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Impact of humeral and glenoid component variations on range of motion in reverse geometry total shoulder arthroplasty: a standardized computer model study

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Background: Multiple modifications of reverse total shoulder arthroplasty (RTSA) since the first Grammont design have developed to improve range of motion (ROM) and avoid notching. The effect of these changes in shoulder kinematics and the best compromise for ROM is still under debate. This computer simulation study evaluates the influence of humeral design, humeral neck-shaft angle (NSA), glenoid lateralization, and glenoid eccentricity on ROM of RTSA.
Methods: We created a 3-dimensional computer model from computed tomography scans of 13 patients with primary osteoarthritis simulating implantation of a standardized reverse shoulder arthroplasty. We analyzed the effect of 4 different variables on impingement-free ROM: humeral design (inlay vs. semi-inlay vs. onlay), humeral NSA (135° vs. 145° vs. 155°), glenoid lateralization, and glenoid eccentricity on ROM.
Results: The use of different humeral stem designs did not have a significant effect on total global ROM. Reducing NSA demonstrated a significant increase in adduction, and external and internal rotation in adduction, whereas a decrease in abduction and external rotation in abduction. Glenosphere lateralization was the most effective method for increasing total global ROM ($P < .0001$); however, extreme lateralization (+12 mm) did not show significant benefit compared with moderate lateralization (+4 mm). Glenosphere eccentricity increased only adduction and internal rotation in adduction.
Conclusion: Only glenoid lateralization has a significant effect on increasing total global ROM in RTSA. The use of the semi-inlay 145° model combined with 4 mm lateralization and 2 mm inferior eccentricity represents the middle ground and the most universal approach in RTSA.
Level of evidence: Basic Science Study; Computer Modeling

Keywords: Reverse total shoulder arthroplasty; range of motion; impingement; neck-shaft angle; onlay; inlay and semi-inlay design; glenosphere lateralization and eccentricity

Ethical approval was received from Kantonale Ethikkommision Bern (project ID 2017/02159).

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The advent of successful reverse geometry total shoulder arthroplasty (RTSA) marked the beginning of a new era in shoulder surgery.[8] The initial design proposed by Grammont advocated medialization and distalization of the center of rotation (COR) of the glenohumeral joint to a point at the bone-implant interface and combining this with a 155° straight stem inlay design. This configuration transformed the torque created by the former native glenohumeral into compressive forces. Consequently, the lever arm of the deltoid muscle was almost double, as was the efficacy of abduction.[15] However, there are further clinically relevant consequences of this change in COR. One of the most common adverse effects of RTSA prosthesis design is scapular notching.[1,15,24] Mechanical abutment and friction from the humeral component against the scapula neck and acromion have been thoroughly studied. Other effects of RTSA design include a reduced lever arm of the external rotators,[9,22] arm lengthening, which may lead to acromial stress fractures,[21,30] and violation of greater tuberosity bone stock.

With expanding indications and use of RTSA, the initial original Grammont design evolved into many modifications of the components trying to solve the aforementioned drawbacks. The main emphases have been drawn to increase the lateralization of the humerus and glenosphere COR.[9,14,15,29] Decreasing neck-shaft angle (NSA) improves adduction and avoids scapular notching, whereas increasing glenosphere lateral offset and inferior eccentricity have a positive effect on external rotation and decrease scapular notching. Recently, several studies based on computer modeling have attempted to analyze the effects of different humeral and glenoid configurations on range of motion (ROM).[4,16,17,19,28]

The optimal configuration for RTSA to obtain the best ROM free of impingement remains controversial. This study aimed to evaluate the effects of humeral stem design, NSA, glenosphere offset, and eccentricity on glenohumeral joint ROM after simulated RTSA using a standardized computer model based on a series of real scapula models.

Material and methods

This basic science study used 3-dimensional (3D) reconstruction computer models of computed tomography (CT) scans obtained from 13 patients with primary osteoarthritis, for which we obtained ethical approval prospectively. We included shoulders with Walch type A1 glenoids[26] and without bony deformity on the glenoid or humeral side in keeping with existing literature in this area, which used normal shoulder CT scans or sawbone anatomical scan data.[10,12,16,27,28] The patients met the inclusion criteria if they had a glenoid of at least 27 mm diameter without significant osteophytes, to accommodate a 24.5 or 27 mm baseplate. We included some variation in glenoid retroversion and superior inclination, although excluded glenoids with retroversion over 20° and superior inclination (beta angle) over 7°. The mean glenoid retroversion was 8° (standard deviation [SD], 7°), and the mean glenoid inclination was 4° (SD, 5°). Regarding the humerus, the mean head retrotorsion measured from the transepicondylar axis was 26° (SD, 8°), and the mean native NSA was 134° (SD, 3°).

Computer model and prosthetic scenarios

The 3D CT reconstructions of the entire scapula and humerus were segmented from CT images using imaging software Mimics (Materialise, Leuven, Belgium). The reconstructions were imported into a computer-aided design software program (SolidWorks; Dassault Systemes SolidWorks, Concord, MA, USA) to virtually implant the prosthetic components on the models. An engineer specialized in computer-aided design generated the models, and positioning of the simulated implants was supervised and agreed by 2 fellowship-trained orthopedic shoulder surgeons.

To simulate a hypothetical native shoulder, the computer model included standard anatomic total shoulder arthroplasty. We used anatomic total shoulder arthroplasty as a comparative baseline in which confounding factors (osteophytes, glenoid version, etc.) were restored and therefore comparable to the RTSA model. For RTSA simulation, in order to measure the effects of humeral and glenoid component variations, the model included a standardized glenoid component to test the different humeral configurations and a standardized humeral component to test the different glenoid configurations.

In the first scenario, testing variations in humeral component configuration, we prepared a standardized glenoid component using a 24.5 or 27 mm circular convex baseplate (depending on patient glenoid size) with a 25 mm central peg. The entry point for the central peg was centered in the glenoid width and at a height that set the baseplate flush with the inferior glenoid rim. The simulated glenosphere that had the best fit in all cases was a 36 mm implant, and we used 0 mm of lateral offset without eccentricity.

We corrected the glenoid version and inclination individually in each case aiming to neutral or the closest to neutral, understood as 0° with respect to the Friedman axis. The glenoid correction was achieved by down-reaming the glenoid anteroinferiorly. We avoided excessive reaming of greater than 3 mm to avoid bone weakening and joint line medialization. We obtained a mean postoperative retroversion of 6° (SD, 4°) and superior inclination of 3° (SD, 3°). Next, we performed a humeral osteotomy at the anatomical neck of the humerus at 135° NSA and 20° of retrotorsion with respect to the transepicondylar axis. The NSA was calculated by measuring the direct angle between the normal vector of the anatomic humeral head osteotomy plane and the humeral canal axis.[20] The mean cut height after a 135° humeral cut was 19 mm (SD, 2 mm) from the most proximal point of the humerus in the humerus axis. Although preoperative native retrotorsion with respect to transepicondylar ranged among patients from 5° to 37° (mean, 26°), a standard 20° retrotorsion stem implantation was chosen in all cases to standardize this step.

We virtually developed 7 different stem configurations with SolidWorks based on the combination of 3 different NSA inclinations and 3 inlay designs (Fig. 1). The prosthesis NSA was defined as the direct angle between the normal vector of the edge of the liner's articular surface and the axis of the humeral stem. We measured dimensions of prosthesis designs from the exit point of the stem axis on the resection plane (Fig. 2). We maintained the

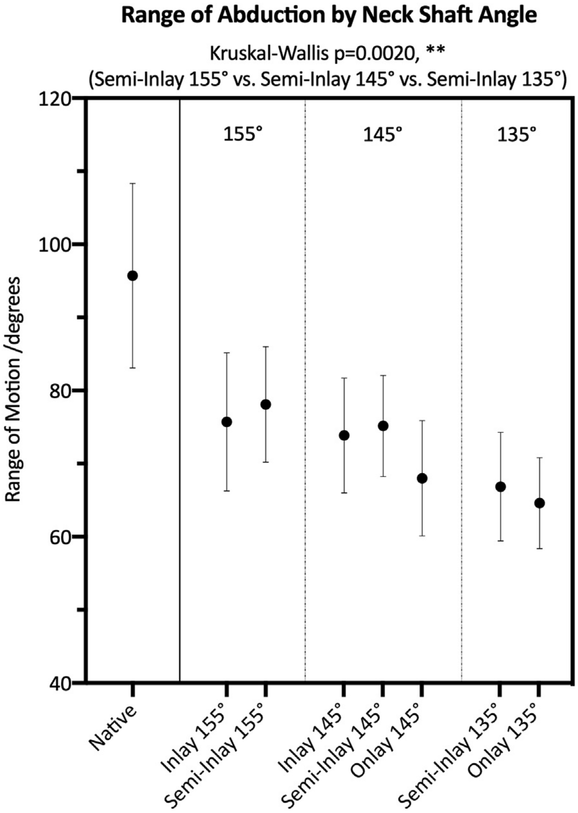

Figure 1 Graph showing the mean range of abduction with 95% confidence intervals for each humeral prosthesis variation arranged by the neck-shaft angle.

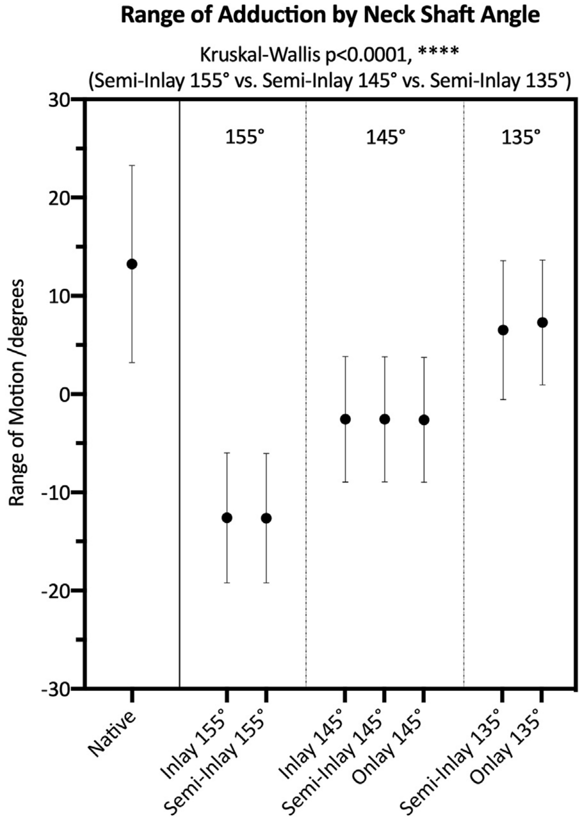

Figure 2 Graph showing the mean range of adduction with 95% confidence intervals for each humeral prosthesis variation arranged by the neck-shaft angle.

COR fixed within the various NSAs for inlay, semi-inlay, and onlay designs, except for the 135° semi-inlay in which an extra 4.5 mm lateralization was necessary to guarantee compatibility with the same reverse metaphysis. Each configuration included a standard 6 mm thickness liner with a 20% jump height ratio to standardize the analysis. The inlay design accommodated NSAs of 145° and 155°; the semi-inlay design accommodated NSAs of 135°, 145°, and 155°; and the onlay design accommodated NSAs of 135° and 145°. We implanted each stem configuration at 20° of retrotorsion with respect to the transepicondylar axis.

In the second scenario, testing variations in glenoid component configuration, the model included a 145° semi-inlay curved anatomical stem implanted in 20° of retroversion. We prepared the scapula as previously described for the first scenario to obtain the closest to neutral version and inclination. We tested 7 different 36 mm glenoid configurations combining 3 different lateral offsets (+0 mm, +4 mm, and +12 mm) and 3 different eccentricity positions (+0 mm, +2 mm inferior, and +2 mm posteroinferior). The +12 mm lateralization was the result of a +4 mm lateralized glenosphere combined with simulated +8 mm bony increased-offset reverse shoulder arthroplasty.[2] The following configurations were tested: centrally positioned glenosphere with 3 lateral offsets (+0 mm, +4 mm, and +12 mm), inferiorly eccentric glenosphere (2 mm inferior to the central glenosphere) with 2 lateral offsets (+4 mm and +12 mm), and posteroinferiorly eccentric glenosphere (2 mm posteroinferior to the central glenosphere) with 2 lateral offsets (+4 mm and +12 mm).

Kinematic simulation

We took the measurements in comparison to a humeral "zero position" related to the scapula.[23] For each of the scans, the anatomical axis of the humerus and the Friedman axis of the scapula were determined to build a bone coordinate system according to the International Society of Biomechanics.[6,31] For each of the RTSA configurations, as well as for the "native" condition, we measured the glenohumeral ROM using SolidWorks to simulate motion in 3 planes: abduction-adduction, forward flexion-extension, and external-internal rotation with the elbow at 10° of abduction (external rotation-1, or ER-1, and internal rotation-1, or IR-1) and with the elbow at maximal abduction for that configuration (external rotation-2, or ER-2, and internal rotation-2, or IR-2). We performed each measurement manually with real-time evaluation and documented the angles for the 2 extreme positions of each ROM as well as the location of prosthetic or bony impingement based on the structural overlap of the scapula onto the humerus or stem models (Supplementary material).

Scapulohumeral position

Further measurements for each of the humerus and glenoid configurations included humeral offset (HO) and acromiohumeral distance (AHD) measured in the frontal plane based on 2D representations. HO equaled the horizontal distance from the COR of

Table I Kruskal-Wallis analysis of ranges of motion by each of the 4 prosthesis design variables (external and internal rotation 1 measured at 10° of abduction; external and internal rotation 2 measured at maximal abduction)

	Kruskal-Wallis analysis			
	Neck-shaft angle	Humeral stem design	Glenosphere lateralization	Glenosphere eccentricity
	Semi-inlay 155° vs. semi-inlay 145° vs. semi-inlay 135°	Inlay 145° vs. semi-inlay 145° vs. onlay 145°	Central (+0 mm) vs. central (+4 mm) vs. central (+12 mm)	Central (+4 mm) vs. inferior (+4 mm) vs. postinferior (+4 mm)
	P value (significance)	*P* value (significance)	*P* value (significance)	*P* value (significance)
Abduction	.0020**	.0570 ns	.0503 ns	.2121 ns
Adduction	<.0001****	.9990 ns	<.0001****	.0177*
Combined abduction and adduction	.0374*	.0252*	<.0001****	.0003***
Flexion	.8783 ns	.9680 ns	.0387*	.1283 ns
Extension	.0818 ns	.7480 ns	.0004***	.7712 ns
Combined flexion and extension	.1580 ns	.6183 ns	<.0001****	.3370 ns
External rotation 1	.0310*	.9987 ns	<.0001****	.0571 ns
Internal rotation 1	.0174*	.8147 ns	.0036**	.0070**
Combined internal and external rotation 1	.0102*	.7696 ns	.0052**	.0308*
External rotation 2	.0177*	.7124 ns	.0004***	.4835 ns
Internal rotation 2	.2467 ns	.2944 ns	<.0001****	.8661 ns
Combined internal and external rotation 2	.0310*	.7520 ns	<.0001****	.8283 ns
Total global range of motion	.9565 ns	.9853 ns	<.0001****	.3557 ns

the humeral cup to the most lateral aspect of the greater tuberosity. AHD equaled the vertical distance from the inferolateral aspect of the acromion to the most superolateral aspect of the greater tuberosity.

Statistical analysis

Data analysis included descriptive statistics: means, SD, and 95% confidence intervals, where appropriate for all ROMs. We employed Kolmogorov-Smirnov testing to evaluate normality of the data, which yielded a mixed pattern of normal and non-normal distributions. In some configurations, there were incalculable data points due to limitations in ROM for those models. In order to account for nonparametric data and missing data points, we maintained statistical validity and robustness by using Kruskal-Wallis analysis to compare ROMs and applied a Dunn correction for multiple intergroup comparisons. Significance was set at $P < .05$.

We performed the statistical analyses with the use of R: a language and environment for statistical computing (R Core Team, 2016. R Foundation for Statistical Computing, Vienna, Austria) and GraphPad Prism version 8.2.1 for Mac OS (GraphPad Software, La Jolla, CA, USA; www.graphpad.com).

Results

Full tables and graphs of results showing all ROMs for all prosthesis configurations are given in the Supplementary material. The most salient findings are summarized below and separated by a prosthesis design variable.

Humeral stem

Influence of humeral stem design on ROM (inlay vs. semi-inlay vs. onlay)

Variation in stem designs (inlay, semi-inlay, onlay), controlled for NSA and AHD/HO, did not show statistically significant differences in total global ROM (P = .9853). Table I shows the results of detailed group comparisons. None of the matched ROM directions demonstrated statistical significance, except for combined abduction/adduction (P = .0252). However, neither isolated abduction nor adduction showed significant differences between the designs.

Influence of humeral inclination (NSA) on ROM (135° vs. 145° vs. 155°)

Variation in NSA (135° vs. 145° vs. 155°), controlled by humeral stem design and AHD/HO, did not have a significant influence on the total global ROM (P = .9565). Nevertheless, isolated ROMs showed statistically significant differences between NSAs. Increasing NSA significantly improved abduction (P = .0020) (Fig. 1). The mean abduction with the same semi-inlay design increased from

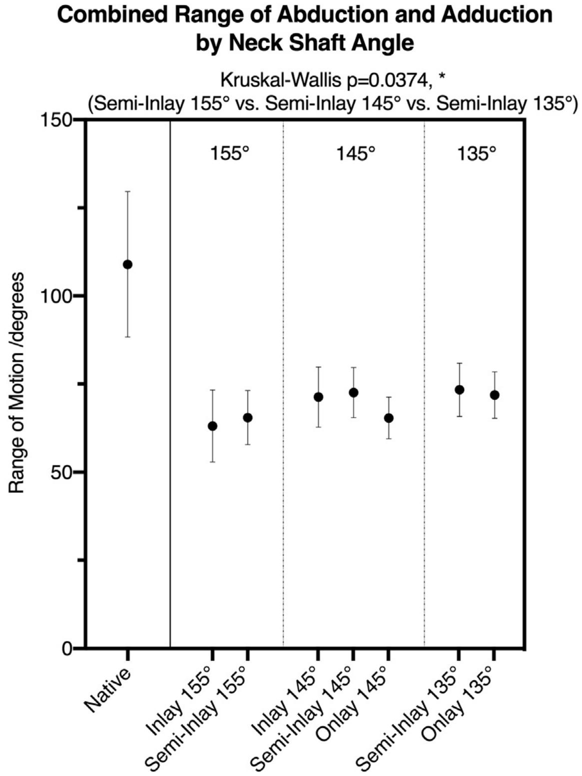

Figure 3 Graph showing the mean combined range of abduction and adduction with 95% confidence intervals for each humeral prosthesis variation arranged by the neck-shaft angle.

67° with the 135° humeral configuration to 75° with the 145° configuration and 78° with the 155° configuration. Conversely, adduction reduced significantly as NSA increased ($P < .0001$): 7° with the 135° configuration, −3° with the 145° configuration, and −13° with the 155° configuration (Fig. 2). Despite these results, combined abduction and adduction showed no significant differences (Fig. 3). Isolated ranges of flexion ($P = .8783$) and extension ($P = .0818$) as well as their combined range ($P = .1580$) were similar between the 3 NSAs. External and internal rotation with the arm by the side, in 10° abduction (ER-1 and IR-1), were significantly different between the groups ($P = .0310$ and .0174, respectively). There was a small gradual decrease in mean ER-1 and IR-1 from 135° to 145° and to 155°. Finally, combined external and internal rotation with the arm in maximal abduction (ER-2 and IR-2) was statistically significant between the NSA configurations ($P = .0310$), increasing with an increase in NSA. This pattern was also seen with isolated ER-2 ($P = .0177$), although no difference was seen with isolated IR-2 ($P = .2467$).

Glenosphere

Influence of glenosphere lateralization on ROM (+0 mm vs. +4 mm vs. +12 mm)

Glenosphere lateralization from the glenoid articular surface, regardless of glenoid eccentricity, resulted in significantly improved total global ROM ($P < .0001$). Similarly, each of the combined ROMs increased significantly with an increase in lateral offset. Isolated ROMs all showed significant differences between lateralization groups apart from abduction, which failed to reach significance ($P = .0503$). All isolated ranges showed an increase in ROM with increasing lateralization apart from IR-1, which showed an initial increase as lateralization reached +4 mm but decreased at +12 mm of lateralization.

Clearly, extreme lateralization will reduce bony impingement with the glenoid neck and/or acromion. Therefore, in order to discern whether +4 mm of lateralization or +12 mm may be required to significantly affect ROM, intergroup comparisons of the data were performed using Kruskal-Wallis analysis with the Dunn correction test (Table II). The +4 mm lateralization configuration demonstrated a significant increase in total global ROM and in all combined ROMs compared with +0 mm lateralization. The use of the +12 mm lateralized glenosphere did not show a significant increase in total global ROM compared with the +4 mm, nor in the combined ROMs other than combined ER-2 and IR-2 ($P = .0034$).

Influence of glenosphere eccentricity on ROM (centered vs. +2 mm inferior eccentricity vs. +2 mm posteroinferior eccentricity)

Glenosphere eccentricity, once controlled for lateralization, had no statistically significant impact on total global ROM

Table II Kruskal-Wallis with Dunn correction for multiple comparisons analysis of glenosphere lateralization

	Kruskal-Wallis with Dunn correction	
	Glenosphere lateralization	
	Central (+0 mm) vs. central (+4 mm)	Central (+4 mm) vs. central (+12 mm)
	P value (significance)	*P* value (significance)
Combined abduction and adduction	.0075**	.0672 ns
Combined flexion and extension	.0218*	.1529 ns
Combined internal and external rotation 1	.0185*	>.9999 ns
Combined internal and external rotation 2	.0366*	.0034**
Total global range of motion	.0295*	.0779 ns

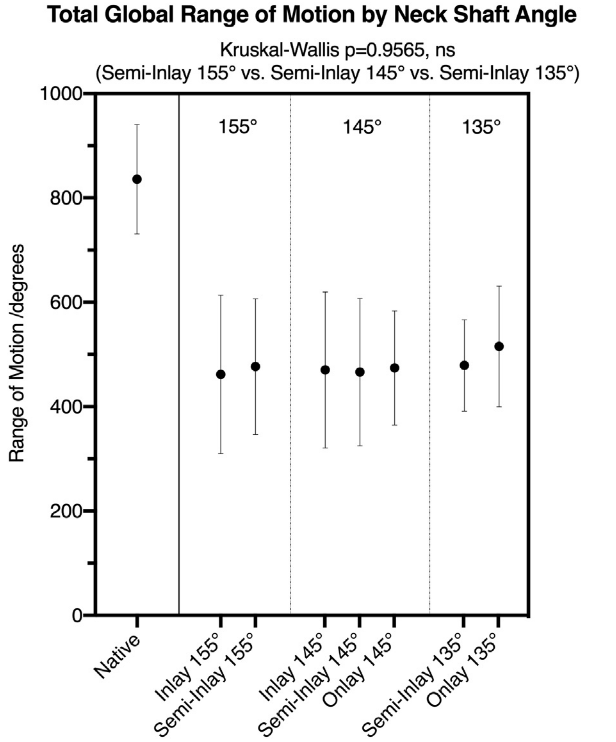

Figure 4 Graph showing the mean total global range of motion with 95% confidence intervals for each humeral prosthesis variation arranged by the neck-shaft angle.

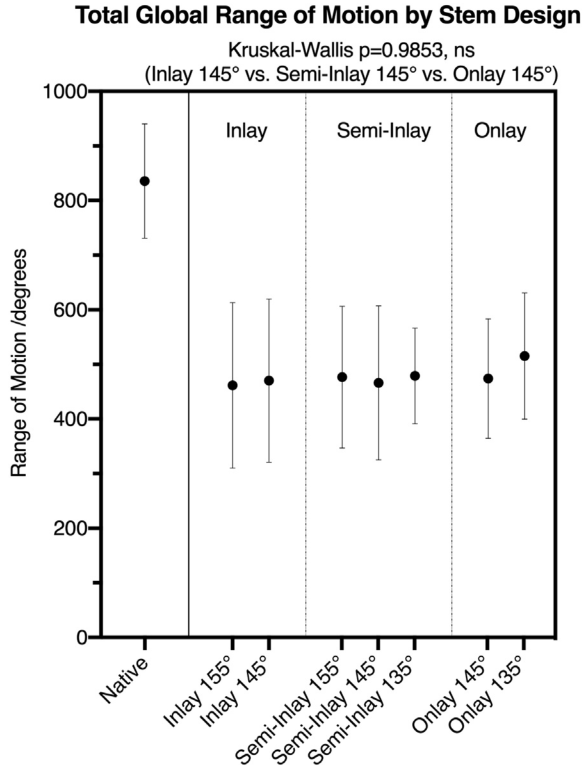

Figure 5 Graph showing the mean total global range of motion with 95% confidence intervals for each humeral prosthesis variation arranged by the stem design.

(P = .3557) or the majority of isolated and combined ROMs. Only isolated adduction (P = .0177) and IR-1 (P = .0070) showed significant differences between groups; these differences were sufficient to significantly affect combined abduction and adduction as well as combined ER-1 and IR-1. In both adduction and IR-1, inferior eccentricity showed the best ROMs compared with centralization or posteroinferior eccentricity of the glenosphere.

Discussion

The evolution in RTSA has led to significant changes in prosthesis design in order to escape from the initial Grammont design complications. These changes were mainly developed to decrease the commonly observed notching and to increase ROM. Numerous studies based on cadavers,[5] sawbone models,[11] and 3D computer models[10,16,17,25,27,28] have investigated the influence of prosthesis variations on ROM. From the latter group of studies, multiple conclusions have been drawn in order to define the "best" RTSA configuration. However, many of them lack isolation of variables such as HO and AHD, mainly in humeral components, when comparing their computer model designs leading to results with mixed concepts. Analyzing the ROMs offered by one brand of 155° inlay humeral stem with an alternative brand of 135° onlay humeral stem does not constitute a scientific comparison of NSA or inlay design, as the basic stem design inherent to each brand is different, and these comparisons fail to control for multiple confounding variables.

The main strength of the present study is that we aimed to evaluate the influence of each humeral and glenoid configuration by controlling the other variables, thereby obtaining a truer effect of prosthesis configurations on ROM. Moreover, this study included gradual variations in both humeral and glenosphere configurations according to the current most common surgical preferences and prosthesis designs available in the market. Our analysis does not permit a direct interbrand comparison of prosthesis currently commercially available; rather it allows a more independent interpretation of the effects of each of the 4 most common variables, namely NSA, inlay design, glenosphere lateralization, and glenosphere eccentricity.

Over time humeral stem configuration in RTSA has evolved toward a more anatomic NSA inclination and to an onlay design. The decrease of NSA from 155° to 145° and to 135° influences ROM, especially resulting in a gain of adduction.[3,16] The evolution from an inlay to an onlay design aimed to improve ROM, particularly external and internal rotation and to be less invasive to metaphysis bone stock. Recently, Lädermann[16] concluded that a 145° onlay design had the best mobility compromise, compared with

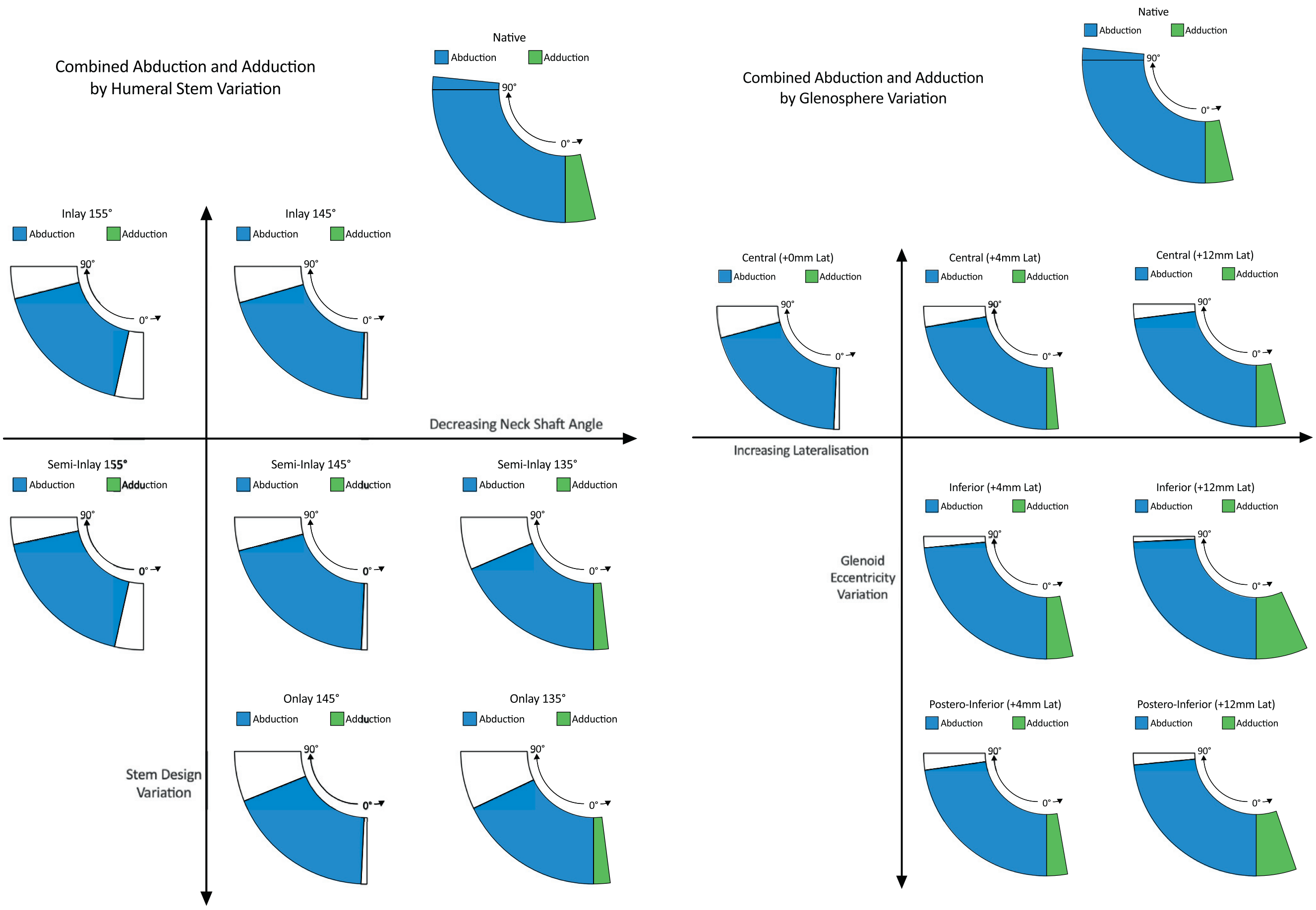

Figure 6 Illustrative depiction of combined abduction and adduction in all humeral stem (left) and glenosphere (right) configurations. Humeral stem variations have virtually no effect on the magnitude of combined abduction/adduction ranges of motion although the position of the arc of motion is altered. Glenosphere lateralization has a significant improvement in combined abduction/adduction range of motion mainly through an increase in adduction. Inferior glenosphere eccentricity presents the best combined abduction/adduction results.

the original 155° inlay. However, abduction and especially ER-2 were dramatically reduced.[16] Werner et al[28] found that a 135° onlay model (using 5 mm glenoid lateralization) provided the best results in impingement-free ROM, except for abduction. These 2 range directions (abduction and ER-2) are crucial for daily life activities such as brushing hair or reaching an overhead object. One of the main findings in our study was that, contrary to the existing literature and our preconceptions, there was no significant difference in total global ROM between any of the humeral configurations (Figs. 4 and 5). In other words, any variation in NSA and stem design had no overall influence in cumulative arcs of motion; rather it resulted in a different ROM pattern, altering the position and shape of the cone of motion. Specific directions of motion were influenced by changes in NSA. More vertical NSA (ie, 135° vs. 155°) reduced abduction and ER-2, but increased adduction, IR-1, and ER-1. These findings are consistent with earlier studies.[4,16,28] A loss of abduction with the 135° onlay can be explained by excessive proximalization and lateralization, leading to an earlier impingement of the greater tuberosity on the acromion.[12,16]

Interestingly, humeral stem design (ie, inlay, semi-inlay, or onlay) had no significant effect on any of the ROMs measured other than a combined arc of abduction and adduction, which varied by only 6° between the inlay (mean, 71°) and onlay (mean, 65°). To our knowledge, there are no previous studies that compare the inlay, semi-inlay, and onlay designs.

Since the initial glenosphere design, which placed the COR on the native glenoid surface,[8] the glenosphere has evolved toward an increased lateral offset, under the pretext of improving rotators tensioning[14,15] and having greater inferior clearance to avoid notching.[1,17,18] Recently, Werthel[29] clarified the definition of lateralization to standardize the lateral offset measurements for the different glenoid and stem designs. In addition, glenosphere inferior eccentricity theoretically improves ROM and decreases inferior scapular notching in adduction.[13,17] In the present study, both concepts were consistent with the literature, showing less scapular neck impingement and better ROMs with lateralized and inferior eccentricity of the glenosphere.[19] Lateralization was the most influential variable in our study demonstrating statistically significant differences in total global ROM and for virtually all of the directions measured. However, another crucial finding of the study was that, although +4 mm lateralization had a significantly better range in all directions than the no lateralization, no further significant improvement was seen from +4 mm to +12 mm, except for ER-2 and IR-2. This finding puts the use of the bony increased-offset reverse shoulder arthroplasty or highly lateralized glenospheres in the spotlight, questioning the necessity for such extreme lateralization. One biomechanical study has demonstrated that lateralization resulted in a proportional increase in joint and muscle loading, which negatively influences the long-term success of RTSA.[7] In addition, a high degree of lateralization is likely to defunction any remaining rotator cuff muscles due to overstretching or make their potential repair or reattachment, particularly of the subscapularis, impossible. Lastly, inferior eccentricity of the glenosphere had a significant impact on 2 range directions: adduction and IR-1. This finding confirms the success of the original aim of inferior glenosphere eccentricity, namely, to reduce notching/scapula neck abutment that mainly occurs in these specific directions.

This study has, for the first time, permitted a much truer independent evaluation of the effects on ROM of the main humeral and glenoid prosthesis variables in RTSA design and implantation. The fact that the total global ROM is unaffected by all humeral component variations goes to show that there may not be an ideal RTSA configuration and that a surgeon must "pick his, or her, poison" in terms of which ROM compromises to accept when selecting a prosthesis for implantation. Fig. 6 shows a pictorial representation of the effect of each configuration on combined abduction and adduction. Additional diagrams are supplied in the Supplementary material representing the effect of each humeral and glenosphere configurations to each of the ROM directions. These figures help to make sense of the large data set generated by this type of computer model analysis and clearly show the benefits of selecting prosthesis in the middle ground in order to maximize the benefits while minimizing the drawbacks from the extremes of the design spectrum.

The limitations of the study include those inherent to computer-based models. First, the study assesses impingement-free passive ROM, but we could not consider muscle activation or influence of soft tissue restrictions. Second, we evaluated glenohumeral ROM but could not consider scapula-thoracic movements. Third, although we standardized the implantation of the components, there were subtle variations in glenoid baseplate and humerus stem positioning, those inherent to the surgical technique in the real life. Furthermore, we focused on the analysis of the 4 main parameters that differ among RTSA designs, but we did not assess variation in glenosphere size, baseplate version, baseplate inclination, or humeral torsion, all of which may have an impact on ROM. Finally, it is important to note that ROM occurs in 3D space, although variations in RTSA configuration occur mainly in the coronal plane. Future studies should consider changes in the other planes, for instance, altering stem torsion or humeral tray eccentricity in the sagittal plane.

Conclusion

Although the aim of this study was to find the best combination of glenoid and humeral components for RTSA, there is no clear answer for this paradigm. Moderate lateralization (+4 mm) of the glenosphere showed significant benefit to ROM; greater lateralization did not yield further significant improvements in ROM. The inferior glenosphere eccentricity of 2 mm improved adduction and IR1, suggesting a reduced notching risk. With regard to humeral configuration, no design produced more total movement than any other, simply different movement characteristics. In that respect, each surgeon must choose where to compromise when selecting prosthesis. Nevertheless, our results point the semi-inlay 145° combined with 4 mm lateralization and 2 mm inferior eccentricity as the middle ground for the most all-purpose approach in RTSA.

Disclaimer

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Supplementary data

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