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ORTHOPEDICS RESEARCH AND TRAUMATOLOGY

ISSN 2473-0963 Open Journal http://dx.doi.org/10.17140/ORTOJ-1-105

Research

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Volume 1 : Issue 1
Article Ref. #: 1000ORTOJ1105

Article History
Received: May 14th, 2016
Accepted: May 25th, 2016
Published: May 25th, 2016

Citation
Erickson BJ, Campbell K, Jain A, et al. Are post-operative drains beneficial in total and reverse total shoulder arthroplasty?. *Orthop Res Traumatol Open J*. 2016; 1(1): 22-27. doi: 10.17140/ORTOJ-1-105

Are Post-Operative Drains Beneficial in Total and Reverse Total Shoulder Arthroplasty?

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ABSTRACT

Background: Total shoulder arthroplasty (TSA) and reverse total shoulder arthroplasty (RTSA) are effective treatments for glenohumeral arthritis and rotator cuff arthropathy.
Purpose: To determine if the use of a post operative closed-suction drain following TSA and RTSA affects hemoglobin levels, clinical outcomes, and complications.
Hypothesis: Patients who did not receive a drain will have less hemoglobin loss, better clinical outcome scores, and lower complication rates following TSA/RTSA.
Methods: All patients who underwent TSA or RTSA by one of two surgeons between January 1, 2011 and May 15, 2013 were recorded. Patient demographic information was recorded. Patients were grouped based on use of a post-operative deep drain. Pre and post-operative hemoglobin, length of hospital stay, clinical outcome scores, and complications were recorded and analyzed.
Results: Sixty-four patients (average age 58.9±9.9 years, 55% male) underwent RTSA (13) or TSA (51) without the use of a post-operative closed-suction drain; 304 patients (average age 66.7±9.6 years, 55% female) underwent RTSA (179) or TSA (125) with the use of a post-operative closed-suction drain. Average follow up was similar in both groups: 14.95±7.22 months in the drain group and 14.55±6.74 months in the no drain group (p=.723). Using multivariate analysis to control for confounding variables and differences between the two groups, drain usage was correlated with significantly lower postoperative hemoglobin (p=0.0002), longer length of stay ($p\leq$0.0001), and lower postoperative SST (p=0.003).
Conclusion: Closed-suction drain usage following RTSA and TSA leads to greater loss of hemoglobin and longer length of stay. No clinically significant differences in transfusion rate and clinical outcome scores were seen with or without drain usage.

LEVEL OF EVIDENCE: III: case-control study.

KEYWORDS: Total Shoulder Arthroplasty (TSA); Reverse Total Shoulder Arthroplasty (RTSA); drain; Hemoglobin (Hgb); Complications; Shoulder.

INTRODUCTION

Total Shoulder Arthroplasty (TSA) and Reverse Total Shoulder Arthroplasty (RTSA) have become common procedures performed by sports medicine, shoulder and elbow, as well as trauma orthopaedic surgeons.[1,2] In 2011 there were an estimated 66,485 shoulder arthroplasty procedures performed in the United States.[3] Indications for TSA and RTSA include glenohumeral arthritis, rotator cuff arthropathy, three and four part proximal humerus fractures, and others.[4] While some surgeons routinely place a drain post-operatively following TSA and RTSA, others do not. Currently there are no studies in the literature that have compared outcomes, complications, and change in hemoglobin levels in patients undergoing TSA or RTSA who have either

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ISSN 2473-0963 Open Journal http://dx.doi.org/10.17140/ORTOJ-1-105

had a closed-suction drain placed *versus* those who did not have a drain placed.

There have been several studies following total and unicompartmental knee arthroplasty as well as total hip arthroplasty that have evaluated the use of post-operative closed-suction drains.[5-7] While many surgeons still routinely use post-operative drains following total knee arthroplasty (TKA), the data suggests this is unnecessary. Bjerke-Kroll et al reviewed the use of post-operative drains in patients following 598 TKA and 536 total hip arthroplasties (THA).[6] The authors found that not only was the use of a post-operative drain associated with an increase in cost of $538 for a THA and $455 for a TKA, but THA and TKA patients who had a post-operative drain placed had an increase in the number of allogeneic blood transfusion, estimated blood loss, and the THA patients had an increased length of hospital stay.[6] Similarly, Al-Zahid et al found no benefit with the use of post-operative closed-suction or re-infusion drains following primary, elective TKA.[5] These results seem to suggest drains may not be warranted following lower extremity arthroplasty, and as such, it is necessary to determine if these drains are necessary following shoulder arthroplasty.

The purpose of this study was to determine if the use of a post operative closed-suction drain following TSA and RTSA affects hemoglobin levels, clinical outcomes, and complication rates. The authors hypothesize that patients who did not receive a closed-suction drain will have less hemoglobin loss, better clinical outcome scores, and lower complication rates compared to those who did receive a post-operative drain.

METHODS

All consecutive patients who underwent primary TSA or primary RTSA between January 1, 2011 and May 15, 2013 were identified. An Institutional Review Board exemption was granted for this study (exemption number ***). All surgeries were performed by one of the two senior authors (*** or ***) who are both Shoulder and Elbow Fellowship trained surgeons. Both TSA and RTSA patients with at least one year follow up data were eligible for inclusion. Exclusion criteria were: less than one-year follow-up, absence of post-operative hemoglobin levels. Patients were divided into two groups: group one had a post-operative closed-suction drain placed while group two did not have a post-operative drain placed. Charts were retrospectively reviewed to obtain the desired information. Patient demographics (age, body mass index (BMI), sex, ASA class, and diabetes) were recorded and compared between drain and no drain groups. Pre and post operative hemoglobin, length of hospital stay, and clinical outcome scores, including American Shoulder and Elbow Surgeons Shoulder Score (ASES), visual analog scale (VAS); and simple shoulder test score (SST) were recorded. Post-operative hemoglobin was checked on every patient in the morning on post-operative day (POD) 1, and this value was used in the analysis. Complications, including superficial and deep infections, as well as number of revision surgeries were recorded. The number of patients who required an allogeneic transfusion, and the overall number of transfusions were recorded.

The two surgeons whose patients were included were both fellowship trained shoulder and elbow surgeons who perform the RTSA and TSA through the standard deltopectoral approach in a modified beach chair position. One surgeon (***) placed a drain in all TSA and RTSA patients during the entire study period. This surgeon removed all drains on POD 1. The second surgeon (***) used a drain in all TSA and RTSA patients at the start of the study period but switched to not using a drain in all TSA and RTSA patients during the study period. In patients who did receive a drain, this surgeon pulled all drains on POD 1. Hence, there were more patients who received a post-operative drain than those who did not. Both surgeons placed the closed-suction drain into the deep layer of closure. All drains were removed on POD 1, prior to discharge from the hospital. No patient was sent home with a drain. Post-operatively, both surgeons followed to a strict transfusion protocol with a threshold of Hgb<8 g/dl, unless the patient had symptoms due to anemia or hypovolemia (tachycardia that did not respond to pain medication and fluids, or hypotension). As transfusions have associated harms and costs, the surgeons balanced the benefit of treating anemia with the desire to avoid unnecessary transfusions.

Statistical Analysis

Descriptive statistics were calculated for drain and no drain groups with mean±standard deviation for continuous variables and frequency with percentage for categorical data. Univariate analysis was performed to compare the drain to no drain group using Student t test for continuous variables and Fisher's exact test for categorical variables. Multiple preoperative variables differed between drain and no drain groups on univariate analysis. Therefore, to account for this difference, multivariate analyses were performed to determine if drain use or other patient variables served as the main determinant of outcomes. In addition to drain use, patient-related independent variables in the model were: type of TSA (reverse or anatomic), sex (male or female), age, ASA class, presence of diabetes (yes or no), and BMI. Dependent variables were postop ASES score, postop VAS score, postop SST score, postop hemoglobin, and transfusion (yes or no). Baseline preoperative outcome scores (ASES, VAS, SST, and preoperative hemoglobin) were also included in the respective multivariate models. Surgical site infection and reoperation were not analyzed with multivariate regression as these events did not occur in the drain group. $p<0.05$ was considered statistically significant.

RESULTS

Sixty-four patientswith an average age of 58.9±9.9 years, 55% male, underwent either RTSA (13 patients) or TSA (51 patients) without the use of a post-operative closed-suction drain during the study period. Conversely, 304 patients with an average age 66.7±9.6 years, 55% female, underwent either RTSA (179 pa-

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ISSN 2473-0963 Open Journal http://dx.doi.org/10.17140/ORTOJ-1-105

tients) or TSA (125 patients) with the use of a post-operative closed-suction drain. Average follow up was similar in both groups: 14.95±7.22 months in the drain group and 14.55±6.74 months in the no drain group (p=.723). Table 1 shows the pre-operative demographics of each group; it was found that the drain group had a higher percentage of RTSA performed, was older age, had lower pre-op hemoglobin, and had lower SST outcome scores. To account for these differences, multivariate analysis was performed.

The average change in hemoglobin from pre to post surgery was significantly less in the no drain group (2.6±1.1 *vs.* 3.1±1.1 (p=.001)) (Table 2). Average postoperative hemoglobin was significantly higher in the no drain group compared to the drain group (11.5±1.5 *vs.* 10.5±1.5 (p<.001). Average length of hospital stay was significantly less in the no drain group (34.0±13.3 hours *vs*. 54.9±23.5 hours p<.001).Also, the postoperative ASES and SST, and change in SST were significantly better in the no drain group. No differences in superficial or deep infections, reoperations, or transfusions existed seen between groups.

Because of the multiple differences between drain and no drain groups on univariate analysis (% RTSA, age, preop-

	Drain	No Drain	*p* value
Number of Patients	304	64	
% Males	45.40%	55.70%	0.224
ASA Class	2.41±0.55	2.27±0.63	0.072
BMI	30.6±6.3	29.4±6.3	0.168
% Diabetics	11.20%	15.60%	0.434
% RTSA	58.90%	20.30%	<0.001
Age (years)	66.72±9.6	58.91±9.9	<0.001
Length f/u (months)	14.95±7.22	14.55±6.74	0.723
Pre-Op Hgb	13.6±1.5	14.1±1.5	0.016
Pre-Op ASES	37.6±16.6	40.7±16.3	0.442
Pre-Op VAS	5.7±2.4	5±2.4	0.234
Pre-Op SST	3.1±2.3	5±2.7	0.002

Table 1: Demographic characteristics of patients who underwent RTSA/TSA and either had a post-operative closed-suction drain placed or did not have a post-operative drain placed. There were significantly more patients in the drain group who underwent RTSA and these patients were also significantly older and had lower pre-op hemoglobin levels. Additionally, these patients in the drain group were noted to have significantly lower pre-op SST. BMI: Body mass index; ASA: American Society of Anesthesiologists; Hgb: hemoglobin; RTSA: reverse total shoulder arthroplasty.

Outcome scores	Drain	No Drain	*p* value
Post-Op ASES	75.8±20.2	93±16.3	<0.001
Change in ASES	38.2±22.3	48.8±23.9	0.058
Post-Op VAS	1.5±2.1	0.7±1.0	0.081
Change in VAS	3.9±2.7	4.1±2.6	0.759
Post-Op SST	6.6±3.2	10.6±1.3	<0.001
Change in SST	3.7±3.3	5.3±2.5	0.037
Complications:			
% Patient Requiring Transfusion	3%	4.70%	0.445
% Patients with Superficial Wound Infections	0.66%	0%	0.999
% Patients with Deep Wound Infections	0.33%	0%	0.999
% Patients Requiring Revisions	3.30%	0.00%	0.221
Other			
Post-Op Hgb	10.5±1.5	11.5±1.5	<0.001
Change in Hgb	3.1±1.1	2.6±1.1	0.001
Length of Hospital Stay (hours)	54.9±23.5	34±13.3	<0.001

Table 2: Univariate analysis of outcomes and complications comparing drain and no drain groups. This analysis showed that the post-op ASES and SST score, as well as the change in SST were significantly higher in the no drain group. Additionally, it was found that the post-op hemoglobin was higher in the no drain group and the change in hemoglobin was also less in this group. Furthermore, patients who did not have a drain had a significantly shorter length of stay in the hospital after shoulder arthroplasty. Significance is P<0.5 Hgb: hemoglobin; ASES: American Shoulder and Elbow Surgeons Shoulder Score; VAS: visual analog scale; SST: simple shoulder test score.

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ISSN 2473-0963 Open Journal http://dx.doi.org/10.17140/ORTOJ-1-105

Outcome	Drain	RTSA	Age	ASA	Diabetic	BMI	Preop Hgb	Preop ASES	Preop VAS	Preop SST
Postop Hgb	0.0002	0.0007	0.9321	0.7812	0.0808	<.0001	<.0001	-	-	-
Length of stay	<.0001	0.0146	<.0001	0.6439	0.4426	0.086	-	-	-	-
Postop ASES	0.0946	0.2577	0.0656	0.4314	0.9733	0.2719	-	0.034	-	-
Postop VAS	0.1193	0.8367	0.0688	0.7119	0.9877	0.4253	-	-	0.0394	-
Postop SST	0.0031	0.413	0.5414	0.7265	0.4032	0.4169	-	-	-	0.0897
Transfusion	0.5355	0.3274	0.6468	0.7299	0.629	0.109	0.0109	-	-	-

Table 3: Multivariate analysis results including the relevant preoperative score in each regression (or preoperative Hgb for transfusion and postoperative Hgb). Drain usage was correlated with lower postoperative hemoglobin (p=0.0002), longer length of stay (p=<0.0001), and lower postoperative SST (p=0.003). Hgb: hemoglobin; ASES: American Shoulder and Elbow Surgeons Shoulder Score; VAS: visual analog scale; SST: simple shoulder test score; RTSA: reverse total shoulder arthroplasty; ASA: American Society of Anesthesiologists; BMI: Body mass index.

erative Hgb, and preoperative SST, as well as a trend for ASA class), multivariate regression was performed to determine if drain use was the main determinant of outcomes, or if other patient variables had an effect on these outcomes (Table 3). The multivariate analysis which controlled for the differences between groups demonstrated that drain usage was independently correlated with lower postoperative hemoglobin (p=0.0002), longer length of stay (p≤0.0001), and lower postoperative SST (p=0.003), but not with postoperative ASES (p=0.0946), postoperative VAS (p=0.1193), and number or rate of transfusions (p=0.5355). RTSA led to longer length of hospital stay and lower postoperative hemoglobin with no difference in transfusion rate or outcome scores.

DISCUSSION

There is a paucity of literature regarding the use of post-operative closed-suction drains after shoulder arthroplasty, as well as the effect these drains have on change in hemoglobin, clinical outcomes, and complication rates following TSA and RTSA. The authors' hypotheses were partly confirmed in that patients who did not receive a closed-suction drain following surgery had less hemoglobin loss, shorter length of hospital stay and higher postoperative SST scores on multivariate analyses than those who did receive a post-operative drain. However, complication rates did not differ between patients who received a drain and those who did not.

There are no current American Academy of Orthopaedic Surgeon (AAOS) clinical practice guidelines (CPG) which comment on the use of a post-operative drain following TSA or RTSA. While very limited literature is currently available regarding post-operative drain use in TSA or RTSA, there are several studies that have evaluated blood loss, change in hemoglobin, clinical outcomes, and complication rates in TKA and THA between patients who received a post-operative drain and those who did not.[5-10] Zhang et al performed a meta-analysis of 15 studies including 1,361 TKA and found that patients with a post-operative drain had less ecchymosis and a decreased need for dressing reinforcement but higher rates of allogeneic blood transfusions than patients without a post-operative drain. The authors also found no differences in post-operative range of motion (ROM) or complication rates including deep venous thrombosis (DVT) or infection between the drain and no drain groups. Similarly, Confalonieri et al evaluated the effectiveness of post-operative drains following unicompartmental knee arthroplasties and found a lower analgesic requirement in patients without a drain and no difference in ROM or length of hospital stay between patients with and without a drain.[11] Finally, Niskanen performed a prospective randomized study of 58 patients who underwent a THA and 39 patients who underwent a TKA with or without use of a post-operative drain and found no difference wound healing, postoperative blood transfusions, complications, or ROM.[12] These results were similar to our study as complication rates did not differ between groups, but there was a lower post-operative Hgb seen in the drain group, independent of other variables.

Gartsman et al performed the only prospective randomized study to date that evaluated the use of post-operative drains in shoulder arthroplasty in 1997.[12] The study looked at wound hematomas/dehiscence, infection, reoperation rates, and length of hospital stay in patients following multiple surgeries including rotator cuff repair, anterior stabilization for instability, and TSA (63 patients) and hemiarthroplasty (37 patients). The results for each indication were reported separately. The authors found no difference between the 49 patients who received a drain and the 51 patients who did not receive a closed suction drain following TSA/ hemiarthroplasty in any of the outcome parameters. The number of patients was much higher in the current study, and multivariate analysis was used to control for the difference in patient numbers for the drain and no drain group. Furthermore, the results of this study differ slightly, as patients who did not have a drain placed had less hemoglobin loss and a shorter hospital stay. While the authors of the previous study, similar to this study, concluded that the use of a post-operative drain following shoulder arthroplasty is not necessary, the differing results may have come from the inclusion of RTSA and exclusion of hemiarthroplasty in the current study or improvements in surgical techniques for shoulder arthroplasty.

With the multitude of studies regarding drain usage following THA and TKA, as well as the randomized trial mentioned above, it seems that the results of this study agree with the current literature.[12] There does not appear to be a benefit for

ISSN 2473-0963 Open Journal http://dx.doi.org/10.17140/ORTOJ-1-105

shoulder arthroplasty patients in post-operative outcomes and complication rates with use of a drain, while not using a drain may lead to decreased length of stay and reduced cost.[6] With the evolving healthcare field and an increased focus on patient centered outcomes and cost consciousness, studies looking at both outcomes and cost are imperative. While cost was not analyzed in this study, prior studies have evaluated the cost of placing a drain in patients following a THA or TKA and have found that placing a drain, on average, costs an extra $538 for a THA and $455 for a TKA.[6] Hence, avoiding the use of a post-operative drain seems to have the benefit of less blood loss (as evidenced by a higher post-operative hemoglobin) as well as cost savings. Similarly, as surgeons continue to move certain procedures to the outpatient setting, it is vital to understand how to achieve the best outcomes, especially in the immediate post-operative period. Given the shorter length of stay and lower loss in hemoglobin in patients who did not receive a drain, it seems logical that if and when TSA/RTSA moves to the outpatient setting in select patients, those patients would benefit from not having a post-operative drain placed.

The clinical significance of the hemoglobin change is unclear as the transfusion rate did not differ between groups in this study, likely related to the low number of transfusions needed in postoperative shoulder arthroplasty patients in general.[13,14] This consecutive series of patients who underwent TSA/RTSA by one of two highly experience shoulder arthroplasty surgeons yielding clinical outcome data is a significant addition to the current literature. Given the results of this study, it appears unnecessary to use a post-operative drain following TSA and RTSA. However, further prospective randomized studies are necessary to validate the results seen in this study.

LIMITATIONS

While this is the first study the authors know of that compares clinical outcomes and change in hemoglobin between patients who received a closed-suction drain and those who did not following RTSA/TSA, there are several limitations.[15] The study is a retrospective comparison of patients from only two surgeons, and although hemoglobin levels, complications, etc. were available for all patients, clinical outcome scores were only available for some patients, which could have introduced bias. Range of motion data was not able to be included nor was patient satisfaction. Both surgeons were fellowship trained shoulder and elbow surgeons, but there is the possibility of small differences in their technique that may potentially affect patient outcomes. The study analyzed both TSA and RTSA patients, so there is a possibility that having a separate, larger, multi-center study that analyzed each set of patients separately would have found different results given some of the differences between procedures (more potential for dead space following RTSA, etc.) There were more patients in this study who had a drain placed than who did not as one author changed his practice part way through the study period, so there were fewer patients without a drain to analyze. Multivariate analysis was used to account for this difference in numbers, but it is still possible that bias was introduced because of this. Preoperative demographic data differed between the two groups, and although a multivariate analysis was performed to control for potential confounding factors, there may be factors that were not controlled for. Finally, surgical indications and rehabilitation protocols were not evaluated which could have introduced bias into the results.

CONCLUSION

Closed-suction drain usage following RTSA and TSA leads to greater loss of hemoglobin and longer length of stay. No clinically significant differences in transfusion rate and clinical outcome scores were seen with or without drain usage.

CONFLICTS OF INTEREST: None.

REFERENCES

1. Leung B, Horodyski M, Struk AM, Wright TW. Functional outcome of hemiarthroplasty compared with reverse total shoulder arthroplasty in the treatment of rotator cuff tear arthropathy. *J Shoulder Elbow Surg*. 2012; 21(3): 319-323. doi: 10.1016/j.jse.2011.05.023

2. Li X, Williams PN, Nguyen JT, Craig EV, Warren RF, Gulotta LV. Functional outcomes after total shoulder arthroplasty in obese patients. *J Bone Joint Surg Am*. 2013; 95(21): e160. doi: 10.2106/JBJS.L.01145

3. Schairer WW, Nwachukwu BU, Lyman S, Craig EV, Gulotta LV. National utilization of reverse total shoulder arthroplasty in the United States. *J Shoulder Elbow Surg*. 2015; 24(1): 91-97. doi: 10.1016/j.jse.2014.08.026

4. Gupta AK, Harris JD, Erickson BJ, et al. Surgical Management of Complex Proximal Humerus Fractures -A Systematic Review of 92 studies including 4,500 Patients. *J Orthop Trauma*. 2015; 29(1): 54-59. doi: 10.1097/BOT.0000000000000229

5. Al-Zahid S, Davies AP. Closed suction drains, reinfusion drains or no drains in primary total knee replacement? *Ann R Coll Surg Engl*. 2012; 94(5): 347-350. doi: 10.1308/003588412X13171221590098

6. Bjerke-Kroll BT, Sculco PK, McLawhorn AS, Christ AB, Gladnick BP, Mayman DJ. The increased total cost associated with post-operative drains in total hip and knee arthroplasty. *J Arthroplasty*. 2014; 29(5): 895-899. doi: 10.1016/j.arth.2013.10.027

7. Zhang Q, Zhang Q, Guo W, Liu Z, Cheng L, Zhu G. No need for use of drainage after minimally invasive unicompartmental knee arthroplasty: a prospective randomized, controlled trial. *Arch Orthop Trauma Surg*. 2015; 135(5): 709-713. doi: 10.1007/s00402-015-2192-z

ISSN 2473-0963 Open Journal http://dx.doi.org/10.17140/ORTOJ-1-105

8. Horstmann W, Kuipers B, Ohanis D, Slappendel R, Kollen B, Verheyen C. Autologous re-transfusion drain compared with no drain in total knee arthroplasty: a randomised controlled trial. *Blood Transfus*. 2014; 12 Suppl 1: s176-s181. doi: 10.2450/2013.0072-13

9. Keska R, Paradowski TP, Witonski D. Outcome in primary cemented total knee arthroplasty with or without drain: A prospective comparative study. *Indian J Orthop*. 2014; 48(4): 404-409. doi: 10.4103/0019-5413.136285

10. Gupta AK, Chalmers PN, Rahman Z, et al. Reverse total shoulder arthroplasty in patients of varying body mass index. *J Shoulder Elbow Surg*. 2014; 23(1): 35-42. doi: 10.1016/j.jse.2013.07.043

11. Confalonieri N, Manzotti A, Pullen C. Is closed-suction drain necessary in unicompartmental knee replacement? A prospective randomised study. *Knee.* 2004; 11(5): 399-402. doi: 10.1016/j.knee.2003.10.001

12. Gartsman GM, Milne JC, Russell JA. Closed wound drainage in shoulder surgery. *J Shoulder Elbow Surg*. 1997; 6(3): 288-290. doi: 10.1016/S1058-2746(97)90018-5

13. Niskanen RO, Korkala OL, Haapala J, Kuokkanen HO, Kaukonen JP, Salo SA. Drainage is of no use in primary uncomplicated cemented hip and knee arthroplasty for osteoarthritis: a prospective randomized study. *J Arthroplasty*. 2000; 15(5): 567-569. doi: 10.1054/arth.2000.6616

14. Chen ZY, Gao Y, Chen W, Li X, Zhang YZ. Is wound drainage necessary in hip arthroplasty? A meta-analysis of randomized controlled trials. *Eur J Orthop Surg Traumatol*. 2014; 24(6): 939-946. doi: 10.1007/s00590-013-1284-0

15. Saltzman BM, Chalmers PN, Gupta AK, Romeo AA, Nicholson GP. Complication rates comparing primary with revision reverse total shoulder arthroplasty. *J Shoulder Elbow Surg*. 2014; 23(11): 1647-1654. doi: 10.1016/j.jse.2014.04.015