Massive rotator cuff tears: new and evolving treatments

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Massive rotator cuff tears (MRCTs) are tears over 5cm in size and often are not directly reparable, or have high failure rates with direct repair. They can present with pain, functional disability or both. Treatment is often multimodal and focused on the patient's specific functional requirements. Improvements in function can often be obtained with patient-specific deltoid rehabilitation regimens, as long as pain is controlled. A large variety of novel surgical reconstructive options are now available and their indications are still being defined. In this article we will review the current new technologies and advancements in the management of MRCTs, while describing our approach to these often complex patients.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1 Understand that massive rotator cuff tears require an informed multimodal approach to achieve the best rehabilitation outcome for each individual patient.
2 Function can often be improved with a patient-specific deltoid rehabilitation regimen.
3 Tendon reconstruction options are preferred for the best outcomes in younger, higher demand patients.
4 In older, lower demand patients, reverse shoulder arthroplasty is usually the best option for good outcomes.

What is a massive rotator cuff tear?

The traditional definition of a massive rotator cuff tear (MRCT) is a tear of more than 5cm in length when measured in the medio-lateral direction. This can be assessed on MRI scan or during surgery. A recent Delphi consensus study has defined massive tears as retraction of tendons to the glenoid rim in either the coronal or axial plane and / or a tear with ≥67% exposure of the greater tuberosity measured in the sagittal plane. The measurement can be performed either with MRI or intra-operatively (Schumaier *et al* 2020).

Several factors affect the outcome of a tendon repair. These include the patient's age, the size (figure 1) and chronicity of the tear, the degree of muscle atrophy and fatty changes. In the presence of these factors, there is a high probability that the tendons will not heal owing to biological insufficiency, even if mobilisation and repair is technically feasible.

In practice, we often refer to MRCT as irreparable, i.e. tears that are not directly reparable with predictable good outcomes of a repair, therefore management of the MRCT is complex, and there are a number of different treatment options.

Recognising and diagnosing MRCT

Massive tears are unusual in patients under 60 years of age. Tears may be traumatic or degenerative, but most frequently occur as a combination of an acute episode on a background of a

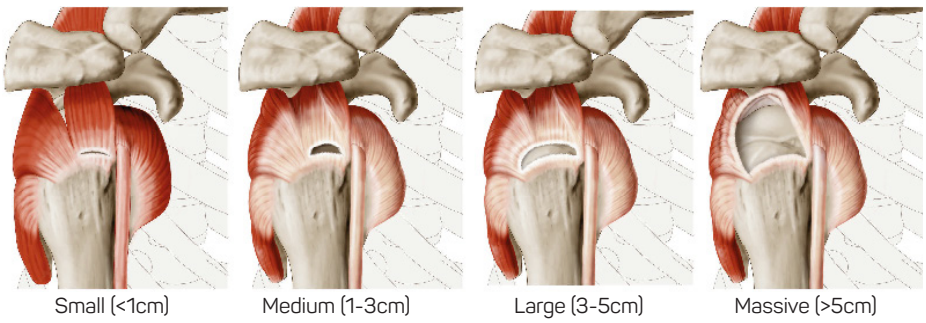

FIGURE 1: Tear sizes (image courtesy of Lennard Funk www.shoulderdoc.co.uk)

"WHEN AN ASYMPTOMATIC DEGENERATIVE ROTATOR CUFF TEAR IS PRESENT, A MINOR INJURY CAN TIP A PREVIOUSLY SYMPTOMLESS SHOULDER INTO A PAINFUL AND WEAK ONE"

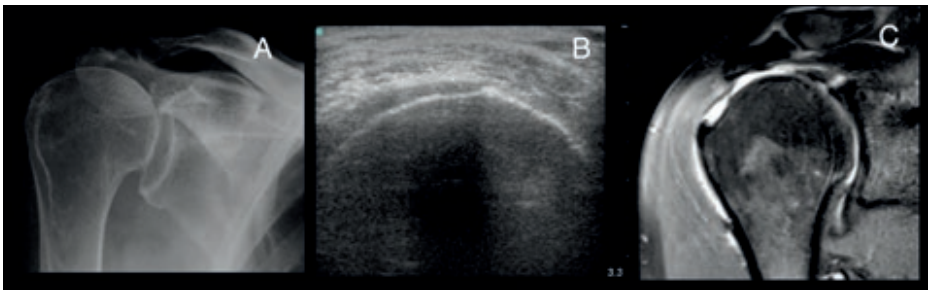

FIGURE 2: (A) Radiograph of MRCT with cranial displacement of the humeral head; (B) Bald head on ultrasound scan; (C) MRI scan showing retracted massive tear with cranially displaced humeral head and muscle wasting

chronically degenerating tendon. It is well recognised that a large proportion of people develop asymptomatic degenerative rotator cuff tears with age, but a minor injury can tip a well-compensated tear to a decompensated tear. Thus a previously symptomless shoulder can suddenly become painful and weak. It is often hard to determine how much of the tear is acute, but there are a number of clues to assist in their assessment.

Patients often present with a loss of strength and pain after a fall, lifting or wrenching injury. Weakness is often such that they are unable to lift their arm without assistance. Clinical findings include rotator cuff weakness with positive lag tests and a drop arm sign. Sometimes more chronic tears have some degree of deltoid compensation. Joint stiffness and pain, however, can affect adequate clinical assessment of the rotator cuff.

Radiographs often show some cranial displacement of the humeral head on the glenoid, with a reduced acromio-humeral interval. If arthritis is present, this is known as a "rotator cuff arthropathy" and not solely a MRCT.

Ultrasound may show an absent rotator cuff, with a "bald head" appearance of the greater tuberosity.

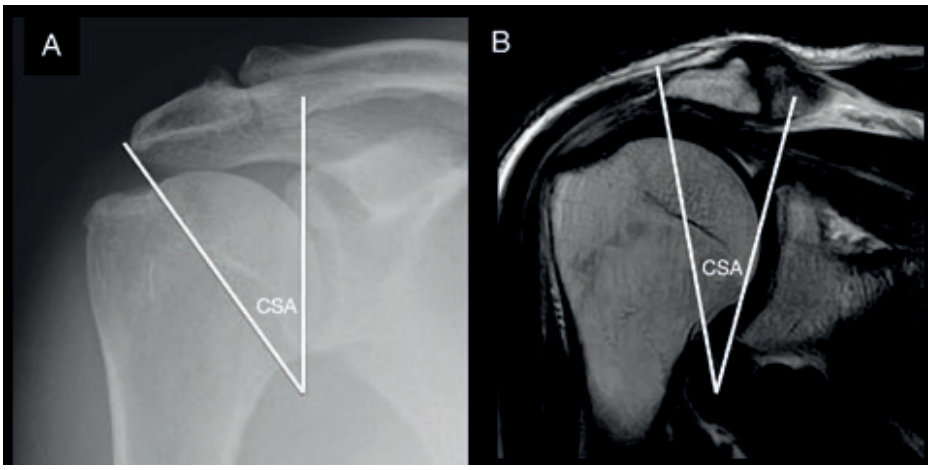

FIGURE 3: The critical shoulder angle (CSA) is measured on true AP radiographs or coronal MRI scan and corresponds to the angle formed between the glenoid plane and a line connecting the inferior glenoid rim with the lateral aspect of the acromion. A high CSA is associated with rotator cuff tears

MRI scan is the imaging investigation of choice as it will show the size of the tear, muscle atrophy, fatty infiltration of the muscles, degree displacement of the humeral head, degenerative joint changes and associated pathologies, all of which are important in determining the most appropriate type of treatment and prognosis (figure 2).

Assessing the glenoid inclination and acromial shape on radiographs or MRI may be beneficial. Recent studies have shown that the shape of our bones may alter the balance of forces around the shoulder and thus predispose to advancing rotator cuff disease (Nyffeler 2019). Patients with a glenoid socket that tilts upwards (superior inclination) and has a larger acromial overhang may be more prone to develop larger tears with poorer outcomes. This relationship between the acromial shape and glenoid inclination is known as the "critical shoulder angle" (figure 3).

Decision making

There are a number of different options for managing MRCT. Therefore, by inference, there is no single definitive solution. This is probably due to the wide spectrum of MRCT patients who present with an equally wide variety of symptoms and functional requirements, in addition to the range of patho-anatomical considerations as mentioned previously. The optimum treatment needs to take all of this into account, together with the experience of the clinician, current evidence and cost-to-risk benefit considerations for the various treatment options.

From the patient's perspective, their main problems will usually be pain and functional limitations, so it is also important to consider these when selecting the optimum treatment strategy. It should also be born in mind that symptoms may change and, therefore, treatment strategies may need to change accordingly.

IMPROVING FUNCTION

Functional therapies focus on optimising or enhancing the deltoid to compensate

for the loss of the stabilising effect of the rotator cuff, along with improving scapula dynamics. Activity modifications are important.

Each MRCT shoulder is individual and unique and may require a combination of different compensation muscle recruitment strategies to provide functional movement into elevation. The primary destabilising force in a MRCT shoulder is predominately from the deltoid, which causes humeral head superior migration in the absence of the inferior translation force that is provided by the rotator cuff. The most obvious biomechanical strategy would be to activate the latissimus dorsi and teres major to provide inferior translation, and re-centering of the humeral head. However, addressing these muscles in isolation may be counter-productive for function as they also have a powerful internal rotation and adduction activation. This recruitment strategy could, therefore, be considered useful in conjunction with other strategies to enhance functional arm elevation in the presence of a MRCT.

Ainsworth (2006) described successful outcomes with a graded anterior deltoid strengthening programme requiring a comfortable movement exercise window to strengthen the anterior deltoid through forward elevation. The rehabilitation principles are in harnessing the effects of gravity by progressing from supine to upright positions, and using lever length by progressing from elbow flexion to extension. The aim is to appropriately challenge the shoulder in flexion in order to provide optimal functional strength and movement (figure 4). Theoretically, strengthening the deltoid is somewhat counterintuitive, given that it has been considered to be a key deforming force in MRCT. However, recent biomechanics research by Hawkes *et al* (2015) challenges the traditional description of the deltoid as only being a humeral head elevator, and highlights its importance for compensatory movement with increased fatiguability demonstrated in shoulders with MRCTs, therefore providing scientific rationale for the re-education of the deltoid.

> "EACH ROTATOR CUFF TEAR IS INDIVIDUAL AND UNIQUE AND MAY REQUIRE A COMBINATION OF DIFFERENT COMPENSATION MUSCLE RECRUITMENT STRATEGIES TO PROVIDE FUNCTIONAL MOVEMENT INTO ELEVATION"

FIGURE 4: Early stage anterior deltoid rehabilitation with short lever in supine

It is also important to consider that most patients with MRCTs will have some residual cuff function, particularly in the transverse force couple of the subscapularis and teres minor. Proprioceptive exercises with the use of hand grip address the activation of the remaining rotator cuff function and enhance the recruitment of scapulothoracic musculature (Alizadehkhaiyat *et al* 2011). Combining this with anterior deltoid activation can further enhance the compensation strategies for shoulder flexion and therefore increase shoulder functional strength (figure 5).

ADDRESSING PAIN

While some patients may have pain but retain good function, for others pain may be limiting their function and it is important to manage the pain to facilitate rehabilitation of function. Options for pain management include:

- **Corticosteroid injections**. These allow short-term anti-inflammatory benefit only, but can be useful in assisting with rehabilitation.
- **Hyaluronan injections**. There is no good evidence for the use of hyaluronan injection in MRCTs, but they have been shown to offer some anti-inflammatory benefit without the adverse effects of corticosteroids.
- **Suprascapular nerve injection or ablation**. The suprascapular nerve provides 70% of the sensation to the shoulder joint (Ergonenc & Beyaz

FIGURE 5: Anterior deltoid rehabilitation with cuff facilitation and proprioception

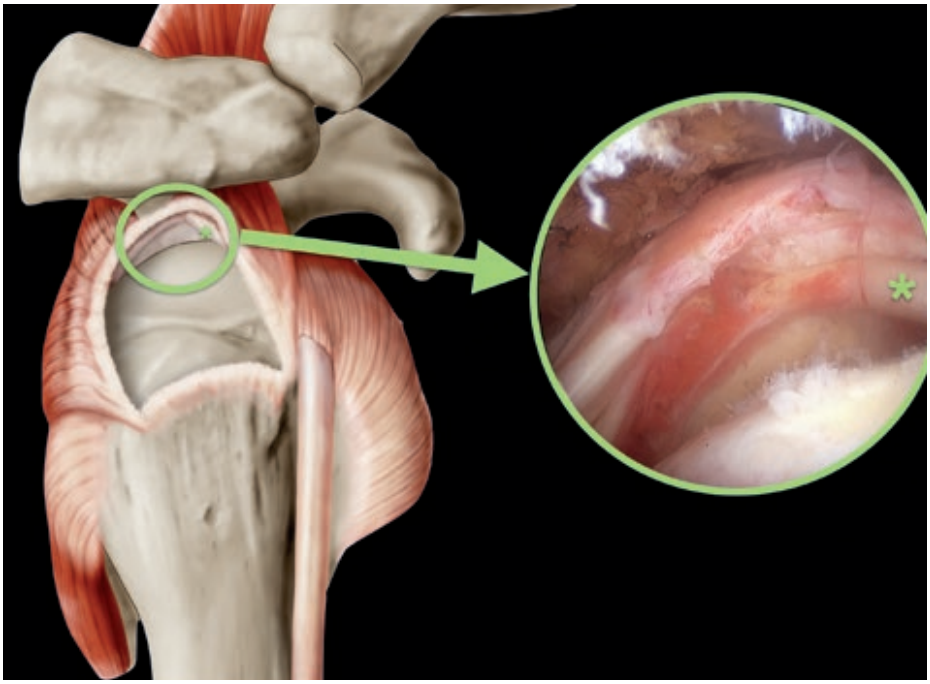

FIGURE 6: MRCT viewed at arthroscopy prior to biceps tenotomy. * denotes the long head of biceps tendon (Image courtesy of Lennard Funk www.shoulderdoc.co.uk)

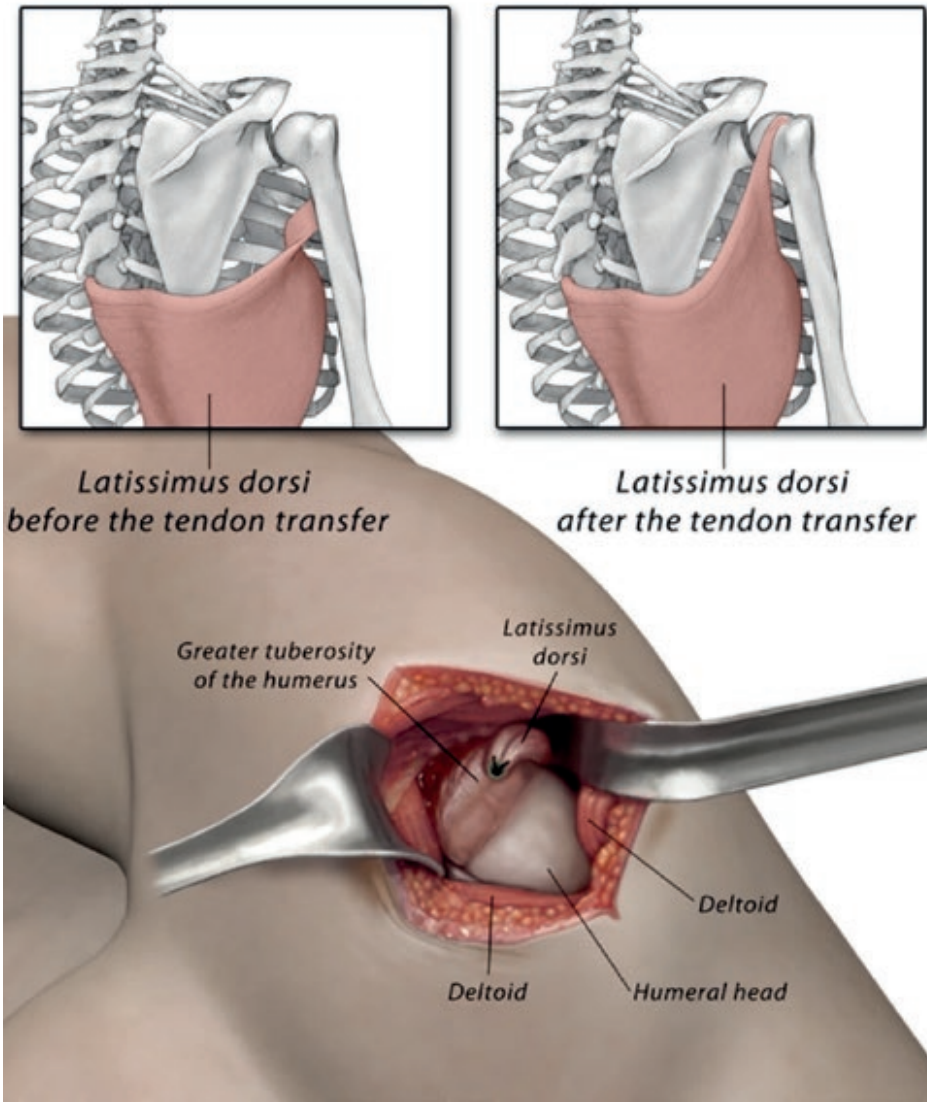

FIGURE 7: Lat dorsi tendon transfer (Image courtesy of Lennard Funk www.shoulderdoc.co.uk)

2018), this treatment inhibits that nerve.

- **Arthroscopic biceps tenotomy & debridement**. The long head of the biceps tendon (LHBT) is a recognised pain generator owing to its high content of pain receptors (Walch *et al* 2005). Pain can be relieved by releasing the LHBT from the shoulder joint (figure 6).

Surgery options

As MRCTs are not directly reparable, or where repair is attempted have a high rate of failure, surgery intervention is aimed at reinforcing and enhancing a partial repair, or reconstructing and restoring some mechano-functional of the rotator cuff.

- **Tendon transfers**. In high functional demand patients with work-related weakness, a tendon transfer can improve functional strength. Latissimus dorsi is usually employed for external rotation strength, but there has been recent interest in utilising the middle trapezius with good results in the right patient. Pectoralis major is traditionally preferred for internal rotation strength, but latissimus dorsi (figure 7) has been a recent option (Clark & Elhassan 2018).
- **Patch augmentation.** Reinforcement of a partial repair is used to biomechanically enhance the repair and / or improve healing, thereby reducing the possibility of failure. Human allograft patches have so far been shown to be the most successful reinforcement option, but new biological patches may offer some other benefits (Ravipati & Wong 2019; Murthi & Lankachandra 2019).
- **Superior capsular reconstruction (SCR)**. The superior capsule has been shown to be a stabiliser of the humeral head, preventing upward migration on arm elevation (Ishihara *et al* 2014). A superior capsular reconstruction (figures 8a and 8b) aims to restore this stabilisation with an allograft or autograft fixed to the glenoid, humerus, and remaining anterior and posterior cuff. This is indicated for cases where a partial

repair is not possible. Early results are favourable for the right indications, which include younger, active patients with good rotation strength but weak arm elevation (Garrigues 2019).

- **Balloon interposition**. The InSpaceTM balloon (Orthospace) is a biodegradable, and therefore temporary spacer that is inserted arthroscopically into the acromio-humeral space to act as a humeral head "depressor". It theoretically improves deltoid function by limiting the upward migration of the humeral head during arm elevation (figure 9). The interposition may also help with pain relief. It is less invasive than other reconstruction options, but definitive clinical data is limited. Pain relief is similar to other constructive options, but function and strength is less, therefore its indication seems to be for patients who prefer a less invasive procedure, are elderly, have medical comorbidities, and / or have lower functional demands (Liu *et al* 2020).
- **Reverse shoulder arthroplasty (RSA)**. This method works by reversing the geometry of the shoulder joint with a ball (glenosphere) on the glenoid side and a cup on the humerus (figure 10); a configuration that lateralises the humerus to both increase deltoid efficiency and, if semi-constrained, to prevent upward migration. Of all the options, RSA is the largest and most invasive procedure, with the highest complication rates. However, it also has the best and most predictable outcomes in improving both pain and function in the most severe cases. It is primarily indicated for rotator cuff arthropathy, but is becoming increasingly used for more elderly patients with irreparable cuffs and pseudoparalytic shoulders (Petrillo *et al* 2017). For younger patients, RSA is rarely used as a primary procedure, but may be used for revision cases.

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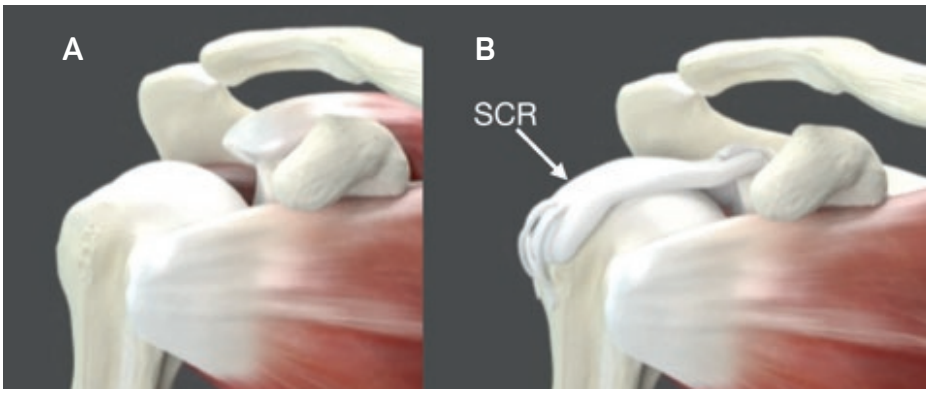

FIGURE 8a: Superior capsular reconstruction. A = before and B = after

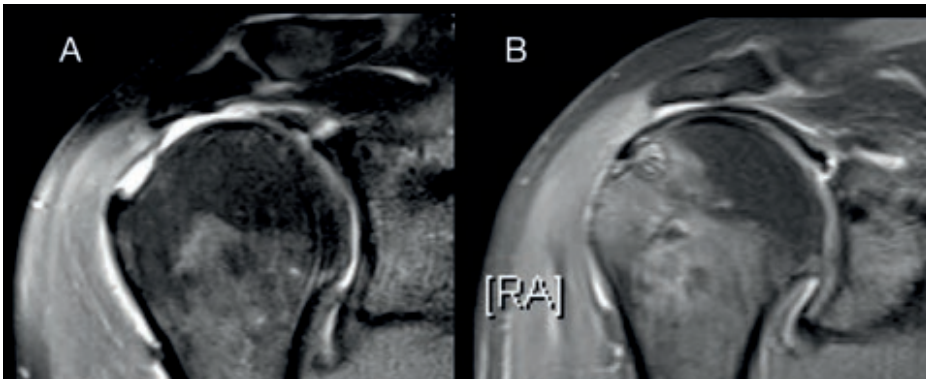

FIGURE 8b: MRI scans of superior capsular reconstruction. A = before and B = one year post-operatively (images courtesy of Lennard Funk **www.shoulderdoc.co.uk**)

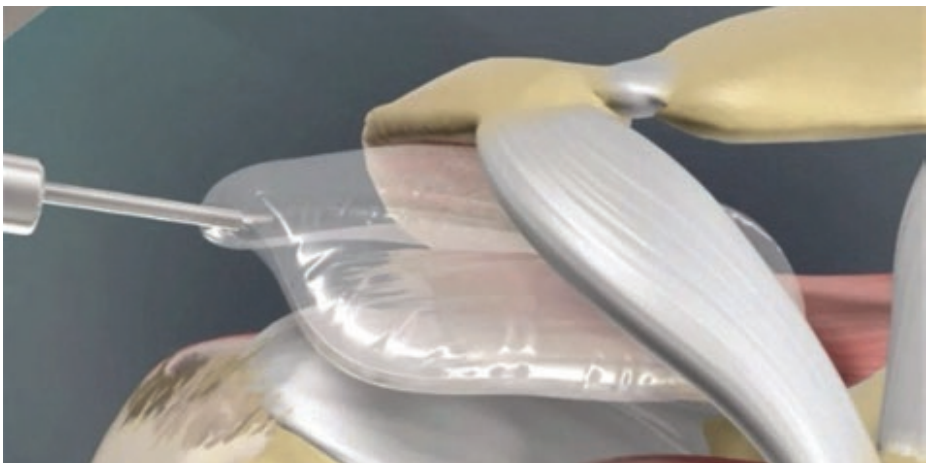

FIGURE 9: InSpaceTM balloon being inserted into acromio-humeral space through percutaneous skin portal (Image courtesy of Orthospace Ltd.)

Biological therapies

These encompass a wide range of bio-active exogenous therapies that can be injected, or added to the repair or reconstruction, to improve healing and reduce failures. Current biological therapies include Platelet-Rich-Plasma, Bio-active scaffolds, stem cell therapies, Bio-active hydrogels and recombinant collagen.

A lot of work has been done in developing biological treatments to enhance healing. Although laboratory research and small clinical studies are promising, higher levels of evidence studies, such as randomised controlled trials, have not shown much benefit for current therapies. However, technologies and knowledge are always evolving and refinement of these treatments will almost certainly define their roles (Samitier *et al* 2020).

Summary

Management of MRCTs usually involves multimodal treatment and a patient-centred approach. The management will depend on:

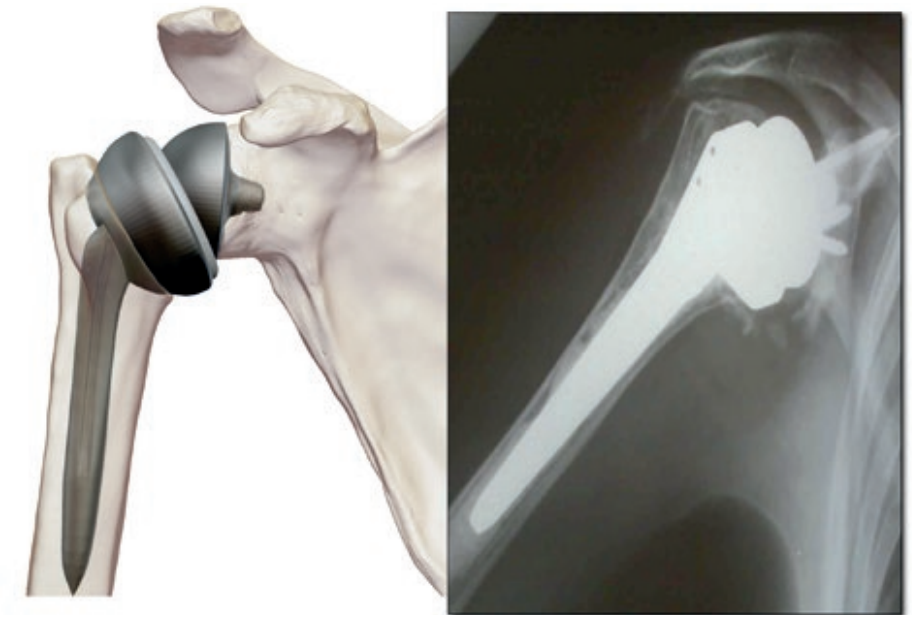

FIGURE 10: Reverse geometry shoulder replacement (Image courtesy of Lennard Funk www.shoulderdoc.co.uk)

- Patient factors: age, activity level, functional requirements, comorbidities and preferences
- Patient symptoms: pain level, functional limitations or both; presence of pseudoparalysis
- Pathology: type of tear, chronicity, muscle atrophy, fatty infiltration, containment of the humeral head, degenerative joint changes and associated pathologies
- Institutional factors: availability and mix of skills, cost implications and clinician bias.

In general, younger patients have better healing potential, therefore reconstruction with existing tendons is preferred. This often involves partial repairs with scaffold patch and / or biological augmentation. In the elderly patient there is less healing potential and it is desirable to limit the number of surgical procedures, therefore the preference is for reverse arthroplasty. Superior capsular reconstruction appears to have a place for younger patients where a partial repair is not possible, whilst the debridement and biceps tenotomy is for those patients who have pain only and prefer a lesser procedure. Tendon transfers are to improve external rotation strength in high demand workers.

Table 1 presents an algorithm that we use as part of our decision making.

About the authors

Lennard Funk

Len is a Consultant Orthopaedic Surgeon and is part of the large upper limb unit at Wrightington Hospital, has a private practice in Manchester, and has established and runs **shoulderdoc.co.uk**. Len is passionate about patient information and education, and providing the best quality of care through a multidisciplinary team. He routinely treats elite and professional athletes.

Len's practice, the Arm Clinic, specialises in sports and soft tissue injuries of the shoulder. Providing second opinions, treating complex cases and performing revision surgery makes up a large proportion of his work. He practices closely with colleagues who specialise in complex trauma and shoulder replacement surgeries, and therapists dedicated to complex shoulder rehabilitation.

Academically, Len has written numerous books and contributed to publications on shoulder surgery and rehabilitation. He is actively involved in research, with more than 100 research publications. He teaches undergraduate and postgraduate medical, sports therapy and sports medicine students.

Michael Walton

Mike is Clinical Director of the Upper Limb Unit at Wrightington Hospital, Centre of Excellence for Orthopaedic Surgery. His practice is exclusively in shoulder surgery with particular specialist interest in revision shoulder replacement and sports injuries. He routinely treats professional athletes from many of the country's leading teams and extreme sport athletes from around the globe. He was recently awarded the prestigious Copeland Fellowship by the British Elbow and Shoulder Society. Mike is married to Julia, specialist shoulder therapist, and has two young sons. He is a keen runner, skier and water sports enthusiast.

Julia Walton

Julia has specialised in shoulder rehabilitation since 2002. She is an Advanced Upper Limb Physiotherapy Practitioner at Wrightington Upper Limb Unit and at Manchester Shoulder Clinic. She works closely with her surgical and therapy colleagues and has extensive experience treating all shoulder conditions from elite athletes, to shoulder complaints that trouble patients in their everyday

	PAIN	WEAKNESS	ER LAG
Young (<60yrs)	Repair + Augment / SCR		Lat Dorsi / Trapezius Tendon Transfer
Intermediate (60-70yrs)	Biceps Tenotomy +/- Balloon	Deltoid rehab	
	Repair + Augment / SCR		Tendon Transfer
Elderly (70+yrs)	Biceps Tenotomy +/- Balloon	Deltoid rehab	Reverse Arthroplasty +/- Tendon Transfer
	Reverse Arthroplasty		

TABLE 1: Simplified decision-making guide to MRCTs

life. She also lectures nationally and internationally on shoulder rehabilitation and is actively involved in clinical research.

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