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Plasty lengthening of the subscapularis and outcomes with reverse shoulder arthroplasty

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Introduction Repair of the subscapularis attachment with reverse total shoulder replacement is important for internal rotation, in particular. **Objective** Evaluate subscapularis plasty techniques to improve shoulder internal rotation with reverse total shoulder arthroplasty. **Material and methods** Long-term results of shoulder arthroplasty using reverse systems were reviewed in 50 patients at 6 months to 6 years following the procedure. The patients reported problems with shoulder internal rotation and daily living chores having hand behind back with shoulder internal rotation restored to 68º and subscapularis muscles strength improved to 70 %. Technique of plasty lengthening of the subscapularis was offered to improve shoulder internal rotation with reverse total shoulder replacement. The method was used for 6 patients including 3 males and 3 females. **Results** Intraoperative measurements showed at least 90º of the passive shoulder internal rotation and 30º of external rotation. The practice allowed for subscapularis lengthening of 2 to 2.5 cm of intraoperative measurements. Clinical examination at 7 months to 1 year showed grade III mobilisation with the shoulder internal rotation in four patients following reverse shoulder arthroplasty and subscapularis plasty, and grade IV mobilisation in two patients. Constant Shoulder Score showed improvement of the shoulder by 67 % and measured 86 points with the Shoulder Rating Questionnaire. Shoulder internal rotation measured 3.4 ± 1.4 N/m that indicated to 83 % improvement in subscapularis strength. **Conclusion** The technique offered showed functional improvements in shoulder internal rotation, anterior shoulder stabilization and the possibility with early rehabilitation.

Keywords: reverse total shoulder arthroplasty, shoulder joint, subscapularis, shoulder internal rotation

INTRODUCTION

Total shoulder arthroplasty (TSA) has been used to treat posttraumatic conditions and diseases of the glenohumeral joint providing pain relief, a functional range of motion and performance of activities of daily living in elderly patients [1]. There are two types of TSA namely, anatomic total shoulder arthroplasty (Neer, 1950) and reverse total shoulder arthroplasty (P. Grammont, 1985) depending on severity of rotator cuff tear and altered shoulder anatomy. Anatomic TSA is a well-established procedure for intact rotator cuff whereas reverse TSA is practical for irreparable rotator cuff tears. Reverse total shoulder arthroplasty has been reported to be associated with a complication rate of 75 % [2]. Functional activities – dressing, bathing, ability to put hand in back pants pockets or tuck shirt behind the back, fastening bra, reaching for toilet hygiene – are provided with internal rotation of subscapularis measuring at least 100°, and insufficient ROM following TSA is reported in 70 % of the patients [3]. Weak lift-off and belly-press tests are observed in 67.5 % and 66 % cases, correspondingly [4]. And several authors do not support bilateral reverse TSA due to difficulties in subscapularis refixation repairing old injury and retracted rotator cuff components Patte types 3 and 4 [5, 6].

Repair of subscapularis attachment site is important in regaining glenohumeral internal rotation at reverse TSA. The clinical experience of 130 reverse TSA showed insufficient subscapularis tendon length with anatomical fixation to lesser tubercle and subscapularis plasty lengthening resulting

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in decreased glenohumeral internal rotation. Review of long-term follow-ups of TSA demonstrated incomplete recovery of glenohumeral internal rotation measuring 72° ± 10.6; 50 % of internal rotator muscle strength and 57 % of the Constant score with maintained function and integrity of rotator cuff muscles [1]. This affected the hand reaching behind the back.

International practice shows a variety of plasty techniques used to repair subscapularis: muscle lengthening through end-to-end and side-to-side suturing with anterior portion of the capsule, transverse Z-plasty of subscapularis tendon, longitudinal Z-plasty of subscapularis tendon, subscapularis lengthening by osteotomy of lesser tubercle or by the usage of additional tendon grafts, plasty with abdominal and costal portions of pectoralis major [5, 6, 7, 8, 9, 10, 11, 12, 13]. Pitfalls associated with the methods include complicated surgical performance, anatomical dissection of the capsule and subscapularis tendon, persisted physiological length and thickness of the tendon, insecure ligature fixation, absence of accurate calculations of gradual subscapularis tendon lengthening.

Objective The purpose of the study was to evaluate subscapularis plasty techniques to improve shoulder internal rotation with reverse total shoulder arthroplasty.

MATERIAL AND METHODS

Inclusion criteria of plasty subscapularis lengthening were prospective shoulder injuries from 4-month-old, MRI-diagnosed retracted subscapularis tears Patte types 3 and 4, negative belly-press, Gerber's lift-off and Napolean tests that indicated to impaired glenohumeral internal rotation. Intraoperatively identified insufficient length of subscapularis played a role in choice of larger implants.

Plasty lengthening of the subscapularis was applied in 6 cases including 3 males and 3 females. The mean age was 52.3 ± 11.9 years. Patients were operated for grade IV and V omarthrosis (n = 1), posttraumatic deformity (n = 5) with the diseases aged from 4 months to 7 years. Four patients had TSA on the right side and two on the left side.

Statistical data analysis was performed using *Statistica 6.0* computer program (StatSoft Inc., USA). Data were presented as Me (Q25–Q75). The Student's t-test was used to confirm differences in cases with normal distribution. Nonparametric Mann-Whitney U-test and χ^2-criteria were used for pairwise comparison.

All patients underwent operative intervention performed by one surgeon using reverse *Delta Revers* implant. A beach-chair position was on the operating table. General aneasthesia was applied. Deltopectoral approach was used for all patients. Plasty of subscapularis using biceps tendon of the shoulder employed deltopectoral approach to make blunt and sharp release of subdeltoid and subacromial spaces and subscapularis was mobilised to the base of coracoid process. Subscapularis tendon was separated from the attachment site by decotrication using a narrow chisel and the stump withdrawn from the wound with ligatures. Then the long head of the biceps tendon was mobilized and maximally cut off from the attachment site at the glenoid using a scalpel with the physiological length maintained. Tenodesis of the long head of the biceps in intertubercle fossa was produced at the humerus cut level 2.5 to 3 cm distally the stump end. Then implant components were placed in a standard manner. Two 4-to-5-cm incisions were made at the stump of subscapularis tendon medially to the bone plate below and above to insert the long head of the biceps tendon. The long head of the biceps tendon was inserted lateral-to-medial through superior incision and medial-to-lateral through inferior incision forming a loop and transosseous sutures were applied at tenodesis site (Priority certificate "Subscapularis lengthening technique using the long head of the biceps tendon" № 2017109545 dtd 21.03.2017).

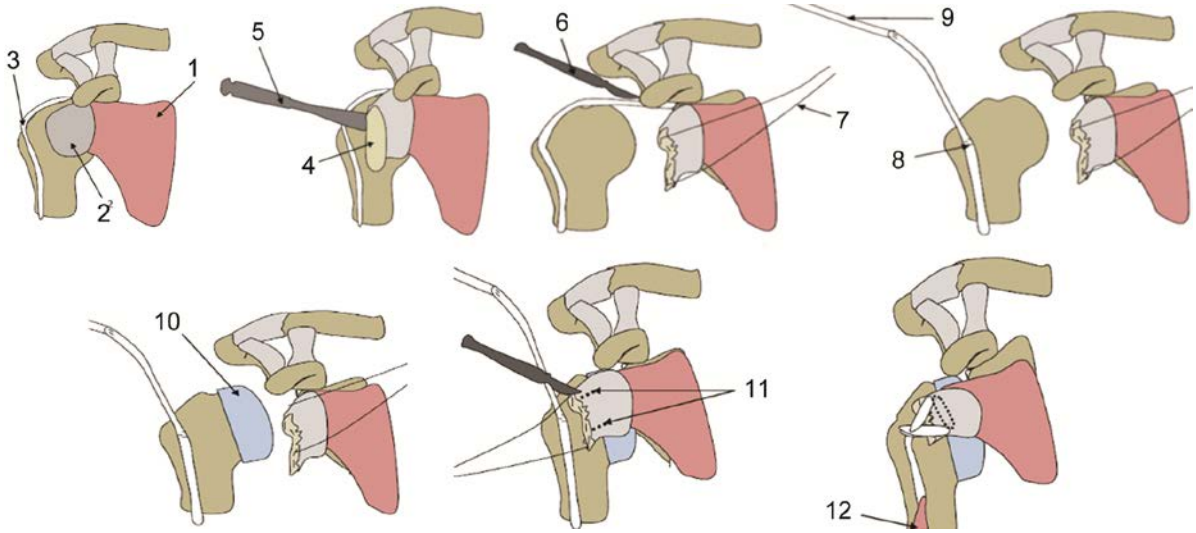

Fig. 1 Техника выполнения удлиняющей пластики подлопаточной мышцы сухожилием длинной головки двуглавой мышцы плеча: 1 – m. subscapularis; 2 – subscapularis tndon; 3 – the long head of the biceps tendon; 4 – bone plate with subscapularis tendon attached; 5 – chisel; 6 – scalpel; 7 – ligatures on subscapularis stump; 8 – tenodesis of the long head of the shoulder; 9 – ligatures on the stump of the long head of the biceps tendon; 10 – component of shoulder implant; 11 – incisions made to insert the stump of the long head of the biceps tendon; 12 – biceps belly

RESULTS

Radiography, clinical examination, angulometry and questionnaires were used to evaluate 7-month-to-one-year follow-up of plasty lengthening in 6 patients. Modified Constant Score and Shoulder Rating Questionnaire were used for assessment of shoulder function**.** Four criteria Constant Score (1 criterion = 1 point) was applied to evaluate ability to tuck shirt behind the back, fasten bra, reach behind buttocks and reach for toilet hygiene using the limb operated on [1].

Intraoperative passive shoulder internal and external rotation measured at least 90º and 30º, correspondingly. The operated limb was fixed with Dezo bandage followed by 6-week immobilisation. Daily isometric exercises were recommended for rehabilitation of shoulder and hand muscles starting from the 1st postoperative day including pendulum exercise bending over at the waist when changing dressing.

Intraoperative subscapularis measurements showed lengthening by 2 to 2.5 cm to get physiological length of the muscle restored for better function.

Clinical function of internal rotation was assessed with three shoulder examination tests and several maneuvers patients were requested to do themselves with no additional support (**Table 1**).

Clinical examination tests showed good recovery of shoulder internal rotation. Belly-press, Gerber's lift-off test and Napoleon test could be produced by all patients. Hand-behind-back was fully restored except for two female patients who were unable to fasten bra strips behind the back.

Table 1

Results of clinical examination following plasty lengthening of the subscapularis using the long head of the biceps tendon

Clinical examination	Result
Belly-press test	«+» (n = 6)
Gerber's Lift-Off test	«+» (n = 6)
Napoleon test	«+»(n = 6)
Ability to tuck shirt behind the back with operated limb	«+» (n = 6)
Ability to reach for toilet hygiene	«+» (n = 6)
Ability to reach behind buttocks	«+» (n = 6)
Ability to fasten bra strap behind the back with operated limb	«+» (1 out of 3)
Put hand behind back and wash the back	«–» (n = 6)
Out hand in back pants pockets	«+» (n = 6)

Fig. 2 Results of plasty lengthening of the subscapularis using the long head of the biceps tendon at 7 months of surgery

Clinical function of internal rotation was assessed in all patients using 10-point outcome score with 5 grades: 2 points (grade 1), regained internal rotation provides reach for greater trochanter with the dorsum of the hand; 4 points (grade 2), ability to reach sacrum with the dorsum of the hand, use back pants pocket; 6 points (grade 3) ability to reach behind low back, tuck shirt behind the back, reach for toilet hygiene; 8 points (grade 4), ability to reach behind thoracic vertebrae (Th10–Th12) with greater abilities to wash the back; 10 points (grade 5), ability to reach behind scapula, fasten bra strap behind the back, free hand-behind-back (**Table 2**) [3].

Table 2 shows outcome score of grade 3 in four patients and grade 4 in two patients following reverse TSA and plasty lengthening of the subscapularis. The patients could tuck shirt behind back and reach for toilet hygiene with the outcomes scores obtained.

Questionnaires showed improved shoulder function in 67 % according to Constant Score with 86 points measured with Shoulder Rating Questionnaire. Shoulder Rating Questionnaire also demonstrated that all patients were satisfied with the treatment. Internal rotation muscle strength measured 3.4 ± 1.4 N/m that indicated to the subscapularis strength improved by 83 %.

Table 2

Outcome score of internal rotation in patients following plasty lengthening of the subscapularis

Outcome score	Internal rotation	Points	Number of patients
1	Reach for greater trochanter	2	6
2	Reach behind sacrum	4	6
3	Reach behind lumbar vertebrae L3–L4	6	4
4	Reach behind thoracic vertebrae Th10–Th12	8	2
5	Reach behind scapula	10	–

Table 3

Results of questionnaires and angulometry

Description	Scores, measurements
Constant Score, %	67 ± 12.7
Shoulder Rating Questionnaire, points	86 ± 12.9
Internal rotation	115° ± 14
External rotation	35° ± 17
Dynamometry (norm 4.1 ± 0.8 N/m (100 %))	3.4 ± 1.4 N/m (83 %)

DISCUSSION

A total of 130 patients underwent reverse TSA between 2008 and 2017. Long-term results of TSA with *Delta Revers* implants were followed in 50 patients from 6 months to 6 years of surgery using radiography of the shoulder, questionnaires, angulometry according to V.O.Marx [1]. Evident postoperative insufficiency of shoulder internal rotation was observed in 30 % of the cases due to intraoperative failure in repair of subscapularis attachment following the subperiosteal dissection to access the glenoid fossa. This occurred in patients with posttraumatic humerus deformity following 3-to-4-segmental fractures aged more than 4 months.

Assessment of long-term follow-ups of reverse TSA showed problematic shoulder internal rotation that resulted in poor activities of daily life including hand-behind-back with shoulder internal rotation improved to 68º and subscapularis strength improved to 63 %. The review of poor results exhibited limited hand-behind-back in 37 % of the patients [1].

Table 4

Results of reverse TSA

Description	Scores
SDQ test, points	5.7 ± 3.9
CC test, %	63 ± 12.82
OSQ test, points	21.2 ± 6.6
Internal rotation	68º ± 14
Axial torque of internal rotation (norm 4.1 ± 0.8 N/m (100 %))	2.9 ± 1.1 N/m (70 %)

Surgical approach for humeral head exposure and repair of subscapularis attachment site with

reverse TSA implants were difficulties we encountered in old posttraumatic deformities of the proximal humerus. When bringing down the rotation centre the scarry tissues hindered subscapularis to be pulled to the lesser tubercle of the humerus even after mobilisation.

Considering the above problems with reverse TSA the technique offered showed functional improvements in the shoulder internal rotation and anterior shoulder stabilization addressing postoperative contracture of the external rotation. Amplitude and strength of the shoulder internal rotation with reverse TSA were reported to be twice as less as with anatomic TSA [1]. Improving physiological length of the subscapularis by 2.5 cm lengthening we could eliminate contracture of the external rotation and provide appropriate muscle tension. Reliable fixation of the subscapularis tendon with the long head of the biceps tendon allows for early rehabilitation and lower risk of postoperative implant dislocation reducing complication rate of reverse TSA.

CONCLUSION

The findings and the review of literature shows the importance of the shoulder internal rotation for activities of daily life in patients who undergo total shoulder arthroplasty and the deficient amplitude and strength of internal rotation results in poorer quality of life. The necessity of subscapularis repair with intact pectoralis latissimus and pectoralis major is substantiated by its role as the major shoulder stabilizer with the forearm and the hand being behind the back without touching. The subscapularis attachment site repair is essential but cannot be always performed due to insufficient length after reverse TSA in particular, primarily due to rotation centre being brought down and the retracted muscle in old injury (more than 6 weeks of trauma). Plasty lengthening of the subscapularis using the long head of the biceps tendon has shown the good clinical effect in postoperative period with the restored physiological length of the subscapularis and posterior stability of the arm.

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