

The role of anterior deltoid reeducation in patients with massive irreparable degenerative rotator cuff tears

Ofer Levy, MD, MCh(Orth), Hannan Mullett, FRCS(TR & Orth), Sarah Roberts, Bsc(Hons), Bed(Hons), MCSP, and Stephen Copeland, FRCS, Reading, United Kingdom

The management of massive rotator cuff tears in medically unfit, elderly patients is difficult. We prospectively assessed 17 patients with radiologically confirmed, nontraumatic, massive rotator cuff tears who were treated with an anterior deltoid rehabilitation program. All patients were medically unfit, with an average age of 80 years (range, 70-96 years). Patients were given standard detailed instruction and an illustrated guide. A video recording of shoulder motion was made before and after treatment. The Constant score increased from a mean of 26 (range, 8-41) before treatment to a mean of 60 (range, 43-77) at a minimum of 9 months after treatment. Range of motion in forward elevation improved from a mean of 40° (range, 30°-60°) at presentation to a mean of 160° (range 150°-180°) after the deltoid rehabilitation course. We recommend that a structured deltoid rehabilitation program is suitable for elderly patients with massive rotator cuff tears. (J Shoulder Elbow Surg 2008;17:863-870.)

Massive, irreparable, degenerative rotator cuff tears represent a major therapeutic challenge. Operative treatment may include débridement or partial rotator cuff repair. There has been interest recently in the role of the reverse prosthesis in this condition, with some encouraging short-term results. However, elderly patients frequently have multiple comorbidities that often dictate against major surgery. The traditional role of the deltoid as a humeral head elevator has been questioned by recent biomechanical analysis. The functional anatomy of the deltoid in the presence of a massive rotator cuff tear has been defined. We have developed a system of rehabilitating the deltoid muscle to compensate for a deficient rotator cuff and report our initial results.

From the Reading Shoulder Unit, Royal Berkshire Hospital.
Reprint requests: Ofer Levy MD MCh(Orth), Reading Shoulder Unit, Royal Berkshire Hospital, Reading, Berkshire RG1 5AN, UK (E-mail: oferlevy@readingshoulderunit.com).

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MATERIALS AND METHODS

Of 540 new patients presenting to a regional shoulder surgery unit in an annual period, 325 had symptoms relating to rotator cuff pathology. Seventeen elderly patients (11 women, 6 men) had clinical and radiologically demonstrated massive irreparable rotator cuff tear. They all had significant pain and marked functional impairment, especially with activities of daily living. The average age was older than 80 years (range, 70-96 years). Shoulder function was assessed using the Constant-Murley score.² The average Constant score was 26, and no patient had active forward elevation greater than 60° (range, 30°-60°).

All patients had pseudoparalysis before treatment. All had full passive range of motion. Their essential complaints were of pain and limitation of movement. The pain cycle was initially controlled by subacromial injection of a local anesthetic (10 mL Marcaine 0.5%; Sanofi-Synthelabo Inc, New York, NY) and long-acting steroid (40 mg Depomedrone, Pharmacia Ltd, Kent, UK). They were advised to take nonsteroidal anti-inflammatory drugs (ibuprofen) or analgesics during the rehabilitation, if needed.

Shoulder radiographs showed a severe decrease in the acromiohumeral distance of less than 7 mm in all the patients, and 12 had severe acromial erosion. According to the radiologic classification of Hamada et al,⁵ 5 patients had grade II changes (upward migration of the humeral head but no significant acetabularization), 7 had grade III changes (concavity of the acromial undersurface with acetabularization), and 5 had grade IV changes (grade III changes plus narrowing of the glenohumeral joint).

All patients had massive rotator cuff tears involving the supraspinatus, infraspinatus, and the subscapularis. The tendon tears were severely medially retracted (for the supraspinatus and the infraspinatus tendons) with grade 3 retraction according to Patte classification⁹ (torn tendon edge at the supraglenoid tubercle). The lower third of the subscapularis tendon was still preserved in only 5 patients. Magnetic resonance imaging (MRI) scans were available for 11 patients. All of the rest had ultrasound scans. The MRI scans showed advanced degree of fatty infiltration in all muscles. All patients showed Goutallier grade 4 fatty infiltration in the supraspinatus and the infraspinatus muscles; 3 patients had grade 3 fatty infiltration of the subscapularis, and the rest had grade 4 fatty infiltration.⁴

All patients had multiple medical comorbidities, placing them at high anesthetic risk. A video record was made of all patients before and after the anterior deltoid rehabilitation.

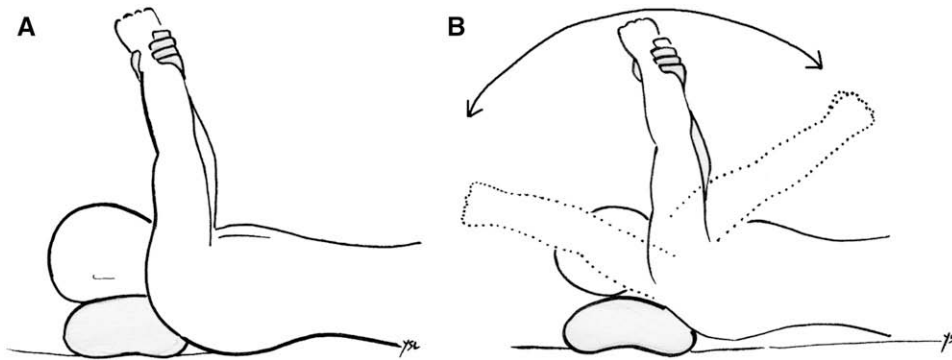


Figure 1 A, The patient is instructed to bring his arm to the upright position first and try to keep it upright with his deltoid muscle contraction force. **B**, Laying down flat, supine, the arm movement is initially within short amplitude from the upright position within a comfortable arc with gravity eliminated.

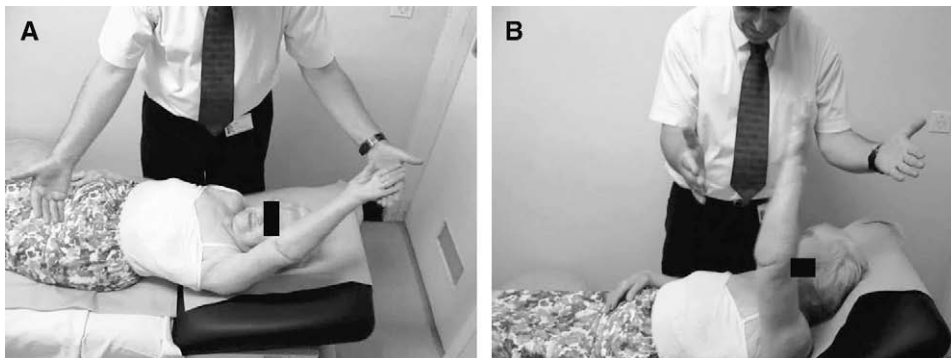


Figure 2 A and B, The arc of movement is demonstrated with the instructor's palms indicating the limits of the arc.

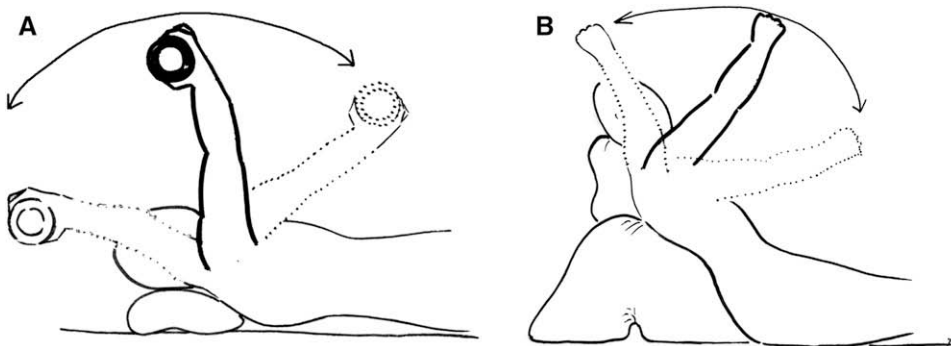


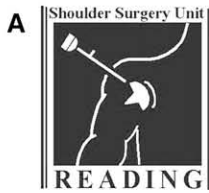
Figure 3 A, The arc is repeated with a small weight, such as a can of beans, and the excursion is gradually increased as confidence increase. **B**, The patient progresses to use the arm against gravity in a semi-sitting position.

Description of exercises

The exercises are initially performed with the patient supine and the head supported. The patient is instructed to bring his arm to the upright position first and try to keep it upright with the contraction force of his deltoid muscle (Figure 1, A). Then, the aim is initially to move the arm upright with gravity eliminated within a comfortable arc

(Figure 1, B). The arc is demonstrated with the instructor's palms indicating the limits of the arc (Figure 2, A and B). As the patient gains confidence, the arc is gradually widened. This stage of the anterior deltoid rehabilitation is performed 3 to 5 times a day for the first 6 weeks.

The next phase is for the patient to take a small weight (eg, a can of beans) and repeat the arc, gradually



Reading Shoulder Unit

Mr Stephen A Copeland, FRCS
Consultant Orthopaedic Surgeon

Mr Ofer Levy, MD MCh (Orth)
Consultant Orthopaedic Surgeon

Anterior Deltoid Exercises Advice for Patients with Massive Rotator Cuff Tears

As a result of prolonged overuse and wear and tear, the muscles arising from the shoulder blade and attaching to the top of your humerus (arm bone) – the rotator cuff muscles - have become torn. This means you are no longer able to easily lift your arm above 90 degrees.

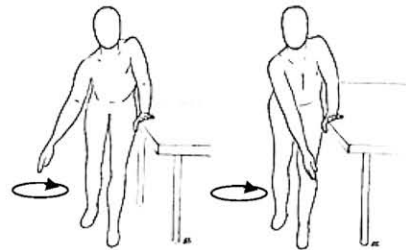
However there is another powerful muscle on the outside of your arm – the deltoid muscle – that may be re-educated to compensate for the torn rotator cuff.

The following exercises should be done three to five times a day to strengthen your deltoid muscle. It will reduce your pain and improve both the range of movement and your arm function.

These exercises must be done for at least 12 weeks and must always be performed starting lying down to begin with. You will be taught the exercise at the unit and reviewed at 6 and 12 weeks.

Exercises:

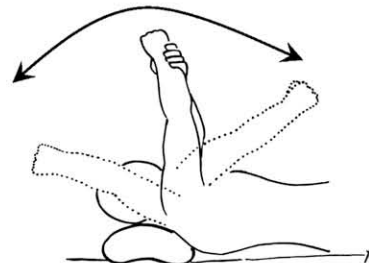
1. While standing, bend forward and let your arm dangle free and perform gentle pendulum movement for about 5 minutes. This will help you in relieving pain and free up your muscles around the shoulder.



2. Lie down flat on your back, with a pillow supporting your head.
3. Raise your weak arm to 90 degrees vertical, using the stronger arm to assist if necessary. The elbow should be straight and in line with your ear.
4. Hold your arm in this upright position with its own strength.



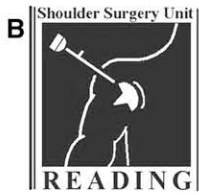
5. Slowly with your fingers, wrist and elbow straight move the arm forwards and backwards in line with the outside of the leg, as per diagram (gentle movement from both sides of the arm upright position.) Keep the movement smooth and continuous for 5 minutes or until fatigue.



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Figure 4 A-C, The Reading Shoulder Unit patient instruction booklet.



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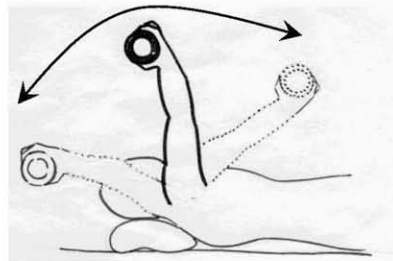
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6. As you get more confidence in controlling your shoulder movement, gradually increase the amplitude of movement until your arm will move from the side of your thigh to above your head, touching the bed, and return.

Keep the movement smooth and continuous for 5 minutes or until fatigue.

7. As you get more confidence in controlling your shoulder movement, a lightweight e.g. a tin of beans or small paperweight, should be held in the affected hand.

Repeat as above (5 and 6).



8. Having more confidence in controlling your shoulder movement gradually go from lying down to sitting and eventually standing.

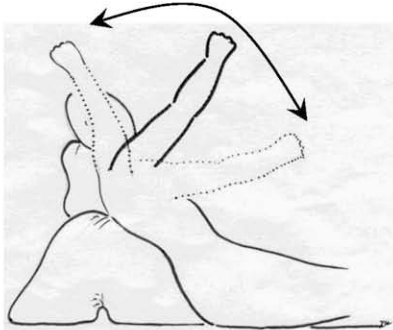
At this stage you may recline the head of your bed or put some pillows underneath your back to recline your position.

Repeat the same exercise again, this time against some gravity.

Start again from holding your arm in the upright position with its own strength.

Repeat as above (5, 6, and 7).

Start first without any weights and progress to use the same lightweight you used before in the lying down position.



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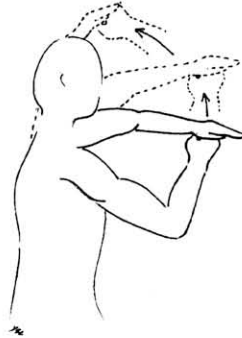
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Consultant Orthopaedic Surgeon

Mr Ofer Levy, MD MCh (Orth)
Consultant Orthopaedic Surgeon

9. Another useful exercise for re-education of concentric contracture of the deltoid muscle.

Performing the exercise:



Make a fist with the hand of the affected side. The flat hand of the opposite side is providing resistance. Push your affected side hand against resistance from the other hand. While doing this, you will notice that you can fully elevate your arm (above your head).

Repeat these exercises in order to 'learn' and re-educate your Deltoid muscle to perform this 'concentric contracture' even without pushing against your other arm.

You should repeat these exercises X 10 in a session, 3 to 5 sessions per day.

10. Stop exercising if your pain increases or you feel unwell.
11. We will review you at the Reading Shoulder Unit at 6 and 12 weeks. We expect to see some improvement by that time.

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Table I Mean Constant score

Variable	Initial (range)	Final (range)
Pain	6 (0-9)	12 (7-15)
Function	5 (0-8)	9 (6-10)
Positioning	3 (2-6)	8 (6-10)
Range of motion	12 (6-18)	34 (24-40)
Power	<1 (0-2)	<1 (0-2)
Total	26 (8-41)	63 (43-77)

increasing the excursion as confidence increases (Figure 3, A). This exercise is repeated until the patient progresses to using the arm against gravity, initially in a semisitting and then in a standing position (Figure 3, B). Each patient is provided with an illustrated guide⁸ that he or she can refer to between physical therapy visits (Figure 4). The exercises were continued for at least 12 weeks. After the initial presentation, the patients were evaluated at 6 weeks, 12 weeks, 6 months, and 9 months.

RESULTS

This initial group of patients was reviewed at a minimum of 9 months after the initiation of deltoid rehabilitation. The mean preoperative Constant score was 26 (range, 8-41). The mean final follow-up score was 63 (range, 43-77). The changes in each component of the Constant score are summarized in Table I. The only component of the Constant score that did not improve was strength, which was less than 1 pound in all patients at presentation. Two patients had improved to a pull-strength of 2 pounds after deltoid rehabilitation, but the mean for the group was unchanged. All components of shoulder motion were improved, but particularly, forward elevation. Range of motion in forward elevation improved from a mean of 40° (range, 30°-60°) at presentation to a mean of 160° (range, 150°-180°) after the deltoid rehabilitation course.

Three patients did not have adequate improvement after the exercise program. One underwent a reverse prosthesis with a good functional result, and another had improved pain relief after arthroscopic subacromial decompression.

At the last follow-up, the 3 patients who did not improve were taking full doses of pain medications, and 3 were taking ibuprofen or paracetamol for analgesia occasionally, sometimes for other joint pain. The rest of the patients recovered from the initial pain, regained a good range of motion (Figure 5), and did not need any pain medication.

DISCUSSION

Open repair of a massive rotator cuff tear is a major surgical challenge. Injudicious surgery may worsen functional outcome, particularly if deltoid integrity is violated. Improvements in arthroscopic techniques

have led to an increase in the number of major and massive rotator cuff repairs being performed. The reverse prosthesis has an evolving role in cuff arthropathy, although it is a significant undertaking for the patient and surgeon, with a high reported complication rate. However, there remains a group of elderly patients with comorbidities who are poor surgical candidates yet have severe pain and inability to perform even elementary tasks of personal hygiene and feeding.

The rationale for reeducation of the deltoid is validated by recent biomechanical research that challenges the traditional description of the deltoid as being a humeral head elevator. Gagey et al³ studied the area of contact between the deltoid and the humeral head in 3-dimensionally reconstructed shoulders. They examined the orientation of the resultant force elements along the vertical axis passing through the acromioclavicular joint. In 19 of the 23 shoulders studied, the resultant axis was downward oriented. They concluded that one of the deltoid's functions is to prevent upward migration of the humeral head and compress it against the glenoid, even in the presence of a large cuff tear.

Burkhart¹ described 3 kinematic patterns in massive rotator cuff tears based on a fluoroscopic study. Stable fulcrum kinematics was seen in patients with normal shoulder motion with a stable glenohumeral fulcrum. Unstable fulcrum kinematics was seen in patients who have an unstable fulcrum of glenohumeral motion that allows anterior and superior translation of the humeral head with attempted active elevation. Captured fulcrum kinematics was seen in a third group. This means that although the coronal plane force couple could not adequately keep the humeral head centered in the glenoid, there was enough deltoid strength to allow elevation the shoulder about the fulcrum that the humeral head developed on the undersurface of the acromion or at the anterior acromiodeltoideus origin. We believe that patients who improved substantially with deltoid rehabilitation changed from unstable to captured fulcrum kinematics.

A few studies document conservative treatment of rotator cuff tears, and although largely retrospective, they do support selective, nonoperative treatment.⁷ Hawkins et al⁶ reported a series of patients who had nonoperative treatment of rotator cuff tears. They found that patient satisfaction was best correlated with improved pain relief, the ability to carry a 10- to 15-pound suitcase at one's side, to use the arm at shoulder level, and to eat using a utensil. However, the average age of the patients in the Hawkins series was 59.6 years, and there was a wide spectrum of cuff tear size. The initial Constant score was almost 80 and improved modestly by an average of 10 points.

We believe the current study to be the first prospective one in a cohort of elderly patients with massive

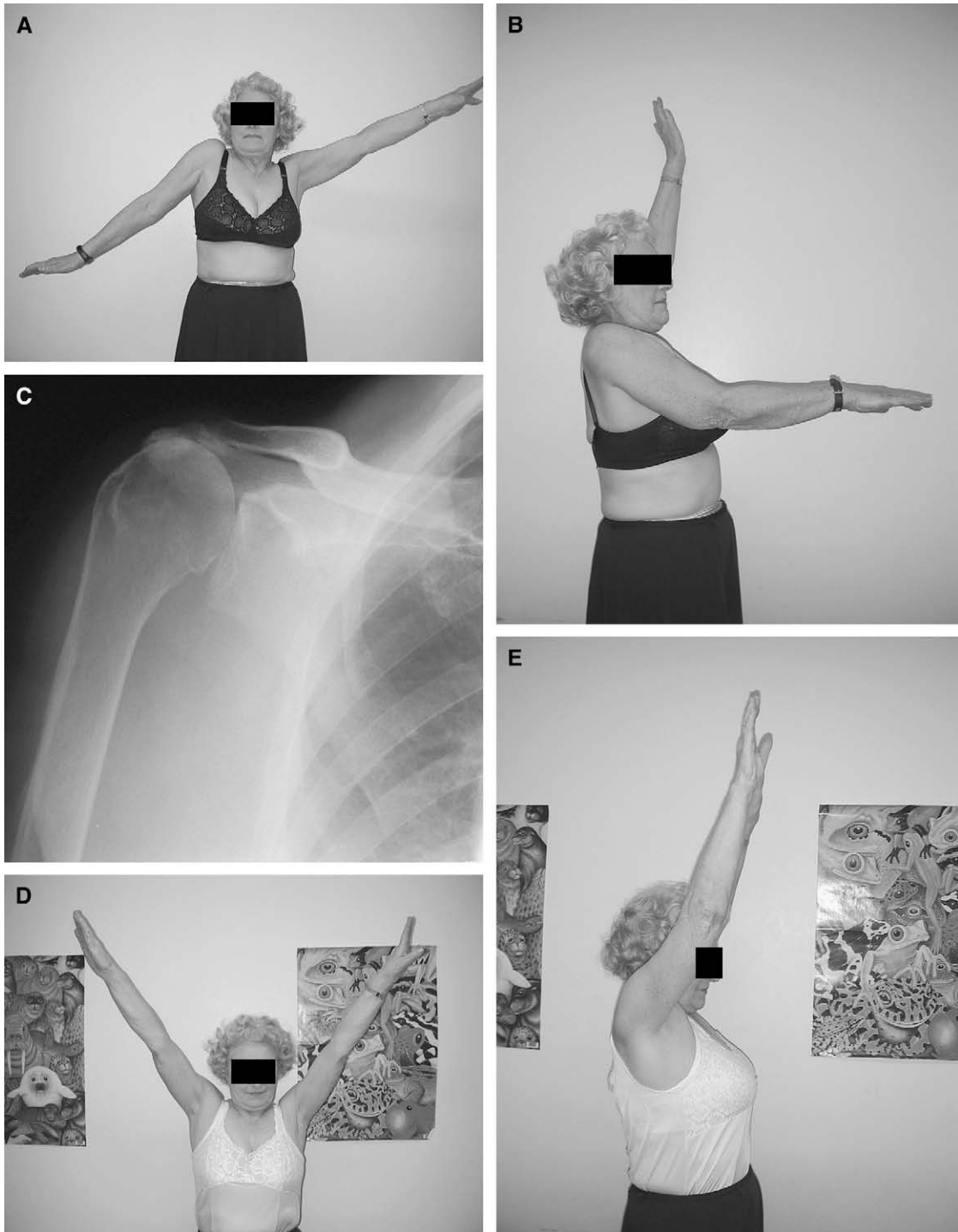


Figure 5 A and B, Case example: The patient presents range of motion of the right shoulder. **C,** The patient's radiograph shows severe superior migration of the humeral head, complete obliteration of the acromiohumeral distance, and erosion of the under surface of the acromion. **D and E,** The patient's range of motion after 6 weeks of exercises according to the deltoid rehabilitation regimen.

rotator cuff tears and unstable fulcrum kinematics. In essence, each of these patients had pseudoparalysis with inability to perform daily activities. The final Con-

stant score is still low compared with the postoperative Constant score in other conditions. However, in this group with low demand and few options in terms of

alternative management, the relative improvement is dramatic. In 90% of patients, the stabilizing effect of recruiting the anterior deltoid was sufficient to improve function and pain adequately. The risks of surgery in this vulnerable group with multiple comorbidities were avoided in all but 3 patients.

In our experience, the exercise regimen has been easy for patients to assimilate and may be taught in approximately 10 minutes. Further reinforcement by a physical therapist is helpful, although not essential. The patient booklet⁸ is key to reminding them to progress in steps with gradual improvement of control of humeral head position and strength. Patients have found it gratifying to review the video recording at presentation and to see tangible evidence of improvement. This deltoid muscle rehabilitation regimen, associated with pain medication, was effective in improving the function and pain in elderly patients with massive cuff tears. In our opinion, this should be the first line of treatment in these patients.

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