Subscapularis dysfunction following anterior surgical approaches to the shoulder

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Subscapularis dysfunction following open surgical exposure of the glenohumeral joint has recently received attention. Clinical studies, in particular those that have investigated the results after open shoulder stabilization or shoulder replacement surgery, indicate that anterior approaches using different subscapularis tendon take-down or incision techniques may impair subscapularis recovery and can negatively influence the final clinical outcome. This review article will focus on the potential pathogenesis, diagnosis, and clinical impact of this more and more recognized condition and summarizes the currently available literature. (J Shoulder Elbow Surg 2008;17:671-683.)

Anterior approaches to the glenohumeral joint are regularly used for different surgical procedures, including open stabilization techniques, rotator cuff repairs, arthrolysis, fracture treatment, and shoulder replacement. Access to the glenohumeral joint is achieved via different types of subscapularis (SSC) tendon take-down or incision techniques. The SSC is the most powerful muscle of the rotator cuff and plays a major role in optimal shoulder function. In 1991, Gerber and Krushell reported a series of isolated tears of SSC tendon, directing attention to the problem of SSC insufficiency. SSC dysfunction following open surgical exposure of the glenohumeral joint via SSC incision or tenotomy approaches has recently received increasing attention. Despite previous impression that these techniques do not significantly disturb the integrity of the SSC musculotendinous unit, postoperative SSC insufficiency is more recognized as a potential clinical problem. Different clinical studies that have investigated the results after open shoulder stabilization or shoulder arthroplasty indicate that surgical approaches using partial or complete SSC tendon take-down techniques may impair SSC recovery and can negatively influence the clinical outcome. The loss of SSC function has been attributed to failure of the tendon repair and/or muscular changes (atrophy and fatty infiltration) resulting in permanent partial or complete SSC insufficiency. This review article focuses on the potential pathogenesis, diagnosis, and clinical impact of this condition and summarizes the currently available literature.

ANATOMY, INNERVATION, AND FUNCTION OF THE SSC MUSCLE

The SSC muscle is a multipennate muscle that arises from the anterior surface of the scapula and inserts on the lesser tuberosity. Hinton et al have shown that the insertion of the SSC into the humerus consists of tendon (approximately 60%) superiorly and muscle (approximately 40%) inferiorly (Figure 1). Cleeman et al divided the SSC insertion into 3 regions: a thick superior tubular tendon, a flat middle tendon, and an inferior portion where the muscle fibres insert directly into the humerus. The anterior humeral circumflex vessels pass laterally and parallel to the tendon, separating the tendinous and muscular portions. The inferior aspect of the SSC muscle at the anterior aspect of the quadrangular space is marked by the axillary nerve and posterior humeral circumflex vessels.

The SSC muscle is innervated by fibres from SSC nerves (mainly superior, middle, and inferior branches) that arise mostly from the posterior cord of the brachial plexus or rarely directly from the...
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Figure 1

Figure 2 Neural innervation of the SSC muscle including superior, middle and inferior subscapulares nerve branches. In this case the superior and middle branches arise from the posterior cord of the brachial plexus whereas the inferior branch arises from the thoracodorsal nerve.

thoracodorsal or axillary nerve penetrating the muscle belly at its anterior aspect (Figure 2). Yung et al found that the middle SSC nerves were always closely related to the upper nerve and appeared to be a part of the upper nerve group. In addition, the lower SSC nerves were found to be in close relationship to the axillary nerve penetrating the muscle posterior or immediately lateral to it.

The SSC is the largest and most powerful muscle of the rotator cuff and is an integral part of optimal shoulder function. Depending on the position of the humerus, it acts as an important internal rotator, shoulder adductor and abductor, humeral head depressor, and active anterior stabilizer of the glenohumeral joint. In addition, the SSC is the anterior part of the transverse force couple and, therefore, balances the external rotators of the shoulder and helps to compress and depress the humeral head into the glenoid cavity. Based on cadaveric, biomechanical, and electromyographic studies, different authors consider the upper and lower portion of the SSC muscle to be 2 separate units with independent functions and innervations. Liu et al suggested that the superior portions may play an important role in generating abduction torque, and the inferior portions may enhance stability.

SSC DETACHMENT, MOBILIZATION, AND REPAIR TECHNIQUES

SSC take-down for instability repair

Rowe et al described complete SSC tenotomy as the standard approach for open instability repair. The SSC musculotendinous insertion is detached 0.5-1 cm medial to the lesser tuberosity. This allows good exposure of the glenohumeral joint, mobilization of the detached tendon, and separation of the capsule, followed by an anatomic tendon-to-tendon repair (Figure 3). Alternatively to complete detachment of the SSC, an inverted L-shaped tenotomy approach is used to preserve the anterior circumflex humeral vessels and the lower muscular attachment of the SSC, thereby putting the axillary nerve at a lower risk during the surgical procedure (Figure 4). For open instability repair in the overhead athlete, Jobe et al recommended a less invasive approach of splitting the SSC tendon in the direction of its fibers (SSC-splitting approach) to prevent postoperative scarring and avoid any limitation in external rotation (Figure 5).

SSC take-down for shoulder arthroplasty

The complete SSC tenotomy approach, as described above, is also routinely used for prosthetic replacement of the glenohumeral joint. For severe internal rotation contracture in advanced osteoarthritis, for example, Habermeyer et al have proposed detachment of the tendon with the underlying capsule directly from the lesser tuberosity down to the insertion of the latissimus dorsi muscle (Figure 6). This technique offers excellent exposure of the glenoid, protects the axillary nerve, allows performance of a bifocal capsulotomy by creating a musculotendinoperiosteal flap that can be repaired by medialization using transosseous tunnels. Different authors have recently advocated the detachment of the SSC using a lesser tuberosity osteotomy technique (Figure 7).

Figure 1 The subscapularis muscle arises from the deep face of the scapula and inserts on the lesser tuberosity. The insertion consists of tendon (approximately 60%) superiorly and muscle (approximately 40%) inferiorly.

Figure 2 Neural innervation of the SSC muscle including superior, middle and inferior subscapulares nerve branches. In this case the superior and middle branches arise from the posterior cord of the brachial plexus whereas the inferior branch arises from the thoracodorsal nerve.
allow bone-to-bone healing that can easily be monitored during the early postoperative period.

In particular with internal rotation contractures, a 360° circumferential release of the SSC musculotendinous unit is necessary for soft-tissue balancing to gain adequate tendon excursion and restore full glenohumeral motion. This includes the release of adhesions at the upper border to the coracoid at the anterior surface underneath the conjoined tendons, the posterior surface from the capsule along the scapular neck, and the inferior border from the axillary nerve and the circumflex vessels (Figure 8). In addition, Miller et al reported resection of the anterior capsule located on the undersurface of the SSC to allow further mobilization. In severely contracted cases, release of the intraarticular SSC tendon, including an oblique incision of the superior tubular portion or Z-lengthening of the SSC tendon in the coronal plane, have been described.

The detached SSC tendon is armed using a modified Mason-Allen suture, the mechanical properties of which have been shown to be superior to the single and mattress stitches. The number of sutures depends on the amount of tendon detached from the lesser tuberosity. Different repair techniques of the detached SSC tendon have been described and are currently a matter of investigation. In cases of open instability repair, the anatomic reattachment of the SSC allowing tendon-to-tendon healing is the preferred method. Fixation of the SSC with a direct...
tendon-to-tendon repair has also been advocated following shoulder replacement surgery, particularly if an internal rotation contracture is not present. This technique has been criticized as not allowing adequate balancing of the anterior soft tissue. With medialization of the SSC insertion, an increase in SSC excursion can be achieved. However, Ahmad et al found that transosseous tunnel repair alters SSC insertional anatomy, resulting in weaker strength of fixation and less contact area when compared with a combined transosseous tunnel and direct tendon-to-tendon repair. The lesser tuberosity osteotomy repair has been shown to be even more secure and stronger than both the transosseous and soft-tissue repair techniques. Although clinical studies that prospectively compare the different SSC repair techniques are not available, the biomechanical data suggest that an anatomic and strong refixation technique should be used whenever possible.

INCIDENCE AND PATHOGENESIS

Postoperative dysfunction of the SSC musculotendinous unit might occur because of different reasons, including failure of the tendon repair and/or muscular changes (atrophy and fatty infiltration).

The literature does not clearly establish the true incidence of failed tendon repairs after open shoulder stabilization or shoulder replacement surgery. In a retrospective study, Greis et al. reported on 88 patients who underwent an open Bankart procedure using a complete SSC tenotomy approach. Of these patients, 4 (4.5%) required reoperation for SSC tendon repair failure. However, other series do not report any revisions due to postoperative SSC tendon disruption. Maynou et al found 3 cases (3.9%) of failed repairs in a group of 77 patients who underwent the Latarjet-procedure using the inverted L-shaped tenotomy approach and were followed with Arthro-CT. Two patients had marked fatty infiltration (stages 3 and 4 according to Goutallier) however, reoperation was not required.

Armstrong et al were the first to evaluate SSC tendon integrity after total shoulder replacement...
for osteoarthritis in a consecutive series with ultrasound. Although none of the patients underwent revision surgery, 4 (13.3%) of 30 shoulders had a failed tendon repair at final follow-up. Miller et al reported on 119 patients who underwent total shoulder arthroplasty. Of these patients, 7 (5.8%) required revision surgery for symptomatic rupture of the SSC tendon between 2 and 53 months after the procedure.

As already described for failed repairs after rotator cuff reconstruction, it seems that failed SSC reattachments after open instability repairs or shoulder replacement surgery can be asymptomatic and/or even unrecognized postoperatively. However, a failed repair that remains undetected seems to follow the natural history of a traumatic SSC tendon rupture, including scarring and progressive atrophy and fatty infiltration, thus making the musculotendinous unit irreparable.

Proposed factors associated with postoperative SSC rupture have included multiple operations with poor-quality tissue, trauma or inappropriate physical therapy during the early postoperative period, insufficient repair techniques, compromise of the tendon repair resulting from various SSC lengthening techniques, or overstuffing of the joint due to oversized prosthetic components. In addition, in recurrent anterior instability, the SSC, as well as other rotator cuff muscles, is subject to the tensile force caused by the dislocated humeral head. Symeonides reported on “healed posttraumatic lesions” of the SSC muscle in patients with anterior instability, who were treated with an open instability repair. It is believed that the SSC musculotendinous unit is lengthened and thinned in shoulders with recurrent anterior dislocations. Tuoheti et al have shown that the SSC tendon undergoes an 18.7% decrease in thickness and a 29.1% decrease in cross-sectional area in patients with recurrent anterior dislocations compared to the contralateral side. Repetitive stretching by the dislocated humeral head may cause the thinning and decrease in cross-sectional area of the SSC tendon. Gamulin et al have found interstitial fibrosis within the SSC muscle that was
compatible with muscle scarring and modifications in the ratio of fiber types, as seen with disuse atrophy in patients with recurrent anterior instability.10 The authors did not find evidence of neurogenic degeneration in the SSC muscle and, therefore, excluded a neurologic etiology. However, it seems obvious that a pre-injured musculotendinous unit may be even more predisposed for further damage due to the surgical procedure.

Atrophy and fatty infiltration of the SSC muscle, in the presence of an intact tendon repair, have also been reported after open instability and shoulder replacement surgery, and the reason for degeneration of the muscle has not been finally investigated15,48,49. Miller et al suggested the possibility of denervation during the surgical approach with release and mobilization of the SSC.39 Mobilization techniques, as described above, may place the integrity and innervation of the SSC muscle at risk. Different cadaveric studies have attempted to provide surgical guidelines for safe surgery about the SSC muscle. Yung et al recommended identification of the axillary nerve at the inferior border of the SSC and protection of the lower SSC nerve.59 In addition, dissection at the anterior surface should be limited underneath the conjoint tendon or within a margin of approximately 1.5 cm (“safe harbor”). Checcia et al evaluated the topographic relationship of the penetrating nerves to the anterior rim of the glenoid concavity based on the position of the arm and found that the upper subscapular branch penetrates the muscle as close as 1 cm from the medial border of the glenoid.6 All the investigated nerve branches were closest to the anterior border of the glenoid when the arm was changed from internal to external rotation. In another study, it was noted that all superior SSC nerve branches were located within a range 2.5 cm vertical distance below the base of the coracoid process.19 Within this vertical distance, there was a 95% probability of finding upper SSC nerves beyond a 2 cm distance medial to the lateral border of the base of the coracoid with the arm in neutral rotation. After circumferential release and with lateral traction on the tendon, there was a 95% chance of finding nerve branches 0.5 cm medial to the lateral border of the base of the coracoid. It seems that there is an increased risk for denervation, in particular of the upper part of the SSC muscle, when the release is performed anterior to the muscle beyond the base of the coracoid, especially with a lateral pull on the tendon.

Despite this potential risk for denervation of the SSC muscle, Gerber et al found no sign of direct or indirect neurologic, subclinical damage after total shoulder replacement using pre-, intra-, and postoperative electromyographic assessment.16 The definite pathogenesis of the structural changes of the SSC remains unclear.

**DIAGNOSIS OF SSC DYSFUNCTION**

Establishing the diagnosis of a failed tendon repair requires a high degree of suspicion, as the condition can be asymptomatic. The physician should be suspicious of a SSC rupture in patients who underwent any kind of anterior approach with detachment of the SSC and who present with pain, recurrent instability, weakness in internal rotation, and increased passive external rotation in the early postoperative period.19,38 An inciting event, with the patient noticing a pop with external rotation or extension of the upper arm, may have occurred. Nevertheless, as mentioned above, it seems that often such tears remain undetected unless a meticulous physical exam is performed.

In the early postoperative period, the specific clinical testing of the SSC interferes with the healing of the tendon. However, the clinical diagnosis of SSC dysfunction is ultimately based on the currently available diagnostic tests and clinical signs that have been published to detect SSC tendon tears. The lift-off test, as described by Gerber and Krushell, is considered positive if the patient is unable to raise the hand posteriorly off the back (Figure 9).12 If the lift-off test is negative, the greatest distance of hand to back achieved actively during the lift-off test can be measured and compared to the opposite side (Figure 10). This measurement allows specification of the test result. The internal rotation lag sign, as described by Hertel et al, is considered positive if the patient cannot actively maintain the position of internal rotation and extension (Figures 11 and 12).24 With the belly-press test, the patient presses the abdomen with the hand flat and attempts to keep the arm in maximum internal rotation. The test is considered positive when the elbow drops in a posterior direction, internal rotation is lost, and pressure is exerted by extension of the shoulder and flexion of the wrist.11 We perform this test slightly modified. With the hand flat on the abdomen and the elbow close to the body, the patient is told to bring the elbow forward and straighten the wrist. If the patient cannot achieve full extension, the final flexion position of the wrist is measured, as described by Burkhart and Tehrany for the Napoleon sign, or for the belly-press test (belly-press angle) using a hand-held goniometer (Kim et al) (Figures 13 and 14).5,30 In a recently published study, it has been shown that the belly-press angle correlated with the degree of structural changes of the SSC muscle after open shoulder instability repair, meaning that higher values had a higher degree of fatty infiltration of the SSC muscle.50 In this study, the belly-press test and belly-off sign, defined as the inability of the patient to maintain the palm of the hand attached to the abdomen with the arm passively brought into flexion and internal rotation, were the most reliable signs to detect mild upper SSC dysfunction in patients after open instability repair.
It has to be mentioned that any restriction in internal rotation will affect the clinical testing of the SSC unit, leading to false-positive results. This problem does not seem to be an issue in the majority of patients after open instability repair; however, in patients after shoulder replacement, the clinical evaluation of the SSC unit is difficult. Armstrong et al concluded that the limitations in internal rotation often seen in patients with osteoarthritis treated with total shoulder arthroplasty can make use of the lift-off test and the belly-press test unreliable.

Different imaging methods have been used to evaluate the SSC musculotendinous unit postoperatively. Although a certain amount of experience is necessary, ultrasound is a useful tool to evaluate SSC tendon integrity in the postoperative period because it is cheap and easy to perform (Figure 17). In addition, as described above, the clinical evaluation using the above described tests in the early postoperative period interferes with the process of tendon healing. Postoperative radiographs become an option, if a lesser tuberosity osteotomy was used to detach the SSC tendon. The integrity of the repair can easily be assessed on standard axillary.

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radiographs (Figure 18). Eventually, anterior subluxation of the humeral head can be observed on the axillary view, in cases of long-standing SSC tendon defects.

Different authors used (Arthro-)CT to detect tendon tears and grade the fatty infiltration as per Goutallier et al. Magnetic resonance imaging can also be used to evaluate the structural integrity of the SSC in patients after open instability repair. Criteria for detection of SSC tendon tears on axial images are a fluid equivalent signal between the ends of a tendon, discontinuity, or retraction of the tendon. Circumscribed signal alteration of the tendon or caliber changes, as described by Pfirrmann et al., cannot be used as diagnostic criteria, as previous surgery had been performed (Figures 2 and 19). MRI has also been described to evaluate atrophy and fatty infiltration of the SSC muscle (Figure 20); however, after total shoulder replacement, MRI is much less reliable as a result of metal artefact.

**CLINICAL IMPACT OF SSC DYSFUNCTION**

Acute postoperative tendon disruption due to trauma in patients after open instability repair may lead to recurrent instability in the early postoperative period. In the study by Greis et al., a prompt re-exploration and repair of the SSC tendon was performed to achieve adequate stability and SSC function. The authors recommended a strong refixation technique, a supervised postoperative treatment protocol, and the use of less invasive exposure techniques. Unless the failed repair is detected and reconstructed quickly, the SSC often retracts and undergoes atrophy and fatty infiltration. When the SSC tendon is deficient or irreparable, a pectoralis major transfer may be used to augment or substitute for the SSC.

In contrast to acute postoperative tendon disruption, chronic SSC insufficiency appears to be a different problem in patients after open shoulder stabilization. In a retrospective study, Picard et al. evaluated the effects of subtotal vertical section (inverted L-shaped SSC tenotomy) of the SSC tendon in 40 patients, who underwent open shoulder stabilization using the Latarjet procedure. The SSC muscle was assessed by measuring strength for internal rotation and the distance from hand to back during the lift-off test. Four years after the surgical procedure, they found...
a 50% loss of the SSC muscle strength and significant fatty degeneration of the muscle (stages II-IV according to Goutallier) in 41% of patients. They recommended avoiding this approach for the Latarjet procedure.

In a subsequent study, Maynou et al compared the clinical function and structure of the SSC muscle after Latarjet-Patte procedure, using an inverted L-shaped tenotomy approach compared to a lengthwise incision (SSC-split). They measured distance and strength by the lift-off test. Integrity of the tendon and fatty degeneration and atrophy of the muscle were also analyzed by Arthro-CT. They found that the distance and strength were significantly reduced and fatty degeneration was significantly increased in the inverted L-shaped tenotomy group. In addition, 3 partial tendon disruptions were observed. According to the Walch-Duplay score, patients in this group had less satisfactory overall clinical results. They concluded that the inverted L-shaped tenotomy results in loss of strength and fatty degeneration and atrophy of the muscle belly, and recommended the SSC split as the standard approach for the Latarjet-Patte procedure.

Sachs et al recently looked at thirty patients after primary open Bankart-repair using an L-inverted tenotomy approach. They analyzed their results based on SSC function. Twenty-three patients (77%) were thought to have a competent SSC (negative lift-off test) and 7 (23%) were thought to have an incompetent SSC demonstrated by a positive lift-off test. No difference was found between the groups using the Constant Score and the American Shoulder and Elbow Surgeons scoring system (ASES). However, patients with a competent SSC had higher subjective satisfaction rates and higher values in the Western Ontario Shoulder Instability Index (WOSI). In fact, the lower WOSI scores confirmed that the SSC dysfunction correlated with an inferior subjective outcome. Because only 1 of the patients with SSC dysfunction had a postoperative MRI, it was impossible to establish a correlation between the clinical deficit and postoperative structural changes of the SSC musculotendinous unit.

In a recently published study, the integrity, structure, and clinical function of the SSC musculotendinous unit in patients after primary and revision open shoulder stabilization using an inverted L-shaped tenotomy approach was evaluated and compared with the overall function of the shoulder. Although no complete tendon disruption was found, we were able to demonstrate that an inverted L-shaped SSC tenotomy approach may lead to atrophy and fatty infiltration, in particular of the upper part of the SSC muscle. Revision procedures, using the same

**Figure 15** Belly-off sign: The affected arm of the patient is brought into flexion and maximum internal rotation. The patient is then asked to keep the wrist straight and actively maintain the position of internal rotation as the examiner releases the wrist.
approach, did further compromise clinical SSC function and structural integrity significantly. Although no statistically significant differences in the respective Constant and Rowe Scores between both groups were found, the modified belly-press test/Napoleon sign and the belly-off sign appeared to be the most reliable signs to detect upper SSC dysfunction.

The results of the above mentioned studies suggest that, as far as deterioration of the clinical function and structure of the SSC muscle, an arthroscopic approach may potentially violate the musculotendinous unit less. In another study, the integrity, structure, and clinical function of the SSC musculotendinous unit after arthroscopic and open shoulder stabilization using a complete SSC tenotomy approach was evaluated. This study confirmed previous observations that open shoulder stabilization using a SSC tenotomy may lead to atrophy and fatty infiltration, particularly of the upper SSC muscle portion, resulting in postoperative SSC dysfunction. As expected, arthroscopic procedures using a 3 portal technique did not significantly compromise clinical SSC function and structural integrity.

As in open instability surgery, postoperative SSC dysfunction is being recognized as a serious clinical problem after TSA. These patients were all found to have SSC tears on operative exploration. Despite repair of this tendon, 3 of 7 patients continued to have instability, thus requiring further surgery.

Miller et al were one of the first who specifically reported on clinical postoperative SSC dysfunction following shoulder replacement surgery. Forty-one patients were included in this study and had been operated on using a complete SSC tenotomy with circumferential release of the SSC tendon. The SSC tendon was repaired using either isolated soft-tissue anatomic side-to-side repairs with No. 2 nonabsorbable, modified, Mason-Allen sutures, or with the addition of bone-tunnels from the anatomic neck to the lesser tuberosity to reinforce the repair. After a mean follow-up of 1.9 years, the authors found abnormal results for the lift-off test in 67.5% and 66.6% for the belly-press examination. In addition, 68.2% of patients reported having difficulties tucking their shirt in the back of their pants. However, no imaging studies had been performed and conclusions concerning the structural integrity of the SSC could not be drawn.

Ponce et al were one of the first who reported on the clinical function of the SSC following lesser tuberosity osteotomy in seventy-six patients after total shoulder replacement. Postoperative SSC function, as evaluated with a belly-press, lift-off, or shirt-tuck tests, was normal in 62 patients, abnormal in 5, and not documented in 9. Radiographic evaluation demonstrated
a single rupture of the lesser tuberosity osteotomy repair. These results of the clinical exam appeared to be much better than those of Miller et al.\textsuperscript{39}

Gerber et al recently published on their technique of lesser tuberosity osteotomy in 36 patients who underwent total shoulder replacement.\textsuperscript{15} The lesser tuberosity was repaired anatomically with bone-to-bone contact with the use of transosseous No. 3 Ethibond sutures (Ethicon Inc., Johnson & Johnson, Somerville, NJ). After a mean follow-up of 39 months, the tuberosity osteotomy fragment healed in an anatomical position in all cases. The clinical exam of the SSC muscle revealed negative lift-off and belly-press test results in 75% and 89% of patients, respectively. However, despite radiological healing of the bone in all cases and absence of musculotendinous tears, 40% of patients had a postoperative increase in fatty infiltration.
by at least 1 stage and 15% of patients by at least 2 stages.

The clinical impact of postoperative SSC dysfunction after total shoulder replacement has not been finally investigated. In a multicenter study, Edwards et al found that postoperative fatty infiltration of the SSC in patients after total shoulder replacement negatively influenced mobility, strength, and overall Constant Scores. However, in the study by Armstrong et al, in 3 of the 4 patients who had documented SSC tears by ultrasound examination, the postoperative ASES scores for the shoulders with an intact SSC were equivalent to those on the side with the torn SSC tendon.

In conclusion, anterior approaches to the shoulder, including different types of SSC tendon take-down or incision techniques with or without releases, carry the risk of iatrogenic damage to the SSC musculotendinous unit. Irreversible changes of the muscle, in particular atrophy and fatty infiltration with or without failure of the tendon repair, may result in permanent loss of SSC function. The true incidence of these structural changes is currently unknown. The degree and clinical impact of SSC dysfunction seems to vary depending on the damage to the musculotendinous unit. However, so far, it remains unclear what degree of SSC dysfunction needs to be present before the results of functional shoulder scores become significantly affected. The SSC split approach seems to be the most benign approach for open instability repairs with regard to SSC integrity. Arthroscopic stabilization procedures seem to prevent the complication of fatty infiltration. The lesser tuberosity osteotomy appears to be a promising approach for TSA in avoiding tendinous failures postoperatively. In any case, the detachment and mobilization of the SSC musculotendinous unit should be carried out with awareness of the innervation of the SSC muscle. Strong and, if possible, anatomic tendon repair techniques should be used, and the repaired tendon must be protected postoperatively.

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