Introduction

The initial reverse shoulder arthroplasty (RSA) design was excellent at restoring forward flexion, but had several design-related complications including bony impingement and scapular notching [31, 38], instability [5], acromial fractures [19], limited range of motion (ROM) (particularly internal and external rotation; [20, 29]), and humeral stem loosening [32, 38]. Many of these have been attributed to the initial Grammont design, which featured a medialized glenosphere and 155-degree straight stem (medial glenoid/medial humerus design) [12].

A variety of changes in prosthetic design have been proposed to address these issues either on the humeral side or on the glenoid side, the goal being to decrease scapular notching, maximize efficiency of the remaining rotator cuff, and improve stability as well as ROM. On the glenoid side, authors have promoted increased lateralization either with bone or metal [4, 15]. On the humeral side, a more anatomic humeral inclination (i.e., 145 or 135 degrees) and inlay and onlay system designs have introduced a myriad of prosthetic configurations that has rendered analysis and delivery of universal guidelines difficult.

Therefore, the aim of this review was to evaluate the advantages and drawbacks of different RSA designs and to provide recommendations accordingly.

Glenoid configuration

Glenoid configuration has an important effect on postoperative ROM. The three most important variables are glenoid offset, eccentricity, and glenosphere size. None of these latter parameters significantly influence the measured bone strains at the glenoid near the bone–implant interface [46].

Glenoid offset (lateralization)

The initial Grammont-style RSA utilized a glenosphere with a medialized center of rotation. While this design reliably improved forward elevation, the high rate of scapular notching and internal and external rotation deficit observed with this design have been attributed to the medialized glenoid design [12, 35]. To address these problems, glenoid lateralization has been proposed to decrease scapular notching, improve soft tissue tension, and increase impingement-free ROM. The glenoid component is considered as lateralized if lateralization equals or exceeds 5 mm compared to the Grammont design [50]. It is important to note that this lateralization of the center of rotation is relative to the implant designed by Grammont, but still medialized compared to the native glenohumeral joint. Lateralization can be achieved with either the placement of bone medial to the baseplate (BIO-RSA) [4] or with metallic lateralization via the baseplate or glenosphere. While both have been associated with clinical improvement [10, 24], metallic lateralization appears to be potentially less subject to displacement, particularly with lateralization beyond 5 mm [8].

Basic scientific studies show several benefits of lateralization. In both saw-bone [17] and computer models [15, 23, 33], lateralization improves ROM in all directions [33]. Lateralization also leads to improved stability [11].

The question remains as to how much lateralization is ideal. While clinical evidence is currently lacking, computer modeling suggests that 5–10 mm of lateralization relative to the native glenoid is ideal [16, 33, 49]. Nevertheless, clinical data to date have not necessarily proved that lateralization improves ROM [6] or outcome scores [21] compared to a traditional RSA. Greiner et al. performed a randomized controlled trial of 17 Grammont RSAs and 17 BIO-RSAs and reported no difference in Constant scores at 1 year postoperatively [14]. In a retrospective study, Athwal et al. did not observe substantial differences between Grammont RSA and BIO-RSA with respect to ROM, strength, or outcome.
scores [1]. The frequency of scapular notching, however, was significantly higher ($P=0.022$) in the RSA cohort than in the BIO-RSA cohort: 75\% vs 40\% [1]. This finding has also been reported by Zitkovsky et al. [51]. At 10 years follow-up, Kennon et al. confirmed that scapular notching rates are significantly higher with medialized components compared to lateralized ones (77\% in vs. 47\%, $P=0.013$) [22]. Notably, all of these studies utilized a 155-degree humeral prosthesis and thus further comparative studies are required with 135-degree and/or 145-degree prostheses.

Glenosphere eccentricity

Inferior eccentric positioning of the glenosphere can also be used to decrease the adduction deficit and thus reduce scapular notching [23, 27]. Mizuno et al. previously reported that an inferiorly eccentric glenosphere reduced the severity of scapular notching with a 155-degree prosthesis [39], thereby improving postoperative rotations with elbow at side [31]. While the differences are small, the eccentric glenosphere provided the greatest ability to limit scapular notching while maximizing ROM by increasing the subacromial space [27, 33]. Abduction is effectively positively correlated with acromiohumeral distance ($r=0.93$; $p<0.001$), which is increased with an eccentric glenosphere [28]. Rotation in abduction is important in activities of daily living. Interestingly, the latter are impossible in most configurations due to inexistent subacromial space (Fig. 1). Posteroinferior eccentricity can also improve extension and could additionally promote internal rotation hand in the back (Fig. 2).

It is important to note, however, that inferior overhang of the glenosphere can be achieved either by an eccentric glenosphere or by a baseplate position. Conversely, an eccentric glenosphere with an improperly positioned superior baseplate will not provide clinical benefit. Thus, the surgeon must be cognizant of both the overhang of the given glenosphere relative to the selected baseplate, as well as any eccentricity in the glenosphere. Furthermore, the benefits of overhang or eccentricity must be weighed against the risks of nerve injury and acromial fracture associated with arm lengthening. The ideal amount of overhang relative to the glenoid appears to be about 2.5 mm based on clinical evidence [20].

Glenosphere size

Both theoretically and clinically, the size of the glenosphere influences postoperative ROM. Lädermann et al. found that a small glenosphere (36 mm) improves external rotation in abduction [27]. However, with the elbow at side, larger diameter glenospheres have been shown to provide a greater impingement-free arc of motion and decrease scapular notching in biomechanical studies. Werner et al. reported superior values for extension and external rotation with a 39-mm glenosphere compared to a 36-mm glenosphere [48]. Berhouet et al. demonstrated in a cadaveric study that a 42-mm glenosphere was associated with improved rotational ROM compared to a 36-mm glenosphere ($p<0.05$) [3]. Another study comparing functional scores and ROM differences between two groups of patients, one receiving a 36-mm glenosphere and the other receiving a 44-mm glenosphere, found that patients with the larger glenosphere had a 12-degree increase in external rotation in abduction compared to those with the smaller glenosphere ($p<0.001$) [41]. Similarly, Mollon et al. showed that a 42-mm glenosphere generated a 15-degree improvement in forward flexion and a 6-degree improvement in external rotation compared to the 38-mm size, with an overall improvement in pain scores [40]. Finally, a study by Haida-mous et al. demonstrated that larger glenosphere size and inferior positioning as well as posterior humeral offset are associated with improved postoperative ROM following RSA with a 135-degree humeral component [20]. Nevertheless, larger glenospheres limit abduction and rotations in abduction and are prone to higher volumetric wear rates and experienced greater polyethylene volume loss [18]. Additionally, one must consider patient size. Overstuffing can occur. Matsuki et al., for instance, demonstrated that small- and large-stature patients achieved lower improvement in ROM with an RSA system with only two glenosphere sizes (38 and 42), likely due to the fact that the small patients were overstuffed and the large patients did not have large enough glenospheres and/or lateralization [37].

Humeral stem designs

The primary humeral stem variables include stem geometry, neck-shaft angle, inlay versus onlay configuration, and humeral spacers.
Stem geometry

Short curved stems were initially developed to facilitate implantation, maintain bone stock, and preserve rotator cuff insertion [25]. These stems also change humeral offset based on their positioning in the humeral canal. In one study, an onlay curve stem led to a 7-mm increase in humeral offset compared with a traditional inlay straight Grammont prosthesis [26]. Curve stems decrease the acromiohumeral distance, which may lead to acromial impingement at small abduction angles [26]. On the other hand, humeral lateralization can be useful to compensate for medialization in the case of bone loss (Fig. 3) and has been theorized to improve the mechanics of the remaining rotator cuff and deltoid musculature [45]. Stem design appeared to lead to acromial impingement at small abduction angles [26]. On the other hand, humeral lateralization can be useful to compensate for medialization in the case of bone loss (Fig. 3) and has been theorized to improve the mechanics of the remaining rotator cuff and deltoid musculature [45].

Neck-shaft angle (inclination)

The Grammont RSA was designed as a non-anatomic implant with a relative valgus humeral neck inclination of 155 degrees. Based on the work by Gutierrez et al. [17], neck-shaft angle has decreased in modern prosthetic designs to a more varus or anatomic inclination of 145 or 135 degrees.

The neck-shaft angle is a major factor influencing length of the arm [30], but has little effect on humeral lateralization; by changing inclination from 155 degrees to 135 degrees within an onlay design, humeral offset only increased by about 2 mm [26].

Theoretically, compared to low neck-shaft angle stems, higher inclinations (155 degrees) increased abduction by 100% and external rotation in abduction, regardless of glenosphere designs [26, 33]. This finding is important as such external rotation is a major factor in the ability to perform activities of daily life such as hair care and facial grooming. However, a 155-degree inclination is associated with decreased adduction external rotation at the side [26, 42, 49] and extension due to medial bony impingement (which also leads to scapular notching) [15, 28, 33, 44, 47, 49]. Lateralization obtained via a lower neck-shaft angle increases adduction by 357% between a 155-degree prosthesis compared with a 135-degree prosthesis. Also, an increase in extension of 381% and external rotation elbow at side of 116% are observed with a 135-degree prosthesis [26]. Such findings are important as external rotation with the elbow at the side and extension led to friction between the scapular pillar and the polyethylene insert. Even if this friction phenomenon does not limit ROM, it likely contributes to progressive polyethylene wear and scapular notching [31]. However, reducing the neck-shaft angle can have some negative effects on RSA contact mechanics. The contact area is reduced by 29% for 155 degrees to 145 degrees and by 59% for 155 degrees to 135 degrees. Consequently, there is an increase in maximum contact stress of 71% for 155 degrees to 145 degrees and of 286% for 155 degrees to 135 degrees [34].

Gobezie et al. published the results of a randomized controlled trial comparing humeral inclination of 135 degrees to 155 degrees among patients undergoing RSA with a neutral glenosphere (no lateralization) and found no significant
difference in forward flexion, external rotation, or functional outcomes [13]. They and other studies have confirmed that scapular notching is decreased with a 135-degree prosthesis [9, 13, 51]. A systematic review of 2222 shoulders comparing 135-degree and 155-degree prostheses reported higher rates of scapular notching in the 155-degree group (16.8% vs. 2.8%), improved external rotation in the 135-degree group, and no difference in instability of forward flexion between groups [9].

Lastly, in the case of fracture, RSA with a 135-degree neck-shaft angle is associated with higher tuberosity healing rates compared to 145 degrees or 155 degrees [43].

Onlay vs. inlay

Compared to inlay design, an onlay humeral design with the same 155-degree inclination increased humeral offset by 6.6 mm [26]. Acromiohumeral distance varied by 9.8 mm, with the smallest occurring with the onlay 135-degree model and the largest occurring with a Grammont inlay 155 degrees. Compared to the inlay design, an onlay humeral design with the same 155-degree inclination decreased the acromioclavicular distance by 4.1 mm. Compared to the onlay 155 degrees model, with the inlay 155 degrees model there was a 10-degree decrease (77.8 to 67.9 degrees) in abduction and a 5-degree (range, –15.3 to –20.2 degrees) increase in adduction [26].

Clinically, Beltrame et al. conducted a prospective clinical study comparing onlay and inlay stems. They found that an onlay design 145 degrees may provide better active external rotation, extension, and adduction [2]. However, there are numerous biases in their study (i.e., different neck-shaft angle and stem lateralization) preventing integration of their results in the present analysis.

A retrospective review reported a trend towards a higher rate of acromial fractures among patients with an onlay (12%) as opposed to an inlay (4%) system [36]. In a retrospective comparative radiological study, Haidamous et al. similarly showed that an onlay humeral stem design resulted in a 10-mm increase in distalization compared to an inlay humeral stem, and a 2.5 times (11.9% vs. 4.7%) increased risk of scapular spine fracture [19]. Thus, it seems that the combination of lateralization and distalization in an onlay system dramatically increases the incidence of scapular spine fractures.

Lengthening of the supraspinatus and infraspinatus is systematically observed with an onlay design. This is greatest using onlay stems (7–30%) and lateralized glenospheres (13–31%) [28]. Subscapularis lengthening is observed for onlay stems combined with lateralized glenospheres (5–9%), while excessive subscapularis shortening is observed for the inlay stem combined with all gleno-
spheres except the lateralized design (>15%) [28].

**Polyethylene insert**

Since inferior impingement between the polyethylene and the scapula is systematic with the arm at the side, another potential way to limit friction and notching in external rotation is to create a notch in the polyethylene inferiorly between 3 and 9 o’clock, as has been done in some prostheses (e.g., Arrow and SMR). Another solution to increase ROM is to reduce the depth of the polyethylene cup. De Wilde et al. found that for every 3-mm decrease in depth of the polyethylene cup, ROM increased by 12 degrees [7].

**Discussion**

The literature is controversial with regard to possibilities of regaining ROM following RSA. While prosthetic designs vary and lead to substantial changes in computer models, many of the theoretical advantages have not been confirmed clinically. Table 1 summarizes implant design considerations to improve ROM.

The results of this review reveal that the optimal compromise in ROM for a primary RSA without bone loss might be a lateralized glenoid with a low neck-shaft angle (145–135 degrees) and an inlay concept. However, all prosthetic designs should be considered on a case-by-case basis to optimize outcome.

**Limitations**

The main limitation of this investigation is its non-systematic character. Another limitation is the omission of soft tissue tension, which can restrict ROM, particularly in revision or post-traumatic cases.

**Practical conclusion**

- Glenoid and humeral stem designs change ROM and complication rates after RSA.

### Table 1 Implant design considerations to improve the range of motion (ROM) when performing a reverse shoulder arthroplasty

| Features/notes                        | Glenoid                        | Humerus        |
|---------------------------------------|--------------------------------|----------------|
| Offset (lateralization)               | Improve ROM and decreased notching by moving the center of rotation lateral to the glenoid | Can lead to humeral lateralization |
| Eccentricity                          | Improve ROM and decreased notching by distalization and prevention of impingement on the inferior glenoid | 135 Degrees leads to decreased notching, possibly improvement in external rotation, and improved tuberosity healing |
| Glenosphere size                      | Larger arc of motion           | Combined distalization and lateralization with onlay features increase risk of scapular spine fracture |
| Stem geometry                         |                               | Scapular notching limited by polyethylene notch |
| Neck shaft angle (inclination)        |                               |                |
| Onlay vs. Inlay                        |                               |                |
| Polyethylene insert                   |                               |                |

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**Compliance with ethical guidelines**

**Conflict of interest.** A. Lädermann is a paid consultant for Wright, Arthrex and Medacta. He received Royalties from Wright. P. Collin is a paid consultant for Wright and Arthrex and received Royalties from Wright. P.J. Denard reports grants and personal fees from Arthrex.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case.

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**References**

1. Athwal GS, Macdermid JC, Reddy KM et al (2015) Does bony increased-offset reverse shoulder arthroplasty decrease scapular notching? J Shoulder Elbow Surg 24:468–473
2. Beltrame A, Di Benedetto P, Cirillo C et al (2019) Onlay versus Inlay humeral stem in
Reverse Shoulder Arthroplasty (RSA): clinical and biomechanical study. Acta Biomech 90:54–63
3. Berhouet J, Garaud P, Favard L (2014) Evaluation of the role of glenosphere design and humeral component retroversion in avoiding scapular notching during reverse shoulder arthroplasty. J Shoulder Elbow Surg 23:151–158
4. Boileau P, Moineau G, Roussanne Y et al (2011) Bony increased-offset reversed shoulder arthroplasty: minimizing scapular impingement while maximizing glenoid fixation. Clin Orthop Relat Res 469(5):1262–1267
5. Chae J, Siljander M, Water JM (2018) Instability in reverse total shoulder arthroplasty. J Am Acad Orthop Surg 26:587–596
6. Collin P, Liu X, Denard PJ et al (2018) Standard versus bony increased-offset reverse shoulder arthroplasty: a retrospective comparative cohort study. J Shoulder Elbow Surg 27:59–64
7. De Wilde LF, Poncet D, Middernacht B et al (2010) Glenoid bone grafting in primary reverse total shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg 19:283–288
8. Erickson BJ, Frank RM, Harris JD et al (2015) The role of glenosphere design and humeral stem design on humeral offset for reverse shoulder arthroplasty. J Shoulder Elbow Surg 24:998–993
9. Emstbrunner L, Werthel JD, Wagner E et al (2017) The influence of humeral head inclination in reverse total shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg 26:1441–1447
10. Ferle M, Pastor MF, Hagenah J et al (2019) Effect of the humeral neck-shaft angle and glenosphere lateralization on stability of reverse shoulder arthroplasty: a cadaveric study. J Shoulder Elbow Surg 28:966–973
11. Gerber C, Pennington SD, Nyffeler RW (2009) Reverse total shoulder arthroplasty. J Am Acad Orthop Surg 17:608–615
12. Gerber C, Pennington SD, Nyffeler RW (2009) Reverse total shoulder arthroplasty: how did medialized and glenoid-based lateralized style prostheses compare at 10 years? J Shoulder Elbow Surg 19:523–531
13. Greiner S, Schmidt C, Herrmann S et al (2015) Clinical performance of lateralized versus non-lateralized reverse shoulder arthroplasty: a prospective randomized study. J Shoulder Elbow Surg 24:1397–1404
14. Gobezie R, Shishani Y, Lederman E et al (2019) Can a functional difference be detected in reverse arthroplasty with 135 degrees versus 155 degrees prosthesis for the treatment of rotator cuff arthropathy: a prospective randomized study. J Shoulder Elbow Surg 28:813–818
15. Green S, Schmidt C, Hermann S et al (2015) Clinical performance of lateralized versus non-lateralized reverse shoulder arthroplasty: a prospective randomized study. J Shoulder Elbow Surg 24:1397–1404
16. Gutierrez S, Comiskey CA, Luo ZP et al (2008) Range of impingement-free abduction and adduction deficit after reverse shoulder arthroplasty. Hierarcy of surgical and implant-design-related factors. J Bone Joint Surg Am 90:2606–2615
17. Gutierrez S, Greiwe RM, Frankle MA et al (2007) Biomechanical comparison of component position and hardware failure in the reverse shoulder prosthesis. J Shoulder Elbow Surg 16:59–512
18. Gutierrez S, Levy JC, Frankle MA et al (2008) Evaluation of abduction range of motion and avoidance of inferior scapular impingement in a reverse shoulder model. J Shoulder Elbow Surg 17:608–615
19. Haidamous G, Ladermann A, Frankle M et al (2020) The risk of postoperative scapular spine fracture following reverse shoulder arthroplasty is increased with an onlay humeral stem. J Shoulder Elbow Surg. https://doi.org/10.1016/j.jse.2020.03.036
20. Haidamous G, Ladermann A, Hartzler Ret al (2020) Radiographic parameters associated with excellent versus poor range of motion outcomes following reverse shoulder arthroplasty. Shoulder Elbow. https://doi.org/10.1177/1758573209362334
21. Helmkamp JK, Bullock GS, Amido ME et al (2018) The clinical and radiographic impact of center of rotation lateralization in reverse shoulder arthroplasty: a systematic review. J Shoulder Elbow Surg 27:2099–2107
22. Kannon JC, Songy C, Bartels D et al (2020) Primary reverse shoulder arthroplasty: how did medialized and glenoid-based lateralized style prostheses compare at 10 years? J Shoulder Elbow Surg 29:523–531
23. Kim SJ, Jang SW, Jung KH et al (2019) Analysis of impingement-free range of motion of the glenosphere versus reverse total shoulder arthroplasty using three different implant models. J Orthop Sci 24:87–94
24. Klein SM, Dunning P, Mulieri P et al (2010) Effects of acquired glenoid bone defects on surgical technique and clinical outcomes in reverse shoulder arthroplasty. J Bone Joint Surg Am 92:1144–1154
25. Ladermann A, Chiu JC, Cunningham G et al (2020) Do short stems influence the cervicodiaphyseal angle and the medullary filling after reverse shoulder arthroplasties? Orthop Traumatol Surg Res 106(2):241–246. https://doi.org/10.1016/j.otsr.2019.12.010
26. Ladermann A, Denard PJ, Boileau P et al (2015) Effect of humeral stem design on humeral position and range of motion in reverse shoulder arthroplasty. Int Orthop 39:2205–2213
27. Ladermann A, Denard PJ, Boileau P et al (2018) What is the best glenoid configuration in onlay reverse shoulder arthroplasty? Int Orthop 42:1339–1346
28. Ladermann A, Denard PJ, Collin P et al (2020) Effect of humeral stem and glenosphere designs on range of motion and muscle length in reverse shoulder arthroplasty. J Shoulder Elbow Surg 19:519–530. https://doi.org/10.1016/j.jse.2019.04.063-2
29. Ladermann A, Denard PJ, Tirefort J et al (2017) Subcapsularis- and deltoid-sparing vs traditional deltoidpectoral approach in reverse shoulder arthroplasty: a prospective case-control study. J Orthop Surg Res 12:112
30. Leduc R, Salazar D, Garbis N et al (2018) Incidence of glenoid sided reverse total shoulder arthroplasty: a review. J Shoulder Elbow Surg 27:808–815
31. Melis B, Defranco M, Ladermann A et al (2011) An evaluation of the radiological changes around the Grammont reverse geometry shoulder arthroplasty after eight to 12 years. J Bone Joint Surg Br 93:1240–1246
32. Mollon B, Mahura SR, Roche CP et al (2016) Impact of glenosphere size on clinical outcomes after reverse total shoulder arthroplasty: an analysis of 297 shoulders. J Shoulder Elbow Surg 25:763–771
33. Muller AM, Born M, Jung C et al (2018) Glenosphere size in reverse shoulder arthroplasty: is larger better for external rotation and abduction strength? J Shoulder Elbow Surg 27:44–52
34. Nelson R, Lowe JT, Lawler SM et al (2018) Lateralized center of rotation and lower neck-shaft angle are associated with lower rates of scapular notching and heterotopic ossification and improved pain for reverse shoulder arthroplasty at 1 year. Orthopedics 41:230–236
35. O’ Sullivan J, Ladermann A, Parsons B et al (2020) A systematic review of tuberosity healing and outcomes following reverse shoulder arthroplasty for fracture according to humeral inclination of the prosthesis. J Shoulder Elbow Surg. https://doi.org/10.1016/j.jse.2020.03.032
36. Oh JH, Shin SJ, McGarry MH et al (2014) Biomechanical effects of humeral neck-shaft angle and subscapularis integrity in reverse total shoulder arthroplasty. J Shoulder Elbow Surg 23:1091–1098
37. Parry S, Stachler S, Mahlys J (2020) Lateralization in reverse shoulder arthroplasty: a review. J Orthop 22:64–67
38. Pauzenberger L, Dwyer C, Obopilwe E et al (2020) Glenoid bone strain changes in reverse shoulder arthroplasty. BMC Musculoskelet Disord 20:587
39. Virani NA, Cabezás A, Gutierrez S et al (2013) Reverse shoulder arthroplasty components and surgical techniques that restore glenohumeral motion. J Shoulder Elbow Surg 22:179–187
40. Werner BS, Chauoi J, Walch G (2018) Glenosphere design affects range of movement and risk of friction-type scapular impingement in reverse shoulder arthroplasty. Bone Joint J 100-B:1182–1186
41. Werner BS, Chauoi J, Walch G (2017) The influence of humeral neck-shaft angle and glenoid lateralization on range of motion in reverse shoulder arthroplasty. J Shoulder Elbow Surg 26:1726–1731
42. Werthel JD, Walch G, Vegehan E et al (2019) Lateralization in reverse shoulder arthroplasty:
a descriptive analysis of different implants in current practice. Int Orthop 43:2349–2360
S1. Zitkovsky HS, Carducci MP, Mahendraraj KA et al (2020) Lateralization and decreased neck-shaft angle reduces scapular notching and heterotopic ossification. J Am Acad Orthop Surg. https://doi.org/10.5435/jaas-d-19-00808