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State of the Art Review

Partial subscapularis tear: State-of-the-art

Ankit Kumar Garg [a], Amit Meena [b,c,d,*], Luca Farinelli [e], Riccardo D'Ambrosi [f,g], Sachin Tapasvi [h], Sepp Braun [c,d]

[a] *All India Institute of Medical Sciences, Raipur, Chhattisgarh, India*
[b] *Division of Orthopedics, Shalby Multi-Specialty Hospital, Jaipur, India*
[c] *Gelenkpunkt–Sports and Joint Surgery, FIFA Medical Centre of Excellence, Innsbruck, Austria*
[d] *Research Unit for Orthopaedic Sports Medicine and Injury Prevention (OSMI), Private University for Health Sciences, Medical Informatics and Technology, Innsbruck, Austria*
[e] *Clinical Orthopaedics, Department of Clinical and Molecular Sciences, Università Politecnica delle Marche, Ancona, Italy*
[f] *IRCCS Ospedale Galeazzi - Sant'Ambrogio, Milan, Italy*
[g] *Università degli Studi di Milano, Dipartimento di Scienze Biomediche per la Salute, Milan, Italy*
[h] *The Orthopaedic Speciality Clinic, Pune, India*

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ABSTRACT

The subscapularis (SSC) muscle is a crucial anterior glenohumeral stabilizer and internal rotator of the shoulder joint. The partial tears of the SSC might result from traumatic injury or intrinsic degeneration. Partial SSC tears can range in severity and be classified into different categories based on the location of the tear, size of the lesion, and associated pathology. The tear usually begins from the superolateral margin in the first facet and propagates downwards. It is frequently associated with biceps pathology or anterosuperior lesions. These tears are now increasingly recognized as distinct pathology that requires specific diagnostic and management approaches. The current management approaches are shifting towards operative, as partial SSC tears are increasingly recognized as a distinct pathology. At present, there is no consensus regarding the timing of repair, but the relative tendency of the SSC to retract much faster than other rotator cuff muscles, and difficulty in mobilization, advocates an early repair for SSC irrespective of the lesion size. An associated biceps pathology can be treated with either tenotomy (biceps delamination/erosion) or tenodesis. The techniques of partial SSC repair are constantly improving. There is no reported difference in use of 2-anchor-based conventional single-row (SR), a 3-anchor-based interconnected double-row technique, or a 2-anchor-based interconnected hybrid double-row construct in the repair construct. However, the 2-anchor-based interconnected double-row provides an advantage of better superolateral coverage with leading-edge protection, as it helps in placing the superolateral anchor superior and lateral to the original footprint. A timely intervention and restoration of the footprint will help restore and rehabilitate the shoulder. Future directions should prioritise injury prevention, early diagnosis with clinic-radiological cues and targeted interventions to mitigate risk.

BACKGROUND AND RELEVANCE

The subscapularis (SSC) is a crucial anterior glenohumeral stabilizer and internal rotator of the shoulder joint. Though often called a “forgotten muscle,” it represents the largest portion of the rotator cuff muscle [1,2]. Subscapularis originates from the subcostal surface of the scapula and then typically splits up in its insertion to the lesser tuberosity. Hinton et al. [3] describe that the upper 2/3rd fibres insert on the lesser tuberosity and interdigitate with anterior fibres of the supraspinatus, while the lower portion inserts with a muscular insertion in the humeral metaphysis. The interdigitation of the fibres superiorly contributes to the rotator interval and transverse humeral ligaments and the stability of the biceps pulley [1,4].

Smith et al. [5] in 1834 reported the first isolated subscapularis tear in a seven-case series. After that, multiple studies reported varied incidences of subscapularis tears. Although it is becoming increasingly recognized today, the reported incidence of isolated subscapularis tear varies around 4% of the total rotator cuff lesions [6–8]. It can be

* Corresponding author. Shalby Multi-Specialty Hospital, Jaipur, 302021, India, Tel.: +91 8467920426.
E-mail address: ameena@uwo.ca (A. Meena).

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associated with injury to the anterosuperior cuff, the biceps tendon's long head, or other rotator cuff tendons. It is more common in men in the fifth decade of their life [9].

Patients with isolated subscapularis tear (ISS) can present with anterior shoulder pain, weakness, and decreased function depending on age and injury [10–13]. The adolescent athletes may present with an associated Salter-Harris type 2 lesser tuberosity fracture or humeral capsular avulsion (HAGL lesion). An athlete in middle age can have traumatic ISS or an associated anterosuperior cuff tear with or without destabilization of the long head of the biceps (31–56% of cases). The asymptomatic tear can extend to a massive tear or involve other rotator cuffs tendons leading to anterior instability due to a compromised rotator cuff. While the complete tear of the subscapularis is aptly detected using clinical examination and imaging, partial tears are often missed [12,14,15]. The isolated tears of the lower (muscular portion) part are rare and described as hidden lesions by Bennet as they are often missed at arthroscopy [16]. A recent study by Yoo et al. [17] reported that 80 % of the tears in SSC occur in the upper third of the tendon only. Even with magnetic resonance imaging, we can diagnose smaller tears with an accuracy of only 70 % [18–20], and thus in addition to MRI, the distinct clinical exam is of high diagnostic value [21]. Hence, arthroscopy remains the gold standard for identifying the partial subscapularis tear.

Partial tears of the subscapularis muscle are increasingly recognized as distinct pathology that requires specific diagnostic and management approaches. This study aims to provide an overview of a comprehensive analysis of the evaluation of isolated partial subscapularis tear to its evaluation, diagnosis, and planning strategies for its successful management and rehabilitation (Box 1–6).

ANATOMY

Recently, several cadaveric studies have detailed the anatomy of the subscapularis tendon and its bone insertion [2,17,22]. This knowledge of subscapularis footprint is crucial for understanding partial tears. The subscapularis arises from the anterior aspect of the scapula. It traverses laterally to split up into two portions, i.e., the tendinous upper two-third, which inserts on the lesser tuberosity, bicipital groove, and the greater tuberosity, while the muscular lower-third portion, which attaches via a thin membranous structure to the inferior part of the lesser tuberosity and the anterior aspect of the humeral metaphysis [1]. The shape is broadly described as trapezoidal, with a more superior attachment. The dimensions are vertically 2.4–2.6 cm and horizontally 1.6–1.83 cm in the superior part to 0.3 cm in the inferior part [4].

Similarly, Ide et al. [22] also described the mean width of the bare area as 3.2 mm in the proximal part and 16.8 distally, which corroborates with the above finding.

Yoo et al. [17] described the insertional footprint of the SSC by the 3-dimensional concept using four facets. The first two facets, representing 60% of the total footprint, correspond to the tendinous portion of the upper SSC attachment. In comparison, the following two facets represent the large muscular insertion in the lower attachment.

The superior part of the SSC tendon forms the medial sling of the biceps pulley along with the superior glenohumeral ligament. Newer reports suggest that the complex anatomical relationship of SSC with the biceps tendon is responsible for tendon stability rather than SGHL and CHL, which was considered as primary stabilizers [23]. The medial pulley, coracohumeral ligament, and interval capsule, often called the "comma sign," serve as an astute landmark to localize the superolateral portion of the SSC [24].

MECHANISM OF INJURY

A partial tear of the subscapularis muscle can occur due to various mechanisms depending on traumatic vs. degenerative aetiology. Typically, the SSC is injured with the arm in forced hyperextension with external rotation. In their series of 16 patients, Gerber described isolated SSC tendon tears with forced external rotation in an adducted arm [11].

One possible mechanism of injury for a partial subscapularis tear is acute trauma or direct impact to the shoulder. This can happen during sports activities such as football, rugby, or wrestling, where there is a high risk of collision or falling onto an outstretched arm. The forceful impact can cause the muscle fibres to stretch beyond their normal limits, leading to tearing or rupture.

Another mechanism of injury for a partial subscapularis tear is repetitive overhead activities or excessive strain on the shoulder joint. Athletes involved in sports like swimming, tennis, or baseball that require repetitive overhead motions are at higher risk for this type of injury. Over time, these repetitive movements can cause micro-trauma to the subscapularis muscle, leading to degeneration and eventual tearing.

Poor technique or improper form during weightlifting exercises can also contribute to a partial SSC tear. When performing exercises like bench or military presses with incorrect form, excessive stress may be

Table 1
Shows the summary of the clinical test.

Test	Pre-requisite	Procedure	Remarks
Lift-off test [10]	1. The patient should have minimum pain 2. The patient should be able to internally rotate the shoulder	The patient internally rotates the hand behind his or her back, with the elbow flexed, and initially rests the dorsum of the hand on the mid-lumbar region.	Positive test – when the patient is unable to lift the hand maintain the hand away from the back Sensitive for upper 1/3rd −1/2nd fibres.
Modified lift-off test [11]		Position of hand same as above. Also, the examiner needs to passively lift the hand off the back and then release it.	Positive when the patient is unable to maintain the positioning of the handoff of the back
Belly press test [10]	1. The patient should have a normal passive ROM. Loss of passive internal rotation will lead to false positive testing. 2. Useful in patients in pain and with limited internal rotation	The patient presses the abdomen with the hand flat, keeping the shoulder in IR and maintaining the elbow at or in front of the mid–coronal plane of the trunk	Positive test – when the patient is forced to volar flex his or her wrist to maintain a forward position of the elbow while the elbow falls posteriorly. "Napoleon" sign [32] A decrease in his or her ability to maintain a forward position of the elbow compared to the contralateral side also indicates subscapularis insufficiency Sensitive for upper 1/3rd fibres
Bear-hug test [31]		The patient will put the palm on the tested side upon the opposite shoulder with fingers extended. The patient then attempts to resist an external force trying to pull the hand away from the shoulder in a perpendicular fashion.	Positive test – when the patient cannot maintain the hand on the opposite shoulder or shows weakness compared to the contralateral side. Sensitive for upper 1/3rd fibres

IR = internal rotation, ROM = range of motion.

Table 2
Shows the classification proposed by Martetschläger et al.

Transverse plane (mediolateral extension)	Coronal plane (cranio-caudal extension of tear)
Type 1: Split Type 2:<10 mm Type 3: 10–15 mm Type 4:>15 mm	Subtype A < 10 mm Subtype B 10–15 mm Subtype C > 15 mm

Table 3
Shows the classification proposed by Yoo et al.

Yoo and Rhee [17] subscapularis tendon tear classification according to facet exposureand the lateral band	
Type I	Fraying or longitudinal split of subscapularis leading-edge tendon
Type II A	<50% subscapularis tendon detachment in the first facet
Type II B	>50% detachment in the first facet without complete disruption of lateral band
Type III	Entire first facet with complete disruption of the ateral band (full-thickness tear of upper one-third of subscapularis superior-inferior length)
Type IV	Up to the second facet tear, the first and second facets are exposed with much more medial retraction of the tendon, which is approximately a two-thirds tear of the entire subscapularis superior-inferior length (the entire tendinous portion)
Type V	Complete subscapularis tendon tear involving the muscular portion

placed on the rotator cuff muscles, including the subscapularis. This can lead to overuse injuries and tears in the muscle fibres.

Age-related degeneration is another factor that can contribute to a partial subscapularis tear. As individuals age, their tendons and muscles become less elastic and more prone to injury [25]. The blood supply to these tissues may also decrease with age, compromising their healing ability. Therefore, older individuals are more susceptible to developing tears in their rotator cuff muscles.

Certain anatomical factors may predispose individuals to a partial subscapularis tear. For example, individuals with a narrow or shallow shoulder socket may have less stability in their shoulder joints, making them more prone to injuries. Additionally, individuals with previous shoulder injuries or surgeries may have weakened or scarred tissues, increasing their risk of developing a subscapularis tear.

The acute traumatic tear presents as “anterosuperior rotator cuff lesions” (due to involvement of supraspinatus along with SSC), or medial biceps tear or medial subluxation due to torn medial sling, which is formed by the superior border of the subscapularis. Lafosse [26] and Braun [27] et al. reported that partial SSC lesions were more common with anterior dislocation of long of biceps tendons and tears of pulley. Repetitive wear and trauma leading to tendinosis, partial tearing and anteromedial dislocation of the LHB tendon are often related with subscapularis lesion. Though poorly understood, the anatomical relationship of subscapularis with the pulley explains the mechanism of such injuries [27].

HISTORY

The symptoms of a partial subscapularis tear can vary depending on the severity of the injury. The patients typically present with pain over the anterior aspect of the shoulder, which is dull aching, which may be aggravated by activities involving overhead movements or reaching across the body. There may be associated weakness in internal rotation of the shoulder, as well as weakness in activities, such as lifting heavy objects or performing push-ups that predominately use the subscapularis muscle. Some may also experience difficulty with external rotation and have a limited range of motion, particularly in internal rotation and abduction (raising the arm to the side). Some individuals may also experience a popping or clicking sensation in the shoulder joint or an associated tenderness over the subscapularis insertion on the lesser tuberosity of the humerus. Patients with degenerative subscapularis tendon tears present with gradual, progressing symptoms, usually in the anterior shoulder region, like those in degenerative superior and posterior rotator cuff tears. It may be associated with biceps tendon pathology, which may be further disabling [8,28–30].

CLINICAL EXAMINATION

A comprehensive physical exam is required to diagnose shoulder pathology and concomitant lesions accurately. The patient is made comfortable in a suitable environment for examination with a shoulder robe. The shoulders should be inspected from the front, side, and back and compared with the other side to look for contour, symmetry, and muscle wasting. The patient may have tenderness over the intertubercular groove or lesser tuberosity along the anterior aspect of the shoulder. The tenderness over the acromioclavicular joint, coracoid process, and position of the biceps muscle will provide additional information regarding the pathology. An astute comparison of both sides' active and passive shoulder range of motion can provide vital information related to SSC tears. The patient may demonstrate an exaggerated passive external rotation. However, the restriction or weakness in internal rotation can often be masked using accessory muscles like pectoralis major, latissimus and teres major, giving a false negative finding. Martetschläger et al. [4] have evaluated active and passive internal rotation of both sides and graded them as buttock, sacroiliac joint, L5 (5th lumbar vertebra), L1 (1st lumbar vertebra) and T7 (7th thoracic vertebra) depending on the reach of the shoulder.

SSC can be tested in isolation with the help of various tests, e.g. the lift-off and belly press tests described by Gerber et al. [10,11] and the bear-hug test by Barth et [31]. A summary of the test is presented in Table 1.

In a study by Tokish et [33], using electromyographic (EMG) validation and comparison, they found that the belly press test and lift-off test preferentially activate the upper and lower subscapularis, respectively. However, another study by Pennock et al. [34] found no difference between the three tests (lift-off test, belly press, bear-hug) with evaluation even at different arm positions. Patients must present with ROM that allows the correct arm position for lift-off testing. Limited ROM may lead to false testing.

It is of utmost importance to palpate the bicipital groove and look for pain with the arm in 10 degrees of internal rotation and external rotation of the arm. This gives a vital understanding of biceps pathology, often associated with the SSC tear. A positive impingement sign, pain with the arm in elevation, and internal rotation denote a biceps pulley lesion. The co-existent tear of the supraspinatus, which forms the anterosuperior rotator cuff, should also be ruled out. Furthermore, a cervical spine examination is necessary to rule out any referred pain.

CLASSIFICATION

Partial SSC tears can range in severity and be classified into different categories based on the location of the tear, size of the lesion and associated pathology.

Martetschläger et al. [4] have given a recent classification system specific to partial subscapularis tear. It is an arthroscopy-based classification system (Table 2), in which tears are sub-classified based on the extension of the lesion in the transverse (mediolateral extension) and coronal plane (craniocaudal extension).

Yoo et al. [17], in their classification system (Table 3), proposed an arthroscopic classification based on subscapularis footprint four-facet exposure and lateral band detachment concept. The lateral hood, formed on the lateral edge of the first two facets, remains intact in partial tear and serves as a differentiating feature with a complete upper-third tear.

A brief summary of other commonly used classification systems and their relevance has been discussed below in Tables 4 and 5.

These classification systems are not mutually exclusive, and a tear can fall into different stages as per various classification systems. The classification systems help in appropriate treatment planning and help as a guide regarding the treatment options.

IMAGING

Partial tears of the subscapularis tendon can be challenging to diagnose due to their subtle nature and the complex anatomy of the shoulder joint. However, several imaging methods can aid in accurately diagnosing partial subscapularis tears. These imaging techniques include radiographs, ultrasound, magnetic resonance imaging (MRI), and arthroscopy. Complementary techniques such as CT scans, CT arthrography, MRA, and ultrasound elastography can further aid in diagnosing partial subscapularis tears. The choice of imaging method depends on factors such as availability, cost-effectiveness, patient characteristics, and clinical suspicion. A comprehensive evaluation using these imaging techniques can lead to an accurate diagnosis and guide appropriate treatment decisions. Other conditions with similar symptoms should also be considered and ruled out through a comprehensive examination.

The initial evaluation should include the radiographs of the shoulder – Anteroposterior view in external rotation, axillary lateral, and a scapular Y view. It gives information on fracture avulsion of the lesser tuberosity (acute cases), the status of the glenohumeral joint, acromion-humeral interval (average 9–14 mm), and an additional assessment of the status of the acromion and acromioclavicular joint.

Ultrasound (USG), though operator-dependent, is another valuable imaging modality for diagnosing partial subscapularis tears. It is increasingly being used as it is cost-effective, readily available, and does not involve exposure to ionizing radiation. It offers real-time dynamic imaging, assessing tendon movement during shoulder motion. USG can identify focal areas of hypoechoic or anechoic signal within the subscapularis tendon, indicating partial tearing. It also enables visualization of associated findings such as fluid accumulation, bursal thickening, and tear retraction. Jesus et al. [18], in their meta-analysis, have reported 87%, 66.7%, and 93.5% accuracy, sensitivity, and specificity in diagnosing partial thickness rotator cuff lesions. Farooqi et al. [41], in their meta-analysis, found that USG is highly specific in detecting SSC tears

Table 4
Shows the summary of various classification systems used.

Subscapularis tear based on the size of the tear	
Laffose et al. [35] (Based on pre-operative CT scan and intra-operative evaluation)	Type 1: Partial tear and erosion on the superior third of the subscapularis (Garavaglia et al. [36] modification Subtype 1A - minor fraying at the subscapularis insertion. Subtype 1B - partial tear at the deep posterior part of subscapularis tendon fibres at the insertion site.) Type 2: Complete detachment of the superior third of the subscapularis Type 3: Complete detachment of the superior two-thirds of the subscapularis without the involvement of the inferior one-third muscular part (limited tendon retraction) Type 4: Complete subscapularis tear from the humeral insertion (well-centred humeral head and fatty infiltration involving less than or equal to grade 3 tear) Type 5: Complete subscapularis tear from the humeral insertion with humeral head anterosuperior subluxation and contact with the coracoid (associated with fatty infiltration) Type A: Isolated deep layer subscapularis tendon tear (for visualization, it is required to elevate the subscapularis tendon by the probe)
Fox et al. [37]	Type 1: Partial-thickness tear of the subscapularis Type 2: Complete tear of the superior 25% of the subscapularis Type 3: Complete tear of 50% of the subscapularis Type 4: Complete rupture of the subscapularis
Pfirrmann et al. [38]	Grade 1: Tear involves less than 25% of the upper part of the subscapularis tendon dimension Grade 2: Tear involves more than 25% of the upper part of the subscapularis dimension Grade 3: Complete tear and detachment of the subscapularis from the lesser tuberosity

Table 5
Shows the summary of various classification systems used based on associated pathology.

Subscapularis tear classification based on associated pathology		
Toussaint et al. [39]	Subscapularis tears based on the associated involvement of the bicipital sling	Type 1: Partial subscapularis tendon separation from the lesser tuberosity and normal anterior bicipital sling wall Type 2: Partial subscapularis tendon separation from the lesser tuberosity and partial tear in the anterior bicipital sling wall Type 3: Complete subscapularis tendon separation from the lesser tuberosity and complete tear in the anterior bicipital sling wall with a preserved attachment of the most superficial fibres of the sling Type 4: Complete subscapularis tendon separation from the lesser tuberosity with a free lateral edge (full-thickness tear with different amounts of retraction)
Habermayer et al. [40]	Lesion of the pulley system may cause LHB instability leading to partial articular-sided lesion.	Type 1: SGHL lesion only Type 2: SGHL lesion and partial articular-side supraspinatus tendon tear Type 3: SGHL lesion and partial articular-side subscapularis tendon tear Type 4: SGHL lesion with partial articular side supraspinatus and subscapularis tendon tear.

LHB: Long head of Biceps, SGHL: Superior Glenohumeral Ligament.

(93%) and comparable diagnostic accuracy (76%) as compared to biceps tendon tears (93%) and supraspinatus tear (83%). Liu et al. [42], in their network metanalysis, found high-frequency USG (>7.5 MHz) to be superior to 1.5T MRI and low frequency (<7.5 MHz) in detecting partial thickness tear (superiority index 0.95 vs. 0.35 vs. 0.18 respectively). Furthermore, functional imaging methods such as ultrasound elastography can be utilized to evaluate the biomechanical properties of the subscapularis tendon. Ultrasound shear wave elastography measures tissue stiffness, allowing for an assessment of tendon elasticity and potential areas of abnormality [42,43].

MRI provides a detailed image of the soft tissues (anatomy and integrity of rotator cuff), allowing for a comprehensive evaluation of the subscapularis tendon. MRI can detect changes in signal intensity within the tendon, indicating a tear or degeneration. Additionally, it can assess associated findings such as inflammation, fatty infiltration, muscle atrophy, tendon retraction, and concomitant pathology such as biceps lesion or labral tear. Using contrast agents during MRI, magnetic resonance arthrography (MRA) can further enhance visualization and improve accuracy than non-contrast MRI [44]. The diagnostic accuracy of the MRI in predicting SSC tears has always been in question. A meticulous evaluation of axial, coronal, and sagittal images will help characterize the tear, detachment of the superolateral portion of the tendon, full thickness tear, degree of muscle atrophy, and retraction or oedema. It can also estimate the extent of the tear in the mediolateral and craniocaudal directions. MRI can identify signal intensity changes at the lesser tuberosity or within tendon substance, narrowing of coracohumeral interval < 7 mm [21], and medial to coracoid on T2-weighted, fat-suppressed images suggestive of subscapularis tear [32]. Using additional sequences like sagittal oblique view (first facet view) gives a higher accuracy (75%) in detecting upper-third lesions [20]. Using two additional views in the sagittal oblique (En-face view and Y-view) helps better differentiate Yoo type IIB, Type III, and Type IV lesions [45].

The MR imaging sensitivity directly correlates to the tear size, with larger tears having higher sensitivity than smaller tears [19,28]. Ryu et al. [20] found that indirect MRA can predict the upper-third SSC tear with accuracy, sensitivity, and specificity of 0.75–0.79, 0.72–0.73, and 0.77–0.83, respectively. Liu et al. [42], in their network meta-analysis of 144 studies, found that MRA had the highest sensitivity, specificity, and superiority index. For partial thickness tears, the diagnostic value was 3-T MRA, 3-T MRI, 1.5-T MRA, >7.5-MHz US, 1.5-T MRI, and <7.5-MHz US (superiority index: 8.15 vs. 5.25 vs. 2.44 vs. 0.95 vs. 0.35 vs. 0.18, respectively) [42].

Arthroscopy is a minimally invasive surgical procedure that allows direct visualization and assessment of intra-articular structures, including the subscapularis tendon. It is considered the gold standard in diagnosing the subscapularis tendon tear. Arthroscopy provides high-resolution images and allows for a thorough evaluation of the subscapularis tendon's integrity [4]. Identification of tendon and lesser tuberosity from the posterior portal can be challenging. Using a 70-degree scope from the posterior or anterolateral portal for visualization can aid in better visualization of the lesser tuberosity, extension of tear, and Subscapularis retraction medial to glenoid face. Additionally, putting an arm in flexed, internal rotation and using posterior humeral translation can help identify the tear's size and extent [46].

Subtle hints, such as medial subluxation or dislocation of the long head of the biceps tendon, the presence of a "sentinel sign" (scuffing or tear in the anterior aspect of the long head of the biceps tendon), or the "comma sign" (comma-like appearance by torn medial sling of biceps to the superolateral portion of subscapularis tendon), can indicate that a thorough evaluation of SSC tears is necessary [8,30,47,48].

In addition to these primary imaging methods, other complementary techniques may be employed to aid in diagnosing partial subscapularis tears. These include CT scans, which can provide detailed bony anatomy and assess for associated fractures or bone abnormalities. CT arthrography involves injecting contrast dye into the shoulder joint before performing a CT scan, enhancing visualization of soft tissues and improving diagnostic accuracy. However, their role is limited.

TREATMENT

Conservative management

Even with limited evidence, conservative management often stays as the first line in partial thickness tears due to the low risk of tear progression, muscle atrophy, and fatty infiltration [29]. The partial tear with fraying or longitudinal split classified in Yoo type 1 or Martetschläger type 1 can be treated conservatively. Conservative management aims to alleviate symptoms, promote healing, and restore function without surgical intervention. It involves a combination of rest, physical therapy, medication, and lifestyle modifications.

The first step in conservative management is often rest and activity modification. This means avoiding activities that exacerbate pain or further damage the subscapularis tendon. Rest allows the injured tissue to heal and reduces inflammation. During this period, it is essential to avoid any heavy lifting or repetitive overhead movements that may strain the shoulder joint. A short course of nonsteroidal anti-inflammatory drugs (NSAIDs) can help reduce pain and inflammation.

Physical therapy plays a crucial role in conservative management by strengthening the surrounding muscles and improving the range of motion. An individualized program that includes exercises targeting the rotator cuff muscles, scapular stabilizers, and other muscles involved in shoulder movement. These exercises may include stretching, resistance training with bands or weights, and functional movements (Internal rotation deficits and posterior capsule tightness) specific to each patient's needs.

In addition to exercise therapy, heat or ice packs may be used to reduce pain and inflammation. Heat can help relax tight muscles and improve blood flow to promote healing. Ice packs can be applied to reduce swelling after exercise sessions or when experiencing acute pain.

In some cases, conservative management may also involve lifestyle modifications. This can include ergonomic adjustments at work or during daily activities to minimize stress on the shoulder joint. For example, proper lifting techniques and maintaining good posture can help prevent further strain on the subscapularis tendon.

The duration of conservative management for partial subscapularis tears varies depending on the severity of the injury and individual factors. Regular follow-up is essential to monitor progress and make any necessary adjustments to the treatment plan. It is important to note that not all partial tears require surgery, and many patients can achieve satisfactory outcomes with conservative treatment alone [29].

Operative treatment

Timing of the repair

The surgical intervention and injury timing inversely correlate with its functional outcome in a complete SSC tear due to marked fatty infiltration and atrophy after a tear. In partial SSC tears, the intact portion of the tendon prevents further fatty infiltration and atrophy. However, there needs to be more evidence to comment on the ideal timing for repair [30]. Kreutz et al. [12] reported that the timing affects the outcome, and improvement after surgery in partial SSC tears is comparatively less than in complete tears.

Diagnostic arthroscopy

A diagnostic arthroscopy should be performed in all patients using standard arthroscopy portals. A thorough systemic examination should be done to evaluate the articular surface of the humerus, glenoid, labrum, and posterosuperior rotator cuff lesions. A special focussed evaluation of the long head of the biceps tendon should be done. Whenever a partial SSC tear occurs, concomitant hidden lesions and biceps pulley defects should also be ruled out. These occult lesions often have a concealed, intra-tendinous SSC tear seen in the bursal view after moving the biceps tendon away from the groove [17]. In a few cases, the "comma sign," which represents the superolateral corner, may help identify the SSC tendon. The visibility of the tendon towards the articular side is limited by intimate association with the middle and anterior band of the glenohumeral ligament complex. The SSC tendon is probed to check its integrity and the presence of any tear [32].

In their study, Yoo et al. [17] explained that tear initiation starts from the superolateral edge of the tendon and then promulgates inferiorly. Previously these tears were considered benign, but newer biomechanical studies show that they may alter glenohumeral kinetics and increase external rotation [49].

Decision-making

The operative treatment decision-making depends on factors such as tear size, patient age, dominant arm, activity level, associated lesions, participation in sports, and patient's clinical symptoms. A failed non-operative treatment is the most common indication of a partial SSC tear. The patient will have anterior shoulder pain, soreness, and decreased functional capacity. It may also have associated shoulder stiffness after an acute traumatic event. The relative tendency of the SSC to retract much faster than other rotator cuff muscles and difficulty in mobilization, advocates an early repair for SSC irrespective of the lesion size.

The partial SSC tears classified by Lafosse type 1 [35] incorporate Yoo [17] type 1, type IIA, type IIB, Fox type 1, and Martetschläger classification [4]. Almost 70–80% of the SSC tear involves 1/3rd or even less than 1/3rd portion. The controversy about whether to repair all the tears exists only for Yoo type I or IIA lesions as currently there is no level 1 evidence supporting its debridement or repair. However, whenever these tears are associated with anterosuperior lesions or biceps pulley pathology, they should be repaired to restore the native footprint. The pulley sling comprises fibres from the upper SSC and anterior SSP, as well as SGHL; the repair of partial tears can avoid further tearing of these tendons. Also, the authors recommend that all acute tears for relatively young patients be repaired using intra-articular techniques. The Yoo type IIB tears, including upper 1/3rd tears, can be repaired with intra-articular and subacromial procedures.

In contrast, the larger tears in type III can be repaired using subacromial techniques. Biomechanical studies [49–54] have found no difference in the use of various techniques like 2-anchor-based conventional single-row (SR), a 3-anchor-based interconnected double-row technique, or a 2-anchor-based interconnected hybrid double-row construct in the repair construct. The 2-anchor-based interconnected double-row is considered to be best for the leading edge as it helps in placement of the superolateral anchor superior and lateral to the original footprint. This leads to better superolateral coverage with the leading-edge protection as also noted using a 2-anchor-based conventional single-row as demonstrated in (Fig. 1).

Based on patient functional requirements, the biceps pathology (tear or subluxation) is treated with either tenotomy or tenodesis. Tenotomy is preferred in biceps delamination or erosion. The outcomes of both tenodesis and tenotomy have been found to be similar [32,55].

In the case series reported by Kim et al. [14], 29 patients with isolated partial subscapularis tears, which were treated with arthroscopic repair using suture anchors, reported good functional outcomes at 27 months follow-up. Lesions less than 5 mm in width were treated with arthroscopic debridement alone. In their series, 26 out of 29 patients had an associated biceps lesion, which required either tenodesis or tenotomy. Similarly, Katthagen et al. [56] reported improved functional outcomes and higher satisfaction in 15 and 16 patients with Lafosse type 1 and type 2 tears in four-year follow-ups. Randell et al. [57] found no significant difference in the outcome of partial-thickness articular-sided upper SSC tendon tear treated with repair vs. debridement.

Laffose et al. [58] reported good outcomes, improvement in functional scores, and low re-rupture rates in their results of 17 patients with detailed analysis of the structural integrity and isolated strength of the SSC muscle at 29 months. The early improvement in the scores has been mentioned in previous studies with short-term follow-up with patients undergoing an arthroscopic repair [24,39,58–64] or with open repairs [6,10,11,65–67].

Seppel et al. [68] reported the first long-term follow-up results of arthroscopic repair of isolated SSC tears in 17 patients. With a mean follow-up of 98.4 months, there was a significant improvement in Constant score and American Shoulder & Elbow Surgeons (ASES) scores which positively correlated with operative intervention, with no effect on

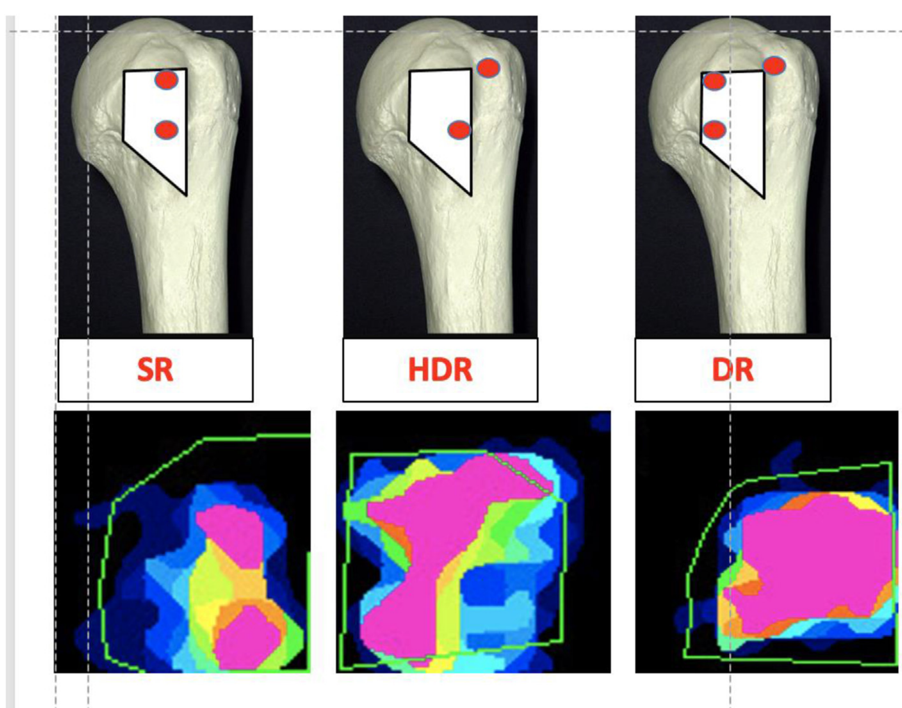

Fig. 1. Shows a conventional SR construct, a hybrid double-row (HDR) construct, or a DR construct and corresponding pressurized footprint coverage [50].

size of lesions.

Kim et al. [69] reported that Yoo type III subscapularis tears had a better outcome with lower retear rates compared to Yoo type IV tears in their study of 109 patients with large subscapularis tears over the first facet ($P < 0.001$).

The ideal number of anchors

The ideal number is determined by tear size, configuration, and local anatomy. Earlier, it was suggested that one suture anchor be used for each centimetre of SSC tendon tear (from craniocaudal). However, a single double-loaded anchor can successfully repair the upper third tear. A more than 50% tear may need a single triple-loaded anchor or two double-loaded anchors. The idea is to have a stable construct rather than depending on absolute numbers [32,56].

CONCLUSION

SSC is an indispensable rotator cuff muscle for shoulder function and preserving glenohumeral joint mechanics. The partial tears of the SSC (traumatic vs. degenerative) are increasingly recognized as distinct pathology. The tear usually begins from the superolateral margin in the first facet and propagates downwards. It is frequently associated with biceps pathology or anterosuperior lesions. Even partial tears in the SSC tendon can affect internal rotation strength and lead to painful impairment and positive clinical tests. The diagnosis can become challenging, despite numerous clinic-radiological cues. They may lead to persistent anterior shoulder pain and altered glenohumeral kinematics if untreated. A timely intervention and restoration of the footprint will help restore and rehabilitate the shoulder.

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Box 1: Key Articles

1. Kim SH, Oh I, Park JS, Shin SK, Jeong WK. Intra-articular Repair of an Isolated Partial Articular-Surface Tear of the Subscapularis Tendon. Am J Sports Med. 2005 Dec; 33 (12):1825–30.
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10. Katthagen JC, Vap AR, Tahal DS, Horan MP, Millett PJ. Arthroscopic Repair of Isolated Partial- and Full-Thickness Upper Third Subscapularis Tendon Tears: Minimum 2-Year Outcomes After Single-Anchor Repair and Biceps Tenodesis. Arthroscopy. 2017 Jul; 33 (7):1286–93.

Box 2: Validated Classification System

Partial subscapularis tear classification

1. Yoo and Rhee [17] subscapularis tendon tear classification according to facet exposure and the lateral band (2015)
2. Martetschläger et al. [4] based on extension of lesion in transverse and coronal plane using arthroscopy (2021).
3. Laffose et al. [35] based on pre-operative CT scan and intraoperative evaluation (2010)
4. Fox et al. [37] based on thickness of tear (2002).

Subscapularis tear classification based on associated pathology

1. Toussaint et al. [39] based on the associated involvement of the bicipital sling (2012).
2. Habermayer et al. [40] based on lesion on pulley system (2004).

Box 3: Key issues of Patient Selection

1. Patient age
2. Dominant arm
3. Activity level
4. Tear size
5. Associated lesions
6. Participation in sports
7. Clinical symptoms

Box 4: Essential Diagnostic Features for Partial Subscapularis tears

1. Clinical examination: lift off test, belly press test, bear hug test
2. Radiographs: AP view in external rotation, axillary, scapula Yview
3. Ultrasound
   a. Thinning of subscapularis tendon
   b. Hyperechoic cleft
   c. Instability of the long head of biceps tendon
   d. Dynamic USG – with shoulder rotation (more sensitive)
4. Magnetic resonance imaging
   a. Use of 2 axial and 2 sagittal oblique views to identify tear, atrophy of subscapularis muscle medial to glenoid.
   b. Collection in superior subscapular recess.
   c. Subluxation/dislocation of the long head of biceps tendon.
   d. Marrow oedema.
   e. Reduced coracohumeral distance $<$7 mm.
   f. Comma sign
5. Arthroscopy
   a. Use of 70-degree scopes from posterior portal
   b. Use of anterolateral portal as viewing portal.
   c. Keeping arm in flexion, internal rotation, and posterior humeral translation.
   d. Using subtle hintslike medial subluxation/dislocation of the long head of biceps tendon, comma sign, sentinel sign to evaluate partial subscapularis tendon tear.

Box 5: Tip & Tricks:

1. A patient with partial subscapularis should be evaluated with detailed history and clinical examination to diagnose shoulder pathology and concomitant lesions (biceps lesion/anterosuperior cuff) accurately.
2. Use of additional views in MRI like sagittal oblique view (first facet view) and sagittal oblique (En-face view and Y-view) can help in better identification and delineation of the lesion.
3. Use of arthroscopy can be considered gold standard to diagnose the lesion. the use “comma sign,” which represents the superolateral corner, can help to identify the Subscapularis tendon. Presence of concomitant hidden lesions and biceps pulley defects should always be ruled out.
4. The concomitant biceps pathology (tear or subluxation) can be treated with either tenotomy (delamination or erosion) or tenodesis.
5. The 2-anchor-based interconnected double-row is best for leading edge as it helps in placement of superolateral anchor superior and lateral to the original footprint. This leads to better superolateral coverage with the leading-edge protection.

Box 6: Major Pitfalls:

1. The diagnosis of Partial Subscapularis tears can be missed in most case despite use of MRI and special views. The gold standard thus remains arthroscopy for diagnosis.
2. In patients with long head of biceps tendon instability, an isolated repair of the subscapularis might result in ongoing biceps instability and pain.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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