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EDITORIAL

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# Routine neutral glenoid version targets in reverse shoulder arthroplasty: Time for a patient-specific, fixation-oriented approach


## Abstract

Routine correction of glenoid retroversion to neutral remains common practice in reverse total shoulder arthroplasty (rTSA), despite increasing uncertainty about whether strict neutralization is clinically necessary. This editorial synthesizes current biomechanical, clinical and imaging-based evidence on glenoid version in rTSA, with particular attention to functional outcomes, implant fixation and the growing role of precision technologies such as three-dimensional (3D) planning and patient-specific instrumentation. Contemporary clinical studies do not show consistent associations between residual glenoid retroversion and patient-reported outcomes, range of motion, complication rates or revision risk when key biomechanical parameters are maintained. Available biomechanical data further support a functional 'safe window' of roughly 0°–20° of combined component retroversion. In this context, routine correction to neutral may drive avoidable bone removal, increase implant cost and compromise fixation without a clear clinical advantage. Neutral glenoid version, therefore, should not be viewed as a universal surgical target in rTSA. A patient-specific, fixation-aware strategy that respects pre-arthritic anatomy and leverages accurate 3D planning may be more rational than rigid angular correction paradigms.


KEYWORDS

biomechanics, constitutional anatomy, glenoid retroversion, patient-specific planning, reverse total shoulder arthroplasty

## INTRODUCTION

Reverse total shoulder arthroplasty (rTSA) has matured from a salvage procedure into a mainstream solution for a host of complex shoulder pathologies, with steadily expanding indications and volumes worldwide [1, 36]. Within this growth, the optimal management of glenoid version remains unsettled. Classical teaching, grounded in biomechanical theory, favours reaming or using bone grafts or posterior augments to 'normalize' retroversion to neutral [5, 13]. The stated goals are to improve stability, optimize contact mechanics and reduce eccentric loading on the glenoid component [33].

Historically, the drive toward neutral version was predicated on the 'rocking horse' phenomenon observed in anatomic components. Biomechanical models suggested that increasing retroversion shifts the joint reactive force vector posteriorly, theoretically increasing shear stress at the bone–implant interface and risking baseplate loosening [16]. However, it remains debated whether the semi-constrained mechanics of modern reverse designs, which convert shear into compression through varying neck-shaft angles (NSAs), are as susceptible to these forces as originally feared [14].

However, this 'one-size-fits-all' approach is being increasingly questioned. The clinical evidence has not consistently demonstrated superior outcomes with routine neutralization, particularly when correction requires significant bone removal or cost-intensive technologies [8, 9, 12, 29, 32]. Furthermore, emerging biomechanical and clinical data suggest that many shoulders may function well within a wider-than-expected range of component version [9, 12]. This discrepancy between theoretical principles and clinical reality, compounded by economic pressures, necessitates a re-evaluation of our surgical targets.

It is critical, however, to clarify what a 'patient-specific' approach entails. In this context, it does not mean chasing an unmeasurable idealized 'native' target but rather selecting a version target that is appropriate for each patient's deformity pattern, implant design and fixation needs [4]. Many patients present with degenerative changes in both shoulders, meaning the pre-arthritic reference may be difficult to reconstruct confidently from the contralateral side [17]. When uncertainty exists, the objective becomes to restore functional

**Abbreviations:** 3D, three-dimensional; aTSA, anatomic total shoulder arthroplasty; NSA, neck-shaft angle; rTSA, reverse total shoulder arthroplasty.

kinematics while minimizing iatrogenic bone loss and to use modern three-dimensional (3D) assessment to determine how much correction is required for stable fixation and impingement-free motion [22].

The transition to a patient-specific approach relies heavily on the accuracy of preoperative measurement. Plain radiographs have been shown to be unreliable for quantifying glenoid version, with significant interobserver variability [26]. Furthermore, unassisted execution of version correction is prone to error; studies demonstrate that surgeons frequently deviate from their planned version when using standard instrumentation [19]. This variability underscores the necessity for 3D planning and guided execution if precise restoration of constitutional anatomy is the goal.

The aim of this editorial is to evaluate whether neutral glenoid version should remain a universal target in rTSA and to propose a patient-specific, fixation-aware framework that integrates contemporary evidence with 3D planning and guided execution.

## CLINICAL RELEVANCE

Routine correction of glenoid retroversion to neutral in rTSA may lead to unnecessary bone removal without proven functional benefit [9, 29, 38]. Contemporary evidence suggests that satisfactory outcomes can be achieved across a broader range of version when fixation principles, joint-line position, inclination and implant design are respected [9, 21, 29]. A patient-specific, fixation-aware approach, supported by accurate 3D planning and guided execution, may help balance bone preservation with secure baseplate fixation, particularly in younger patients or in the presence of compromised glenoid bone stock [4, 22, 37].

### Clinical evidence: Outcomes are often version-independent

Contemporary evidence does not support glenoid version as an independent or dominant determinant of clinical outcomes in either anatomic or rTSA [29]. Across high-level studies, both residual retroversion and substantial correction magnitudes fail to demonstrate consistent associations with patient-reported outcomes, range of motion, complication rates or revision risk when key biomechanical parameters are respected [9]. The persistent emphasis on achieving neutral version targets is therefore increasingly difficult to justify. Instead, optimal shoulder arthroplasty outcomes appear to depend on a more integrated, anatomy-driven strategy that prioritizes joint-line preservation, appropriate inclination, lateralization and overall implant positioning [23, 25]. Future surgical planning should move beyond rigid angular correction paradigms and focus on restoring functional kinematics rather than geometric neutrality.

High-level evidence from anatomic total shoulder arthroplasty (aTSA) challenges the notion that version is a primary driver of outcomes [8, 29, 32]. A systematic review of 16 studies (1211 shoulders) [15] found no association between pre- or postoperative retroversion and patient-reported outcomes, range of motion or revision rates. Only isolated studies suggested worse abduction or higher failure when postoperative retroversion exceeded ~15°, while correlations with radiographic lucency were inconsistent. The authors concluded that version rarely dictates outcomes independent of other factors like joint-line maintenance [29].

Similar findings were reported on rTSA cohorts [9]. In a 2-year series comparing navigation to standard instrumentation, final glenoid retroversion above or below 10° and even correction magnitudes greater than 15° did not adversely affect outcomes or complication rates. This finding undercuts the assumption that achieving a specific neutral target is universally beneficial [38]. A systematic review similarly found no sufficient evidence to implicate pre- or postoperative glenoid version as an independent determinant of rTSA performance, once variables like inclination, lateralization and joint-line position are considered [2].

Inferior scapular notching remains a prevalent concern, driven largely by mechanical impingement in adduction. While varus positioning is the primary culprit, excessive retroversion can exacerbate posterior impingement and anterior instability [34]. However, recent kinematic simulations suggest that maintaining some native retroversion may actually mitigate anterior impingement in internal rotation, a common functional limitation in rTSA patients [2].

### Biomechanics: Defining an 'acceptable' window

The concept of a 'safe window' serves as a vital guide for therapeutic planning, yet it requires careful definition. Recent biomechanical syntheses provided a scientific basis for accepting residual retroversion. A systematic review analysed 11 studies and established clinically useful boundaries [2]. Unlike anatomic replacement, where stability relies heavily on glenoid concavity, rTSA stability is largely conferred by the semi-constrained nature of the prosthesis and soft-tissue tensioning.

Within this context, strict neutrality appears less critical. Modest glenoid retroversion was found to reduce subluxation risk while increasing external rotation and overall range of motion.

The collective evidence favoured restoring approximately 0°–20° of combined component retroversion (humeral and/or glenoid) as a broad 'safe window' that balances motion, stability and impingement risk [2]. This supports a strategy of 'recovering what the shoulder had' rather than forcing it to a new, neutral position.

The definition of a 'safe window' is likely implant-dependent. Prosthetic factors, specifically the NSA and glenoid lateralization, drastically alter the tolerance for retroversion. While traditional Grammont-style prostheses (155° NSA) rely on inherent stability, more lateralized designs or those with a 135° NSA may increase the risk of instability if significant retroversion persists [10, 27]. Consequently, the acceptable envelope of version must be interpreted in the context of the specific implant geometry utilized [24].

Fixation requirements impose practical limits on version targets in rTSA. Neutral or near-neutral positioning can increase the available depth and trajectory for a central peg or screw, which may be particularly important in small glenoids, advanced bone loss or poor bone quality [23, 31]. In such cases, the objective should be fixation optimization rather than angular neutrality per se. Metallic augmented baseplates can preserve bone while improving central fixation and screw purchase by restoring geometry without excessive eccentric reaming [20, 21]. Consequently, case-specific 3D planning is essential to determine how much retroversion correction is required to balance fixation security with bone preservation [3, 22].

In practice, the 'best' version target is often the one that maximizes central fixation depth and an intrabony trajectory while preserving bone. A conceptual example is shown in Figure 1, where maintaining moderate retroversion permits a more central and longer central peg/screw trajectory than forcing correction to neutral.

Focusing solely on the glenoid ignores the other half of the equation: humeral version. The 'combined version', the sum of glenoid and humeral retroversion, is a more accurate predictor of impingement and range of motion than glenoid orientation alone [28]. Surgeons may be able to offset native glenoid retroversion by adjusting humeral retroversion or utilizing specific stem designs (inlay vs. onlay), thereby keeping the total articular arc within a functional range without excessive glenoid reaming [18].

Internal rotation is also influenced by humeral version, soft-tissue balancing and releases and the size and shape of the glenosphere.

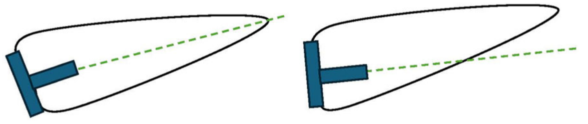


**FIGURE 1** Central peg/screw trajectory illustrates why neutral version is not always optimal. Schematic comparison of baseplate placement planned at 0° (neutral) versus 15° retroversion. In some glenoids, maintaining moderate retroversion can allow a more central intrabony trajectory and greater central peg/screw length, whereas forcing neutral correction may shift the trajectory off-centre and reduce fixation depth. The figure is conceptual and highlights the rationale for fixation-optimized, case-specific planning rather than a universal neutral target.

## Advantages of recovering pre-arthritic version

A strategy that aims to recover the patient's constitutional version potentially offers several benefits. By avoiding extensive eccentric reaming and unnecessary correction to neutral, surgeons may preserve bone stock and the joint line while achieving equivalent pain relief and function [13, 24]. When correction is required for fixation, metallic augmented baseplates may reduce the need for bone removal while improving central peg/screw trajectory and peripheral screw purchase [31, 38]. This may reduce operative time, minimizes bone loss and preserves the native joint line [35]. The economic argument is nuanced: while implant costs may increase with augments, the costs of inaccurate correction (bone loss, joint-line alteration and suboptimal fixation) and the need for accurate planning to differentiate acquired from constitutional deformity may increase reliance on preoperative 3D planning software or intraoperative guidance.

## Disadvantages and unknowns

The primary concern with retaining retroversion is asymmetric loading on the polyethylene liner, which could plausibly accelerate wear and glenoid micromotion [11]. The mid- to long-term survival of implants under a 'recover-don't-neutralize' paradigm remains underreported. While severe retroversion has been correlated with radiographic signs of osteolysis around the central peg in aTSA, clinical data on these findings are inconsistent and uncertain [11, 15]. Analogous long-term radiographic-to-clinical correlations for rTSA are even more limited.

Nevertheless, these concerns remain primarily theoretical in rTSA and should be interpreted in the context of implant design, fixation strategy and the limited availability of long-term comparative data.

## Generalizability

The tolerance for residual retroversion and the trade-offs between bone preservation and fixation are context-dependent [6, 23]. Implant design (NSA, degree of lateralization, inlay vs. onlay), glenoid size, bone quality and the pattern/severity of posterior wear may all influence the optimal version target [6, 18, 23, 24]. Accordingly, the proposed framework should be applied using case-specific 3D planning rather than interpreted as a single numeric target for all patients [4, 22, 37].

## Recommendations and future directions

To translate these principles into reproducible surgical practice, both planning and execution accuracy must be considered.

### Implementation in practice

If version targets are individualized, the limiting step becomes execution accuracy [4, 7, 22]. Computed tomography (CT)-based 3D planning can quantify deformity, simulate baseplate seating and screw trajectories and define a fixation-optimized target rather than a rigid neutral goal [4, 37]. Patient-specific instrumentation, navigation or robotic assistance may improve fidelity between planned and achieved baseplate position, particularly for central peg/screw trajectory and fixation depth [7, 22, 30]. Future studies should report planned versus achieved version alongside fixation metrics to link precision with clinical and radiographic outcomes.

A personalized approach argues for restoring pre-arthritic retroversion when deformity is modest and functional goals are achievable within the biomechanical 'safe window'. Conversely, severe posterior wear with instability may still merit targeted correction. To advance this field, the following are needed:

1. Develop patient-specific decision rules: Prospective algorithms that integrate version, inclination, joint-line and morphology to predict who benefits from correction versus recovery.
2. Identify 'at-risk' morphologies: We currently lack definitive data on which pre-arthritic morphologies predispose patients to arthritis. It is possible that the constitutional retroversion we aim to restore was itself a contributing factor to the joint's failure. Future research must utilize predictive models, such as statistical shape modelling, on both arthritic and normal shoulders. This will help identify specific phenotypes at risk of arthritic evolution and clarify if restoring these morphologies perpetuates the pathology.
3. Generate longitudinal comparative evidence: Registry-embedded or randomized studies powered for revision, loosening and polyethylene wear at 5–10 years, stratified by residual version.
4. Perform pragmatic cost-effectiveness analyses: Head-to-head modelling of correction versus recovery strategies, weighing the savings of standard implants against the costs of necessary precision planning tools.
5. Standardize reporting: Routine capture of planned versus achieved version, joint-line medialization and impingement signs to clarify which surgical levers truly drive outcomes.

## CONCLUSION

Routine neutralization of glenoid retroversion in rTSA lacks consistent clinical justification. Contemporary evidence supports a broader functional envelope of version when fixation principles and implant-specific biomechanics are respected. A patient-specific, fixation-oriented strategy, enabled by accurate 3D planning and guided execution, can help balance bone preservation with secure baseplate fixation and functional kinematics, while acknowledging that long-term wear and implant survival require ongoing surveillance and higher-level comparative data.

**CONFLICT OF INTEREST STATEMENT**

The authors declare no conflicts of interest.

**ETHICS STATEMENT**

The authors have nothing to report.

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