17 Nonoperative Treatment: The Role of Rehabilitation

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17.1 Rehabilitation of Massive Rotator Cuff Tears

Treatment for rotator cuff tendon diseases ranges from conservative treatment (including exercise, electrotherapy, manual therapy, injection therapy, hydrotherapy, taping…) to different surgical strategies: simple debridement, partial or complete tendon repair with or without tissue substitutes, synovectomies, biceps tenotomies, or tendon transfers [1–3]. So far, several systematic reviews have compared the effectiveness of operative management to nonoperative treatment (NOT), reaching ambiguous conclusions [4–6]: whereas some evidence supports surgical options [6, 7], others have equated them with conservative treatments [2, 8].

Not all patients meet all criteria to be eligible for surgical repair [9] in the context of massive rotator cuff tears (RCT), especially those who remain asymptomatic [10] and are often identified accidentally [11]. Reasons for non-eligibility include comorbidities that contraindicate surgery and tears considered upon evaluation to be irreparable [9]. Additionally, surgery has been thought to be less successful in elderly population when RCT have retracted medially to the glenoid rim and are massive in size (>5 cm) [2, 12].

In these landscapes, several studies [9, 13–17] have observed that conservative treatments can produce improvements in terms of pain relief and motion and disability enhancements, although they are still few in number. Among the conservative treatments considered, exercise combined with injection therapy and pharmacological management has been by far the most popular. These studies have widely shown relevant benefits with conservative treatment for its capacity to (1) improve motion (especially forward elevation, internal and external rotations), (2) strengthen muscle power, and (3) reduce pain in elderly patients with low activity levels and/or patients unsuitable for surgery due to severe comorbidities [18]. This reveals that the best primary treatment option should be chosen to palliate symptom worsening and in some cases NOT may be considered to improve activities of daily living [9, 13, 18, 19] (Table 17.1).

It is hopeful that both exercise and physical therapy have been shown to be the most viable

Table 17.1 Indications for rehabilitation in nonoperative treatment of massive rotator cuff tears

– Patients without significant pain
– Elderly patients with low activity level
– Patients with a functional range of motion of the shoulder
– Patients who have progressively improved with a multimodal physical treatment
– Contraindications for surgery

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alternative option to surgery [2, 5, 20], but it has to be noted that researchers have found great difficulties to synthesize and standardize robust evidence-based rehabilitation programs, because most of them have been developed in observational non-randomized studies [2, 21, 22]. Some of these researches will be displayed throughout the present chapter.

Although the lack of high-quality studies has been highlighted, one of the latest systematic reviews [23] on exercise therapy in massive nonoperative RCTs (2018) has remarked that, in general, there is enough consistent evidence confirming that exercise is an effective treatment in these patients, with a Grade B recommendation.

One of the most relevant and current studies supporting physical therapy was a prospective multicenter research designed by the French Arthroscopic Society and carried out in 12 different centers [9]. NOT methods included analgesics, anti-inflammatory drugs, rehabilitation, and subacromial corticosteroid injections. Patients were followed up for 3, 6, and 12 months after the start of NOT. ROM, Visual Analogue Scale (VAS), Constant Score, and Subjective Shoulder Value (SSV) were assessed. Out of 71 eligible patients, only three failed to complete the whole NOT program and partial RCT repairs were performed. After 12 months, the remaining 68 presented improvements in mean Constant scores (40.7 ± 17.0 [range 9–75] to 57.1 ± 15.3 [range 20–86]) and in mean weighted Constant score (54.9% ± 22.7% [range 13–103] to 76.8% ± 0.2% [range 31–120]). Also, improvements in mean SSV (39% ± 15.8 [range: 0%–80%] to 65.2% ± 15.8 [range 20%–99%]) and ROM (especially forward elevation: improved from 112.2° ± 45.1 [range 20°-180°] to 137.4° ± 33.1° [range 60°–180°]) were observed.

This study supports the short-term usefulness of NOT in patients with irreparable massive RCTs regardless of the site of the initial tear, which showed no correlation with final functional outcomes or final ROM at 12 months. However, it must be taken into account that both the mean Constant scores and active forward elevation were significantly improved after 3–6 months of follow-up but, on the other hand, neither of them improved significantly between 6 and 12 months. Although it lacked a control group and a longer follow-up, it is the only one to provide data for function and motion range recovery during NOT and concludes that surgery treatment must be considered only in those patients with no or insufficient improvements after 6 months of conservative treatment.

Neri et al. [1] also described, in 2009, that nonoperative management of massive RCTs should only be reserved for those patients whose symptoms did not involve significant pain, because improved function may be achieved with activity modification, judicious use of steroid injections, and physical therapy (focused on anterior deltoid training, reeducation of muscle recruitment, coordination of co-contraction, maintenance of motion or periscapular strengthening).

Most massive tears tend to be classified, according to the location of the tear, as antero-superior or postero-superior, each with different incidence, clinical presentation, examination findings, and prognosis [1]. Classically, the contraction of the deltoid has been thought to promote the humeral head stabilization beneath the coracoacromial arch, modifying the center of rotation of the humerus in this situation [11]. However, current literature has observed that the deltoid may even play a major role in the prevention of upward migration of the humeral head in shoulders with large RCT [24]. In this research, Gagey et al. examined the orientation of resultant forces along the vertical axis beyond the acromioclavicular joint and in 19/23 shoulders it was noted that the resultant vector was oriented downward [24].

Burkhart [25] radiographically evaluated 12 shoulders with massive, irreparable RCTs and described 3 patterns of glenohumeral kinematics based on fluoroscopy: stable, unstable, and captured fulcrum. Those patients belonging to the first group maintained a stable glenohumeral fulcrum and, therefore, a stable kinematics during elevation. In the second group, an unstable glenohumeral fulcrum led to anterior and superior translation of humeral head in active elevation. In the third group, although the incapacity to keep the humeral head centered in the glenoid cavity was noticeable, the elevation was performed at the undersurface fulcrum of the acromion.

With proper training, he found that the force couples around the joint could be maintained in patients with isolated tears of the supraspinatus, which relatively preserved shoulder function. However, if the tear extended also into the anterior (i.e., subscapularis involvement) or posterior (i.e., posterior infraspinatus or teres minor) cuff tendons, the force balances around the joint were disturbed and could lead to unstable kinematics and loss of function. Burkhart's "suspension bridge" concept argued that function could be maintained, even in the presence of a large tear, if the force balancing about the joint was preserved [25].

Hence, when put into practice, Anterior Deltoid Reeducation (ADR) has been proposed as an alternative treatment to compensate the altered biomechanics in shoulders with RCTs. Although it has been shown to be helpful in the short term, specifically in the debilitated elderly population, little is known about the durability of its benefits and effects on functional outcomes [19]. Levy et al. [19] enrolled elderly patients with debilitated or pseudoparalytic shoulders presenting with anterosuperior RCTs. They followed an ADR program and reported that 82% of patients succeeded in terms of pain, important ROM improvements (mean forward elevation improved from 40° to 160°), and perceived function (measured with Constant Scale). However, their follow-up was only considered for the first 9 months.

The application of protocols based on isolated ADR has proven to be effective ($p < 0.005$) on patients with massive RCT also at long term [26], but only a 40% of success was reported in this case. This protocol consisted on a home-based program applied for a period of 3 months in elderly patients who were followed up during 24 months and assessed for pain, ROM, strength, SSV, and American Shoulder and Elbow Surgeons (ASES) score. According to the results of this study, the success achieved following this ADR program was not statistically dependent on any of the ADR factors analyzed except for ROM: those patients with a forward flexion of less than 50° at the beginning of the ADR program reached to an unsuccessful outcome at 2 years compared to those with a forward flexion of 50° or more ($p < 0.022$).

From our point of view, ADR programs conform to standards in shoulder rehabilitation of massive RCTs, but not as a unique and independent treatment approach.

So much so that, studies such as the one carried out by Collin et al. [13] have reported improvements in a prospective study of 45 patients with irreparable massive RCTs with pseudo-paralysis by using a multimodal specific rehabilitation program. This protocol aimed to reduce pain and scapulo-thoracic dyskinesia, correct faulty humeral head centering, strengthen scapular stabilizers, and restore proprioception. Excellent outcomes were observed in those patients with postero-superior tears (supraspinatus and infraspinatus), but no improvements were seen in those with complete antero-superior tears (subscapularis and supraspinatus tears). Unlike Ainsworth [2, 27, 28] or Levy [19], Collin supports the idea that isolated strengthening of Anterior Deltoid may overstate the anterior decentering of the humerus as well as the isolated eccentric work on humerus depressors (latissimus dorsi and pectoralis major), as other studies have stated [29]. For these reasons, other kind of training approaches considering scapula, voluntary control of humeral head movements, or proprioception may be the key in conjunction to ADR programs, whose effectiveness have been undoubtedly demonstrated.

In this sense, later biomechanical studies have proven that compensatory increases in the deltoid force are required to preserve shoulder function in patients with massive RCTs but also the remaining rotator cuff is essential to improve kinematics in this context [26]. In the presence of a massive RCT, stable glenohumeral abduction without excessive superior humeral head translation requires significantly higher forces in the remaining intact portion of the rotator cuff. These force increases are within the physiologic range of rotator cuff muscles for 6-cm tears and most 7-cm tears [26]. Increases in deltoid force requirements occur in early abduction; however, greater relative increases are required from the rotator cuff, especially in the presence of larger rotator cuff tears [11].

Therefore, while rehabilitation of the deltoid is indeed important, these results highlight the relatively greater importance of rehabilitation of the rotator cuff muscles to prevent superior humeral head translation and subacromial impingement. Indeed, emphasis on rotator cuff strengthening has become a mainstay of NOT [11, 30].

Steenbrick et al. [31] evaluated the electromyograpic muscle activation pattern in 8 patients suffering a massive rotator cuff tear pre- and post-lidocaine injection. Before the injection, they observed a different activation pattern of the adductor muscles (pectoralis major/latissimus dorsi/teres major) comparing to normal shoulders. They noticed a contraction of the humeral head depressors in order to avoid humeral head impingement and pain. After the lidocaine injection, pain disappears and the adductor abnormal pattern becomes normal.

According to this previous biomechanical issue, we believe that the adductor muscles also should be activated in the presence of massive rotator cuff tears, in order to stabilize the humeral head and avoid superior migration as much as possible. Therefore, a specific rehabilitation protocol should include isolated or combined exercises for improving the adductor muscles group.

In 2009, Ainsworth et al. [27] compared the outcomes between elderly patients with massive RCTs whose physiotherapy management included conventional modalities (ultrasound, advice, encouragement, and analgesia) vs. those whose management had the addition of a specific exercise program. A total of 60 patients were recruited and followed up for 12 months and their assessment included: Oxford Shoulder Score (OSS) for shoulder disability, SF-36 for pain and goniometry for range of motion (ROM). Both groups experienced improvements at medium term (12 months) in all variables studied (perhaps because of the fact that increased knowledge about their shoulder condition encouraged them to use the arm without fear of worsening their tears), but those who followed the specific exercise program found greater and faster results at short and short-medium term. Within this study, two conclusions can be drawn with no difficulties: multimodal treatments are probably more effective in reducing pain and improving shoulder function and quality of life in these patients as long as they focus on a physical therapy adapted to the patient condition.

Patient education is fundamental for the patient to understand what the matter is with their shoulder, and they should be taught that pain in the shoulder does not always correlate with worsening harm.

17.2 The Role of Latissimus Dorsi in the Rehabilitations of Massive Rotator Cuff Tears

Scapular dyskinesia (SD) is an alteration associated with shoulder pathologies, producing an abnormal dynamic scapular control. It can be caused by fatigue, neurologic dysfunction, weakness of the periscapular muscles, and intraarticular glenohumeral pathologies such as subacromial impingement and massive rotator cuff tears [31]. Scapular stability based on the periscapular muscles strengthening could improve the ROM, decrease the acromiohumeral contact, and reduce pain.

The stability of glenohumeral joint is mainly given by the rotator cuff and the periscapular muscles. However, in massive RCT the superior subluxation of the humeral head occurs due to the strength of the deltoid muscle. Some authors showed that the periscapular muscles such as latissimus dorsi (LD) and pectoralis major (PM) have an important role in avoiding the superior migration of the humeral head [32]. Halder et al. [33] found, in their biomechanical study, that the depression of the humeral head was most effectively achieved by the latissimus dorsi and the teres major. The activations of these muscles increased after massive rotator cuff tear, showing that LD is the most effective depressor of the humeral head. Hawkes et al. [34] evaluated in an electromyographic (EMG) study the shoulder muscles activations after massive rotator cuff tear. EMG signal amplitude was significantly higher for the biceps, trapezius-serratus anterior, latissimus dorsi, and teres major. The author concluded that activation of LD is an attempt to compensate the destabilizing forces of the deltoid in massive RCT.

Lee et al. [35] examined the biomechanics of the massive RCT and the role of LD/PM muscles in a cadaveric model, including measurement of kinematics, acromiohumeral contact pressure (migrations of the humeral head), and glenohumeral joint forces. Acromiohumeral contact pressures were undetectable when the LD/PM were loaded but increased significantly after LD/PM unloading, concluding that in massive RCT the LD and PM are effective to improve glenohumeral kinematics, reduce acromiohumeral pressure, and could delay the progression of the cuff tear.

Often, a general program of rehabilitation exercises addressed to strengthen the periscapular muscles is recommended for the NOT of the massive RCT. However, taking into account the aforementioned studies, exercise rehabilitation program must focus also on the LD and PM strengthening to reduce pain, delay the progression of cuff tear arthropathy, and improve shoulder function.

17.3 Exercises Protocol

1. **Mixed Exercises:** Combining both scapular corrections and shoulder movements. Examples:
   - **Wall side with a towel** (especially for serratus anterior deficits): The patient is asked to hold a towel in her hand and place it on a wall with her elbow flexed 90°. Then she is asked to slide the towel diagonally (scapular protaction movement −30°) until the elbow is completely extended. 3 series (s) × 8–12 repetitions (r) (Fig. 17.1).
   - **Frontal elevation with resisted external rotation** (especially for rotator cuff, rhomboids, and medium trapezius deficits): The patient is asked to keep her elbows stuck to her trunk and flexed 90°. Then she is asked to take a band (low resistance) with her hands and externally rotate 15° with each shoulder. From this position, a shoulder frontal elevation up to

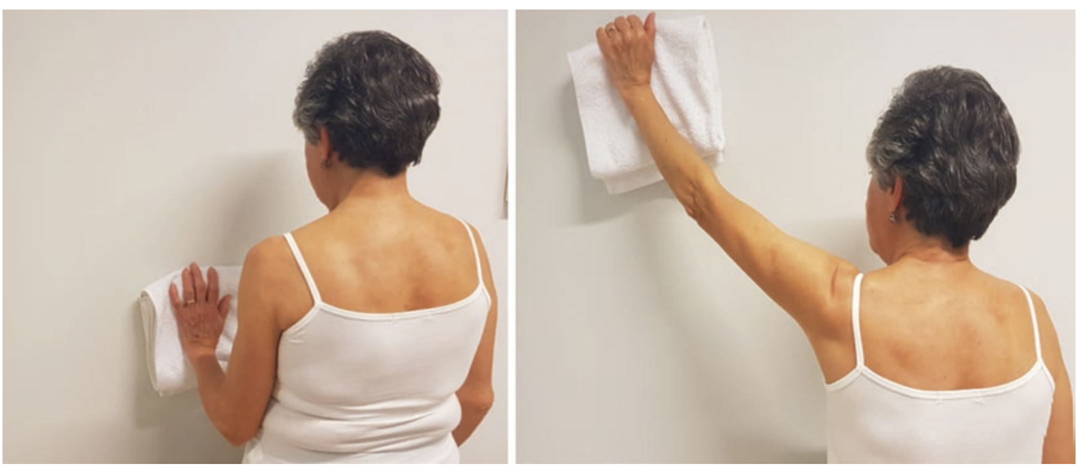

Fig. 17.1 Wall side with a towel. Especially for serratus anterior deficits

90° is carried out while holding the band tension. 3s × 8-12r (Fig. 17.2).
 - **Frontal elevation with resisted adduction** (especially for latissimus dorsi deficits): The patient is asked to take a band starting from 30° of shoulder abduction and move her arm close to her trunk with her elbow extended. Then she is asked to carry out a frontal elevation up to 90° while holding the band tension. 3s × 8-12r (Fig. 17.3).
2. **Scapulothoratic Exercices:** Aimed to correct scapular dyskinesia by recruiting hypoactive muscles and lengthening hyperactive muscles in the dysfunctional movement. Examples:
   - **Serratus punch:** The Patient standing with her shoulder in 90° of flexion and elbow extended, from a scapular retraction position. The patient is asked to carry out a scapular protraction with the elbow extended against the resistance of a band tied around her back. Exercise specific for serratus anterior when pectoralis minor is hyperactive. 3s × 20r (Fig. 17.4).
   - **Scapular retraction:** The Patient standing with her arms relaxed along his body and elbows extended. She is asked to hold the ends of a band (medium resistance) tied to a fix bar in front of her and to extend her arms to place them closed to her greater trochanters. The movement is completed with a scapular retraction, when the patient tries to join the medial border of both scapulas. Exercise specific for medium trapezius and rhomboids

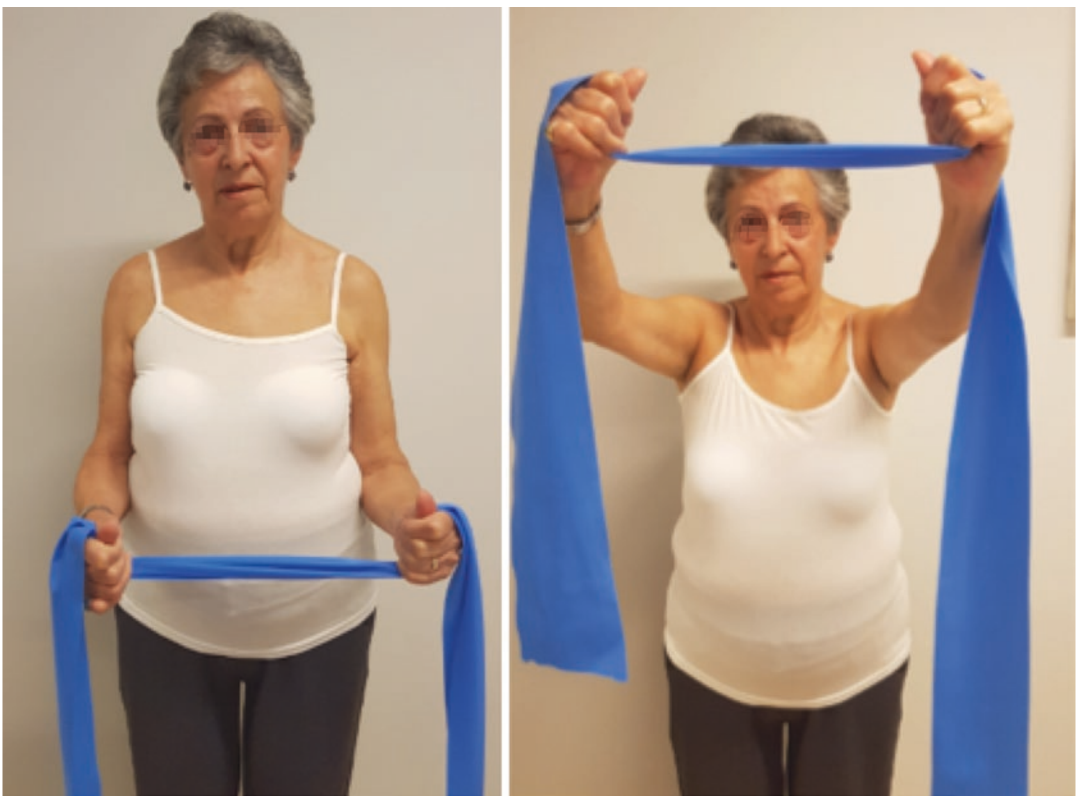

Fig. 17.2 Frontal elevation with resisted external rotation. Especially for rotator cuff, rhomboids and medium trapezius deficits

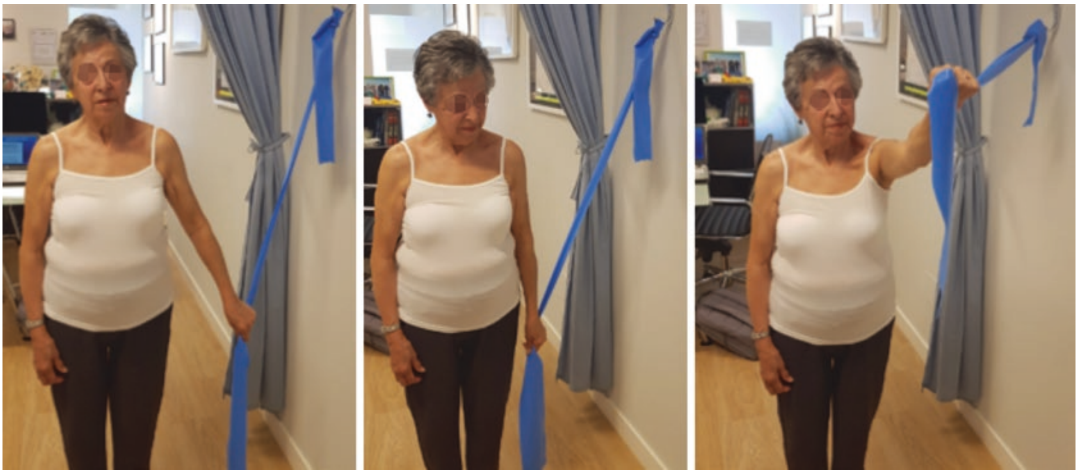

Fig. 17.3 Frontal elevation with resisted adduction. Especially for latissimus dorsi deficits

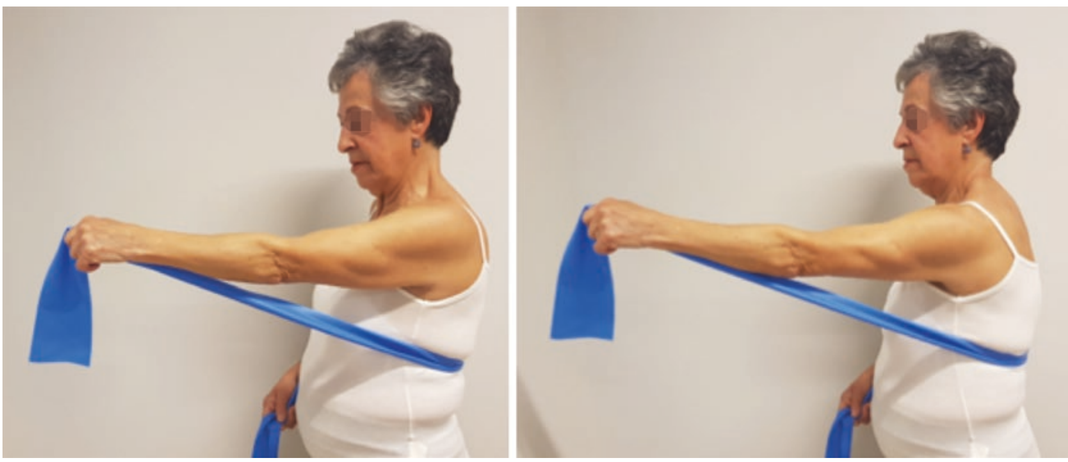

Fig. 17.4 Serratus Punch. Exercise specific for serratus anterior when pectoralis minor is hyperactive

when pectoralis minor and superior trapezius remain hyperactive. 3s × 20r (Fig. 17.5).

- **Horizontal abduction with external rotation:** The patient in prone (also, it could be done with a light dumbbell 0.5–1 kg if the patient can do it), starting from an external rotation (thumbs to the ceiling) and 90–120° of shoulder flexion with elbow extended. She is asked to perform a horizontal abduction up to trunk plane. 3s × 20r (Fig. 17.6).

3. **Anterior Deltoid and Rotator Cuff Exercises**: Exercises based on Torbay Protocol.
   - **Exercise 1:** The patient in supine, with arm extended (also, it could be done with a light dumbbell 0.5–1 kg). She is asked to, firstly, flex the elbow up to 90°. Then she is asked to flex the shoulder toward

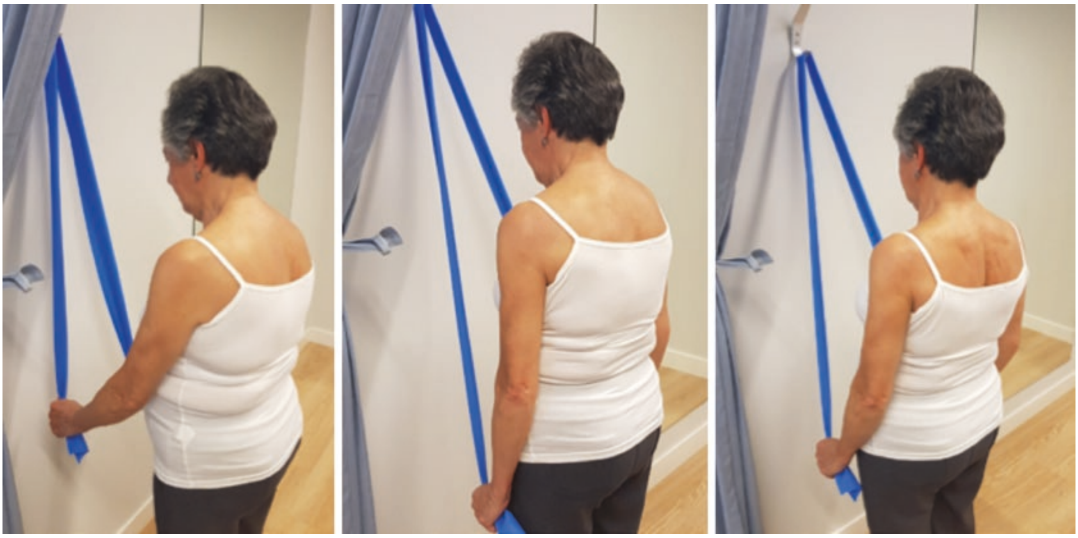

Fig. 17.5 Scapular Retraction. Exercise specific for medium trapezius and rhomboids when pectoralis minor and superior trapezius remain hyperactive

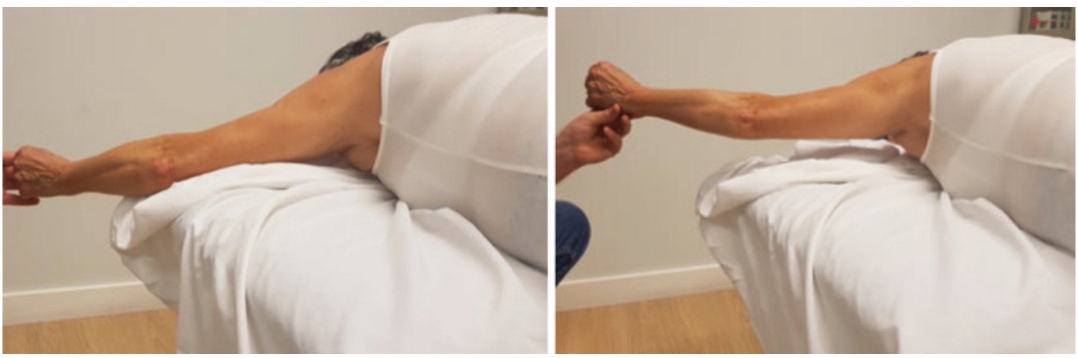

Fig. 17.6 Horizontal Abduction with external rotation

her head with the elbow flexed, and in this position, she extends the elbow toward the ceiling. Finally, the patient slowly swings the arm up and down before coming back to the starting position following the opposite way. 3s × 8-12r (Fig. 17.7).

- **Exercise 2:** The patient in front of a wall with a towel on the affected hand. The patient is asked to slide it up along the wall, with the aid of the opposite hand to reach as far as possible without pain. 3s × 8-12r.
- **Exercise 3:** The patient in lateral decubitus with the elbow next to the body and a light dumbbell begins to do shoulder external rotation to strengthen the remaining rotator cuff (Fig. 17.8).
- **Exercise 4:** The patient standing with the arm next to the body with 90° flexion of the elbow; the subject takes the band and begins to do shoulder internal rotation in

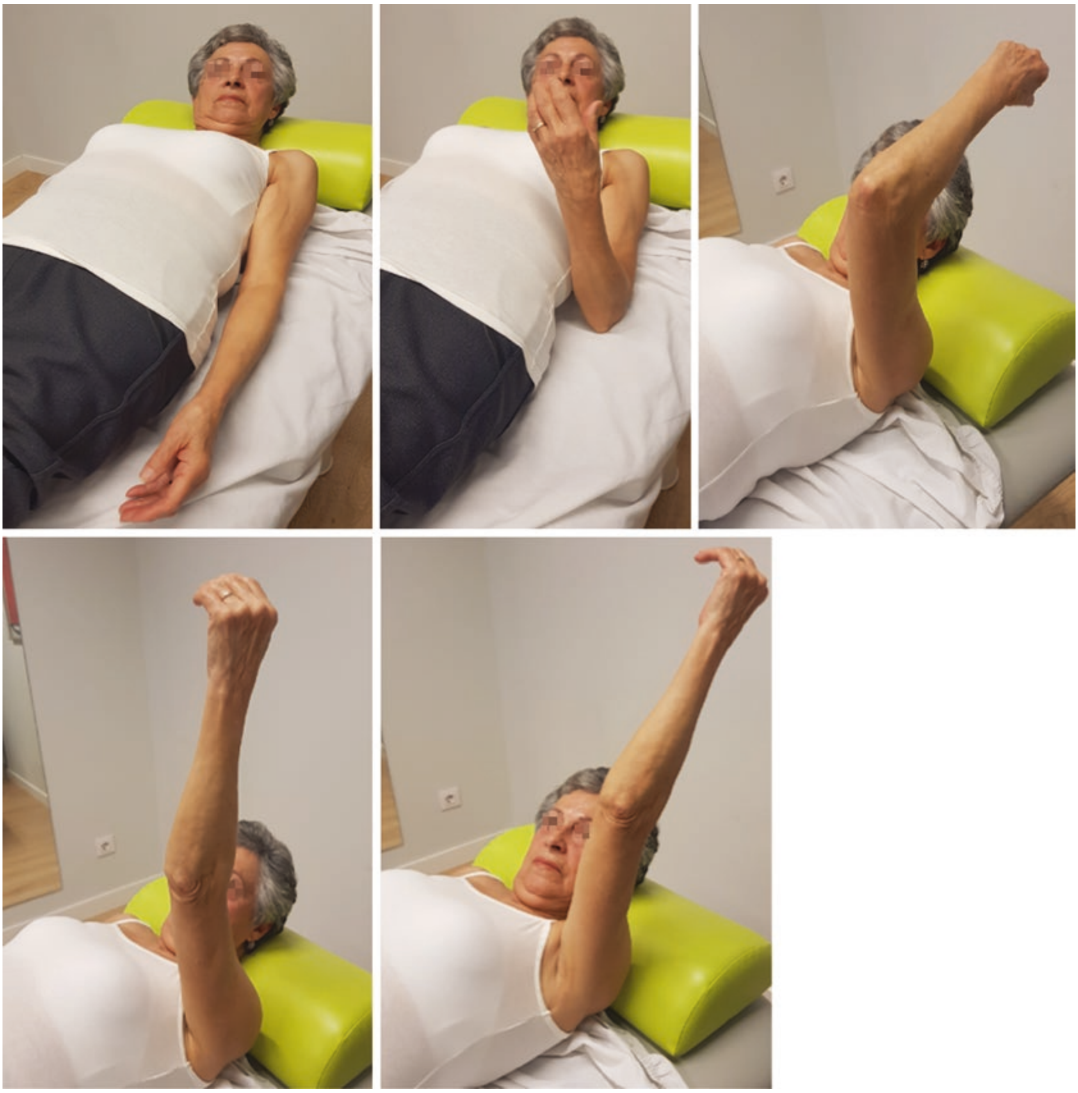

Fig. 17.7 Strengthening the anterior deltoid

order to strengthen the subscapularis tendon (Fig. 17.9).

17.3.1 Patient Education

Patients should be given a thorough explanation of what has happened to their shoulder and why their function is impaired. Time should be spent re-assuring the patient that whilst pain in the shoulder does not always correlate with harm, there is little to be gained by using the shoulder when pain increases. Patients should also be aware of the goals of the rehabilitation program because no progress will be made if the patient fails to engage with the process. Realistic and achievable goals should be set.

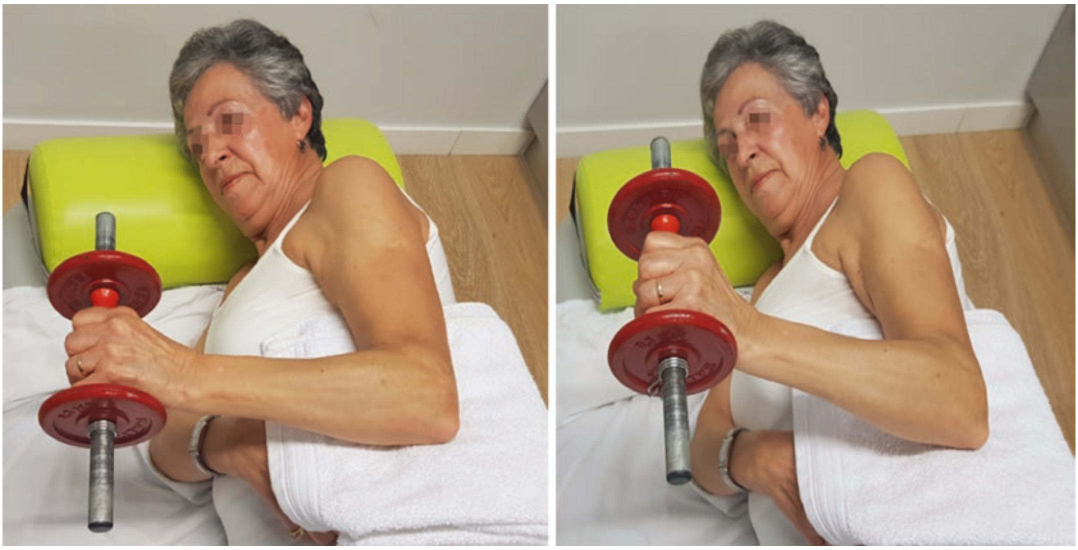

Fig. 17.8 Shoulder external rotation to strengthening the remaining rotator cuff

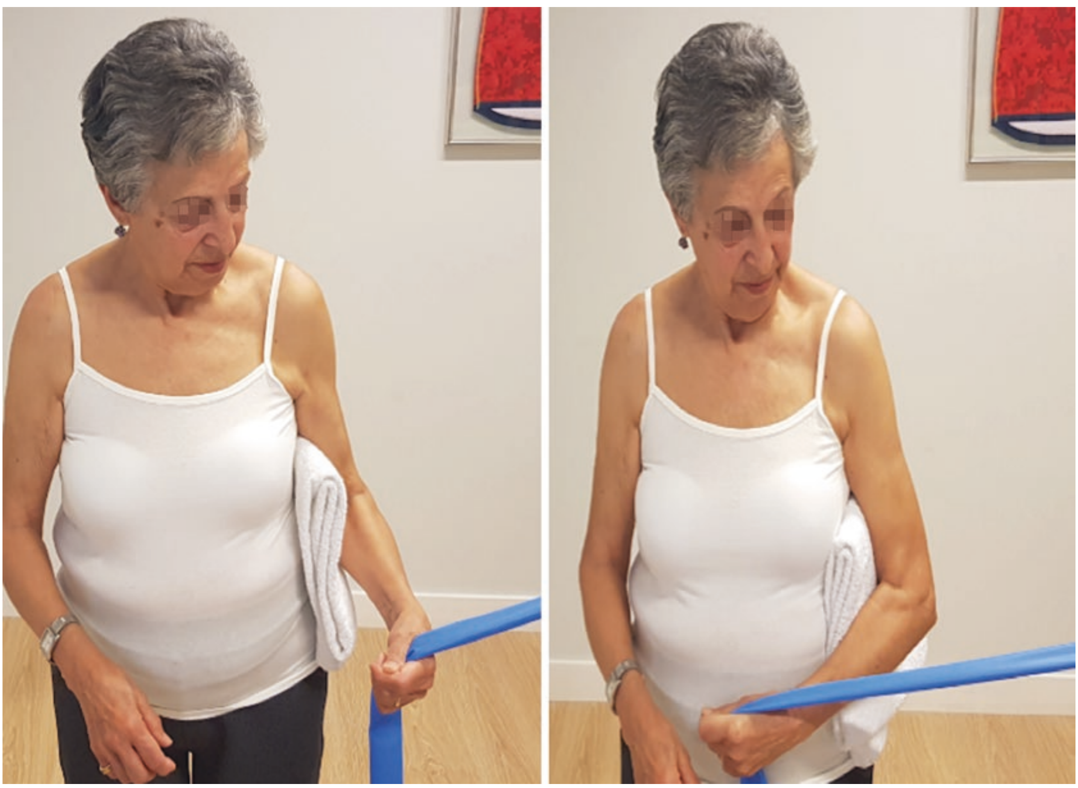

Fig. 17.9 Shoulder internal rotation to strengthening the subscapularis tendon

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