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The influence of humeral head inclination in reverse total shoulder arthroplasty: a systematic review

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Background: Humeral component inclination may play an important role in implant stability and the incidence of scapular notching in reverse total shoulder arthroplasty (RTSA). This study was conducted to determine if a difference exists between RTSA prostheses with a 135° vs 155° humeral component inclination angle with respect to dislocation rates and scapular notching rates. We hypothesized that the rate of dislocation would be significantly higher with the 135° inclination design and that the rate of scapular notching would be significantly higher with the 155° inclination design.

Methods: A systematic review was registered with PROSPERO and performed with Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines using 3 publicly available free databases. Therapeutic clinical outcome investigations reporting the number of dislocations, number of patients with scapular notching, and postoperative range of motion after RTSA with levels of evidence I to IV were eligible for inclusion. All study and subject demographics were analyzed. Statistics were calculated using 2-proportion z tests.

Results: Thirty-eight studies including 2222 shoulders (average age, 70.3 ± 3.91 years; 67% female) undergoing RTSA were included. Of these, 1762 (79.3%) used the 155° inclination prosthesis and 460 (20.7%) used the 135° inclination prosthesis with a lateralized glenosphere. The rate of scapular notching was 2.83% in the 135° group and 16.80% in the 155° group ($P < .0001$, $z = -7.7107$). The rate of dislocation was 1.74% in the 135° group and 2.33% in the 155° group ($P = .4432$, $z = -0.7669$).

Conclusions: Our systematic review of 38 studies and 2222 shoulders found that the rate of scapular nothing was significantly higher with the 155° prosthesis than with the 135° prosthesis with a lateralized glenosphere, with no difference in dislocation rates between prostheses.

Level of evidence: Level IV, Systematic Review.

Keywords: Reverse total shoulder arthroplasty; rotator cuff arthropathy; head neck angle; scapular notch; dislocation

Institutional Review Board approval was not required for this study.

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Reverse total shoulder arthroplasty (RTSA), first described in the 1970's by Neer, is a well-accepted treatment for symptomatic rotator cuff tear arthropathy in patients with pseudoparalysis and a functional deltoid.[7,9] Since the inception of the reversed prosthesis, there have been several design permutations, including changes in humeral head inclination, an increase in the size of the glenosphere, and the medialization of the center of rotation of the humeral head.[7] The medialization concept was introduced by Paul Grammont in the 1980s as a way to decrease shear forces at the glenosphere and increase the deltoid lever arm in patients with rotator cuff deficiency.[1,7] By moving the center of rotation medially and inferiorly, the Grammont style prostheses increased the number of deltoid fibers available for abduction and forward elevation, increased the deltoid's efficiency by elongating the deltoid muscle, but weakened the teres minor and posterior deltoid for external rotation.[13]

Medialization of the center of rotation was accompanied by the radiographic finding of scapular notching. In scapular notching, erosion of the glenoid neck occurs secondary to abutment of the humeral polyethylene inferiorly on the scapular neck in arm adduction.[13] This finding is typically seen on anteroposterior radiographs of the shoulder. Currently, there is debate about the clinical significance of this finding. Some authors believe it to be a complication that can lead to osteolysis, chronic inflammation, and ultimately, implant loosening.[19] Others contest that it is an incidental finding that does not affect clinical outcomes and occasionally represents osteophyte formation rather than true erosion.[10,14,23,25]

To address scapular notching, the neck-shaft angle of some prostheses was reduced from 155° to 135°; however, this alteration raised concern over stability. One biomechanical study showed this reduction in inclination did appear to resolve the issue of scapular notching but at the cost of shoulder stability, specifically at 30° of internal rotation.[15] However, the 155° configuration was less stable in 30° of external rotation compared with the 135° prosthesis. This study also demonstrated decreasing the neck-shaft angle did not significantly lateralize the center of rotation. Thus, the influence of neck shaft angle on stability and scapular notching is still being actively debated.

The purpose of this study was to determine if a difference exists between RTSA prostheses with a 135° vs 155° humeral component inclination angle with respect to dislocation rates and scapular notching rates. We hypothesized that the rate of dislocation would be significantly higher with the 135° inclination design and that the rate of scapular notching would be significantly higher with the 155° inclination design.

Methods

A systematic review was conducted according to Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines using a PRISMA checklist.[11] Systematic review registration was performed using the PROSPERO International prospective register of systematic reviews (registration number CRD42014012902, dated July 26, 2014).[22] Two reviewers independently conducted the search on March 25, 2014, using the Medline, Cochrane Central Register of Controlled Trials, and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases. The electronic search citation algorithm used was reverse (title/abstract) *and* shoulder (title/abstract) *and* arthroplasty (title/abstract) *not* arthroscopic (title/abstract)*not* cadaver (title/abstract) *not* biomechanical (title/abstract).

Level I to IV evidence (2011 update by the Oxford Centre for Evidence-Based Medicine[21]) clinical studies reported in the English language were eligible. References within included studies were cross-referenced for inclusion if missed by the initial search. If a duplicate population was detected, the study with the greater number of patients or the longer duration follow-up was used and the other excluded. Excluded from this review were level V evidence reviews, medical conference abstracts, letters to the editor, cadaveric studies, basic science, biomechanical studies, arthroscopic shoulder surgery, imaging, surgical technique, and classification studies.

Patients of interest in this systematic review underwent RTSA for one of many indications, including rotator cuff tear arthropathy, rheumatoid arthritis, osteoarthritis, post-traumatic arthritis, instability, osteonecrosis, pseudoparalysis, bone tumors, locked shoulder dislocation, acute proximal humeral fractures (2-, 3-, and 4-part), and revision from previously failed total shoulder arthroplasty (TSA), open reduction internal fixation, closed reduction percutaneous pinning, or hemiarthroplasty. A minimum of 24 months of clinical follow-up was required, but there was no minimum rehabilitation requirement. Studies that included patients aged <50 years were excluded.

Study and subject demographic parameters analyzed included year of publication, years of patient enrollment, presence of study financial conflict of interest, number of shoulders, preoperative and postoperative range of motion (ROM), prosthesis used, and head-neck angle of the prosthesis. Number of dislocations, number of patients with scapular notching, and ROM (when reported) were recorded for all studies. Study methodologic quality was evaluated using the Modified Coleman Methodology Score.[4]

Statistical analysis

Study descriptive statistics were calculated. Continuous variable data are reported as mean ± standard deviation from the mean. Weighted means and standard deviations were calculated for all patient and demographic parameters. Categoric variable data are reported as frequency with percentages. $P < .05$ was considered statistically significant for all statistical analysis measured and calculated from study data extraction or directly reported from the individual studies. A two-proportion z test with equal variance and $\alpha = 0.05$ was used to compare (1) the proportion of shoulders that had undergone RTSA with a subsequent instability event with 135° or 155° inclinations, and (2) the proportion of shoulders that had undergone RTSA with subsequent scapular notching with 135° or 155° inclinations. The z value scores and P values were calculated using a free publicly available calculator (http://insilico.net/tools/statistics/ztest/).