SCAPULAR SUBSTITUTION AFTER ROTATOR CUFF REPAIR CORRELATES WITH POSTOPERATIVE PATIENT OUTCOME

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ABSTRACT

Background: Scapular substitution is an alteration of scapulohumeral kinematics that may occur when patients have shoulder pain or dysfunction. These abnormal scapular kinematic patterns have been recognized in patients with rotator cuff tears. It remains unknown if 1) normal scapular kinematics can be restored with rehabilitation after rotator cuff repair surgery and 2) abnormal scapular kinematics are associated with inferior patient-determined outcome scores, range of motion, or strength.

Purpose: The purpose of this study was to determine 1) if scapular substitution can be decreased or improved with rehabilitation after rotator cuff repair surgery and 2) if the presence or amount of scapular substitution was correlated with patient-determined outcome scores, range of motion, or strength after rotator cuff repair surgery.

Study Design: Retrospective review of prospectively collected data (LOE IV)

Methods: Forty-eight patients who underwent post-operative rehabilitation after an arthroscopic rotator cuff repair were reviewed for this study. The outcomes measures of interest included: patient-determined outcome scores (WORC, Simple Shoulder Test, the ASES Score, the Shoulder Activity Score, and the SANE rating), identification and quantification of scapular substitution, active range of motion, and strength. Outcomes were prospectively collected up to 12 months after surgery and assessed retrospectively.

Results: As patients progress through their first year of rehabilitation from a rotator cuff repair, the amount of scapular substitution decreases but remains statistically significantly greater than the contralateral, asymptomatic side. At all post-operative time points, patients with scapular substitution, (determined subjectively by a physical therapist), had 1) inferior WORC, ASES, SANE, and SST scores, 2) inferior flexion, abduction, and external rotation range of motion, and 3) inferior scaption strength compared to those patients without subjective scapular substitution.

Conclusions: Rehabilitation decreases but does not normalize the amount of scapular substitution up to one year after rotator cuff repair. Subjective identification of scapular substitution is associated with inferior patient-determined outcome scores, range of motion, and strength.

Level of Evidence: 4 – Prognosis study

Keywords: Patient outcomes; rotator cuff repair; scapular kinematics; scapular substitution

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BACKGROUND

Scapular substitution is an alteration of scapulo-humeral kinematics that may occur when patients have shoulder pain or dysfunction. Blevins et al have described the clinical observation of scapular substitution as the “shrug sign”.¹ When normal 3-dimensional scapular kinematics are examined during shoulder elevation, the scapula rotates laterally, tilts posteriorly, and protracts/retracts depending on the plane of elevation.² When scapular kinematics are examined in 2-dimensions (which does not require expensive or complex laboratory equipment), the scapula translates both medially and vertically with forward elevation and elevation in the scapular plane (scaption) movements of the shoulder.^{3,4} In patients with shoulder pain and dysfunction, the vertical and medial translation of the scapula becomes further accentuated and has been termed scapular substitution since the scapulothoracic joint appears to substitute for loss of motion at the glenohumeral joint.^{4,5} This increase in scapular elevation has been associated with increased activity of the trapezius and decreased serratus anterior activity during arm elevation.⁶ Although abnormal scapular kinematic patterns have been recognized in asymptomatic, well-functioning individuals,⁷⁻¹⁰ they have also been demonstrated in postoperative patients,² patients with rotator cuff impingement,^{6,11-15} rotator cuff tears,¹⁶⁻¹⁹ glenohumeral instability,¹⁵ osteoarthritis,² adhesive capsulitis,^{2,20} and patients after reverse total shoulder arthroplasty.²⁰

One observational study revealed that scapular kinematic alterations can improve with verbal instruction and practice.⁵ However, longitudinal studies that examine if scapular kinematics can be improved with rehabilitation after surgery are rare.²¹ In addition, studies do not exist that examine the correlation of scapular kinematics with patient-determined outcome scores, range of motion, or strength.

The purpose of this study was to determine 1) if scapular substitution can be decreased or improved with rehabilitation after rotator cuff repair surgery and 2) if the presence or amount of scapular substitution was correlated with patient-determined outcome scores, range of motion, or strength after rotator cuff repair surgery. The hypothesis of this study was that rehabilitation after rotator cuff repair

surgery would decrease the amount of scapular substitution over time. In addition, patients with increased scapular substitution would have inferior outcomes in patient-determined outcome scores, range of motion, and strength.

METHODS

Prior to initiation of this study, institutional review board approval was obtained (Avera 2008.009). Informed consent was obtained from all subjects and the rights of the subjects were protected. Forty-eight study subjects were obtained from a database that has been reported in a previous publication on patients enrolled in a randomized trial evaluating the efficacy and safety of pulley exercises after rotator cuff repair.²² Baseline data for demographic, pre-operative range of motion and strength testing and magnetic resonance imaging findings are described in Table 1. Concomitant procedures and number of anchors used in the repairs are described in Table 2.

The inclusion criterion was patients undergoing immediate post-operative rehabilitation for an arthroscopic supraspinatus repair between October 2008 and November of 2012. Patients undergoing concomitant procedures such as subacromial decompression, distal clavicle resection, subscapularis repair, and biceps tenodesis were also included to increase the generalizability of this study since it is common clinically to perform combined procedures. Exclusion criteria were: patients with a history of previous rotator cuff repair on the ipsilateral or contralateral sides, concomitant preoperative adhesive capsulitis, history of glenohumeral dislocation, axillary or suprascapular neuropathy, cognitively impaired patients, and patients with subjective pain, weakness, or dysfunction on the contralateral side, and patients with less than one-year follow-up. All patients followed a comprehensive physical therapy protocol that was supervised by one of two physical therapists with significant experience in treating shoulder pathology both nonoperatively and postoperatively (RO, MJZ) [Appendix A].

The outcomes measures utilized for this study included patient-determined outcome scores, identification and quantification of scapular substitution, active range of motion, and strength. The independent observer that recorded scapular substitution,

Table 1. Baseline demographic data, range of motion, motor strength and magnetic resonance imaging findings.

		All Patients	Yes – Visually-determined Subjective Scapular Substitution at Final Follow-up	No - Visually-determined Subjective Substitution at Final Follow-up	p- value
Number		48	17	31	
Mean Age		59.8	61	59.3	0.54
Gender		22 males (46%)	8 males (47%)	12 males (39%)	0.57
Dominant Hand		30 (63%)	10 (59%)	20 (65%)	0.7
Traumatic Onset		18 (38%)	5 (29%)	13 (42%)	0.39
Worker's Compensation		5 (10%)	2 (12%)	3 (10%)	0.82
Preoperative External Rotation		51	50	52	0.64
Preoperative Flexion		133	130	135	0.75
Preoperative Mean Muscle Strength	Supraspinatus	4.5	4.4	4.5	0.75
Intraoperative External Rotation		66	65	67	0.53
Intraoperative Flexion		157	154	158	0.15
Intraoperative Mean Outerbridge Grade		0.63	0.53	0.68	0.68
Presence of Supraspinatus Atrophy		7	3 (18%)	4 (13%)	0.66
Presence of Infrapinatus Atrophy		2	1 (6%)	1 (3%)	0.66
Goutallier Changes					
	Grade 0	31	10	21	0.8
	Grade 1	14	5	9	
	Grade 3	1	0	1	
Supraspinatus Retraction					
	Within 1 cm Greater Tuberosity	30	9	21	0.66
	Midhumeral	14	4	10	
	Glenohumeral	2	2	0	

Table 2. Concomitant Procedures and Number of Anchors Utilized.

	Patients
Infraspinatus Repair	1
Subscapularis Repair	10
Acromioplasty	47
AC Joint Resection	24
Labral Repair	2
Biceps Debridement for Rupture	4
Biceps Tenodesis	14
Biceps Tenotomy	4
Coracoplasty	2
Excision Os Acromiale	1
# of Medial Anchors	
0	2
1	12
2	26
3	7
4	1
# of Lateral Anchors	
0	4
1	4
2	32
3	8

range of motion, and strength was blinded to the patients-determined outcome scores to decrease bias. The patient outcome scores utilized in this study included the Western Ontario Rotator Cuff Index (WORC),²³ Simple Shoulder Test (SST),²⁴ the American Shoulder and Elbow Score (ASES),²⁵ the Shoulder Activity Level,²⁶ and the Single Alpha-numeric Evaluation (SANE).²⁷ These outcome scores were collected at baseline, 6 weeks, 12 weeks, 18 weeks, 6 months, and 12 months.

In this study, scapular substitution was measured using both a subjective technique and an objective technique. The subjective scapular substitution measurement was performed by a physical therapist that answered a yes or no question if they felt that a patient had visually apparent scapular shrug (vertical and/or medial translation of the scapula) with scaption.^{1,28,29} The objective scapular substitution was determined using a previously published technique.⁴ This method has been shown to have good inter-rater reliability (ICC = 0.81) when measuring

two-dimensional scapular translation during scaption. Each study subject had a marker placed on each acromion and stood a standardized distance from a light. The shadow projected from the marker onto a standardized, data collection board was measured during the 1) resting, and 2) scaption to 90 degrees positions for bilateral shoulders. The horizontal (medial) and vertical (superior) translations of the shadows were measured and compared to the resting point for scaption. For this current study, the objective absolute vertical and medial scapular measurements and the subjective scapular substitution measurements were recorded at the 12 week, 18 week, 6 month, and 12 month post-operative time (post-op) time points. In addition, the difference in side-to-side scapular measurements was reported by subtracting the vertical scapular translation of the nonoperative, asymptomatic side from the absolute vertical scapular translation of the operative side.

Range of motion assessments were performed with a standard goniometer with the patients in the standing position with their back resting against a wall. Active forward elevation, external rotation in 90 degrees of abduction, internal rotation in 90 degrees of abduction, and abduction were measured for both the operative and nonoperative arms at the 6 month and 12 month post-op time points.

Strength assessment was performed using a hand-held dynamometer. Isometric scaption strength was tested in both the “empty can” and the “full can” positions for both the operative and nonoperative shoulder at the 6 month and 12 month time points. Strength was not tested prior to 6 months post-op to allow for appropriate rotator cuff tendon healing and to allow the effects of the strengthening protocol of the rehabilitation to manifest. Strength outcomes were reported as a ratio of operative side to nonoperative side since baseline strength testing was not determined. This method was considered acceptable since patients with contralateral shoulder symptoms or a history of contralateral shoulder surgery were excluded.

Statistical analyses were conducted using SAS 9.4 and included mixed model (2 between x 4 within) split plot ANOVAS (PROC MIXED) to test trends (linear trends whose slope differs from zero across

time) and t-tests to determine differences between groups from baseline to 12 months post-surgery. A Chi-square test was used to examine categorical variables, and the Cochran-Armitage test was utilized to determine trends. The level of significance was $p = 0.05$. Since multiple hypotheses were tested, effect sizes (Cohen's d) with 95% confidence intervals were calculated to determine the size of the differences between groups (Cohen's d 0.2 = small effect, Cohen's d 0.5 = medium effect, Cohen's d 0.8 = large effect).^{30,31}

RESULTS

The proportion of patients exhibiting subjective scapular substitution decreased significantly from 82% to 35% ($\chi^2 = 21.38$, $p < 0.0001$) through their first year following rotator cuff repair. This represents a greater than 50% relative reduction in subjective scapular substitution (Figure 1). This finding was confirmed using the absolute objective scapular substitution measurements which showed significant negative trends (slope) in both vertical ($p = 0.04$) and medial ($p = 0.01$) scapular translation during scaption (Figure 2). In addition, repeated measures ANOVAs revealed significant negative effect (i.e. slope) across time for the differences between operative and non-operative shoulders' objective vertical translation ($p < 0.0001$) and medial translation ($p = 0.01$) during scaption (Figure 3).

At all post-operative time points, the operative side had greater absolute vertical scapular translation

Figure 1. Percentage of patients subjectively observed to have the presence of Scapular Substitution by a physical therapist (Yes/No).

Figure 2. Objective Absolute Scapular Translation with Scaption. Each study subject had a marker placed on the acromion of the both shoulders and stood a standardized distance from a light. The shadow projected from the marker onto a standardized, data collection board was measured during the 1) resting, and 2) scaption to 90 degrees positions for both the operative and nonoperative shoulders. The horizontal (medial) and vertical (superior) translations of the shadows were measured and compared to the resting point for scaption for both shoulders..

Figure 3. Side to Side Difference in Scapular Translation with Scaption. The difference in side-to-side scapular measurements was reported by subtracting the objective absolute scapular translation of the nonoperative, asymptomatic side from the objective absolute scapular translation of the operative side.

during scaption compared to the asymptomatic, nonoperative side (Figure 2). The operative side had statistically greater absolute medial translation with scaption at the 12 week and the 6 month time points (Figure 2).

Subjective scapular substitution is associated with objective scapular substitution. Patients with subjective substitution had a mean vertical side-to-side difference of 1.62 centimeters and absolute vertical translation of 5.15 cm. Those without subjective substitution had a significantly smaller mean 1) vertical side-to-side difference (0.36 cm; $p < 0.0001$) and 2) absolute vertical translation (3.41 cm; $p < 0.0001$).

At all post-operative time points, patients with subjective substitution had inferior WORC, ASES, SANE, and SST scores compared to patients without subjective substitution. These differences were statistically significant at the 18-week time point for the WORC and the ASES, 18 week and one year time point for the SANE, and the year time point for the SST (Figure 4). There were no clinical or statistical differences in the Shoulder Activity Level for those with subjective substitution compared to those without subjective substitution at any time point.

At all post-operative time points, patients with subjective scapular substitution had less flexion, abduction, and external rotation active range of motion compared to patients without subjective scapular substitution. These differences reached statistical significance for both flexion and external rotation at both the 6- and 12-month time points ($p = 0.007$ and $p = 0.001$, respectively), and for abduction at the 12-month time point ($p = 0.04$) [Figure 5]. There was no clinical or statistical difference in internal rotation between patients with subjective substitution and those without substitution at the 6-month time point (52° vs 54° ; $p = 0.72$) and the 12-month time point (57° vs 59° ; $p = 0.61$).

At all post-op time points, patients with subjective scapular substitution had inferior empty can and full can scaption strength compared to those patients without subjective scapular substitution. These differences reached statistically significant differences at the 6-month time point for empty can scaption strength ($p = 0.03$) and the 12-month time point for full can scaption strength ($p = 0.01$) (Figure 6).

At the 12 month point the strength of patients without scapular substitution approximated that of the contralateral, unaffected side (empty can; $p = 0.17$) (full can; $p = 0.18$) suggesting that their strength returned to pre-injury status at 12 months post-op.

Figure 4. Patient-determined Outcome Scores and Subjective Scapular Substitution Western Ontario Rotator Cuff Index (WORC); American Shoulder and Elbow Score (ASES); Single Alpha-numeric Evaluation (SANE).

DISCUSSION

The results of this study demonstrated that rotator cuff repair rehabilitation decreases but does not normalize objective scapular substitution. In addition, the results indicate that patients with subjective scapular substitution had inferior patient-determined outcome scores, range of motion, and strength compared to patients that did not have subjective scapular substitution.

Studies that examine if postoperative rehabilitation after rotator cuff repair can improve scapular kinematics are rare.²¹ This appears to be the first study to examine the association between scapular substitution and patient outcomes after rotator cuff repair. Patients identified with subjective scapular substitution had inferior patient outcome scores (except the Shoulder Activity level), decreased flexion, abduction, and external rotation active range of motion,

and decreased scaption strength when compared to patients without scapular substitution. These findings are similar to those of Harris et al. who found an association with the presence of subjectively-determined scapular dyskinesis with a decrease in WORC index and ASES scores of 6.85 and 4.07, respectively, in patients that were identified as having full thickness rotator cuff tears.³²

In a study of patients with adhesive capsulitis and osteoarthritis, Fayad et al suggested that the scapulohumeral rhythm of the affected shoulder was inversely related to the severity of the limitation of shoulder range of motion.² Kontaxis et al. suggested that reverse total shoulder arthroplasty patients with good recovery and large range of humeral elevation after surgery had a small change in their scapular rhythm whereas those with muscle weakness and smaller ranges of motion had greater amounts of

Figure 5. Active Range of Motion and Subjective Scapular Substitution.

Figure 6. Scaption Strength and Subjective Scapular Substitution

E.C. = Empty Can Scaption Strength; F.C. = Full Can Scaption Strength]

scapular kinematic alterations.³³ However, neither of these studies utilized validated, patient-determined outcome scores or quantitatively or qualitatively examined the strength of the subjects.

Previous studies have found altered shoulder kinematics including scapular elevation in patients with impingement^{3,6,11,13} and rotator cuff tears.^{11,16,18,19} Mell et al. reported that individuals with full thickness rotator cuff tears were more likely to have greater scapular elevation with arm elevation than in asymptomatic shoulders or in patients with tendinosis but no full thickness tears.¹⁶ The authors of that study admitted that their study was not designed to determine a relationship between these motion patterns with symptoms or function in rotator cuff patients and suggested future studies were needed to determine their effects.¹⁶ Scibek et al. demonstrated a trend toward improved scapulohumeral

rhythm after a subacromial injection performed in patients with full thickness rotator cuff tears suggesting that pain is a potential cause of impaired scapular kinematics.^{14,17}

It is unknown if scapular substitution is an adaptive mechanism that assists patients with glenohumeral dysfunction or if it is part of a pathologic process that affects patient outcomes. Several studies demonstrated that altered scapular kinematics may result as a patient attempts to avoid impingement and the scapula becomes rotated to a greater degree to reduce the requirement for the elevation of the glenohumeral joint.^{2,16,35,36} Scibek et al suggested that these scapular substitution patterns are a method of compensating for pain and when pain was decreased, the scapular kinematics improved.¹⁷ Lukasiewicz et al. presumed that increased scapular elevation is a compensatory pattern that may be secondary to weakness or restricted range of motion because of capsular tightness, which may also increase scapular elevation.³ On the contrary, other studies demonstrated that altered scapula kinematics could reduce the available subacromial space, thus contributing to development or progression of impingement as well as a poor environment for tissue healing.^{11, 37} Mell et al. concluded that it was impossible to determine from their study if the altered scapular kinematics was a useful adaptation of a pathologic pattern that contributed to pain and dysfunction.¹⁶ Ludewig et al suggested that without the ability to follow human subjects longitudinally, it is difficult to fully discern if alterations found in scapular kinematics are compensatory or contributory to an impingement mechanism of rotator cuff disease.¹¹

Unfortunately, the current study was not designed to determine if scapular substitution is a cause of inferior patient outcomes or an effect of inferior patient outcomes. However, the findings of this study suggest that scapular substitution is either 1) a pathologic process or 2) a compensatory process that is inferior to normal scapular kinematics in regards to patient-determined outcome scores of pain and function, range of motion, and strength when following the rehabilitation of patients up to a year after a rotator cuff repair.

One previous study demonstrated that with verbal instruction patients had decreased mean scapular

vertical displacement with forward elevation.⁵ However, no differences were found in horizontal displacement after instruction. The current study did reveal both decreased objective vertical and medial translation of the scapula during scaption with rehabilitation over a one-year period. Although both subjective and objective scapular substitution was decreased, the rehabilitation program that was utilized over this time did not normalize scapular kinematics. Future studies will be necessary to determine if a postoperative rehabilitation protocol that focuses on elimination of scapular substitution (possibly by decreasing upper trapezius activation and increasing serratus anterior and lower trapezius activity)^{6, 10} as an outcome can normalize scapular kinematics and improve patient outcomes.

The current study was limited by the lack of baseline scapular translation measurements. To control for this, patients with contralateral shoulder pain, dysfunction, or history of surgery were excluded, and contralateral scapular motion was tested on the non-operative extremity to use as a comparison. Other studies support this methodology as an appropriate means of comparing scapular kinematics over time.^{3,34} Another limitation was that 3-D measurement of scapular kinematics was not utilized. However, at this time, there is no universally accepted, gold standard for a clinical method for identifying subjects that may have abnormal scapular kinematics. However, the technique that was utilized was previously validated and has been shown to have good reliability for measuring scapular translation with scaption and is suitable for routine clinical use.^{4,14,28,29} Lastly, it was difficult to quantify the amount of compliance to the home rehabilitation protocol for each patient. However, there was no evidence that any patient was subjectively “noncompliant” with the home rehabilitation recommendations.

CONCLUSION

The findings of the current study indicate that rehabilitation decreases but does not normalize the amount of scapular substitution up to one year after rotator cuff repair. The presence of subjective visual identification of scapular substitution is associated with inferior patient-determined outcome scores (WORC, ASES, SST, SANE), active range of motion (flexion, external rotation, abduction), and scaption strength.

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Rotator Cuff Rehabilitation Protocol

Maximum Protection Phase: 0-3 Weeks Post-Op

Goals:

- Permit early healing to occur without affecting repair
- Begin recovering shoulder range of motion within pain free range
- Ensure elbow, wrist and hand range of motion is maintained at pre-operative level

Protection

- Sling immobilization at all times unless performing personal hygiene or exercises

Rehabilitation program

Joint Range of Motion activities

- Range of motion activities (performed 3-5 x daily)
 - Pendulum exercises to be performed in sagittal and transverse planes
 - Passive supine elevation with therapist or with spouse/significant other after instruction or with opposite hand or performed seated at table
 - Passive external rotation with therapist or with spouse/significant other after instruction or with wand in sitting or performed in sitting performing external rotation at a table.
 - Hand, wrist, elbow range of motion and progressive resistive exercises (unless biceps tenodesis performed)

Muscle activation (performed 2x daily)

- Scapular active range of motion / isometric / stabilization exercise in protective range – for scapular elevation, protraction, retraction, depression (pain free)
- Deltoid isometrics - submaximal and pain free in neutral at glenohumeral joint.

Moderate Protection Phase: 4-5 Weeks Post-Op

Goals:

- Continue to protect the repair to permit optimal healing
- Continue with recovering pain free shoulder range of motion
- Ensure elbow, wrist and hand range of motion is maintained at pre-operative level

Protection

- Sling immobilization at all times unless performing personal hygiene or exercises

Rehabilitation Program

Joint Range of Motion Activities

- Continue above exercises progressing range of motion to tolerance (3-5 x daily), and add the following:
 - Supine wand exercises for flexion
 - Seated (arm at the side) or supine (arm in slight abduction supported on bolster) external rotation low load stretching with wand to end range.
 - May initiate hydrotherapy (pool exercises) active assisted range of motion once incisions heal

Muscle activation activities (2x daily)

- ER / IR **pain free** submaximal isometrics at glenohumeral joint neutral (shoulder not in extension)
- Progress **pain free** deltoid isometric exercise as tolerated
- Weight shifts using table/counter or exercise ball

Early Strengthening Phase: 6 – 14 weeks Post-Op

Goals:

- Recover full shoulder range of motion
- Recovery of low level functional activity
- Initiate recovery of muscle strength to include rotator cuff

Protection

- Discontinue sling use (may still use sling when in crowded areas)

Rehabilitation Program

INITIATE JACKINS EXERCISE VS PULLEY EXERCISES PER GROUP ASSIGNMENT

Joint Range of motion activities

- Continue to progress range of motion exercises to tolerance (2-3 x daily)
 - Flexibility exercises adjusted to address areas of tightness
- Joint mobilization to address any residual capsular tightness

Muscle activation activities

- Initiate humeral head stabilization exercises (1-2 x daily)
 - Begin active isotonic exercises for external rotation at glenohumeral joint neutral and progress to gentle resistance band exercises (side-lying external rotation)
 - Begin active isotonic exercises for internal rotation with glenohumeral joint neutral and progress to gentle resistance band strengthening (standing internal rotation with arm at the side and elbow flexed to 90 degrees provides good activation of subscapularis and pectoralis major muscles with low to medium resistance)
 - Incorporate rhythmic stabilization activities
- Scapular exercises (1-2x daily) (should be performing at least 15 repetitions of each exercise)
- Continue scapular stabilization exercises by performing scapular clock exercises
 - Advance to low level closed chain activities as tolerated (pain free) by performing either prone on elbows or quadruped (on knees) push up plus as able
 - Perform scapular adduction in sitting and/or prone
 - Active scapular adduction without resistance
 - Resisted scapular adduction via resisted shoulder extension with elastic tubing
 - Prone rowing exercise
 - Perform scapular adduction in sitting and/or prone (continued)
 - Prone horizontal abduction with arm elevated to 100 degrees if can achieve without discomfort. Hand position with thumb up if able to perform, but if not, palm parallel to floor is acceptable.
 - Begin exercises focused on scapular depressors (pectoralis major, latissimus dorsi and teres major)
 - When shoulder elevation is adequate, begin performing pull down exercise with arms in front of body with wide (shoulder width) grip (provides best activation of latissimus dorsi and teres major muscles)
 - Low level activation of the pectoralis major occurs in the quadruped weight bearing position. The activation increases as the individual performs a tripod position (both knees and involved arm in contact with surface). Pushup position with feet on a bench and one arm pushup position are not appropriate at this time.
- Additional muscle activation (1-2 x daily)
 - Deltoid (flexion and abduction) isometrics at 30 degrees elevation
 - Other deltoid muscle activation activities
 - Supine shoulder flexion provides activation of anterior deltoid
 - Seated or standing active elevation for anterior deltoid (monitor scapular elevation)
 - Prone horizontal abduction with arm in 100 degrees elevation (as able) with hand supinated (as able) provides best activation of posterior deltoid.
- Include biceps brachii and triceps brachii strengthening in a progressive resistive exercise program
- Upper body ergometry (daily or as equipment is available)

Late Strengthening Phase: 14-22 Weeks Post-Op

Goals:

- Maintain full shoulder range of motion
- Recovery of intermediate level functional activity
- Advance muscle strengthening resistance activities

Rehabilitation Program

Joint Range of Motion Activities

- Continue to progress range of motion and flexibility (1-2 x daily)
- Address any remaining capsular tightness with joint mobilization
- Address any muscle length issues with appropriate stretching activities.

Muscle activation activities

- Progress resistance to 12-15 repetitions and 2 sets for each exercise
- Progress rotator cuff isotonics as tolerated (1x daily as able or every other day as appropriate)
 - May perform upright resistive band scaption exercises (full can) when able to perform upright active forward elevation to 130 degrees
- Upper extremity progressive resistive exercises for large muscle groups; pectoralis, latissimus dorsi (1x daily)
- Initiate plyometric exercises below horizontal (1x daily as able, or every other day as appropriate)
- Advance scapular stabilization strengthening activities to intermediate level as tolerated (1x daily)
 - Increased weight bearing in quadruped position by lifting non-operative arm forward (must be pain free)

Return to Sport Phase: 22-28 Weeks Post-Op

Goals:

- Maintain full shoulder range of motion
- Recovery of high level functional activity to include throwing activities
- Performance of high level strengthening and resistance activities

Rehabilitation Program

Joint Range of Motion Activities

- Should have full joint range of motion. If does not, address with joint mobilization and specific stretching activities.

Muscle activation activities

- Should be performed with resistance such that person is performing 10-12 repetitions for each exercise without shoulder joint discomfort on an every other day basis (2-3x per week has been found to be optimal in strength literature)
- Aggressive upper extremity progressive resistive exercises – internal and external rotation isokinetics, velocity spectrum on individual basis (every other day).
- High level scapular stabilization activities (every other day)
 - Push up position
 - Push up position while lifting non operated arm
 - Weight bearing on small plyoball in various positions
 - Perturbations while weight bearing on plyoball
- Progress plyometrics to include throwing activities (every other day): for subjects who wish to return to throwing activities