Management of the failed rotator cuff repair

Abstract

Rotator cuff repair is increasingly being performed, and this is likely to continue to given the ageing population. An improvement in functional outcome can be achieved, with the best results noted in those tendons that go on to heal. Failure of repair following surgery can be associated with debilitating symptoms that are not always amenable to non-operative measures, so further surgery may be indicated for these patients. Several operative strategies have been described, but careful evaluation is required to determine the most suitable option. This review describes the decision-making strategies and treatment options available during management of a failed rotator cuff repair.

Key words: Revision surgery; Rotator cuff; Rotator cuff repair; Shoulder pain; Tendon healing

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Introduction

Rotator cuff repair is increasingly being performed, and this is likely to continue given the ageing population (Jensen et al, 2017). It is typically performed following 2.5 years of persistent symptoms and after the failure of conventional non-operative measures (eg analgesia, injections and physiotherapy) that aim to reduce pain and therefore improve range of motion (Carr et al, 2015). Successful surgery is defined by less pain, reduced stiffness, increased strength, improved range of motion, the return to normal activities (sporting or otherwise), and healing of the repaired tendon. However, a retear or a failure of tendon-bone healing does not necessarily mandate further intervention because, despite these being structural problems, some patients can still maintain satisfactory function (Galatz et al, 2004). In patients with persistent symptoms and a retear, careful evaluation is required to determine the need for revision surgery and the precise operative strategy to be used.

This review describes the decision-making strategies and treatment options available to manage structural failures following a rotator cuff repair.

Causes of structural failure

Many studies have identified patient characteristics associated with an increased risk of structural failure (such as retears and/or a lack of tendon-bone healing) after a rotator cuff repair, including patient, metabolic, anatomical and surgical variables (Table 1) (Denard and Burkhart, 2011; O'Donnell et al, 2020).

The purpose of identifying factors associated with postoperative retears is not only to attempt to modify those that are potentially correctable (for example smoking or a vitamin D deficiency), but to also stratify patients who are at risk of needing further revision surgery. Lee et al (2020) evaluated the results of 98 patients who were diagnosed with a retear within 2 years of having a primary rotator cuff repair. Compared to those who did not have further surgery, those who underwent revision surgery complained of persistent pain, reduced function and muscle weakness after the primary repair. Preoperative factors which were found to significantly contribute to this included fatty infiltration of the infraspinatus muscle, raised serum cholesterol levels, raised serum low-density lipoprotein levels and an increase in the antero-posterior dimension of the retear. The latter was attributed to the subsequent involvement of the infraspinatus muscle in retears and the associated disruption of the transverse force couple.

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Table 1. Factors associated with retears following a rotator cuff repair	
Patient	■ Increased age ■ Smoking ■ Obesity ■ Systemic disease, such as diabetes and rheumatoid arthritis
Metabolic	■ Raised serum cholesterol ■ Raised serum low-density lipoprotein ■ Vitamin D deficiency
Anatomical	■ Muscle quality, for example atrophy or fatty infiltration ■ Tendon quality, for example tendinopathy, remnant tendon length or delamination ■ Tear morphology, including the size of the tear, the number of torn tendons and the extent of retraction
Surgical	■ Aggressive postoperative rehabilitation ■ Surgical volume

Clinical assessment

Worsening clinical symptoms often do not correlate to a structural failure following a rotator cuff repair, and even in the presence of a residual defect, there can still be an improvement in function provided there has been partial healing (Denard and Burkhart, 2011; Lädermann et al, 2016). It is therefore crucial to conduct a meticulous evaluation in all suspected cases of structural failure, in order to identify the cause of the persistent symptoms, as well as those patients that may benefit from further surgery (Denard and Burkhart, 2011).

History

Pain, stiffness and weakness are frequently reported after surgery, so distinguishing a normal postoperative recovery from adhesive capsulitis, infection or potential structural failure can be challenging. In the case of persistent symptoms, the first investigation should be to rule out a *Cutibacterium acnes* infection, as this has been isolated in 29% of surgical site infections occurring after a rotator cuff repair (Pauzenberger et al, 2017). Intermittent pain related to activities is suggestive of rotator cuff pathology, whereas constant pain in the presence of systemic upset should raise suspicion of an infection. Carefully reviewing the initial rehabilitation protocol implemented may identify early aggressive motion and strengthening that may contribute to structural failure (Zhang et al, 2013).

Physical examination

As with all orthopaedic examinations, detecting structural failure following a rotator cuff repair should follow the well-established framework of 'look, feel and move'. Emphasis should be placed on the pathology not dealt with during the index procedure, such as that involving the acromio-clavicular joint, glenohumeral joint and biceps tendon. Missed tears to the subscapularis muscle should specifically be sought, but this can be difficult to do preoperatively because even magnetic resonance imaging has a 30% sensitivity and 89% specificity in doing this (Ward et al, 2018). Previous surgical incisions should be inspected for signs of infection. If an open repair was carried out then the pathology of the deltoid muscle should be assessed, as 78% of patients with preserved function have a satisfactory result following revision surgery, compared to only 57% of patients who have compromised deltoid integrity (Djurasovic et al, 2001).

When assessing the patient's range of motion, the presence of stiffness may warrant ultrasound-guided hydrodilatation or an isolated capsular release, provided there is no concomitant recurrent tear (Lädermann et al, 2021). Pseudoparalysis can be defined in a number of ways, but it is generally characterised by less than 90° of active elevation with full passive range of motion (Ernstbrunner et al, 2021). Up to 75% of patients recover from pseudoparalysis after a primary repair but there is little data to suggest a similar outcome following revision surgery (Denard and Burkhart, 2011). The inability to maintain external rotation with the arm in 20° of abduction, as well as the maximal external rotation of the arm,

is considered a positive lag sign, and has a reported sensitivity of 65% for detecting tears extending into the infraspinatus muscle (Castoldi et al, 2009). Additionally, the inability to maintain external rotation with the arm at the side, and the inability to externally rotate the arm from a position of 90° abduction with the elbow flexed to 90°, have 100% sensitivity for detecting grade three or four fatty infiltration of the infraspinatus muscle and the teres minor muscle respectively (Walch et al, 1998).

Diagnostic tests

Persistent symptoms after a rotator cuff repair should raise the possibility of deep infection (0.7% of cases), with *Staphylococcus epidermidis* and *C. acnes* being the most commonly isolated pathogens (Frank et al, 2020). Erythrocyte sedimentation rate and C-reactive protein levels are commonly assessed when ruling out an infection. However, following surgery the sensitivity of erythrocyte sedimentation rate and C-reactive protein levels at detecting infection are 60% and 50% respectively. In cases where infection is suspected, joint aspiration should be performed and cultures should be retained for at least 7 days in order to isolate *C. acnes* (Athwal et al, 2007). Overall, the sensitivity, specificity, positive predictive value and negative predictive value of diagnostic aspiration is 33%, 98%, 80%, and 83% respectively (Hecker et al, 2020). It should be noted that despite a deep surgical infection following a primary rotator cuff repair, satisfactory results can still be achieved following either a one or two-stage revision procedure (Athwal et al, 2007).

Diagnostic imaging

Following surgery, the rotator cuff can be evaluated by plain radiography, ultrasonography, computed tomography, and magnetic resonance imaging (Table 2). However, during the first 6 months after surgery the appearance of the rotator cuff is difficult to characterise, so accurately identifying a retear can be challenging. Detailed soft tissue imaging is required to determine the mode of failure and identify factors that may influence the outcome of a potential revision surgery (Lädermann et al, 2016). Five predominant patterns of failure have been described:

1. Failure of the tendon to heal
2. Poor tendon quality

Table 2. The role of diagnostic imaging in the assessment of the rotator cuff following primary repair

Diagnostic modality	Relevant information that can be obtained
Plain radiographs	The presence of arthritis, particularly in the glenohumeral or acromio-clavicular joint
	Proximal migration of the humeral head or cuff tear arthropathy
	Fracture of the acromion following an acromioplasty
	Loose suture anchors
	Critical shoulder angle
Ultrasonography	Repair integrity
Computed tomography	Fracture of acromioplasty
	Complications of suture anchors
	Bone integrity or the presence of cysts
Magnetic resonance imaging	Repair integrity
	The quantity and quality of bone remaining for potential revision surgery
	Quality of muscle and/or tendon as indicated by the tangent sign and fatty infiltration
	Level of tendon retraction in the case of a retear
	Other pathology such as concomitant tears of the subscapularis muscle

3. Fatty infiltration or atrophy
4. Retear medial to the medial row of fixation
5. Bone defects (Lädermann et al, 2016).

Results of non-operative treatment

After sustaining a retear, the majority of patients still gain functional improvement (Chalmers et al, 2018). In a systematic review comparing the intermediate to long-term (a minimum of 5 years) results of a rotator cuff repair to the non-surgical treatment of rotator cuff tears, there were no differences in functional outcome and tear enlargement (Chalmers et al, 2018). Additionally, maintenance of clinical outcomes has been demonstrated in massive tears at 10-year follow ups, despite a progression in proximal humeral migration and cuff tear arthropathy, suggesting that healing is not essential for a long-term satisfactory outcome (Paxton et al, 2013).

Surgical strategies

Several factors need to be considered before selecting the most appropriate form of surgical intervention (Figure 1).

In the absence of arthritis, revision repair can be considered provided there is evidence of minimal fatty infiltration, as this may limit tissue mobility and anatomical reduction of the tendon to its footprint (Denard and Burkhart, 2011). The presence of more extensive fatty infiltration and an intact or reparable subscapularis muscle warrants the consideration of a graft reconstruction (superior capsular reconstruction or bridging graft), or a tendon transfer where the subscapularis muscle is irreparable (Desmoineaux, 2019). In those patients with arthritis, or in older patients which a massive tear and/or widespread fatty infiltration and/or pseudoparalysis, a reverse total shoulder arthroplasty should be considered (Figure 2) (Dukan et al, 2020).

Revision repair

Indications

Revision repair may be considered for patients with persistent symptoms despite optimal non-operative management. A comprehensive diagnostic evaluation must be undertaken before surgery to exclude infection and ensure there has not been progression towards cuff tear arthropathy, with or without glenohumeral osteoarthritis. The presence of fatty infiltration does not present a direct contraindication to further repair, since Burkhart et al (2007) reported that functional improvement was still achievable in patients with Goutallier grade 3 changes.

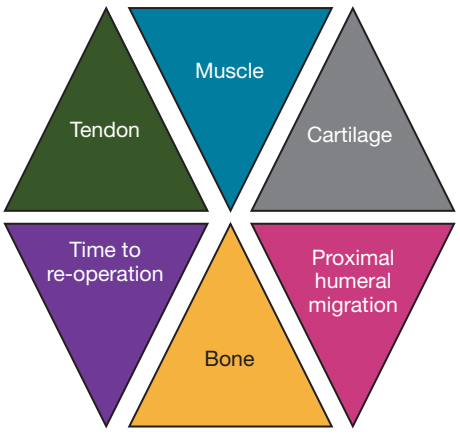

Figure 1. Factors that need to be considered before deciding upon the type of surgery.

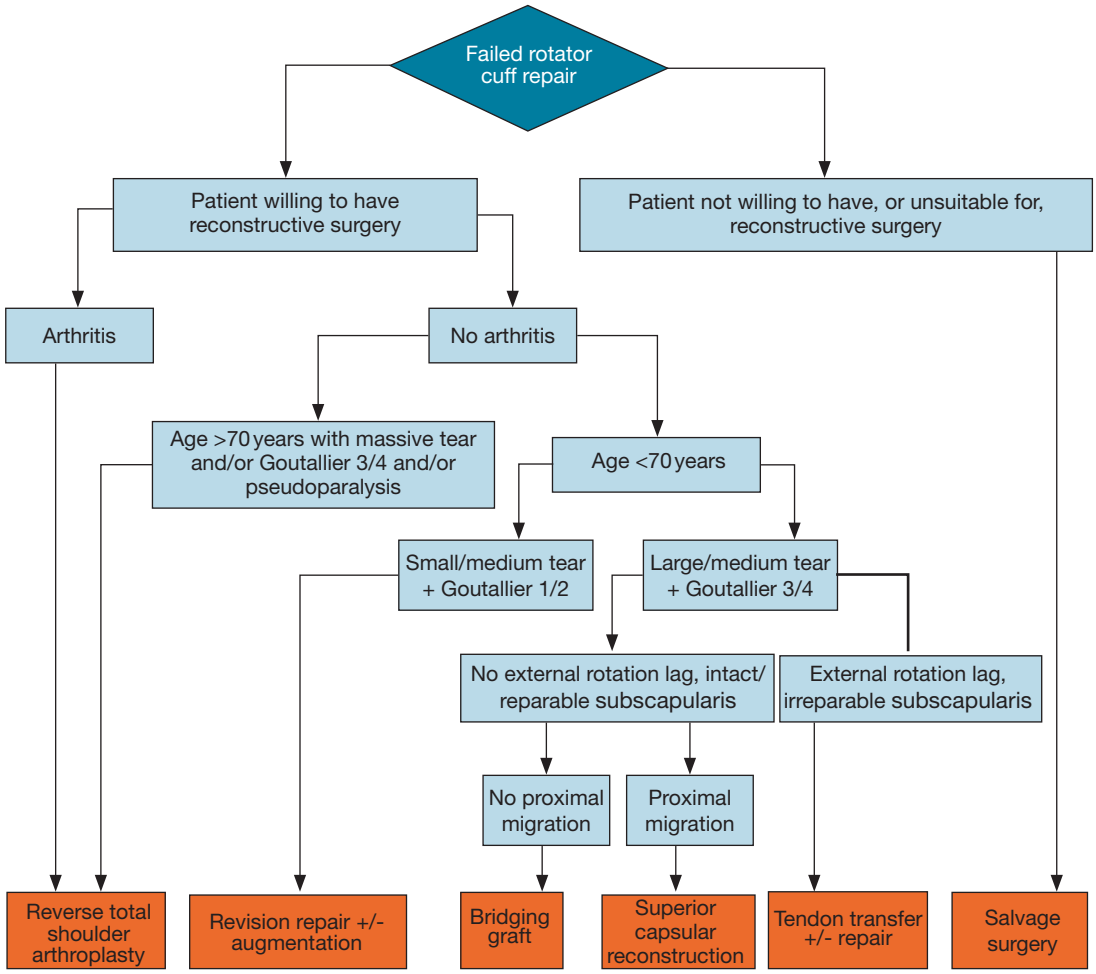

Figure 2. Treatment algorithm guiding the choice of surgical strategy following a failed rotator cuff repair.

Principles of surgery

An important consideration in any revision surgery is the exclusion of infection. The recognition of *C. acnes* as a leading cause of prosthetic shoulder joint infection has largely changed the way in which surgical site infections are viewed because of its indolent course and limited manifestation on diagnostic tests (Frank et al, 2020). Currently, there is no clear guidance as to whether intraoperative tissue sampling should be routinely carried out during a revision cuff repair, and the authors recommend maintaining a low index of suspicion for this as a cause of failure.

Burkhart and colleagues described seven key procedural steps that sequentially progress in an anterior-to-posterior direction when repairing the rotator cuff (Table 3) (Lädermann et al, 2012). In the case of large or massive tears, these steps are still required, even when performing alternative surgical procedures such as a superior capsular reconstruction. Formal acromioplasty is discouraged because it may cause antero-superior escape and instead, the coraco-acromial ligament should be preserved with the only bony excision involving a downward sloping acromion or lateral osteophyte. Burkhart's seven key steps include a biceps tenotomy or tenodesis procedure, but these procedures may not be required in the absence of tendinopathic changes, or where presence of the tendon does not compromise the repair.

One of the most difficult aspects of a revision repair is discerning between normal cuff tissue and fibrous adhesions. This requires skeletalisation of the scapula spine and the undersurface of the acromion. Isolating the scapular spine is particularly useful because it provides a clear distinction between the anterior supraspinatus muscle fibres and the posterior infraspinatus muscle fibres. Debriding bursal leaders (projections of scar tissue) is essential and can be facilitated by internally rotating the arm to bring any intact cuff elements on the greater tuberosity into view. Visualisation of the anterior lesser tuberosity,

Table 3. Seven steps to a successful revision rotator cuff repair

Step	Procedure
1	Biceps tenotomy in preparation for potential tenodesis
2	Repair of the subscapularis muscle ■ Consider a three-sided release (anterior, posterior and superior) to improve mobility ■ The tendon can be medialised by up to 5 mm without compromising the outcome
3	Biceps tenotomy or tenodesis dependent upon surgical preference
4	Isolate bony landmarks (acromion, acromio-clavicular joint and scapular spine), posterior gutter and lateral gutter
5	Mobilise the supraspinatus and infraspinatus muscles
6	Anterior and/or posterior interval slide
7	Rotator cuff repair based on the tear pattern

the narrow posterior subacromial space, can be additionally aided using a 70° arthroscope, because it provides a 'bird's-eye' view while alternating between posterior and lateral portals (Lädermann et al, 2012).

A prerequisite to performing a tension-free repair is adequate tissue mobilisation. Initially, this should involve releasing the capsule deep to the tendon without proceeding more than 10 mm medial to the glenoid rim to avoid injury to the suprascapular nerve. Residual anterior immobility may require the release of the coraco-humeral ligament from the base of the coracoid. A formal anterior interval slide in-continuity is routinely performed in anterosuperior tears. Conversely, if the cuff is tethered posteriorly, a posterior interval slide may be required using arthroscopic scissors to release the tissue between the two tendons. Once again, being mindful of the suprascapular nerve here is essential (Lädermann et al, 2016). Recognising the tear pattern and completing the repair are the final stages. Bone marrow stimulation is a useful adjunct to surgery and has been demonstrated to reduce the retear rate (Ajrawat et al, 2019).

Postoperative care

Rehabilitation following a revision cuff repair focuses on protecting the repair in preference to avoiding stiffness or restricted motion. Movement is prevented for 6 weeks, following which passive overhead exercises and external rotation are started. Strengthening is introduced at 4 months, but the specific exercises are dependent upon the surgical strategy used (Lädermann et al, 2012).

Results

Outcomes following a revision rotator cuff repair are favourable, with an observed reduction in pain and an improvement in both range of motion and functional outcome (Denard and Burkhart, 2011). Most clinical improvement occurs in the first 6 months following the repair and is maintained at 5 years (Hoffman et al, 2020). Complications occur in up to 12% of cases and typically involve a retear (32% of cases), stiffness and infection (Hoffman et al, 2020).

Rotator cuff repair augmentation

When a complete repair is not possible, the use of scaffolds and cell-based strategies (for example growth factors) in conjunction with revision rotator cuff repair have become more popular. Scaffolds can be considered in cases of severe tendon retraction to the glenoid, extensive fatty infiltration (Goutallier grade 3 or 4), and an intact or reparable subscapularis muscle (Mihata et al, 2013). In this situation, a partial repair is still attempted to balance the force couples about the shoulder. The residual defect may then be 'bridged' by spanning a graft between the residual rotator cuff tendon to the greater tuberosity. Alternatively, the graft may be used to span the defect between the superior glenoid and the greater tuberosity, known as a superior capsular reconstruction, to repair the superior capsule and prevent proximal humeral migration (Mihata et al, 2013).

Both strategies are technically demanding, and it is unclear which procedure is superior or should be indicated in which patient. Furthermore, surgical heterogeneity related to indications, tear size, graft type and postoperative rehabilitation limits the generalisability of much of the literature. However, most studies demonstrate an improvement in range of motion and functional outcome. Even in patients where the graft has re-ruptured, improvement in outcome can still be achieved (Mihata et al, 2013; Mirzayan et al, 2019).

Tendon transfers

Loss of elasticity, tendon retraction and muscle atrophy can preclude revision repair of the rotator cuff (Muench et al, 2020). Under these circumstances, tendon transfer presents an appealing option and should be considered in the absence of arthritis, when passive motion is preserved, and when there is a functioning subscapularis muscle, as is the case in irreparable postero-superior tears, and should be considered to balance the force couple (Clark and Elhassan, 2018). Options for postero-superior tears include transfer of the latissimus dorsi and more recently, lower trapezius. The latter has been advocated for because of its favourable external rotator lever arm and closer adherence to the fundamental principles of tendon transfer (Clark and Elhassan, 2018). Outcomes of a latissimus dorsi transfer following a previously failed rotator cuff repair are variable, and are associated with a complication rate of 27% and conversion to reverse total shoulder replacement in 14% of cases (Muench et al, 2020). An acromio-humeral interval <7 mm and fatty infiltration Goutallier grade 3 or 4 have been identified as risk factors for these poor outcomes. In contrast, lower trapezius transfer can result in significant improvements in functional outcome and range of motion (Clark and Elhassan, 2018). Nevertheless, this is still a relatively novel procedure and further studies are required to establish it as a reliable method of treating failed postero-superior cuff repair.

Tendon transfers for antero-superior rotator cuff failure typically involve the pectoralis major, latissimus dorsi and, more recently, the pectoralis minor muscle (Clark and Elhassan, 2018). Anterior migration of the humeral head with eccentric glenoid wear contraindicates surgery and thus, preoperative radiographs should be carefully reviewed (Paladini et al, 2013; Moroder et al, 2017). Pectoralis major tendon transfer has been regarded as the 'gold standard' and can lead to an improvement in functional outcome (Clark and Elhassan, 2018). Latissimus dorsi tendon transfer has emerged as a potential alternative because its line of pull is similar to that of the subscapularis muscle, in that it is posterior to the body's axis and its function is more expendable (primarily adduction) than that of the pectoralis major muscle (reaching across the body) (Clark and Elhassan, 2018). Few studies have evaluated its role in the treatment of failed rotator cuff repairs, with those that do reporting good reduction in pain associated with restoration of function and range of movement (Clark and Elhassan, 2018). Subcoracoid pectoralis minor transfer has been suggested because of its favourable force vector, and potential in allowing bone-to-bone healing since it can be harvested with a flake of bone. Preliminary results have demonstrated that it is a safe technique associated with an improvement in functional outcome and low risk of nerve injury (Paladini et al, 2013).

Reverse total shoulder arthroplasty

Reverse total shoulder arthroplasty was initially conceived for the treatment of cuff tear arthropathy, but its indications have expanded rapidly over the years. Studies evaluating the use of arthroplasty following a failed rotator cuff repair, in the absence of arthritis, are variable, with some demonstrating an improvement in both functional outcome and range of movement (Sadoghi et al, 2011). However, patients with a previously failed repair experience inferior clinical outcomes compared to those without a history of previous surgery (Boileau et al, 2009). In general, reverse total shoulder arthroplasty may be considered in older patients (>70 years old), with significant pain and functional deficits (for example pseudoparalysis). However, given the need for potential revision surgery, a degree of caution should be exercised before using it in younger patients.

Non-reconstructive arthroscopic procedures

To prolong function before a reverse total shoulder arthroplasty in younger patients, and for older patients who do not wish to undergo a reverse shoulder arthroplasty, a range

Key points

- Understanding the subtle differences between how patients and surgeons perceive failure following a rotator cuff repair surgery is crucial to providing the most appropriate form of treatment and directing expectations.
- Following a failed rotator cuff repair, worsening clinical symptoms do not always correlate to a structural failure, and even in the presence of a residual defect, there can still be an improvement in function provided there has been partial healing.
- Persistent symptoms after a rotator cuff repair should raise the possibility of infection, with *Staphylococcus epidermidis* and *Cutibacterium acnes* being the most isolated pathogens.
- After sustaining a retear, the majority of patients are still able to obtain an improvement in functional outcome.
- Although a satisfactory outcome can result from non-operative treatment, some patients remain refractory to this and require a more definitive solution. If a revision repair cannot be performed then other reconstructive options should be considered, such as a partial repair, the use of grafts, tendon transfers, a subacromial balloon spacer and subacromial decompression.
- If there has been a progression towards arthritis then reverse total shoulder arthroplasty may be the most suitable option, with or without glenohumeral osteoarthritis.

of salvage procedures can be used to provide some degree of pain relief. These include capsular release, biceps tenotomy, sub-acromial decompression (acromioplasty and bursectomy), implantation of a subacromial balloon spacer and debridement of the tear (Desmoineaux, 2019).

Conclusions

The management of patients with structural failure following a rotator cuff repair is challenging. Although a satisfactory outcome can be achieved from non-operative treatments, a proportion of patients remain refractory to this and require a more definitive solution. To formulate a management plan, careful clinical assessment and diagnostic evaluation must be conducted. For older patients with arthritis or a failed cuff repair without arthritis, a reverse total shoulder arthroplasty may be a suitable option. In younger patients without arthritis or in a selected group of older patients, further reconstructive surgery can be successful, although the decision depends upon patient preference, tear morphology and the extent of fatty infiltration.

Conflicts of interests

The authors declare that there are no conflicts of interest.

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