

Use of Planning Software to Quantify Change in Periscapular Muscle Length in Reverse

Shoulder Arthroplasty

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Abstract

Aim

This study analyzed differences in preoperative periscapular muscle length between glenohumeral osteoarthritis (GHOA) and rotator cuff tear arthropathy (RCA) patients, and compared the effects of different rTSA prosthesis configurations on postoperative muscle length.

Background

Advancements in surgical planning, technique, and prosthesis design have allowed for better adaptation to patient anatomy in reverse total shoulder arthroplasty (rTSA). Changes in periscapular muscle length after rTSA are important to consider and may vary based on preoperative indication and prosthesis choice.

Methods

Ten shoulder arthroplasty surgeons used preoperative planning software to plan rTSA cases for 20 subjects (10 GHOA, 10 RCA) following surgical guidelines. Each surgeon planned each case using three prosthesis configurations: (1) 8-mm lateralized glenosphere and 135° neck-shaft angle (135+8), (2) 4-mm lateralized glenosphere and 145° neck-shaft angle (145+4), and (3) 0-mm lateralized glenosphere and 155° neck-shaft angle (155+0). Preoperative periscapular muscle lengths, including vectors on the subscapularis, infraspinatus, and teres minor, as well as anterior, middle, and posterior deltoid, were automatically calculated and compared between the GHOA and RCA cohorts. Percentage-change and postoperative muscle lengths were calculated and compared between prosthesis configurations within each indication.

Results

The RCA cohort had significantly shorter vectors in the posterior, lateral, and anterior deltoid ($P < 0.001$), a longer inferior vector of the subscapularis ($P = 0.022$), and a longer teres minor ($P = 0.001$) than the GHOA cohort. Other preoperative muscle length comparisons were not statistically significant ($P > 0.05$). ANOVA and post-hoc analysis showed that post-planning muscle lengths of each deltoid vector were greater in the 155+0 configuration compared to the 135+8 configuration in the RCA cohort ($P < 0.001$, $P = 0.003$, $P = 0.032$, respectively), and the anterior and middle deltoid vectors were also greater for the same comparison in the GHOA cohort ($P = 0.004$ and $P = 0.017$, respectively). Interestingly, there were no significant differences in post-planning deltoid lengths between the 135+8 and 155+0 configurations in either diagnosis cohort ($P > 0.05$). All post-planning rotator cuff muscle lengths (subscapularis, infraspinatus, and teres minor) differed significantly ($P < 0.001$) between all prosthesis configurations in both diagnosis cohorts, with the 135+8 configuration resulting in the longest lengths and the 155+0 configuration resulting in the shortest lengths.

Conclusion

Automated pre-operative planning software calculates muscle length vectors, which vary between GHOA and RCA diagnoses. Varying rTSA implant geometries result in predictable differences in deltoid lengthening and rotator cuff shortening. Lateralized center of rotation designs better approximate pre-morbid anatomy and muscle length vectors compared to medialized designs. Surgeons can use this software to understand normal muscle anatomy more accurately.

Table I: Comparison of Preoperative Muscle Length by Diagnosis			
Muscle	GHOA <i>N = 10</i>	RCA <i>N = 10</i>	P Value
Deltoid (mm.)			
Posterior	186.1 ± 9.9	170.8 ± 8.7	< .001*
Middle	177.3 ± 8.6	170.0 ± 7.0	< .001*
Anterior	201.3 ± 7.2	191.5 ± 6.8	< .001*
Infraspinatus (mm.)			
Middle	133.7 ± 7.6	136.4 ± 15.2	.137
Superior	135.0 ± 13.7	135.5 ± 9.5	.773
Inferior	145.6 ± 10.7	146.2 ± 11.3	.693
Subscapularis (mm.)			
Middle	111.6 ± 7.5	114.1 ± 14.8	.160
Superior	102.7 ± 7.1	104.9 ± 14.2	.202
Inferior	145.1 ± 10.2	149.8 ± 16.7	.022*

Teres Minor (mm.)	102.4 ± 8.4	106.1 ± 6.7	.001*
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* Statistical significance with alpha risk of 0.05;

GHOA, Glenohumeral osteoarthritis; RCA, Rotator cuff tear arthropathy

Table II: Comparison of final and change in muscle length by prosthesis configuration in the GHOA cohort							
Muscle	Prosthesis Configurations			ANOVA P Value	Post Hoc Pairwise Comparison† P Values		
	135 +8 [‡] N= 100	145 +4 [†] N= 100	155 +0 [¶] N= 100		135+8 / 145+4	135+8 / 155+0	145+4 / 155+0
Deltoid							
Anterior, final (mm)	222.6 ±10.9	223.9 ±10.7	227.6 ±11.1	.004*	>.999	.004*	.051
Anterior, Δ (%)	10.6 ±2.4	11.2 ±2.8	13.1 ±3.9	**	.460	**	**
Middle, final (mm)	199.1 ±13.1	200.4 ±14.2	204.7 ±14.8	.016*	>.999	.017*	.105
Middle, Δ (%)	12.2 ±3.4	13.0 ±3.8	15.4 ±4.0	**	.430	**	**
Posterior, final (mm)	207.9 ±11.5	208.1 ±11.1	210.6 ±11.5	.182	-	-	-
Posterior, Δ (%)	11.8 ±3.3	11.8 ±3.6	13.2 ±3.8	.007*	>.999	.017*	.024*
Infraspinatus							
Middle, final (mm)	131.2 ±8.4	122.8 ±7.7	115.4 ±7.8	**	**	**	**
Middle, Δ (%)	-1.8 ±5.4	-8.1 ±5.4	-13.6 ±5.6	**	**	**	**
Superior, final (mm)	142.4 ±10.0	133.4 ±9.6	125.8 ±10.0	**	**	**	**
Superior, Δ (%)	-2.17 ±4.8	-8.1 ±5.4	-13.4 ±5.8	**	**	**	**
Inferior, final (mm)	131.0 ±9.4	124.5 ±8.9	118.4 ±8.9	**	**	**	**
Inferior, Δ (%)	-2.6 ±5.1	-7.3 ±5.1	-12.0 ±5.3	**	**	**	**
Subscapularis							
Middle, final (mm)	112.4 ±7.8	104.3 ±7.3	97.2 ±7.7	**	**	**	**
Middle, Δ (%)	0.88 ±4.6	-6.3 ±4.9	-12.7 ±5.4	**	**	**	**
Superior, final (mm)	110.25 ±6.7	103.4 ±5.9	98.2 ±6.3	**	**	**	**
Superior, Δ (%)	7.43 ±4.9	0.899 ±5.1	-4.17 ±5.4	**	**	**	**
Inferior, final (mm)	136.9 ±9.1	127.8 ±9.0	119.1 ±9.1	**	**	**	**
Inferior, Δ (%)	-5.5 ±4.4	-11.7 ±4.7	-17.8 ±5.0	**	**	**	**
Teres Minor, final (mm)	95.1 ±7.0	86.6 ±7.5	79.0 ±8.1	**	**	**	**
Teres Minor, Δ (%)	-6.9 ±5.2	-15.4 ±5.5	-22.9 ±5.7	**	**	**	**

† Statistical significance with alpha risk of .05; ** represents P < .001; ‡ 135 + 8 cases were planned with glenospheres with +8mm lateralized center of rotation (COR) and 135° neck-shaft angles; † 145 + 4 cases were planned with a glenosphere with a +4mm lateralized COR and 145° neck-shaft angle; ¶ 155 + 0 cases were planned with a glenosphere with a +0mm lateralized COR and 155° neck-shaft angle; † Pairwise t-test with bonferroni corrections; Δ, the percentage change in muscle length between pre- and post-surgical planning

Table III: Comparison of final and change in muscle length by prosthesis configuration in the RCA cohort

Muscle	Prosthesis Configurations			ANOVA P Value	Post Hoc Pairwise Comparison† P Values		
	135 +8 [‡] N= 100	145 +4 [‡] N= 100	155 +0 [‡] N= 100		135+8 / 145+4	135+8 / 155+0	145+4 / 155+0
Deltoid							
Anterior, final (mm)	219.9 ±10.4	223.4 ±11.0	227.1 ±11.5	**	.113	**	.069
Anterior, Δ (%)	15.0 ±4.0	18.6 ±5.0	18.9 ±5.0	**	.027*	**	.019*
Middle, final (mm)	198.8 ±11.9	201.1 ±12.1	204.7 ±11.9	.004*	.581	.003*	.144
Middle, Δ (%)	16.9 ±3.90	18.3 ±4.3	20.3 ±4.5	**	.094	**	.004*
Posterior, final (mm)	200.1 ±8.2	201.3 ±8.6	203.4 ±8.9	.036*	>.999	.032*	.318
Posterior, Δ (%)	17.2 ±4.1	18.0 ±4.3	19.1 ±4.5	.009*	.775	.008*	.176
Infraspinatus							
Middle, final (mm)	131.0 ±8.4	122.5 ±8.6	114.8 ±8.5	**	**	**	**
Middle, Δ (%)	-3.3 ±5.9	-9.5 ±5.8	-15.2 ±5.9	**	**	**	**
Superior, final (mm)	138.2 ±10.1	129.6 ±9.5	122.5 ±9.3	**	**	**	**
Superior, Δ (%)	-5.3 ±4.6	-11.3 ±5.1	-16.1 ±5.9	**	**	**	**
Inferior, final (mm)	133.6 ±11.4	126.7 ±11.2	120.7 ±10.9	**	**	**	**
Inferior, Δ (%)	-1.5 ±3.9	-6.5 ±4.2	-10.9 ±4.9	**	**	**	**
Subscapularis							
Middle, final (mm)	110.8 ±10.7	102.8 ±10.1	95.3 ±10.1	**	**	**	**
Middle, Δ (%)	-2.4 ±4.7	-9.6 ±4.4	-16.2 ±4.0	**	**	**	**
Superior, final (mm)	109.5 ±10.2	102.8 ±9.7	97.2 ±9.5	**	**	**	**
Superior, Δ (%)	5.0 ±5.5	-1.4 ±5.4	-6.8 ±5.2	**	**	**	**
Inferior, final (mm)	134.7 ±12.8	125.1 ±12.3	116.3 ±12.2	**	**	**	**
Inferior, Δ (%)	-9.8 ±4.0	-16.2 ±4.0	-22.3 ±3.8	**	**	**	**
Teres Minor, final (mm)	93.1 ±7.7	84.2 ±8.1	76.6 ±8.8	**	**	**	**
Teres Minor, Δ (%)	-12.1 ±6.2	-20.5 ±6.8	-27.8 ±7.5	**	**	**	**

* Statistical significance with alpha risk of .05; ** represents P < .001; † 135 +8 cases were planned with glenospheres with +8mm lateralized center of rotation (COR) and 135° neck-shaft angles; ‡ 145 +4 cases were planned with a glenosphere with a +4mm lateralized COR and 145° neck-shaft angle; § 155 +0 cases were planned with a glenosphere with a +0mm lateralized COR and 155° neck-shaft angle; † Pairwise t-test with bonferroni corrections; Δ, the percentage change in muscle length between pre- and post-surgical planning