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Clinical outcome of wedged glenoid reconstruction in anatomic total shoulder arthroplasty for osteoarthritic retroverted glenoid: a minimum 2-year follow-up

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Background: Glenoid retroversion and humeral head subluxation is a progressive disorder due to abnormal force coupling and increased contact force. In situ placement of anatomic total shoulder arthroplasty (TSA) components in this scenario results in edge loading, progressive subluxation, and early failure. Wedged glenoid components have been demonstrated to improve glenohumeral alignment, but have not been correlated with mid-term clinical outcomes.

Methods: Patients undergoing TSA using a wedged all-polyethylene glenoid component for retroverted glenoid deformity were identified from a prospectively maintained database. Preoperative planning computed tomography was routinely performed and compared to postoperative correction on radiographic evaluation. Evidence of loosening was correlated to prospectively collect clinical outcome using patient-reported outcome measures. A matched group of neutrally aligned glenohumeral joints undergoing anatomic TSA was used to compare improvement in clinical outcomes.

Results: Over a 5-year period, 17 patients with mean age 60 (range 43–81, standard deviation 10.5) were identified with a mean preoperative neoglenoid retroversion of 16.7° (standard deviation 4.5). At a mean follow-up of 43.8 months (range 27–60), no revision surgeries were undertaken. Improvement in the Oxford Shoulder Score was 18 points ($P < .0001$). The mean improvement was compared to a matched control group demonstrating a comparable magnitude of improvement of 20.4 points.

Conclusion: Wedged polyethylene components for Walch B2-type glenoids in TSA yield acceptable correction of the joint line, excellent clinical outcomes, and survivorship is maintained in the short term. The clinical and radiological outcome demonstrated similar improvement to that seen in A type deformities.

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The incidence of glenohumeral arthroplasty continues to increase relative to that of hip and knee.³⁶ In contrast to hip and shoulder replacements, the relatively low bone stock available in the shoulder introduces a number of technical challenges. One such challenge is that of the retroverted glenoid. Seminal work

by Gilles Walch used axial computed tomography (CT) to describe glenoid deformity and relationship with the humeral head in the arthritic shoulder into various types.³⁷ Type B2 are characterized by static posterior subluxation of the humeral head relative to the glenoid and a biconcavity of the glenoid surface. A crest delineating a worn posterior neoglenoid is seen delineating it from an intact anterior paleoglenoid.³⁷ Type B3 glenoids were added to the original classification, whereby progressive posterior wear leads to a monoconcave glenoid with retroversion more than 15° and/or humeral head subluxation of more than 70%.²

This study was exempt from institutional review board approval.

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Retroverted glenoids represent a surgical challenge for a number of reasons: (1) the angular deformity may be corrected to neutralize asymmetric loading of the component; (2) the associated soft tissue contraction should be addressed; and (3) adequate surgical exposure to provide an en face view to allow accurate component positioning is more difficult. These factors combine to create the potential for a postoperative eccentric wear environment which has been postulated to result in posterior loading^{4,5} erosion and early failure.^{8,15,34,39}

Methods of addressing the retroverted and arthritic glenoid vary. Options described include (1) ream flat accept the retroversion, (2) partial/complete correction of deformity via high-sided reaming, (3) bone grafting, and (4) wedged components.²⁴

Outcomes of implant driven correction of this deformity vary, which may represent the evolving technical aims or evolution of manufacturing techniques.^{12,14,23} The relatively recent introduction of an augmented cemented all-polyethylene half-wedge component (Stryker; Kalamazoo, MI, USA) allows a component correction of version (following appropriate releases). This component design does not require a metal-backed glenoid component, which has been linked to early failure.⁴

It has been previously demonstrated that the use of this component corrects glenoid version and humeral head subluxation; however, no clinical outcomes have been reported to corroborate this technical achievement with clinically important measures.^{7,35}

This study aims to establish the short-term clinical outcomes of a wedged all-polyethylene glenoid component for correcting significant glenoid deformity in anatomic total shoulder arthroplasty (TSA). The secondary aim was to compare the clinical outcomes with a control group of patients undergoing anatomic TSA without significant glenoid retroversion using standard glenoid components.

Methods

Consecutive adult patients undergoing primary anatomic TSA for idiopathic osteoarthritis (December 2016 to January 2020) were identified via hospital records. Included were shoulders with a minimum of 24 months clinical and radiological follow-up. Patient

notes, plain radiographs, and cross-sectional imaging were reviewed (J.A.C. and D.W.S.) to confirm preoperative B2 glenoid deformities (defined as a posteriorly subluxed humeral head with biconcave and retroverted glenoid) and quantify the severity of the deformities, using the modified Friedman technique.³⁰ Using CT reformatted to account to the plane of the scapula, this method establishes a line parallel to the true glenoid face (paleoglenoid) and the deformed eroded face (neoglenoid). The angle of these lines is the tangent with the neutral version, which is perpendicular to the scapular axis from the medial border of the scapular to the midpoint of the true glenoid fossa (Fig. 1). Routine patient demographics were recorded, along with prospectively reported Oxford Shoulder Score (OSS). A control group of patients, matched for gender and body mass index, undergoing anatomic TSA without significant glenoid retroversion (Walch Type A) and a minimum 2-year follow-up was used for comparison of clinical outcome. These cases were selected from a prospectively maintained database during the same time period with the same CT method to confirm deformity parameters.

Surgical technique

Preoperative planning for all cases (including controls) was performed using a standardized CT protocol (Tornier Blueprint, San Martin, France) given the limitation in estimating morphologies via 2-dimensional imaging²⁶ as 3-dimensional reconstruction better predicts the need for augmented components.⁶ The selection of implant augment was determined using this software based on the correction required to restore a neutral glenoid version. Patients were positioned in the beach-chair position and a double skin preparation with alcoholic betadine was performed. A deltopectoral approach is employed using sharp dissection. The proximal 1 cm of pectoralis major tendon is released and a subpectoral biceps tenodesis is performed. Subscapularis is released via a vertical tenotomy and the humeral head is delivered. Humeral head resection is performed as per the humeral implant design (in this series, a platform-based metaphyseal-bearing onlay system was used—Aequalis Ascend Flex [Stryker, Kalamazoo, MI, USA]). The glenoid is exposed, cartilage removed, and size is confirmed with preoperative planning. The glenoid subchondral bone is drilled and

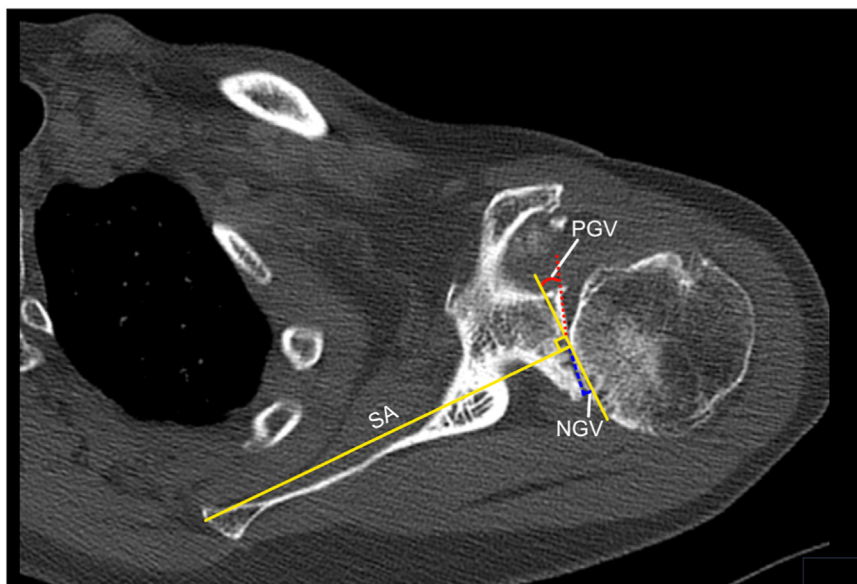


Figure 1 Axial CT measurements. SA, scapular axis; PGV, paleoglenoid version; NGV, neoglenoid version; CT, computed tomography.

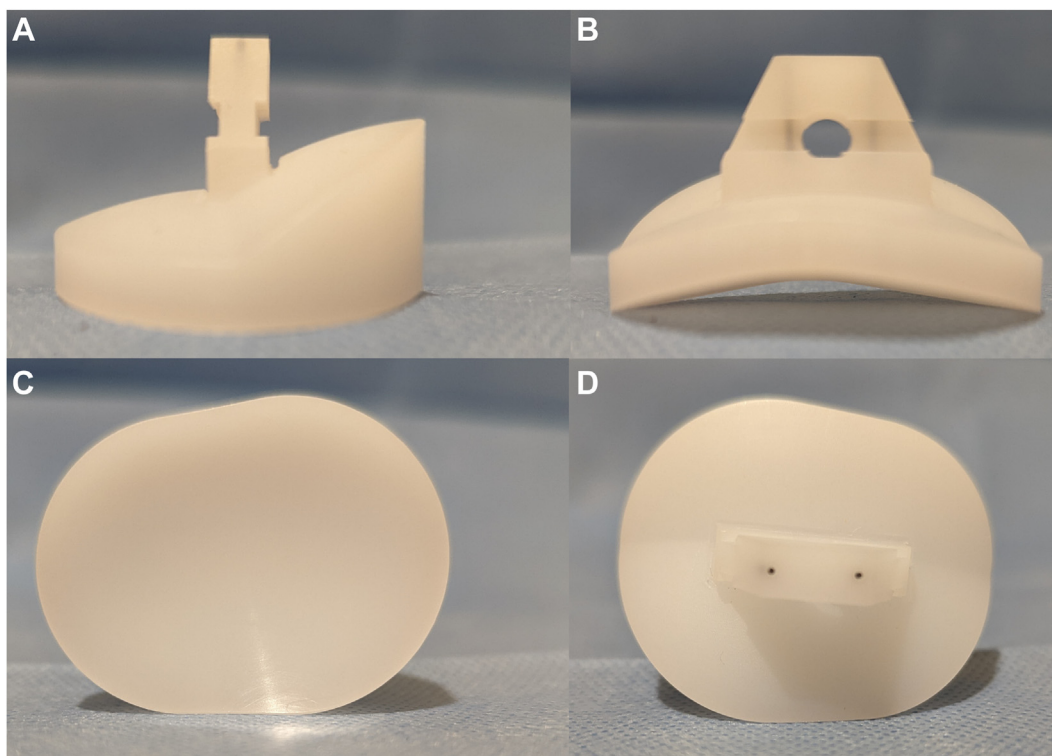


Figure 2 The Aquelia Perform + is an all polyethylene half wedge implant designed for cemented fixation into native bone. In this series, a keeled version was used for all cases; however, the angle of wedge varied according to the deformity (15° , 25° , or 35°). Design is visible from (A) superior, (B) lateral, (C) articulating surface, and (D) backside.

prepared for insertion of antibiotic cement. The all-polyethylene keeled wedge glenoid component (Aequalis Perform+; Stryker, Kalamazoo, MI, USA) (Fig. 2) is cemented using Palacos bone cement (Haraeus, Hanau, Germany). The appropriately sized humeral component is seated to accommodate a well-balanced rotator cuff environment, subscapularis repaired, and skin closed in a conventional manner. A typical postoperative radiograph is outlined in Fig. 3.

Data were compared using SPSS Statistics (version 28.0 for Macintosh; IBM Corp., Armonk, NY, USA) with *t*-test and Mann-Whitney U tests for continuous variables and Chi-squared for categorical data. Post-hoc power analysis of using difference in OSS (with a minimally clinically important difference of 4.3), power 0.8 and alpha 0.05 estimated that 10 patients required recruitment to reject a type-2 error. A *P* value < .05 was considered significant.

Results

During the 3-year study period, 207 shoulder arthroplasty procedures were performed by the lead author, of which 17 used an all-polyethylene wedged glenoid component of which all were followed up in this study. The mean age was 60 years, 9 shoulders were in females, and 11 left shoulders. The mean body mass index was 29.7 (Table 1). The mean preoperative paleoglenoid version was -9.2° (range 0° to -18° , standard deviation [SD] 5.7) and neoglenoid -16.6° (range -11° to -22° , SD 3.6).

At a minimum 24 months and mean of 44 months of follow-up, there was no revision of components. Two patients required secondary surgery, one for a traumatic subscapularis tear requiring successful patch-augmented fixation and the second for persistent acromioclavicular pain managed with joint excision (Table 2).

Mean preoperative OSS was 27 (SD 14.3) of 60, rising to a mean of 45 (SD 6.6) score at latest follow-up.

When compared to the improvement observed in neutrally aligned glenoids, there was a significant difference in age between the retroverted (mean 60 years) and neutrally aligned glenoids (mean 72 years). Other demographic parameters were statistically indifferent (Table 3); both groups demonstrated statistically comparable improvement in OSS at a minimum of 24 months of follow-up (18 vs. 18.3 for B2 and A-type glenoids, respectively).

Discussion

Retroverted glenoid deformities pose a series of technical difficulties to the shoulder arthroplasty surgeon, not least because of the challenges in dealing with the erosion and bone stock, but also as a result of the tight anterior structures encountered in the approach and a glenoid face which is orientated deeper into the surgical wound.

There are several accepted methods of dealing with biconcave retroverted glenoids. A “ream-and-run” technique may be employed in which the biconcavity is flattened out with a reamer, the net retroversion not corrected, and a hemiarthroplasty implanted. This technique involved limited compromise of bone stock, however, potentially leaves patients with persistent pain.^{3,11,38} Alternatively, implantation of a standard glenoid polyethylene in a retroverted position gives good early function and pain relief, but has not been shown to be a sustainable option in the mid to long term.²⁵

Alternatively, reaming to partially/completely correct the orientation to a more neutral version can be performed. This “high-side reaming” approach can be effective, however medializes the center of rotation³¹ and shortens the rotator cuff muscles which are key to function following a TSA.²⁹ Furthermore, it can crucially reduce the remaining glenoid vault and compromise subchondral bone,⁴⁰ therefore increases risk of peripheral peg perforation.^{5,16,17}

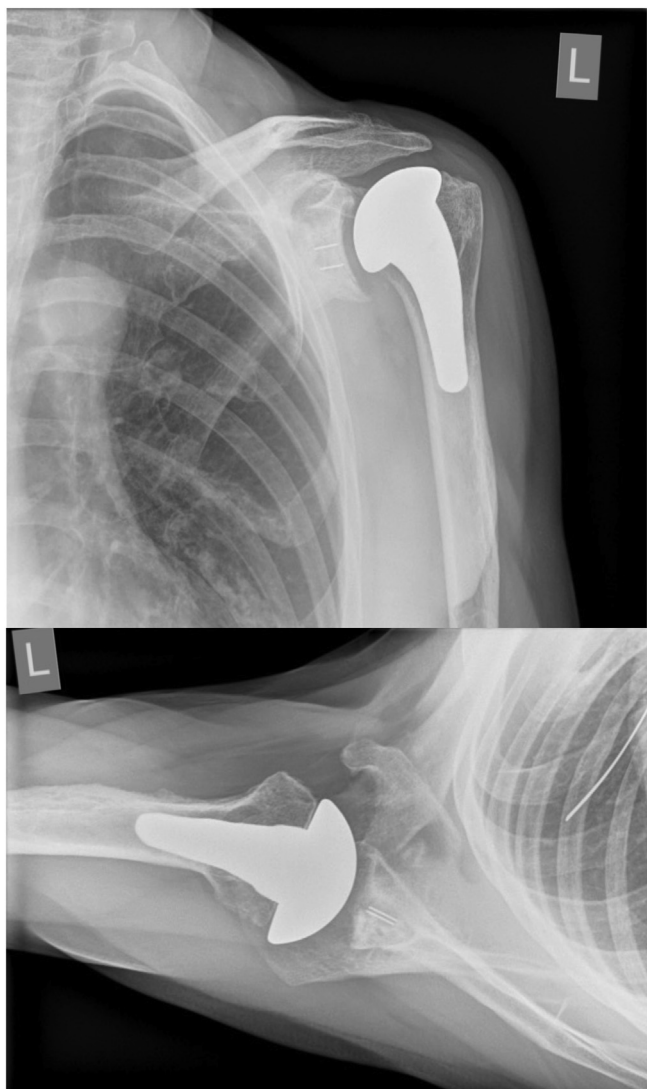


Figure 3 Postoperative X-rays.

For these reasons, reamer-based correction of orientation is typically reserved for lower magnitudes of retroversion (typically 10°–15°).³⁹

For greater degrees of retroversion, particularly in the setting of bone loss, bone grafting can be performed. This was described by Neer in 1988 using internally fixed bone graft, demonstrating excellent satisfaction in 16 of 19 grafts at a mean of 4.4 years.²⁸ This seminal work has had mixed results from subsequent studies, raising questions regarding the generalizability of this technique.^{10,13,18,22,27,39}

The use of glenoid components to augment deficient bone and correct version to an acceptable neutral position has been explored for more than a decade. In 2008, Rice et al used an early generation implant and found satisfaction rates were poor.²⁸ Six years later, Cil, from same institute reported differing components and found satisfactory results at 7 years, with the exception of metal-backed glenoids.⁴ The use of all-polyethylene full-wedge components remove less bone and reduce stresses at the glenoid interface; however, hemi-wedges have greater resistance to lift off.^{1,19,21} Zhang et al concluded that grafting may result in similar revision rates and pain improvement as wedged components for moderate

Table 1
Patient demographics.

Outcome	Measure
Mean age (SD)	60.1 (10.3)
Male:Female	8:9
Left:Right	11:6
Mean follow-up (range)	43.8 mo, 27–60 mo
Mean BMI (SD)	29.7 (5.9)
Smoking	14 never, 3 previous
Diabetes (n)	1
Mean preoperative paleoglenoid (°)	−9.2
Mean preoperative neoglenoid (°)	−16.6

BMI, body mass index; SD, standard deviation.

Table II
Clinical and radiological outcomes.

Outcome	Patients (n = 17)
Revision	0
Secondary interventions (n)	2
Mean Preoperative OSS	27
Mean Postoperative OSS	45

OSS, Oxford Shoulder Score.

B2 deformities, leaving a philosophical equipoise in surgeon preference.⁴²

Iannotti et al reported patients with preoperative posterior subluxation had lower American Shoulder and Elbow Surgeons score scores, more pain, and less external rotation than patients without subluxation.²⁰ A previous retrospective series from Service et al indicated restoration of version does not affect outcome at 2 years.³² The results of this contemporary study challenge the finding with patient-reported outcome measures that are comparable to the improvement observed in TSA for Walch Type A glenoids.

Previous studies have reviewed alternative posteriorly augmented glenoid (PAG) components. In 2015, Favoritio et al presented a case series of 22 patients with a stepped-cut designed wedge augment at a mean follow-up of 3 years describing favorable clinical improvements; however, 2 patients required secondary surgery for instability.⁹ Stephens et al reported a series of 21 patients undergoing PAG reconstruction of biconcave retroverted glenoids demonstrating improved clinical outcomes, complete osseointegration of fixation pegs, and no adverse clinical events.³³ Ho et al 2018 retrospectively reviewed a series of 71 patients with posterior stepped components, demonstrating primarily an improvement in humeral head centering and clinical outcomes.¹⁴ Recently, Grey reports a series of 68 patients with a Walch Type B deformity managed with an 8° polyethylene wedged component, concluding an improvement of humeral centering from 22% to 100%. Corresponding clinical outcomes improved; however, 2 glenoid components required revision for loosening.¹²

Wright et al retrospectively reviewed 27 patients at a minimum of 2 years following implantation of wedged polyethylene components and found comparable clinical and radiographic outcomes with neutrally aligned arthritic shoulders.⁴¹ In 2010, Priddy et al retrospectively matched 37 PAG components with standard components. Both groups exhibited a range of glenoid deformities with a tendency toward more retroverted deformities in the PAG group. A range of component angles were used (8°, 12°, and 16°), many of which would fall close to levels at which contemporary literature would support high-sided reaming techniques. They noted similar clinical and radiographic outcomes; however, subgroup analysis of larger wedges demonstrated a statistically favorable clinical outcome. Ko et al compared 48 cases managed with varied sizes

Table III
Comparison with control group demographics.

Outcome	Retroverted glenoids	Neutral glenoids	P value
Mean age (SD)	60 (10.3)	72 (9.2)	.002
Female:Male	9:8	12:5	.290
Left:Right	11:6	10:7	.724
Mean follow-up, mo (range)	43.8 (27–60)	40.0 (28–50)	.252
Mean preoperative paleoglenoid (°)	9.2 (5.3)	–1.5 (3.7)	<.001
Mean preoperative neoglenoid (°)	16.6 (3.6)	N/A	N/A

SD, standard deviation.

Bold indicates statistical significance.

of posterior glenoid stepped wedges (3, 5, and 7 mm), against high-sided reaming. Despite the retrospective nature, selection bias, and relatively modest increments in wedges, their findings indicate improved correction with increasing magnitude of PAG, which was correlated with an increased change of peg perforation.²³

Limitations

The primary limitation of this study is its retrospective nature and the inherent heterogeneity between the pathology associated with retroverted glenoids (Type B2) and that neutral version (Type A). This is reflected in the age difference between the groups compared in this study which despite the direction of bias favoring the neutrally aligned deformity, a statistically similar clinical result was found.

Conclusion

All-polyethylene wedged components reliably improve function in anatomic TSA at a minimum of 2-year follow-up. Improvements were comparable to patients with a neutrally aligned glenoid undergoing anatomic total shoulder replacement with conventional components.

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