

RESEARCH ARTICLE

Comparison of Asymmetric Reaming versus a Posteriorly Augmented Component for Posterior Glenoid Wear and Retroversion: A Radiographic Study

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Abstract

Background: Managing posterior glenoid wear and retroversion remains a challenge in shoulder arthroplasty. Correcting glenoid version through asymmetric reaming (AR) with placement of a standard glenoid component and the use of posteriorly augmented glenoid (PAG) components are two methods used to address this problem. Our objective is to report the radiographic outcomes of patients with posterior glenoid wear and/or retroversion treated with either approach.

Methods: Patients with posterior glenoid wear and a minimum of 15 degrees of retroversion, treated with AR and standard glenoid component or with a PAG component (3 mm, 5 mm, or 7 mm posterior augmentation), were consecutively identified through retrospective chart review. Pre-operative axillary views were evaluated for version, humeral head subluxation in relation to scapular axis and to mid-glenoid face. Post-operative axillary views were reviewed to measure corrected inversion and humeral head subluxation.

Results: There were 48 patients in the AR group and 49 patients in the PAG group. Version improved 6.8 degrees in the AR group. In the PAG group, version improved 8.8 degrees with 3 mm augment, 13.4 degrees with 5 mm augment, and 12.8 with 7 mm augments. There were significantly more central peg perforations in the 5 mm PAG group compared to other groups. The humeral head was re-centered within 6.1% of normal in all groups except 7 mm augments.

Conclusion: This study demonstrates that AR and PAGs have the ability to re-center the humeral head when utilized in patients with retroversion and posterior wear. Use of a PAG component may allow for greater correction of glenoid retroversion, however, there is an increased risk for central peg perforation with the specific implant utilized in this study. Long-term follow-up is ongoing and needed to understand the clinical implications of these findings.

Level of evidence: IV

Keywords: Augmented glenoid, Glenoid reaming, Shoulder arthritis, Total shoulder arthroplasty

Introduction

Primary glenohumeral arthritis is the most common indication for anatomic shoulder arthroplasty and often produces a predictable pattern of posterior

glenoid wear with progressive subluxation of the humeral head as described by Walch *et al.* (1,2). In their original series, Walch *et al.* reported that 41% of their shoulders

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demonstrated posterior wear and/or humeral head subluxation (2). While routine total shoulder arthroplasty without pre-existing posterior glenoid wear and subluxation usually provides predictably good results, some authors have highlighted the higher rate of post-operative complications associated with anatomic shoulder arthroplasty in the setting of glenoid biconcavity (3,4).

Reasons for the increased rate of complications in this population are hypothesized to be related to persistent eccentric loading on the glenoid component if version is not corrected and if the normal balance of forces across the glenohumeral joint are not restored. This assertion has been supported by several biomechanical studies (5-7). In turn, this may lead to an increased rate of lucent lines about the glenoid and result in early glenoid component loosening.

One of the common methods utilized to address this issue is to eccentrically ream the anterior glenoid in an effort to remove any biconcavity and attempt to normalize glenoid version. However, it is now recognized that there are limitations with this approach. The amount of correctable version is limited to approximately 15 degrees before risking perforation of the glenoid vault (8,9). Additionally, eccentric reaming medializes the joint line, alters tension on periscapular musculature, and reduces subchondral bony support for the glenoid implant (10, 11). Another emerging approach utilized to address this problem is the use of augmented glenoid components. Anatomical studies have demonstrated that use of these components can restore glenoid version without joint line medialization while preserving glenoid bone stock (11). This could potentially help to normalize the forces across the glenoid by minimizing the shear stresses that it encounters, and in theory, increasing implant longevity.

Currently, there is a paucity of studies examining the clinical application of either asymmetric reaming or use of augmented glenoid components. While computer and biomechanical modeling have demonstrated the capabilities of each method to address glenoid deformity,

it remains unknown how well each of these methods performs in clinical practice, particularly with more modern components (11, 12). The present study's objective is to report on the radiographic outcomes of a consecutive series of patients with posterior glenoid wear and/or retroversion who were treated with either asymmetric reaming of the anterior glenoid and placement of a standard anchor-peg glenoid or treated with a posteriorly augmented anchor-peg glenoid component.

Materials and Methods

A retrospective chart review was performed on a consecutive series of patients with posterior glenoid wear and/or retroversion who were treated with asymmetric anterior glenoid reaming and placement of a standard glenoid component or treated with a posteriorly augmented glenoid component (Step Tech APG, Depuy, Warsaw, IN). In order to qualify for the study, a minimum of 15 degrees of glenoid retroversion needed to be present on pre-operative axillary radiographs. All patients were treated by a single surgeon (G.R.W.). Due to alterations in the surgeon's practice patterns and the market availability of augmented glenoid components, all patients who underwent asymmetric reaming for management of their glenoid retroversion had their surgery performed between September of 2007 and August of 2012 with the majority of the surgeries being performed prior to 2010. All patients who underwent shoulder arthroplasty with an augmented glenoid component for management of their arthritis associated posterior wear and or retroversion had their surgery performed between March 2010 and October of 2012.

Radiographic Measurements

All patients had evaluation of their pre-operative and post-operative axillary x-rays for glenoid retroversion in relation to the scapular axis. Additionally, the percentage of posterior humeral head subluxation was measured in relation to the scapular axis [Figure 1] and in relation to the glenoid face [Figure 2] (13). All pre-operative images were classified

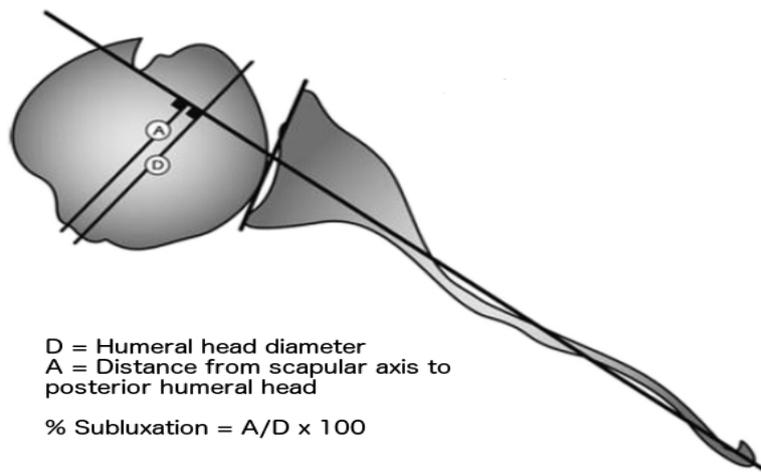


Figure 1. Humeral head subluxation in relation to the scapular axis.

based upon the Walch Classification (2). All post-operative x-rays were taken within 6 months of the surgery. Post-operative measurements were made in a similar manner; however, post-operatively glenoid version was determined from a line perpendicular to the radio-opaque marker in the central anchor of the glenoid since post-surgical bony landmarks could be distorted and not indicative of the true version, particularly with a posteriorly augmented component. Similarly, the radio-opaque marker was used as the glenoid centerline in post-operative shoulders for measurement of posterior humeral subluxation. Examples of how the radiographic measures were performed are demonstrated Figure 3a-d. Patients were excluded from the study if there was inadequate radiographic follow-up or if pre-operative x-rays could not be located.

Surgical Technique

All patients had their procedure performed through a

standard deltopectoral approach with routine humeral preparation. Following exposure of the glenoid, any biconcavity was removed using a combination of a burr and reamer. Glenoid retroversion was normalized as much as possible based upon the pre-operative and intraoperative assessment of the treating surgeon without compromising implant stability. This included trying to contain the entire glenoid component within the glenoid vault and providing it with as much subchondral support as possible. For posteriorly augmented components, the goal of each procedure was to restore any posterior bone loss with the appropriately sized posteriorly augmented component and to normalize glenoid version as much as possible based upon pre-operative and intra-operative assessment (14). Similar considerations for implant stability and bony support were considered when choosing the appropriate amount of posterior augmentation. Every case underwent an

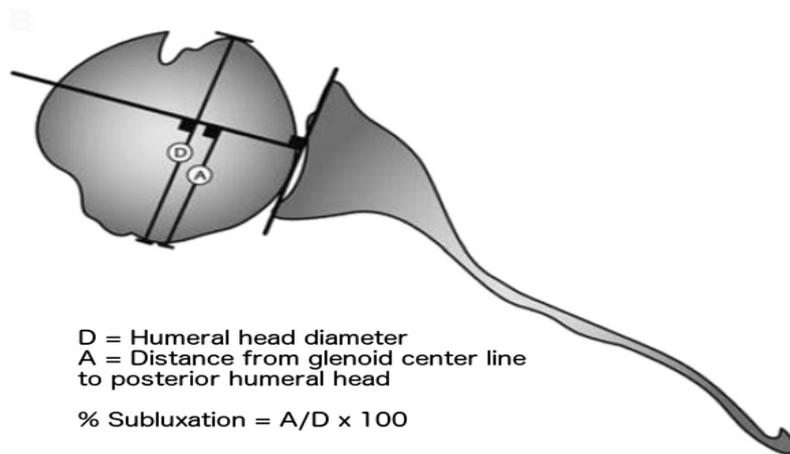


Figure 2. Humeral head subluxation in relation to the glenoid face.



Figure 3a. Original axillary radiograph of a total shoulder performed with an augmented glenoid component.

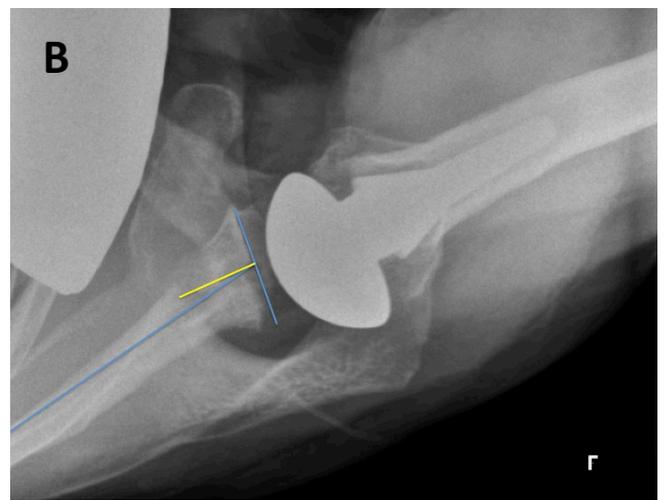


Figure 3b. Measurement of post-op glenoid retroversion.

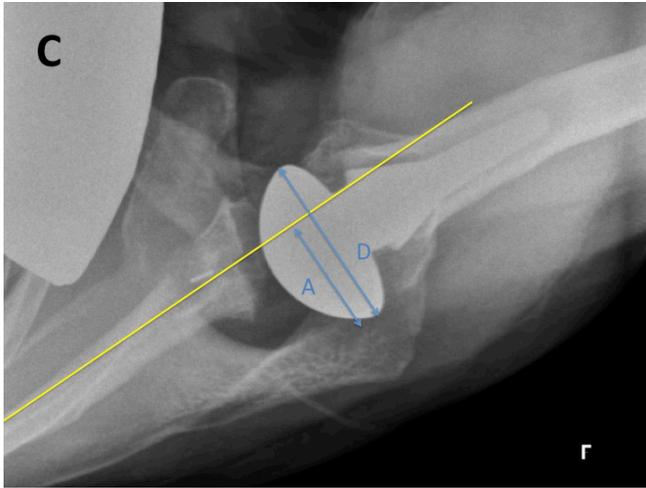


Figure 3c. Measurement of posterior humeral head subluxation in relation to the scapular axis.

intra-operative assessment following glenoid preparation to determine if there had been perforation of the glenoid vault by the central anchor peg hole. None of the patients underwent any posterior capsular plication for management of their wear and subluxation.

Results

There were 59 patients identified who underwent asymmetric reaming and 53 patients who underwent placement of an augmented glenoid component. 11 patients in the asymmetric reaming and four patients in the augmented glenoid group had inadequate radiographic follow-up and were excluded. In the group that met inclusion criteria, there were 48 patients (32 male, 16 female, 8 B1 glenoids, 33 B2 glenoids, 7 C glenoids) with an average age of 65.3 years identified in the asymmetric reaming group. There were 49 patients in the posteriorly augmented glenoid group (29 male, 20 female) with an average age of 67.4 years. Within the posteriorly augmented glenoid group, 20 patients had placement of 3 mm posteriorly augmented component (1 B1, 14 B2, 5 C), 25 patients had a 5 mm posteriorly augmented component (2 B1, 19 B2, 4 C), and four patients had a 7 mm posteriorly augmented component (0 B1, 4 B2, 0 C). The pre-operative Walch Classification for each of the groups is listed in Table 1.

Table 2 demonstrates the pre-operative and post-

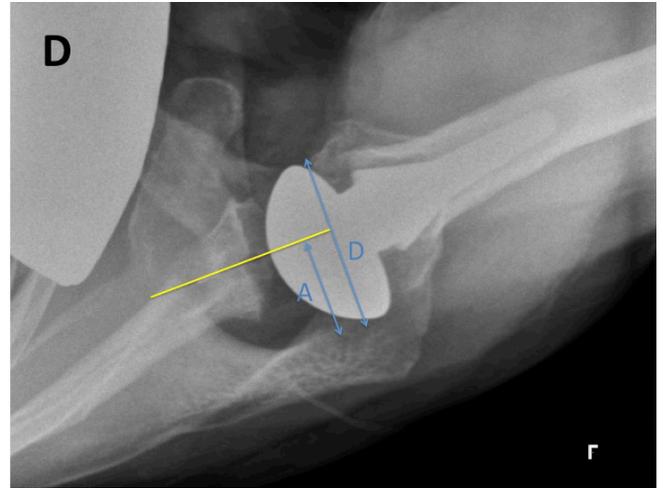


Figure 3d. Measurement of posterior humeral head subluxation in relation to the glenoid face.

operative radiographic parameters including the amount of change in each. In the asymmetric reaming group, retroversion improved from an average of 22.7 degrees pre-operatively to 16.1 degrees post-operatively ($\Delta = 6.8$). In the 3-mm posteriorly augmented group, retroversion improved from 27.1 degrees pre-operatively to 18.3 degrees post-operatively ($\Delta = 8.8$). In the 5-mm posteriorly augmented group, retroversion improved from 29.5 degrees pre-operatively to 16.1 degrees post-operatively ($\Delta = 13.4$). Lastly, in the 7-mm posteriorly augmented group, the retroversion improved from 36.1 degrees pre-operatively to 23.3 degrees post-operatively ($\Delta = 12.8$).

The amount of humeral head subluxation was improved in all the groups [Table 2]. Subluxation in relation to the mid-glenoid face was corrected to within 3.1 % of center in all groups except for the small number of 7-mm augmented components which was excluded from analysis. There were no significant differences between groups in the ability of re-center the humeral head in relation to the glenoid face.

There was significantly more central peg perforations in the 5-mm posteriorly augmented glenoid group ($n=11$, 44%, $P < 0.05$) compared to the other groups. Overall, there were 15 (36%) central peg perforations in the augmented glenoid group compared to 8 (16.7%) central peg perforations in the asymmetric reaming group. We

Table 1. Pre-Operative Walch Classifications

Walch Classification	Asymmetric Reaming (n=48)	All Posteriorly Augmented Components (n=49)	3mm Posteriorly Augmented Components (n=20)	5mm Posteriorly Augmented Components (n=25)	7 mm Posteriorly Augmented Components (n=4)
B1	8	3	1	2	0
B2	33	37	14	19	4
C	7	9	5	4	0

Table 2. Pre-Operative and Post-Operative Radiographic Parameters

Groups	Pre-Op			Post-op			
	Retroversion (Degrees)	% Subluxation (Scapular Plane)	% Subluxation (Glenoid Face)	Retroversion (Degrees) (Δ)	% Subluxation (Scapular plane) (Δ)	% Subluxation (Glenoid Face) (Δ)	Central Peg Perforations (n) (%)
Asymmetrical Reaming (n=48)	22.9	73.5	60.4	16.1 (6.8)	64.3 (9.3)	53.0 (7.4)	8 (17)
3mm Step-Tech (n=20)	27.1	79.8	63.8	18.3 (8.8)	65.6 (14.2)	53.1 (10.7)	3 (15)
5mm Step-Tech (n=25)	29.5	81.4	65.7	16.1 (13.4)	62.9 (18.5)	50.2 (15.5)	11 (44)
7mm Step-Tech (n=4)	36.1	95.1	74.2	23.3 (12.8)	79.2 (15.9)	59.8 (14.2)	1 (25)

Note: 50% = completely centered, >50% indicates posterior subluxation, <50% indicates anterior subluxation

Table 3. Central Peg Perforation Results

		No Peg Perforation	Peg Perforation	P-value
Asymmetric Reaming	Pre-Op Retroversion	22.89°	22.75°	<i>P=0.9596</i>
	Version Correction	7.23°	4.66°	<i>P=0.3164</i>
Augmented Glenoid	Pre-op Retroversion	27.43°	31.58°	<i>P=0.1242</i>
	Version Correction	10.32°	13.26°	<i>P=0.2266</i>

performed an analysis to see if the pre-operative retroversion or the amount of version correction correlated with an increased risk of glenoid vault perforation with the central peg. Results are listed in Table 3. In both the asymmetric reaming and augmented glenoid group, neither the pre-operative retroversion nor the amount of version correction achieved at surgery was associated with an increased risk of central peg perforation.

Discussion

Patients with glenohumeral arthritis associated with significant glenoid retroversion and posterior wear continue to present a challenge for shoulder surgeons. In this comparative radiographic study of two techniques utilized to manage this clinical problem, the results demonstrate that both asymmetric reaming and augmented glenoid components have the ability to re-center the humeral head in relation to the glenoid face. Additionally, all groups demonstrated improvements in glenoid version and humeral head subluxation in relation to the scapular plane.

Shoulders that had an augmented glenoid component demonstrated greater improvements in glenoid retroversion and humeral head subluxation in relation to both the glenoid face and scapular plane suggesting that an augmented component may allow for greater correction in these radiographic parameters.

Both methods improved the centering of the humeral head in relation to the center of this glenoid face. The ability to re-center the head was not significantly different in any of the groups except for the small number of 7-mm augmented components, which were excluded from

analysis. This suggests that centering the head in relation to the glenoid face does not require complete normalization of glenoid version and can be achieved with appropriate soft tissue balancing and the creation of a stable single concavity of the glenoid face using either technique.

Interestingly, there were significantly more central peg perforations with use of the 5-mm posteriorly augmented glenoid component. While it is not entirely certain why there were more in this particular group, it does raise some concern for long term implant stability, especially since it occurred in 44% of these cases. In theory, the joint line is not medialized as much to correct version with an augmented component. This should lessen the risk of peg perforation; however, this was not what we found in this series. In the particular implant utilized in this study, the length of the central peg in the augmented component is similar to the non-augmented glenoid component. The largest augment (7mm) does have a slightly longer central peg, but it is only 2 mm longer than the standard anchor peg glenoid. The 5 mm augmented component has the same length central peg as a standard glenoid component with the medium to large glenoid sizes.

Studies using standard components suggest that about 15 degrees of correction is achievable prior to risking perforation of the glenoid vault using standard components (8, 9). There are likely similar limitations in the amount of version that can be corrected with augmented glenoid components that have yet to be established. We did not find any association between the amount of pre-operative retroversion and the amount of

version correction with a risk of central peg perforation. There was a slight trend in the augmented glenoid group towards increased peg perforations with greater pre-operative retroversion and with greater amounts of version correct, but this did not reach statistical significance in our study.

While the clinical implications of central peg perforations are not well elucidated some studies have demonstrated that these patients have worse clinical function (15). More importantly, it raises some concern for the long term implant stability in a patient population that are more prone to seeing eccentric forces on their glenoid component post-operatively since long term stability of an anchor peg component is related to achieving bone ingrowth of the central peg (16).

This study is limited by its retrospective nature. Also, other factors that need to be taken into account when evaluating glenohumeral arthritis are patient age, activity, and symptoms as well as the radiographic findings which was the primary source in this study. (17). the use of historical controls, and the lack of clinical outcome measures. Additionally, axillary radiographs were utilized rather than CT scans which may have diminished the accuracy of some of the radiographic measurements. Considerations for cost, the need to compare similar pre-operative and post-operative imaging modalities, and concern for additional radiation exposure made the use of CT scan unfeasible. Also, the use of historical controls and differences in the pre-operative measurements for each of the groups make it difficult to draw definitive conclusions. Additionally, this should be viewed in light of the goals of surgery. Namely, that consideration was given to preservation of glenoid bone and subchondral support for the glenoid component when determining how much version to correct and the amount of reaming to perform. Therefore, complete normalization of glenoid version may not have been achievable or attempted in many of the cases. However, this is the first clinical study to compare radiographic measures in patients with posterior glenoid wear and subluxation treated with two commonly employed techniques for surgical management.

Both asymmetric reaming and augmented glenoid components can improve centering of the humeral head in relation to the glenoid face. Augmented components

may allow for increased correction in glenoid retroversion and increased ability to re-center the head in relation to the scapular axis. However, this may come at the expense of an increased risk for perforation of the glenoid vault with the central peg. Further research is needed to understand the clinical implications of these findings and to determine the optimal treatment option for this challenging patient population.

Patient Consent: Informed consent from study participants was not needed due to the nature of the study. All

PHI was stripped from study data once the initial query was completed. Subsequently, patients were strictly referred to by an identification number.

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References

1. Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. *J Bone Joint Surg Am.* 2011; 93(24):2249-54.
2. Walch G, Badet R, Boulahia A, Khoury A. Morphologic study of the glenoid in primary glenohumeral osteoarthritis. *J Arthroplasty.* 1999; 14(6):756-60.
3. Iannotti JP, Norris TR. Influence of preoperative factors on outcome of shoulder arthroplasty for glenohumeral osteoarthritis. *J Bone Joint Surg Am.* 2003; 85(2):251-8.
4. Walch G, Moraga C, Young A, Castellanos-Rosas J. Results of anatomic nonconstrained prosthesis in primary osteoarthritis with biconcave glenoid. *J Shoulder Elbow Surg.* 2012; 21(11):1526-33.
5. Couteau B, Mansat P, Estivaleres E, Darmana R, Mansat M, Egan J. Finite element analysis of the mechanical behavior of a scapula implanted with a glenoid prosthesis. *Clin Biomech.* 2001; 16(7):566-75.

6. Farron A, Terrier A, Buchler P. Risks of loosening of a prosthetic glenoid implanted in retroversion. *J Shoulder Elbow Surg.* 2006; 15(4):521-6.
7. Terrier A, Buchler P, Farron A. Influence of glenohumeral conformity on glenoid stresses after total shoulder arthroplasty. *J Shoulder Elbow Surg.* 2006; 15(4):515-20.
8. Clavert P, Millett PJ, Warner JJ. Glenoid resurfacing: what are the limits to asymmetric reaming for posterior erosion. *J Shoulder Elbow Surg.* 2007; 16(6):843-8.
9. Gillespie R, Lyons R, Lazarus M. Eccentric reaming in total shoulder arthroplasty: a cadaveric study. *Orthopedics.* 2009; 32(1):21.
10. Hsu JE, Ricchetti ET, Huffman GR, Iannotti JP, Glaser DL. Addressing glenoid bone deficiency and asymmetric posterior erosion in shoulder arthroplasty. *J Shoulder Elbow Surg.* 2013; 22(9):1298-308.
11. Sabesan V, Callanan M, Sharma V, Iannotti JP. Correction of acquired glenoid bone loss in osteoarthritis with a standard versus an augmented glenoid component. *J Shoulder Elbow Surg.* 2014; 23(7):964-73.
12. Iannotti JP, Lappin KE, Klotz CL, Reber EW, Swope SW. Liftoff resistance of augmented glenoid components during cyclic fatigue loading in the posterior-superior direction. *J Shoulder Elbow Surg.* 2013; 22(11):1530-6.
13. Kidder JF, Rouleau DM, Pons-Villanueva J, Dynamidis S, Defranco M, Walch G. Humeral head posterior subluxation on CT scan: validation and comparison of 2 methods of measurement. *Tech Shoulder Elbow Surg.* 2010; 11(3):72-6.
14. Mori D, Abboud JA, Namdari S, Williams GR. Glenoid bone loss in anatomic shoulder arthroplasty: literature review and surgical technique. *Orthop Clin North Am.* 2015; 46(3):389-97.
15. Hsu JE, Namdari S, Baron M, Kuntz AF, Abboud JA, Huffman GR, et al. Glenoid perforation with pegged components during total shoulder arthroplasty. *Orthopedics.* 2014; 37(6):587-91.
16. Noyes MP, Meccia B, Spencer EE Jr. Five- to ten-year follow-up with a partially cemented all-polyethylene bone-ingrowth glenoid component. *J Shoulder Elbow Surg.* 2015; 24(9):1458-62.
17. Schumaier A, Abboud J, Grawe B, Horneff JG, Getz C, Romeo A, et al. Evaluating glenohumeral osteoarthritis: the relative impact of patient age, activity level, symptoms, and Kellgren-lawrence grade on treatment. *Arch Bone Jt Surg.* 2019; 7(2):151-60.