidence of scapular notching during follow-ups up to 30 months. Conversely, Bacle and colleagues [15] found that after early scapular notching diagnoses were made, there was a 39% increase in the rate of notching beyond the 2-year follow-up period. Thus, superfluous research is essential to answer this question.

Another common short term complication deals with postoperative stability resulting in shoulder dislocations. Wierks [12] and colleagues as well as Bacle [15] and colleagues found 10% and 22% of dislocations occurred during the short term period. Of note, Bacle and colleagues [15] published that of the 15 dislocations documented in the sample size of 67, no cases were reported after the 2 year follow-up period. Zhou and colleagues [26] reviewed the most common and serious complications associated with RTSA and concluded that instability was a result of "lack of soft tissue tension, mechanical impingement, mismatch of the glenosphere and humeral socket size and improper version of the prosthesis". Therefore, to obtain the best outcome for patients, extensive knowledge of the prosthesis is imperative, along with understanding how to achieve soft tissue tension using vertical offset of your acromion—greater tuberosity distance and lateral offset of the tuberosity-glenoid distance [26]. Conversely, controversy exists within the RTSA literature regarding the decision to repair the subscapularis. Friedman and colleagues showed that subscapularis repair proclaimed no statistical significance over no repair [27]. In the study, 340 patients with RTSA plus repair had 0% dislocation rate, versus 251 patients with RTSA without repair showing a 1.2% dislocation rate; stating the claim that RTSA plus subscapularis repair is not indicated due to the absence of increase in overall complication rates [27].

Lastly, infections can have serious ramifications on patient satisfaction as well as the overall outcomes of the RTSA, resulting in one or two-stage revisions. A study conducted by Wierks and colleagues [12] in 2009, had a 5% infection rate and a study by Bacle and colleagues [15] in 2017, had an infection rate of 12%. It is important to emphasize that Bacle and colleagues [15] documented 8 infections within the first 24 months as compared to only 2 cases in the 12 year follow-up period. In the same study, with regards to revision cases in the short-term period, 6 out of the 8 revision surgeries were caused by infections [15]. Thus, postoperative infections that occur in the first two years are the most common reason for revision surgery. In the review conducted by Zhou and colleagues [26] in 2015, they compared primary cases and revision cases, to find that revision cases were statistically higher than primary cases with regards to infections rates, 5.9% vs. 2.9% respectively. *Propionibacterium acnes* and *Staphylococcus epidermidis* were the most commonly cultured organisms. Recommendations to decrease infections include continuation of preoperative antibiotics within one hour of incision and use of antibiotic-impregnated cement for surgeries that employ cement the humeral component [26].

6. Long-term outcomes

The patient's age at the time of the arthroplasty plays a critical role in the survival of the prosthesis; younger patients (i.e., < 55 years of age) are more likely to be active in the workforce, while older patients are less likely to participate in physically strenuous activities and be retired [16]. In younger patients, prosthesis survival can exceed 10 years. For example, Bacle and colleagues [15] observed a 93% implant survival rate at 10 years; whereas Ek and colleagues [28] observed an implant survival rate of 88% at 5 years and 76% at 10 years postoperatively, regardless of any complications that may have arisen.

The RTSA has been shown to improve pain, strength, range of motion in abduction, external rotation, and forward flexion; in addition to showing improvement in metrics, such as ASES, SST, CMS, SPADI, and UCLA Should and UCLA Shoulder Score [16, 23, 24, 29]. Outcomes beyond the 24-month mark may be impacted by multiple variables, some of which include, prosthesis sizes, involvement of fracture, primary versus revision RTSA, and the lifestyle or activity level of the patient. In regards to repair of proximal humeral fractures, RTSA was found to provide superior results to a hemiarthroplasty for at least 5 years, respectively [30]. Muller and colleagues [24] investigated the size of the glenosphere, 36 mm and 44 mm, on functional outcomes following RTSA and found that both groups exhibited the most substantial progress in the first 6–24 months, followed by a plateau. Patients' progress was monitored by measuring flexion, abduction, external rotation at 0° and 90° of abduction, internal rotation at 90° of abduction, CMS, SPADI, and strength (kg) in abduction. Interestingly, Anakwenze and colleagues [31] found that a higher body mass index (BMI) put a patient at risk for deep surgical site infection (SSI) up to 3 years following RTSA. Their study looked at the effects of increased BMI on postoperative outcomes following a RTSA and total shoulder arthroplasty (TSA). Every 5 kg/m [2] increase in BMI was associated with higher risk of 3-year deep SSI [31]. In addition to BMI, tobacco use influences the success of the prosthesis up to 12 years after an RTSA [32]. Hatta and colleagues [32] found that current smokers had an increased risk for infection, component loosening, and fractures compared to non-smokers. Specifically, they found that the percentage of patients with periprosthetic fractures jumped 20% at the 9 year mark after RTSA [32].

Although, as previously stated, this study implies 24 months as the short-term interval for outcomes following an RTSA, short-term complications have the potential to extend into the long-term if not addressed or managed appropriately—eventually affecting the longevity of the prosthesis. More commonly, long-term complications include glenoid and/or humeral component loosening, polyethylene component wear, and scapular notching. Less common long-term complications include deep SSI, dislocation, readmission, and fracture; which primarily occur within the first 2 years postoperatively. As mentioned above, glenoid or humeral loosening is the most common complication observed 2 years after RTSA, particularly with an increased risk following a previously failed shoulder arthroplasty and excess mechanical load related to increased BMI [15, 33]. Further, the incidence of component loosening doubles between the second and fifth year follow-up as reported by Alentorn-Geli and colleagues [29]. Particlization of the polyethylene component may be of concern with RTSA in younger patients due to necessary durability and lifespan of the implant. Riley and colleagues [34] investigated the outcomes following RTSA using a metal-on-metal design and concluded that it is not an acceptable alternative to RTSA in young patients; they maintain that the polyethylene component is the more suitable option. Ek and colleagues [28] conducted a study evaluating RTSA in patients younger than 65 years of age using two groups: revision RTSA and primary RTSA. This study observed an increased incidence of scapular notching at less than 12 months follow-up and greater than 10 years follow-up; with 56% of patients experiencing some degree of scapular notching overall [28]. Conversely, Mollon and colleagues [34] reported that only 10% of patients experienced scapular notching; noting that risk factors for scapular notching included lower body weight, lower BMI, and RTSA on the non-dominant upper extremity. It is also worth mentioning the correlation between longer-term follow-up and increasing incidence of scapular notching [34]; which may be attributed to variation in size and placement of the glenosphere, and center of rotation of the prosthesis.

7. Conclusion

Throughout this literature review, several limitations were encountered that include the following: unspecified “normal” postoperative physical rehabilitation protocols, risk factors pertinent to specific complications, and lack of research investigating the long term outcomes for RTSA. Additional research is needed to examine the aforementioned limitations to enhance future outcomes following RTSA.

Scapular notching, dislocations, and infections lead the forefront of persistent complications for RTSA. As evidenced in this literature review, the vast majority of improvement plateaus around 6 to 24 months. Thus, patient optimization may be accomplished by implementing a short-term course of preoperative physical therapy focused on shoulder girdle strength. Further, numerous inconsistencies and contradictions were observed in the literature regarding the impact of BMI on RTSA outcomes. Research requires further confirmatory evidence before making any strong conclusions about limiting the use of RTSA in patients with increased BMI. On the other hand, tobacco use negatively impacts the outcomes following RTSA by nearly doubling the overall complication rate.

Author details

Sydney C. Cryder[1]*, Samuel E. Perry[2] and Elizabeth A. Beverly[3]

*Address all correspondence to: sc323908@ohio.edu

1 Department of Medicine, Ohio University, Heritage College of Osteopathic Medicine, Athens, United States

2 Department of Graduate Medical Education, Adena Health System, Chillicothe, United States

3 Department of Family Medicine, Ohio University, Heritage College of Osteopathic Medicine, Athens, United States

References

[1] Berliner JL, Regalado-Magdos A, Ma CB, Feeley BT. Biomechanics of reverse total shoulder arthroplasty. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeons…[et al.]. Jan 2015;**24**(1):150-160

[2] Nam D, Kepler CK, Neviaser AS, et al. Reverse total shoulder arthroplasty: Current concepts, results, and component wear analysis. The Journal Of Bone And Joint Surgery. American volume. Dec 2010;**92**(Suppl 2):23-35

[3] Schairer WW, Nwachukwu BU, Lyman S, Craig EV, Gulotta LV. National utilization of reverse total shoulder arthroplasty in the United States. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeon. Jan 2015;**24**(1):91-97

[4] 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 demographics, complications, and surgical indications. The Iowa Orthopaedic Journal. 2015;**35**:1-7

[5] Wiater BP, Baker EA, Salisbury MR, et al. Elucidating trends in revision reverse total shoulder arthroplasty procedures: A retrieval study evaluating clinical, radiographic, and functional outcomes data. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeon. Jul 2015;**24**(12):1915-1925

[6] Middernacht B, Van Tongel A, De Wilde LA. Critical review on prosthetic features available for reversed Total shoulder Arthroplasty. Biomed Research International. 2016;**2016**:3256931

[7] Jo SH, Kim JY, Cho NS, Rhee YG. Reverse Total shoulder Arthroplasty: Salvage procedure for failed prior Arthroplasty. Clinics In Orthopedic Surgery. Jun 2017;**9**(2):200-206

[8] Dilisio MF, Miller LR, Siegel EJ, Higgins LD. Conversion to Reverse Shoulder Arthroplasty: Humeral Stem Retention Versus Revision. Orthopedics. Sep 1 2015;**38**(9):e773-e779

[9] Gadea F, Bouju Y, Berhouet J, Bacle G, Favard L. Deltopectoral approach for shoulder arthroplasty: Anatomic basis. International Orthopaedics. Feb 2015;**39**(2):215-225

[10] Gerber BS, Brodsky IG, Lawless KA, et al. Implementation and evaluation of a low-literacy diabetes education computer multimedia application. Diabetes Care. Jul 2005; **28**(7):1574-1580

[11] Wierks C, Skolasky RL, Ji JH, McFarland EG. Reverse total shoulder replacement: Intraoperative and early postoperative complications. Clinical Orthopaedics And Related Research. Jan 2009;**467**(1):225-234

[12] Zhou HS, Chung JS, Yi PH, Li X, Price MD. Management of complications after reverse shoulder arthroplasty. Current Reviews In Musculoskeletal Medicine. Mar 2015;**8**(1): 92-97

[13] Jarrett CD, Brown BT, Schmidt CC. Reverse shoulder arthroplasty. The Orthopedic Clinics of North America. Jul 2013;**44**(3):389-408 x

[14] Bacle G, Nove-Josserand L, Garaud P, Walch G. Long-Term Outcomes of Reverse Total Shoulder Arthroplasty: A Follow-up of a Previous Study. The Journal of Bone And Joint Surgery. American volume. Mar 15 2017;**99**(6):454-461

[15] Otto RJ, Virani NA, Levy JC, Nigro PT, Cuff DJ, Frankle MA. Scapular fractures after reverse shoulder arthroplasty: Evaluation of risk factors and the reliability of a proposed classification. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeons. Nov 2013;**22**(11):1514-1521

[16] Wylie JD, Beckmann JT, Granger E, Tashjian RZ. Functional outcomes assessment in shoulder surgery. World Journal of Orthopedics. Nov 18 2014;**5**(5):623-633

[17] Roy JS, Macdermid JC, Goel D, Faber KJ, Athwal GS, Drosdowech DS. What is a successful outcome following reverse Total shoulder Arthroplasty? The Open Orthopaedics Journal. 2010;**4**:157-163

[18] Booker S, Alfahad N, Scott M, Gooding B, Wallace WA. Use of scoring systems for assessing and reporting the outcome results from shoulder surgery and arthroplasty. World Journal Of Orthopedics. Mar 18 2015;**6**(2):244-251

[19] Conboy VB, Morris RW, Kiss J, Carr AJ. An evaluation of the constant-Murley shoulder assessment. The Journal of Bone And Joint Surgery. British volume. Mar 1996;**78**(2): 229-232

[20] McCormack HM, Horne DJ, Sheather S. Clinical applications of visual analogue scales: A critical review. Psychological Medicine. Nov 1988;**18**(4):1007-1019

[21] MacDermid JC, Solomon P, Prkachin K. The Shoulder Pain and Disability Index demonstrates factor, construct and longitudinal validity. BMC Musculoskeletal Disorders. Feb 10 2006;**7**:12

[22] Simovitch R, Flurin PH, Marczuk Y, et al. Rate of improvement in clinical outcomes with anatomic and reverse Total shoulder Arthroplasty. Bulletin of the Hospital for Joint Disease. Dec 2015;**73**(Suppl 1):S111-S117

[23] Muller AM, Born M, Jung C, et al. Glenosphere size in reverse shoulder arthroplasty: Is larger better for external rotation and abduction strength? Journal Of Shoulder And Elbow Surgery/American Shoulder and Elbow Surgeons. Jul 24 2017

[24] Yoon JP, Seo A, Kim JJ, et al. Deltoid muscle volume affects clinical outcome of reverse total shoulder arthroplasty in patients with cuff tear arthropathy or irreparable cuff tears. PLoS One. 2017;**12**(3):e0174361

[25] Feeley BT, Zhang AL, Barry JJ, et al. Decreased scapular notching with lateralization and inferior baseplate placement in reverse shoulder arthroplasty with high humeral inclination. International Journal Of Shoulder Surgery. Jul 2014;**8**(3):65-71

[26] Friedman LG, Griesser MJ, Miniaci AA, Jones MH. Recurrent instability after revision anterior shoulder stabilization surgery. Arthroscopy. The Journal Of Arthroscopic & Related Surgery: Official Publication Of The Arthroscopy Association of North America and the International Arthroscopy Association. Mar 2014;**30**(3):372-381

[27] Ek ET, Neukom L, Catanzaro S, Gerber C. Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: Results after five to fifteen years. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeons. Sep 2013;**22**(9):1199-1208

[28] Alentorn-Geli E, Clark NJ, Assenmacher AT, et al. What Are the Complications, Survival, and Outcomes After Revision to Reverse Shoulder Arthroplasty in Patients Older Than 80 Years? Clinical Orthopaedics And Related Research. Jul 2017;**475**(11):2744-2751

[29] Boyle MJ, Youn SM, Frampton CM, Ball CM. Functional outcomes of reverse shoulder arthroplasty compared with hemiarthroplasty for acute proximal humeral fractures. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeons. Jan 2013;**22**(1):32-37

[30] Eneanya ND, Goff SL, Martinez T, et al. Shared decision-making in end-stage renal disease: A protocol for a multi-center study of a communication intervention to improve end-of-life care for dialysis patients. BMC Palliative Care. 2015;**14**:30

[31] Hatta T, Werthel JD, Wagner ER, et al. Effect of smoking on complications following primary shoulder arthroplasty. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeons. Jan 2017;**26**(1):1-6

[32] Statz JM, Schoch BS, Sanchez-Sotelo J, Sperling JW, Cofield RH. Shoulder arthroplasty for locked anterior shoulder dislocation: A role for the reversed design. International Orthopaedics. Jun 2017;**41**(6):1227-1234

[33] Riley C, Idoine J, Shishani Y, Gobezie R, Edwards B. Early Outcomes Following Metal-on-Metal Reverse Total Shoulder Arthroplasty in Patients Younger Than 50 Years. Orthopedics. Sep 01 2016;**39**(5):e957-e961

[34] Mollon B, Mahure SA, Roche CP, Zuckerman JD. Impact of scapular notching on clinical outcomes after reverse total shoulder arthroplasty: An analysis of 476 shoulders. Journal Of Shoulder And Elbow Surgery/American Shoulder And Elbow Surgeons. Jul 2017;**26**(7):1253-1261