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ORIGINAL ARTICLE

The Relevance of Open Rotator Cuff Repair in 2021

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Abstract

Background The last decade has seen a large increase in rotator cuff surgery and arthroscopic surgery. We were asked to define the relevance of open rotator cuff repair in 2021.

Purpose To define whether there are proven advantages to arthroscopic or open rotator cuff repair surgery.

Method We reviewed the recent literature regarding recent trends, anaesthetic time, rehabilitation, post-operative pain, complications, economic considerations, the learning curve and outcomes. We outlined the senior authors' technique preferences, rationale and patient reported outcomes.

Results There is no clear evidence of proven advantage in arthroscopic rotator cuff repair compared to open rotator cuff repairs, with regard to outcomes or the other aspects reviewed. There were no differences in the outcomes of arthroscopic and open repairs in the senior authors practice with his procedure indications.

Conclusions Open rotator cuff repair surgery remains a valid option and has some appeal in specific indications and in settings where arthroscopic resources are limited. We believe surgeons should learn both techniques and the principles of good patient selection, tissue handling, and fixation techniques are of paramount importance in both arthroscopic and open rotator cuff surgery.

Keywords Shoulder · Rotator · Cuff · Arthroscopic · Open · Sports

Introduction

In the last 30 years, there have been major advances in many fields of medicine resulting in vastly improved outcomes. Techniques have changed and evolved. Elegant arthroscopic techniques are what most of us aspire to. In many countries, most rotator cuff surgery is performed arthroscopically. But has this resulted in shorter anaesthetic time, less post-operative pain, fewer complications, more rapid recovery, better economics, broader indications, and perhaps most importantly, better outcomes for patients? What are the ethics and practicalities of the learning curve? Let's examine those aspects with a review of the peer reviewed literature, mainly over the last decade, as well as opinion of the authors.

Recent Trends

A number of publications from the United States, reviewing insurance databases, have documented increasing numbers of rotator cuff repairs and in particular, increasing incidence of arthroscopic repairs in the last two decades. Jensen [1] reviewed Medicare data from 2005 to 2011 and the trends are illustrated in Fig. 1.

Day et al. [2] reviewed the Humana database from 2007 to 2015. There were 54,740 rotator cuff repairs, with 68% being arthroscopic and the rest open or mini-open. The proportion of arthroscopic procedures increased from 56.9% in 2007, to 75.1% in 2015. A Florida database [3] found a two-fold increase in rotator cuff repairs between 2000 and 2007, with a 353% increase in arthroscopic rotator cuff repair and corresponding decrease in the percentage of open repairs.

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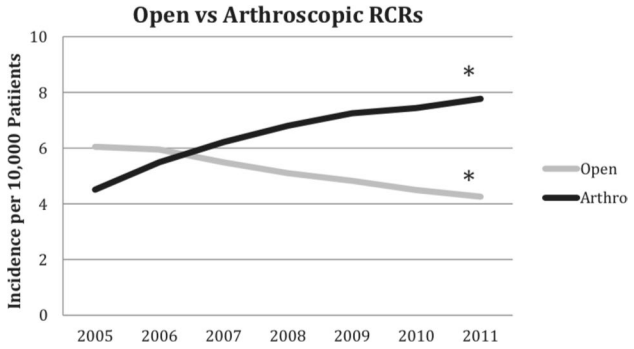

Fig. 1 Annual incidence of open and arthroscopic rotator cuff repairs per 10,000 Medicare (USA) patients. *Statistically significant trend, $p < 0.01$ (Reproduced with permission from The Orthopaedic Journal of Sports Medicine, 2017 [1])

Austin et al. [4] studied the spread of arthroscopic rotator cuff surgery in the United States using Medicare and Medicaid database figures from 2006 and 2014. Overall, there has been a great increase in the proportion of arthroscopic rotator cuff repairs, with substantial regional variation (Fig. 2).

The trends in other countries have not been documented in the literature. The New Zealand Rotator Cuff Registry [5] recorded data on 2441 rotator cuff repairs performed by 92 surgeons in 2009 and 2010, with significantly lower proportions of arthroscopic repairs compared to the United States data. In the New Zealand study, there were 17.3% arthroscopic procedures, 39.5% mini-open and 43.2% open procedures.

Anaesthetic Time, Surgical Steps and Rehabilitation

The literature reports open rotator cuff repair to be quicker than arthroscopic in large database series. Day et al. [6] reviewed the American College of Surgeons Quality Improvement Program database for 11,314 rotator cuff repairs performed from 2005 to 2013. The mean operative time was less in the open rotator cuff repair group at 78 min, compared to 91 min in the arthroscopic rotator cuff repair group ($p < 0$–001). Carr et al. [7] in the UKUFF multicentre trial reported a significantly shorter operative time in the open group compared to the arthroscopic group (57.2 min vs 69.4 min $p = 0.010$) and significantly shorter operating theatre time (87.6 min vs 100.3 min $p = 0.021$).

Regardless of the approach, rotator cuff repair surgery requires adequate visualization for diagnosis, planning and repair. The subacromial space should be adequately debrided and decompressed as required with bursectomy and acromioplasty. The rotator cuff may need to be mobilized with bursal

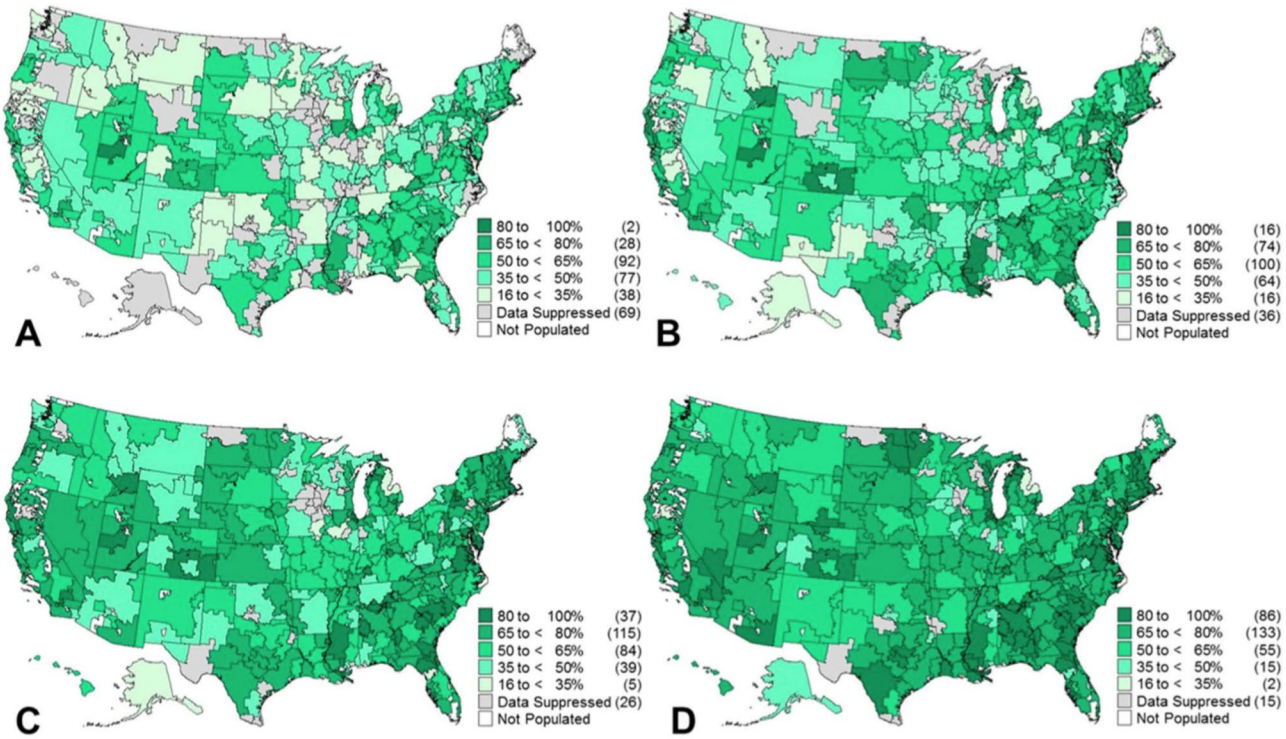

Fig. 2 The trend towards arthroscopic rotator cuff repair surgery over time. **a** 2006, **b** 2008, **c** 2011, **d** 2014 (Reproduced with permission from Clinical Orthopaedics and Related Research, 2019 [4])

side, coracohumeral ligament and articular side releases. The tuberosity in the region of the repair should be prepared and the rotator cuff attached, commonly with suture anchors. Some side-to-side soft tissue rotator cuff suturing may be required and the long head of biceps may also require tenotomy or tenodesis. We believe all these steps may be performed by the skilled arthroscopist or skilled open surgeon. Rehabilitation protocols are rarely if ever, to our knowledge, influenced by the approach. The healing time of the rotator cuff is the primary determinant of post-operative immobilization and rehabilitation protocols.

Postoperative Pain

Pain is a subjective phenomenon. Patient factors, surgical and pharmacological factors may contribute to the pain experienced. There may be significant variability between individual assessment among the different groups and requiring large sample sizes to detect differences.

Recent studies have not demonstrated improved pain outcomes with arthroscopic cuff repair in comparison to open repair. Pham et al. [8] described his experience after arthroscopic versus open rotator cuff repair. They concluded there was no evidence that arthroscopic repair was superior to open repair for postoperative pain. Carr et al. [9], in the UKUFF randomised controlled trial found no clinically important differences in pain between the arthroscopic and open groups two weeks from surgery. Williams et al. [10] found no difference in the duration of postoperative pain, presence of residual pain at 6 weeks post surgery, average weekly postoperative pain levels and analgesic use, cumulative postoperative pain levels and analgesic use. Kasten et al. [11] in their randomized controlled study showed that pain scores on the VAS were similar in the 3 weeks between the arthroscopic and mini open group, although fewer NSAIDs were needed in the arthroscopic group compared to mini-open group; however, from week 4 to 8, the mini-open group had less pain. They concluded there is no clear superiority of the arthroscopic technique regarding postoperative pain compared to the mini-open group in the first 3 months.

Modern postoperative pain strategies include nerve blocks administered by guided techniques, pain pumps and large volume infiltration with diluted local anaesthesia. We believe that postoperative pain can be well controlled and this should not be a factor in determining whether a patient has an arthroscopic or open repair.

Complications

Complications of rotator cuff surgery include inadequate improvement, infection, stiffness, failure of tendon healing or re-tears and deltoid problems. Other rare complications include acromial fracture, neurological injury and chondrolysis.

Day et al. [6] reviewed patients for early postoperative complications. Complications were rare with the overall complication rate 1.3%. The most common complications were unplanned return to the operating room (0.36%), urinary tract infections (0.30%), surgical infections (0.30%), and thromboembolic (0.36%). The authors found age above 65 years, open cuff repair and operative time greater than 90 min were predictive of complications. However, the paper reported the operative time to be mean 78 min for open repair and 91 min for arthroscopic repair. They also noted that patients in the open repair group were older, more frequently smokers ($p < 0.001$), alcohol abusers ($p < 0.38$), had COPD ($p < 0.0019$), hypertension ($p < 0.001$), were ASA 4 or 5 ($p < 0.0001$), and higher body mass index ($p < 0.001$).

Infection

Owens et al. [12] compared the complications in the United States Veterans data between the years 2003 and 2008 and concluded that prevalence of both superficial and deep wound infection was higher in the open group compared with the arthroscopic group. However, the incidence of deep infection was 0.3% in the open group compared to 0.1% in arthroscopic group. In a large sample size of 6975 open rotator cuff repairs and 2918 arthroscopic rotator cuff repairs, this might become statistically significant, but the clinical significance is debatable.

Day et al. [6] in their retrospective comparative study noted that patients who underwent open repair had a higher incidence of surgical site infection, 0.63% and 0.2% for open and arthroscopic repair, respectively. However, patients who underwent open rotator cuff repair were more likely to be older, current smokers, alcohol abusers, have hypertension, COPD, elevated body mass, and belong to the ASA classification of 4 or 5. The role of smoking [13] and elevated body mass [14] are well described. Jensen et al. [1] found the incidence of infection in the first 6 months as generally low but higher in the open repair group (0.86% in the open group vs 0.26% in the arthroscopic group) [1].

Based on the literature data available, there is a slightly higher rate of surgical site infection in open cuff repairs compared to arthroscopic repairs, particularly when mini-open is grouped with open repair. However, the open repair group may be heterogenous (larger, more complex tears, obese, older, etc.) and have other confounding factors which likely contribute. Antibiotic prophylaxis directed against Staphylococcus and Propionibacterium, surgical-site preparation with use of Chlorhexidine-based solutions for surgical preparation has been shown to reduce the risk of surgical-site infections.

Re-tear

Most studies over the last decade have not found a significant difference in the re-tear rate for arthroscopic of open repairs. Carr et al. [9] in the UKUFF study reported a re-tear rate of 46.4% in the arthroscopic group and 38.6% in the open group ($p=0.256$). All patients in their study were assessed with MRI or high-definition ultrasound 12 months after surgery. Bayle et al. [15] evaluated 44 arthroscopic repairs and 43 open repairs 12 months following surgery with ultrasound scans with re-tear rates of 7 and 9%, respectively. Cho et al. [16] in their study of arthroscopic and open repairs in large and massive tears with MRI scans at 6 or more months post-surgery reported a re-tear rate of 38% in the arthroscopic group and 30.4% in the open group ($p=0.74$). De Castro Veodaet al [17] also had similar re-tear rates between the open and arthroscopic group but their rehabilitation protocol was different. Then, open group had passive movements after 15 days whereas they waited for 28 days in arthroscopic group, partly because of concerns of re-tear in the arthroscopic group.

Deltoid Injury and Dehiscence

Open repair is performed through a formal take-down of the anterior deltoid and "mini-open" techniques involving deltoid split. Arthroscopic repairs involve multiple small splits in the deltoid, with usually 4 or more 1 cm incisions. Loss of the anterior deltoid can be a devastating complication of open cuff repair, as there are no reasonable fixation alternatives and the patient loses anterior deltoid function.

Cho et al. [16] specifically studied alterations in the deltoid after open and arthroscopic repairs. 135 patients underwent surgical repair for severely retracted large to massive tears, with 56 open repairs and 79 arthroscopic repairs. All patients had MRI scans 6 months post-surgery looking for deltoid detachment and measuring the deltoid thickness in five zones. There was no significant difference in the two groups. Attenuation of the proximal deltoid origin and atrophy were similar (both were 5.4% in the open group vs 5.1% in the arthroscopic group). These findings are consistent with our experience and we believe that a surgeon with the skill to perform a good arthroscopic repair would have the skill to carefully and effectively repair the anterior deltoid after open repair. We advise number 2 non-absorbable sutures, through the deltoid with the coracoacromial ligament and transosseous through the acromion.

Other Complications

Stiffness may be influenced by patient factors and rehabilitation. The study by Jensen et al. [1] reported that patients in the open repairs were more likely to undergo intervention for shoulder stiffness within 1 year of surgery than arthroscopic repairs (1.4% vs 1.1%, $p=0.01$). The difference was numerically small but reached statistical significance in this large study of 372,109 patients. Neurological injuries in rotator cuff repair are uncommon. Injuries may relate to patient positioning, anaesthetic nerve blocks, portals in arthroscopic surgery and axillary nerve injury in deltoid splitting for open surgery. Rotator cuff mobilization may cause injury to the suprascapular nerve. Thankfully, significant neurological injuries are rare and not a consideration in choosing the between an open or arthroscopic approach. Chondrolysis is uncommon but has been reported in association with intra-articular local anaesthetic pain pumps and may potentially occur with thermal injury with radiofrequency devices used in arthroscopic procedures [18]. Acromial fracture has been reported in literature and is associated with acromioplasty rather than rotator cuff repair. The cause of such acromial fractures is said to be mostly technical errors due to over-resection of the acromion.

Economic Considerations

In 2010, Adla et al. [19] looked at the cost-effectiveness of open versus arthroscopic rotator cuff surgery in a small cohort of patients ($n=30$). They factored in theatre costs (including staff wages), consumables (See Tables 1 and 2, below) and analgesia costs. They did not consider costs of infrastructure and maintenance, or indirect costs, such as absence from work and social costs. Although the clinical outcomes were similar (mean change Oxford score: 24.9 open vs 25.5 arthroscopic), the cost difference was £675 in favour of open. The cost of unit of improvement in the Oxford shoulder score was £7.84 for open vs £34.15 with arthroscopic techniques.

The setup cost of arthroscopy (monitors, camera, fibreoptic cable, stack etc.), however, is not insignificant.

Table 1 Consumables for arthroscopic surgery (Reproduced with permission from The Journal of Shoulder and Elbow Surgery, 2010 [18])

Item	Cost (£)
Drapes	23
Cannule	35
Connecting tubes	91
Saline	16
Acromionizer	78
Thermal probe	170
Needle for suture passer	90
Anchors (average, 1.8/case)	352
Sling (shoulder immobilizer)	15
Total	870

Table 2 Consumables for open surgery (Reproduced with permission from The Journal of Shoulder and Elbow Surgery, 2010 [18])

Item	Cost (£)
Drapes	15
Anchors (average, 0.4/case)	97
Saw blade	18
Diathermy tip	2
Ethibond suture	12
Sling (shoulder immobilizer)	15
Diagnostic arthroscopy (3 cases)	36
Total	195

Engineering care and maintenance costs of arthroscopic equipment are ongoing and must be considered.

Churchill and Ghorai [20] study of the New York State Ambulatory Surgery Database for the year 2006 for all rotator cuff repair surgery ($n=5224$) showed mini-open repair technique required less operative time and was less expensive than arthroscopic techniques.

The UK Rotator Cuff Surgery (UKUFF) trial published in 2015 [9], found a significant difference in total initial procedure-related costs between the arthroscopic group and the open repair group, with arthroscopic repair being more costly by £371 (95% CI £135–£607). The overall treatment cost at 2 years was £2567 (SD £176) for arthroscopic surgery and £2699 (SD £149) for open surgery, according to intention-to-treat analysis, which represented no significant cost difference, nor clinically significant difference in outcomes.

The delivery of healthcare and the funding structures across the globe vary widely. The provision of rotator cuff repair surgery and the associated payment structures is variable and multifactorial. However, if the same procedure is carried out open or arthroscopic, there may be a cost-saving in favour of open surgery, though this does not appear significant and may be equivocal over the course of the total patient journey.

The Learning Curve

The concept of a learning curve originates in aeronautical engineering, first published by Wright [21]. In this, he showed how, as experience and skill of the workforce increased, quality improved and industry measures, such as cost and production time decreased. It is, however, more complex when assessing clinician's performance.

A common misnomer in clinical use is the description of difficult, complex and technically demanding procedures as having a 'steep learning curve'. A steep learning curve is when the skills to perform a procedure are acquired rapidly

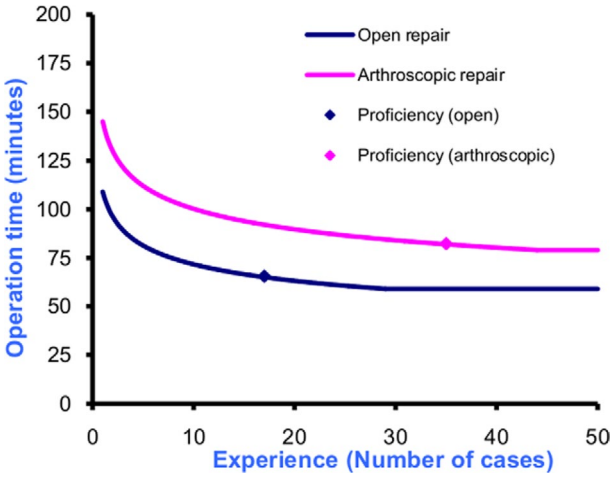

Fig. 3 Surgeons' perceived learning curve for rotator cuff surgery (Reproduced with permission from The PLOS One Journal, 2012 [23])

because it is simple. Complex procedures have a gradual learning curve with small progressive improvements [22].

There are numerous studies that have shown that the typical number of cases to reach the acceptable standard is 30–50 cases, again dependent on the complexity of the surgery and previous experience of the surgeon. It is also important to acknowledge that the learning curve is specific to an individual surgeon, not a given procedure. Though it may be methodologically correct in an efficacy-based randomised trial to exclude the learning curve, the learning curve needs to be acknowledged as part of the introduction of new techniques and technologies to have effective transparency when comparing two procedures.

As an aside to the UKUFF study, Cooke et al. [23] carried out a questionnaire to orthopaedic surgeons participating in the UKUFF study to gather perception and aggregate responses of the learning curves for both open and arthroscopic rotator cuff repair (Fig. 3). The summary distribution of surgeons' belief regarding the number of cases required (for a trainee) to acquire proficiency had median (IQR) of 17 (10–23) and 35 (23–50) cases, respectively, for the open and arthroscopic procedures summary distribution of surgeons' belief regarding the number of cases required (for a trainee) to acquire proficiency had median (IQR) of 17 (10–23) and 35 (23–50) cases, respectively, for the open and arthroscopic procedures. Overall, the distributions suggest substantial variation amongst trainees in acquiring proficiency for both procedures. However, the number of cases required to achieve proficiency has a lower mean value for open versus arthroscopic.

Regarding learning arthroscopic repair techniques, we recommend utilisation of skills laboratories and dedicated teaching. The clinical transition may include using

arthroscopic suture passing and knot tying techniques through open approaches and a willingness to convert from arthroscopic to open repair if required.

Outcomes

Over the last decade, a number of publications have compared the outcomes of open and arthroscopic rotator cuff repairs (Table 3). These range from single surgeon retrospective series through to multicentre prospective randomised controlled trials and one national registry study. Outcome measures using PROMS (patient reported outcome measurement scores) have not shown any consistent proven difference in the outcomes of arthroscopic versus open rotator cuff repairs.

The UKUFF randomised controlled trial (Carr [9] and Murphy [25]) recruited 273 patients (136 to arthroscopic surgery and 137 to open surgery) from 19 teaching and general hospitals in the United Kingdom. The two groups were well matched for age, (mean 62.9 years in both groups), gender (59.6% vs 64.2% male), other socioeconomic demographics, previous treatments (including cortisone injections) and tear size. In the 'Intention-to-treat' arm of the study, surgeons used their preferred method of repair. The primary outcome measure at 2 years was the Oxford Score (OSS). The OSS improved from 26.3 to 41.7 in the arthroscopic group and 25.0–41.5 in the open group (Fig. 4). There was no difference in the quality adjusted life years (QALYs) between the two groups.

In New Zealand, a Rotator Cuff Registry was established by The New Zealand Shoulder and Elbow Society under the leadership of Michael Caughey and Matt Brick, collecting data on 2418 rotator cuff repairs performed by 92 surgeons between March 2009 and December 2010 [5]. There were 418 (17.3%) arthroscopic, 956 (39.5%) mini-open and 1044 (43.2%) open procedures. Flex Shoulder Function (Flex SF) and pain scores were collected pre-operatively and at 6, 12 and 24 months post-operatively. Overall, good to excellent outcomes were found with

Table 3 Summary of recent trials assessing arthroscopic and open rotator cuff repair surgery

Author	Study design	Results (arthroscopic vs open)	Conclusion
Neviaser [24]	Retrospective cohort comparison 57 patients (18 Open, 39 Arthroscopic) single surgeon	Mean 29 months (min 11.7 months): ASES 80 vs 79	No difference
Carr [7]	Prospective, randomised, 19 hospitals (UKUFF Trial) 273 patients	Oxford Scores at 2 years	
		41.7 vs 41.5	No difference
		Re-tear at 1 year	
		46.4% vs 38.6%	No difference
Bayle [15]	Prospective 87 patients	At 1 year	No difference
		Constant Score 72 vs 75	No difference
		ASES 88 vs 91	No difference
		SSV 81 vs 85	No difference
		Re-tear 7% vs 9%	No difference
Bond [5]	Prospective registry data collection	At 2 years:	
	92 surgeons, 2418 patients	FLEX SF 40.4 vs 40.2	No difference
	418 Arthroscopic	Pain Score 1.4 vs 1.6	No difference
	956 Mini-open	Return to work by 3 months	
	1044 Open	55.3% vs 55.2%	No difference
Murphy [25]	UKUFF Trial quality of life measures	At 2 years	
		QALYs 1.34 v1.35	No difference
		EQ-5D 0.74 vs 0.76	No difference
Lucena [26]	Single surgeon consecutive cohort. Open, Arthroscopic knotted, Arthroscopic knotless (86 patients followed out of 159 patients)	Data included patient ranked pain and function scores (modified L'Insalata questionnaire)	Arthroscopic knotless repair group reported less difficulty with overhead activity than open group However, two way ANOVA found no difference in repair technique
De Castro Vaedo [17]	Prospective 60 patients	At 1 year: UCLA scores	
		93.5% vs 93.1%	No difference
		(good or excellent)	
		Re-tears 2 vs 3 patients	No difference

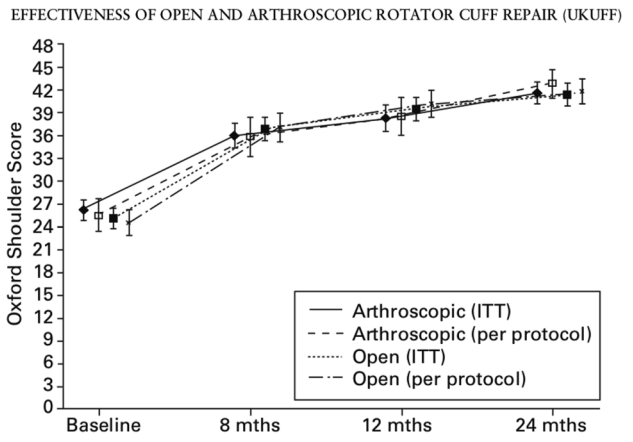

Fig. 4 Mean and 95% confidence intervals of Oxford Shoulder Scores for arthroscopic and open surgery for the Intention-to-treat (ITT) and per protocol analyses (Reproduced with permission from The Bone and Joint Journal, 2017 [9])

regard to improvements in pain and function at 2 years. A multivariate analysis was performed to determine if there was a difference in pain or functional outcome scores. 24 months' data were obtained in 71% of the patients. There was no difference in Flex SF or pain scores at 24 months (Fig. 5). There was also no difference in return to work times between the three groups.

Discussion

Although there is a major trend to increasing numbers of arthroscopic rotator cuff repairs, the literature does not define a clear advantage to arthroscopic rotator cuff repairs over open rotator cuff repairs. Studies report operative time is longer with arthroscopic repairs and infection rates lower. These differences are small and thankfully the infection rate is low. There is no consistently reported difference in post-operative pain, rehabilitation, return to work, costs, deltoid complications, re-tear rate or patient reported outcomes. Many of the outcomes reported in the literature are the results of expert and experienced surgeons. The complexity of learning arthroscopic techniques and the implications of the "learning curve" should be acknowledged. So, what is the role of open rotator cuff surgery in 2021? We come down to opinion and here is the opinion of one of the authors (KDM) with preferences and outcomes (Table 4).

Arthroscopic rotator cuff tear can be performed efficiently by the adequately skilled surgeon in most small- and medium-sized tears. The relative increase in operating time and difficulty in achieving good repair increase with large and massive tears. The author's preference has been to perform these open.

In a younger patient with an instability and posterosuperior cuff tear, both can be addressed arthroscopically. In an older patient with instability and a cuff tear, the main pathology to target is generally the rotator cuff tear. However, a HAGL injury combined with subscapularis injury can

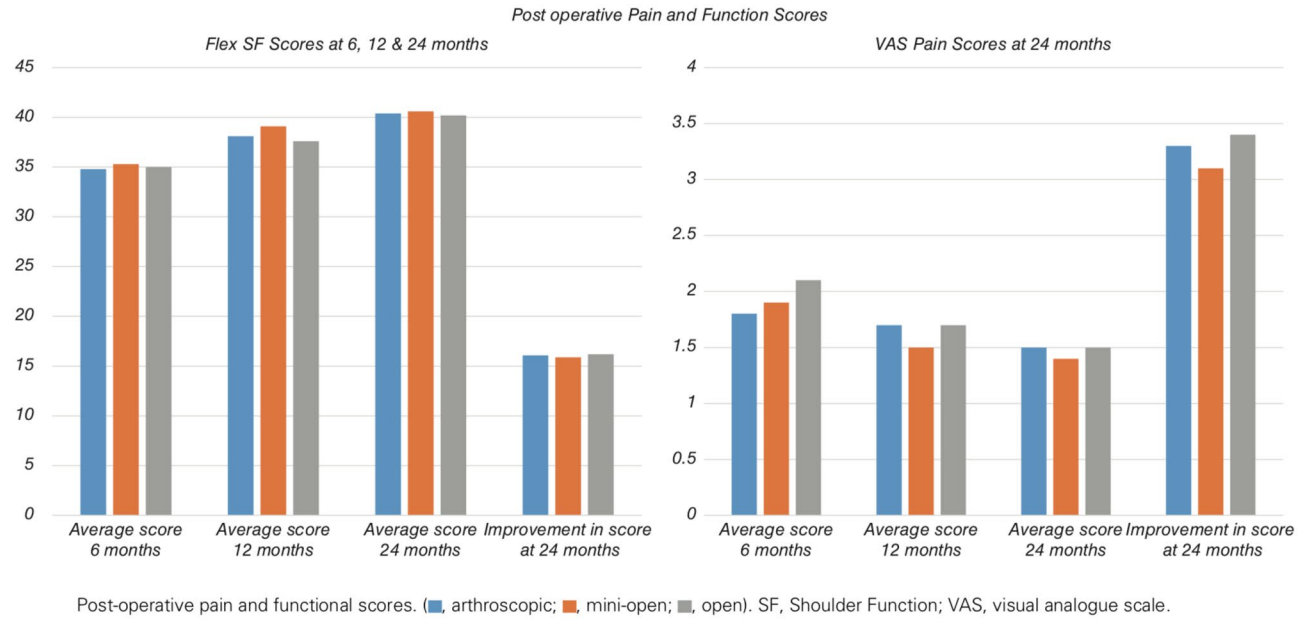

Fig. 5 Approaches for rotator cuff repair from New Zealand Rotator Cuff Registry results (Reproduced with permission from The ANZ Journal of Surgery, 2018 [5])

Table 4 Author (KDM) preference for decision open or arthroscopic

Arthroscopic preference	Open preference
Small and medium sized tears supraspinatus, infraspinatus and superior subscapularis	L shaped tears, significantly longer medial to lateral compared to anterior to posterior
Check for and treat intra articular pathology	Large and massive tears
Partial thickness tears	Complete tear subscapularis
Assess and treatment of long head of biceps pathology in small or medium rotator cuff tears	Poor quality tissue, extensive lamination
Assessment of repairability of large and massive tears	Revision repairs where arthroscopic has already failed
Superior capsule reconstruction with a graft	Superior capsule reconstruction with long head of biceps with partial repair of massive rotator cuff tear

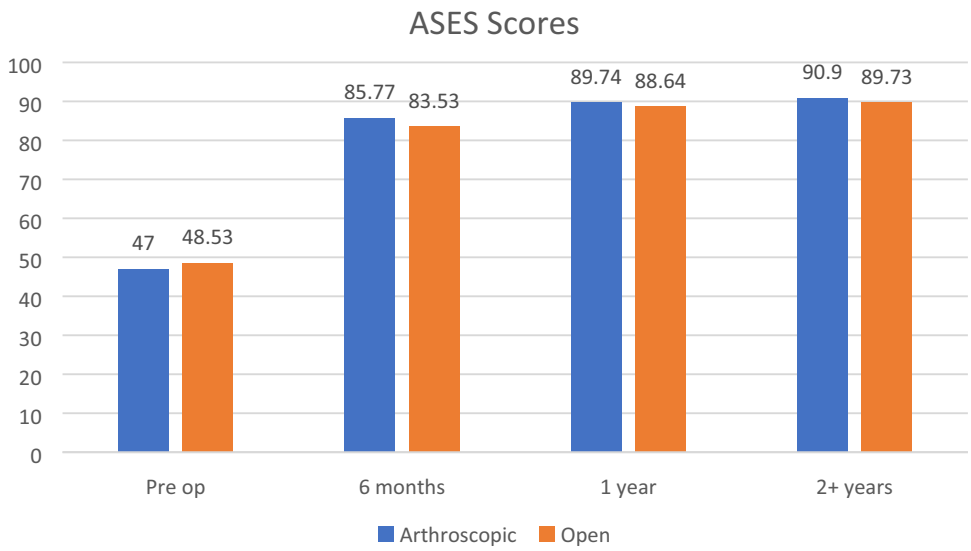

Fig. 6 Prospective American Shoulder and Elbow (ASES) Scores for Author KDM's 5 year continuous cohort (2013–2017) for all rotator cuff surgery

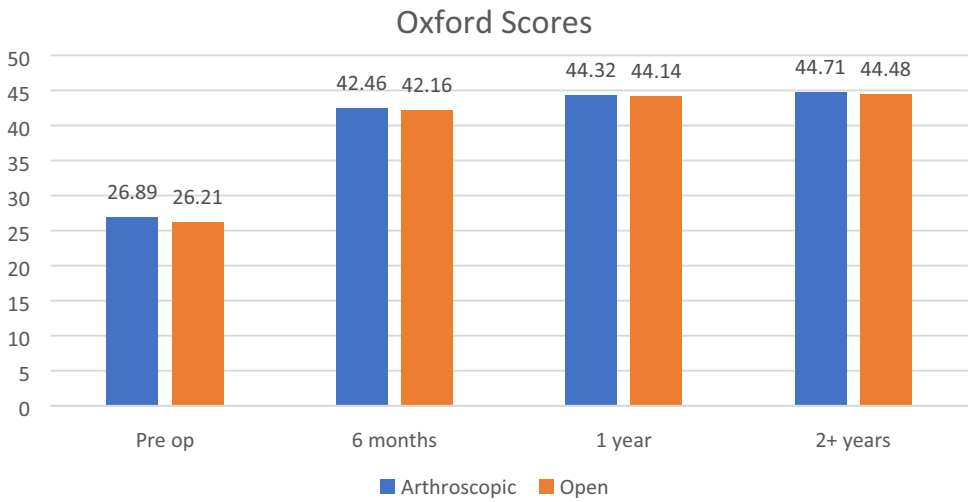

Fig. 7 Prospective Oxford Shoulder Scores (OSS) for Author KDM's 5 year continuous cohort (2013–2017) for all rotator cuff surgery

be well addressed open and one of the authors (KDM) has had experience with this in professional rugby players. In middle-aged and older patients, labral pathology is not commonly a significant pain generator compared to a rotator cuff tear and does not generally need to be targeted in the surgery.

Partial thickness tears are often on the articular side and certainly best evaluated and approached arthroscopically. The long head of biceps can be well visualized and treated in a large rotator cuff tear but the intra-articular portion cannot be visualized through a small rotator cuff tear.

If a surgical patient has a symptomatic rotator cuff tear with retraction towards the glenoid rim, satisfactory muscle quality (Goutalier Grade 1–2), no arthritis and mild narrowing of the subacromial space, you may not know until you attempt to mobilize the tendon if it is repairable. If not repairable, one option may be debridement, biceps tenotomy and rapid rehabilitation. In such a case, the patient may mobilize rapidly after an arthroscopic approach compared to a period of immobilization to protect the healing deltoid after an open approach. Of course, the options now for such a patient may potentially include superior capsule reconstruction and tendon transfer, but these are beyond the scope of this discussion. If the preoperative imaging indicates that the tear is not repairable (marked narrowing of the acromiohumeral interval, retraction beyond the glenoid, severe fatty degeneration of the cuff), then neither open nor arthroscopic surgery to attempt to repair the cuff are indicated. Superior capsule reconstruction with a graft that requires suturing to the glenoid requires an arthroscopic approach. If the long head of biceps is used for superior capsule reconstruction, this is easily performed open as it is already attached at the glenoid.

Open cuff repair has no disadvantage and may have advantage in some situations. Long L-shaped tears often have associated tendinopathic changes and may be impingement-related with a large subacromial spur. The large spur, bursal and surface laminated changes are easily dealt with open. The configuration of the tear and reduction are easily appreciated and repaired.

There is no muscle take-down in a deltopectoral approach, so subscapularis tears can be approached and treated without potential morbidity from the approach. Complete tears involving the whole subscapularis can be treated more easily open. For small- and medium-sized supraspinatus, infraspinatus and tears of the superior subscapularis, the author prefers arthroscopic repair.

Using these indications, the results of 805 primary rotator cuff repairs performed by one of the authors (KDM) between 2013 and 2017 are reported in Figs. 6 and 7. Superior capsule reconstruction was not performed in this cohort during this study period. Over this 5-year period, 55% of cases were performed arthroscopically. Outcome measures were collected prospectively with 99% of patients completing preoperative ASES scores and 96.5% completing preoperative Oxford scores. At a minimum of 2 years, we obtained ASES scores in 68% of patients and Oxford scores in 65% of patients, with lesser follow-up at 6 months (44%) and 1 year (63%). Although the case selection for open repair was generally larger tears, the patient-reported outcomes are very similar. At 1 year, the subjective percentage of normal rating was also very similar with arthroscopic repair patients rating their shoulders as 82% of normal and open repair patients rating their shoulders as 79% of normal. Both groups had a high satisfaction rating (90% for the arthroscopic group and 91% for the open group).

Conclusion

Increasing numbers of rotator cuff repairs are performed arthroscopically and result in good outcomes, as good as those reported with open techniques. We believe surgeons should train in and aspire to having expertise with open and arthroscopic rotator cuff repair techniques. There are some situations where arthroscopic techniques may confer a theoretical advantage, for example evaluating and managing partial thickness tears and biceps lesions. However, we also believe that surgeons should have competence with open techniques and personal preferences can be justified based on similar outcomes. There is an appeal to open techniques in larger tears with the relative ease of repair. More important than the approach may be appropriate patient selection, careful tissue handling, good mobilization and fixation techniques and expert rehabilitation. If a surgeon does not have access to arthroscopic resources, good outcomes can be obtained with good open surgery.

We agree with the editorial comment by Gil and Owens [27] in their Editorial Commentary in Arthroscopy (2018):

> *In cases where bone and tendon tissue quality is compromised, tear size is massive, or the skill set of the surgeon does not allow for an effective arthroscopic repair, an open approach may be preferable. We believe that it is important for shoulder surgeons to be facile with both techniques and apply them as needed to perform an effective repair.*

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent All patients who generated prospectively collected outcome data has given informed consent for it to be presented in this scientific journal.

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