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Arthroscopic, open and mini-open approach for rotator cuff repair: no difference in pain or function at 24 months

Elizabeth C. Bond,* Lynette Hunt,† Matthew J. Brick,‡ Warren B. Leigh,‡ Anthony Maher,§ Simon W. Young* and Michael A. Caughey¶

*Orthopaedic Department, Wellington Regional Hospital, Capital & Coast District Health Board, Wellington, New Zealand
†Department of Statistics, The University of Waikato, Hamilton, New Zealand
‡Orthosports North Harbour, Millennium Institute, Auckland, New Zealand
§Orthopaedic Department, Taranaki District Health Board, New Plymouth, New Zealand and
¶Auckland Orthopaedic Consultants, Auckland, New Zealand

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Correspondence
Dr Elizabeth C. Bond, Orthopaedic Department, Wellington Regional Hospital, Capital & Coast District Health Board, Private Bag 7902, Wellington 6242, New Zealand.
Email: elizabeth.bond@ccdhb.org.nz

E. C. Bond MBChB; **L. Hunt** MSc, DPhil; **M. J. Brick** MBChB, FRACS (Ortho); **W. B. Leigh** MBChB, FRACS (Ortho); **A. Maher** MBChB; **S. W. Young** MBChB, FRACS (Ortho); **M. A. Caughey** MBChB, FRACS (Ortho).

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Abstract

Background: The New Zealand Rotator Cuff Registry was established in 2009 to collect prospective functional, pain and outcome data on patients undergoing rotator cuff repair (RCR).

Methods: Information collected included an operation day technical questionnaire completed by the surgeon and Flex Shoulder Function (SF) functional and pain scores preoperatively, immediately post-operatively and at 6, 12 and 24 months. A multivariate analysis was performed analysing the three surgical approaches to determine if there was a difference in pain or functional outcome scores.

Results: A total of 2418 RCRs were included in this paper. There were 418 (17.3%) arthroscopic, 956 (39.5%) mini-open and 1044 (43.2%) open procedures. Twenty-four-month follow-up data were obtained for pain and Flex SF in 71% of patients. At 24 months, there was no difference in the average Flex SF score for the arthroscopic, mini-open and open groups. There was no difference in improvement in Flex SF score at 24 months. At 24 months, there was no difference in mean pain scores. There was no difference in improvement in pain score from preoperation to 24 months. Most patients returned to work within 3 months of surgery, with no difference between the three surgical approaches.

Conclusion: RCR has good to excellent outcomes in terms of improvement in pain and function at 2-year follow-up. We found no difference in pain or functional outcome at 24 months between arthroscopic, open and mini-open approaches for RCR.

Introduction

In recent years, there has been a shift towards all-arthroscopic rotator cuff repair (RCR),[1,2] with the goal of minimizing surgical trauma and providing a more rapid recovery. However, there is limited comparative literature on the choice of surgical approach, and no consensus on the most efficacious surgical approach for the repair of full thickness rotator cuff tears. The ISAKOS Committee was unable to recommend a specific approach, citing a lack of comparative studies.[3,4] Systematic reviews on this topic have been unable to draw firm conclusions, due to limited and conflicting evidence from often underpowered studies.[5,6] The New Zealand Rotator Cuff Registry was established to collect functional, pain and outcome data on patients undergoing RCR. To our knowledge, it forms the largest prospective study of RCRs and presents multicentre, multisurgeon data from across New Zealand in a real-world analysis.

The purpose of this study is to determine whether surgical approach affects clinical outcome following RCR, with the null hypothesis that there was no difference between the three groups.

Methods

The New Zealand Rotator Cuff Registry collected information from 92 surgeons across New Zealand from 1 March 2009 to 31 December 2010. All surgeons performing RCRs in New Zealand were invited to participate. Patient enrolment concluded in December 2010; however, prospective follow-up data

continues to be collected. Approval was obtained from the National Ethics Committee. Procedures included primary repairs of full thickness RCRs. Revision surgery and isolated subscapularis repairs were excluded from this analysis. Recruitment occurred at the time of booking, and patient consent was obtained. Patients who were recruited but did not proceed to surgery or did not complete the preoperative questionnaires were excluded.

The preoperative questionnaire collected baseline demographic information, including age, gender, self-reported ethnicity, hand dominance, smoking status, recreational/occupational activity, duration of symptoms and whether the tear was related to trauma. The Flex Shoulder Function (SF) score is a validated shoulder-specific functional assessment score that is rated highly when compared to other shoulder scores.[7–9] A lower score represents a greater disability. Pain scores were ascertained by a four-question, self-administered questionnaire about pain status over the preceding month using the visual analogue scale (VAS).

An operation day questionnaire was completed on the day of surgery by the primary operating surgeon. Technical information collected included the surgical approach (arthroscopic, mini-open and open), type of repair (single row and double row), suture type, type and number of anchors, any associated acromioplasty, distal clavicle resection and/or long head of biceps intervention (tenodesis and tenotomy).

The operative approach was considered arthroscopic when the entire repair was performed through arthroscopic ports, mini-open if the acromioplasty was done arthroscopically with no deltoid detachment or open if the tear was directly visualized and repaired through an incision with deltoid takedown.

Intraoperative findings were recorded including which tendons were involved, tendon quality, tear size and presence of long head of biceps or labral pathology. Tears were classified as partial or full thickness. Tendon quality was reported as poor, thin, good (some deterioration) or very good (normal thickness). Tear size was reported in both the anterior–posterior (AP) dimension and extent of retraction. The tear size, retraction and tendon quality were estimated by the operating surgeon on the day of surgery – surgeons were asked to compare tear size to an instrument of known diameter (e.g. a probe). Tear size was classified into five categories intraoperatively and further categorized into two categories (<3 cm and >3 cm) for the purposes of statistical analysis. Tear area was a multiple of AP tear size and tear retraction.

Flex SF, VAS pain scores and return to work/recreational information were collected at 6, 12 and 24 months post-operatively.

Statistical analysis

Data were analysed using GenStat 18 (VSN International, Hemel Hempstead, UK) and Minitab 17.2 (Minitab Inc., State College, PA, USA) softwares with the assistance of a professional statistician (LH). Differences between groups were considered statistically significant when *P*-values were <0.05. ANOVA testing was used for univariate analysis between the three groups. A multiple linear regression model was used to control for potential confounders and assess the Flex SF score at 24 months, pain score at 24 months, improvement in pain at 24 months and improvement in Flex SF at 24 months. This included the following variables: age, ethnicity, gender, smoking status, repair technique (single or double row), fixation method, concurrent acromioplasty, biceps tendon intervention, tendon quality, surgical approach, tear retraction and tear size (AP).

Results

A total of 2441 RCRs were included in the registry, of which 2418 had the surgical approach recorded and met the inclusion criteria for this study. There were 418 (17.3%) arthroscopic, 956 (39.5%) mini-open and 1044 (43.2%) open procedures. Twenty-four-month follow-up data were obtained for pain in 1734 (71%) and Flex SF in 1749 (71.7%) patients.

Demographics

The majority of patients were males and below the age of 65 years, and a similar age distribution was seen across all three groups. The three groups were comparable with regard to smoking status, type of repair and associated procedures, but the arthroscopic group had a higher proportion of suture anchors used as the method of fixation (Table 1). Pain at 24 months was significantly higher in smokers and those with larger tears, and Flex SF score at 24 months was significantly lower in tears with poor tendon quality, larger tear size and more retraction (Table 2). Of the patients lost to follow-up (29%), there were 14.6% who had an arthroscopic, 41.6% mini-open and 43.7% open approach. This is comparable to 17.3%, 39.5% and 43.2%, respectively of the overall numbers of the patients included in the study who we have complete follow-up data for.

Tear factors and surgical approach

Tear area was significantly smaller in the arthroscopic group, compared to mini-open and open approaches (Table 3, $P < 0.005$). Larger tears tended to be managed with an open approach with more tears over 3 cm in the open group compared to arthroscopic and mini-open groups ($P < 0.005$). There were more retracted tears in the open group ($P < 0.005$). Surgical approach was independent of tendon quality with a similar distribution across all three groups, and the majority of tendons were of good quality in all the three groups (Table 3).

Clinical outcomes

At 24 months, there was no difference in the average Flex SF score – arthroscopic group 40.4 (95% confidence interval (CI): 39.5–41.3), mini-open group 40.6 (95% CI: 39.9–41.3) and open group 40.2 (95% CI: 39.6–40.8) ($P = 0.646$). There was also no difference in the improvement in Flex SF score at 24 months – 16.1 (14.9–17.3) points in the arthroscopic group, 15.9 (15–16.8) in the mini-open group and 16.2 (15.3–17.1) in the open group ($P = 0.892$) (Fig. 1).

At 6 months, there was no difference in mean Flex SF between the three groups ($P = 0.219$) with the arthroscopic group at 34.7 (33.6–35.7), mini-open group at 35.4 (34.6–36.3) and open group at 34.4 (33.6–35.2). At 12 months, the mini-open group had a

Table 1 Characteristics of patient groups

	Arthroscopic	Mini-open	Open
Age			
>65 years	95 (22.7%)	194 (20.3%)	240 (23%)
<65 years	317 (75.8%)	758 (79.3%)	799 (76.5%)
Not recorded	6 (1.4%)	4 (0.4%)	5 (0.5%)
Sex			
Male	266 (63.6%)	683 (71.4%)	739 (70.1%)
Female	152 (36.4%)	273 (28.6%)	305 (29.9%)
Not recorded	0	0	0
Smoking status			
Smoker	30 (7.2%)	62 (6.5%)	50 (4.8%)
Non-smoker	238 (56.9%)	453 (48.4%)	413 (39.6%)
Not recorded	150 (35.9%)	441 (46.1%)	581 (55.7%)
Fixation method			
Bone tunnels	0 (0%)	84 (8.8%)	110 (10.5%)
Suture anchors	392 (93.8%)	672 (70.3%)	681 (65.2%)
Combination	1 (0.2%)	173 (18.1%)	174 (16.7%)
Not recorded	25 (6%)	27 (2.8%)	79 (7.6%)
Type of repair			
Single row	174 (41.6%)	389 (40.7%)	399 (38.2%)
Double row	221 (52.9%)	493 (52.6%)	568 (54.4%)
Not recorded	23 (5.5%)	74 (7.7%)	77 (7.4%)
Associated acromioplasty			
Yes	392 (93.8%)	884 (92.5%)	997 (95.5%)
No	26 (6.2%)	72 (7.5%)	47 (4.5%)
Not recorded	0	0	0
Bursectomy			
Nil	11 (2.6%)	52 (5.5%)	90 (8.6%)
Limited	93 (22.2%)	424 (44.4%)	546 (52.3%)
Extensive	313 (74.9%)	474 (49.5%)	396 (37.9%)
Not recorded	1 (0.3%)	6 (0.6%)	12 (1.1%)
Distal clavicle resection			
Yes	40 (9.6%)	38 (4%)	74 (7.1%)
No	364 (87.1%)	854 (90.3%)	907 (86.9%)
Not recorded	14 (3.3%)	64 (6.7%)	63 (6%)
Long head of biceps intervention			
Left *in situ*	218 (52.2%)	306 (32%)	397 (38%)
Tenodesis	28 (6.7%)	170 (17.8%)	193 (18.5%)
Tenotomy	104 (24.9%)	250 (26.2%)	135 (12.9%)
Not recorded	68 (16.2%)	230 (24%)	319 (30.6%)

higher Flex SF score (39.1, 38.4–39.9) compared to the open group 37.6 (36.8–38.4, $P = 0.018$). The arthroscopic group Flex SF score (38.1, 36.9–39.3) was not significantly different from the mini-open group.

At 24 months, there was no difference in mean VAS pain scores between the three groups: 1.4 (1.3–1.6) for arthroscopic, 1.4 (1.3–1.5) for mini-open and 1.6 (1.5–1.7) for open ($P = 0.539$). There was no difference in improvement in pain score from preoperation to 24 months which was 3.3 (3.1–3.6) for the arthroscopic group, 3.1 (2.9–3.3) for the mini-open group and 3.4 (3.2–3.6) for the open group ($P = 0.086$) (Fig. 1).

At 6 months, the arthroscopic and mini-open groups had lower mean pain scores of 1.8 (1.6–2) and 1.9 (1.8–2.1), respectively, compared to the open group – 2.1 (1.9–2.2, $P = 0.048$). At 12 months, the mini-open group had a lower mean pain score (1.5, 1.3–1.6) than the arthroscopic (1.7, 1.5–1.9) and open groups (1.7, 1.6–1.8, $P = 0.014$).

There was no difference in the return to work time post-surgery between the three surgical approaches ($P = 0.071$). Most patients returned to work at 1 month or less (24.9% in arthroscopic, 26.4% in mini-open and 24.4% in open) or 1–3 months (30.4% in arthroscopic, 29% in mini-open and 30.8% in open).

Multivariate analysis

There was no difference in Flex SF at 24 months, improvement in Flex SF, pain score at 24 months or improvement in pain score between the three surgical approaches when the potential confounding variables were accounted for. Patients with a larger tear size had a lower Flex SF score at 24 months ($P = 0.018$), a lower improvement in Flex SF ($P = 0.012$) and a higher pain score at 24 months ($P = 0.05$) but no difference in pain improvement. Smokers had a higher pain score at 24 months ($P = 0.018$), but there was no difference between smokers and non-smokers in terms of pain improvement.

Discussion

Functional outcome has been shown to correlate with the integrity of the rotator cuff[10] and RCR has overall been shown to be an effective procedure with high patient satisfaction.[11] The results of this study would support this as it showed excellent improvement in pain and function following RCR regardless of the chosen surgical approach. Increasing numbers of arthroscopic RCR are being performed;[1,2] however in this study, we were unable to confirm the

Table 2 Univariate analysis of Flex Shoulder Function (SF) and pain scores at 24 months by demographic variable

	Mean Flex SF at 24 months	Mean VAS pain at 24 months
Smoking status		
Non-smoker	40.37	**1.29**
Smoker	40.05 (*P* = 0.737)	**1.86 (*P* = 0.018)**
Repair pattern		
Double row	40.38	1.47
Single row	40.54 (*P* = 0.711)	1.45 (*P* = 0.774)
Fixation method		
Bone tunnels	40.68	1.51
Suture anchors	40.70	1.43
Combination	40.36 (*P* = 0.790)	1.46 (*P* = 0.820)
Acromioplasty		
No	38.44	1.75
Yes	40.47 (*P* = 0.052)	1.44 (*P* = 0.085)
Biceps intervention		
Left *in situ*	**40.81**	1.43
Tenodesis	**40.26**	1.37
Tenotomy	**39.82 (*P* = 0.00)**	1.47 (*P* = 0.589)
Tendon quality		
Very good	**41.14**	1.47
Good	**40.81**	1.41
Thin	**38.47**	1.55
Poor	**37.28 (*P* = 0.00)**	1.52 (*P* = 0.394)
Tear size (anterior–posterior) (cm)		
<1	**41.86**	**1.34**
1.1–2	**41.33**	**1.41**
2.1–3	**40.32**	**1.44**
3.1–4	**39.92**	**1.45**
4.1–5	**36.40 (*P* = 0.00)**	**1.74 (*P* = 0.01)**
Tear retraction (cm)		
<1	**41.34**	**1.50**
<1.1–2	**40.80**	**1.39**
<2.1–3	**39.72**	**1.38**
<3.1–4	**39.74**	**1.48**
<4.1–5	**35.92 (*P* = 0.00)**	**1.89 (*P* = 0.002)**

Bold value indicates statistically significant result. VAS, visual analogue scale.

Table 3 Tear size, retraction and area, tendon quality and surgical approach

	Retraction (cm)		AP tear size (cm)		Average area (cm^2)	Very good	Tendon quality		
	0–3	3.1–5	0–3	3.1–5			Good	Poor	Thin
Arthroscopic	356 (91.8%)	32 (8.2%)	350 (84.5%)	64 (15.5%)	3.85	142 (34.5%)	230 (55.8%)	9 (2.2%)	31 (7.5%)
Mini-open	783 (86.6%)	121 (13.4%)	749 (78.8%)	202 (21.2%)	4.84	238 (25.5%)	531 (56.9%)	54 (5.8%)	110 (11.8%)
Open	779 (79.1%)	206 (20.9%)	713 (69.5%)	313 (30.5%)	5.76	197 (20.2%)	552 (56.7%)	71 (7.3%)	154 (15.8%)

AP, anterior–posterior.

theoretical advantages of a less invasive arthroscopic repair on clinical outcome.

Proponents of the arthroscopic technique argue that it is minimally invasive requiring less soft tissue dissection and that it avoids the morbidity associated with deltoid takedown with a lower risk of complications, such as post-operative stiffness.[4,12–14] It also allows the surgeon to evaluate the glenohumeral joint and treat any related pathology simultaneously.[3,4,13] Arthroscopic repair has a higher cost–utility ratio than open or mini-open repair,[15] has a longer mean operating time[16] and is associated with a significant learning curve for the operating surgeon.[17,18] Open RCR is the gold standard for comparison when developing new techniques. Mini-open RCR was developed to circumvent the disadvantages of both open and arthroscopic techniques.[14,19] Mini-open RCR conveys the major diagnostic advantage of arthroscopic repair, and gives the surgeon the ability to perform transosseous fixation and theoretically better footprint restoration.[20]

There have been four randomized controlled trials comparing arthroscopic to mini-open RCRs – none of which has showed a difference in clinical outcome between these two approaches. Zhang *et al.*[21] had a total study population of 125 patients and showed that the University of California shoulder score, American Shoulder and Elbow Surgeons shoulder index and muscle strength were significantly increased in both groups at 24 months with no significant difference between the groups. There was however a higher re-tear rate in the arthroscopic group. van der Zwaal *et al.*[17] found no difference in pain, function, range of motion

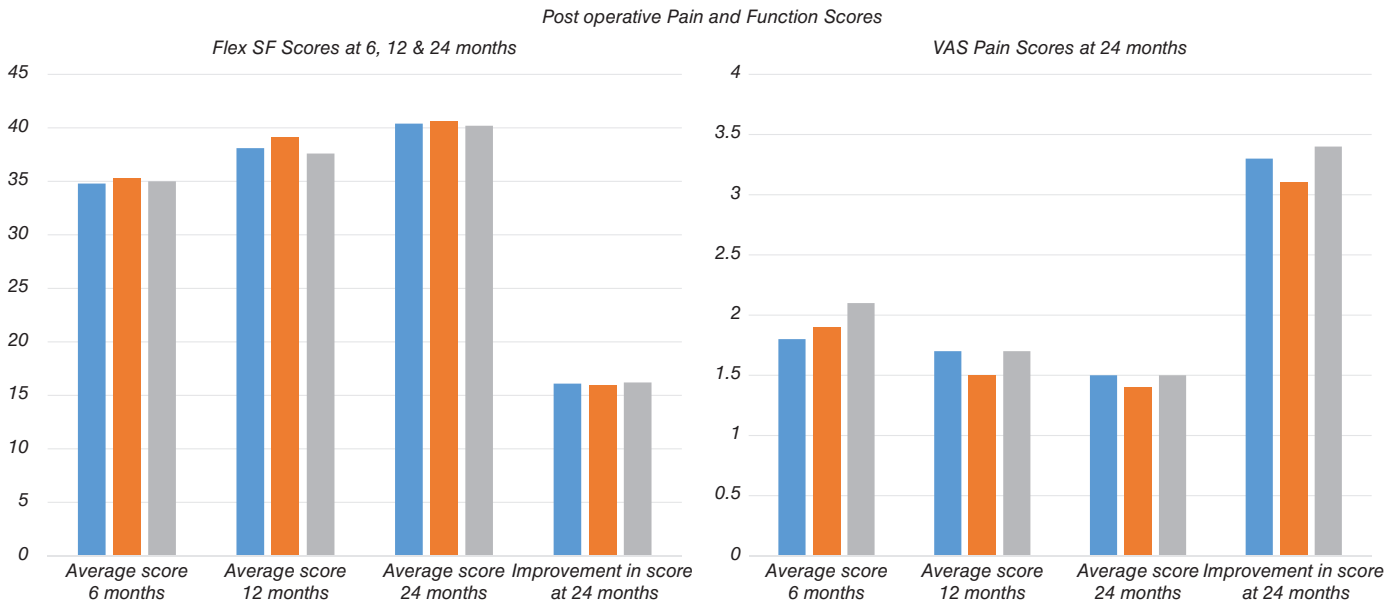

Fig. 1. Post-operative pain and functional scores. (■, arthroscopic; ■, mini-open; ■, open). SF, Shoulder Function; VAS, visual analogue scale.

(ROM) or complications between patients treated with arthroscopic or mini-open RCR at 1-year post-surgery. Similarly Cho *et al.*[22] found no difference in clinical outcome between these two approaches, although the arthroscopic group had a lower pain score at days 1 and 2 with less use of additional analgesics. However, this did not lead to improved ROM or a shorter rehabilitation period, this may be because healing time is unchanged regardless of repair technique. The pain scores at 6 months in this study are also lower for the arthroscopic and mini-open groups; however, these differences diminish with time. Kasten *et al.*[23] aimed to evaluate post-operative pain and ROM and also found less use of analgesia in the first week, but the mini-open group in their study had less pain from weeks 4 to 8. All parameters were similar between the groups at 6 months.

Shan *et al.*[24] combined three of these randomized controlled trials along with a number of retrospective comparative studies in a meta-analysis with a total of 770 patients and found no difference in functional outcome, pain scores, re-tear rate or the incidence of adhesive capsulitis between arthroscopic and mini-open RCRs. Our study supports the findings of these reviews in a large prospective cohort of 2441 patients, is the first study to compare the three surgical approaches simultaneously and is the largest study on surgical approach to RCR to date.

Limitations

Firstly, we assessed clinical outcome at 24 months post-surgery; therefore, many potential early benefits of a minimally invasive approach were not evaluated. However, surgeons can be reassured that any such benefits do not seem to alter mid-term outcome. Secondly, the majority (>75%) of tendons in this study were judged to be of good or very good quality; similarly, the majority of tears were <3 cm in size and <3 cm retracted. Tear size and retraction are important, but accurate measurement is difficult to standardize between surgeons. The size of tear did differ between the groups, with open tears tending to be managed with an open procedure. We accounted for this with our multivariate analysis. Finally, the preoperative and follow-up assessments were based on questionnaire and no objective physical examination findings were included. We did not have access to pre- or post-operative magnetic resonance imaging findings. The type of tendon rupture and amount of muscle fatty infiltration may affect outcomes but were unable to be assessed in this study. Loss to follow-up was significant (29%) despite attempts to minimize this. However, the proportions of those lost to follow-up were similar to those of the overall study population and should not affect the conclusions drawn from these data.

Conclusions

In summary, this 'real-world' clinical study with a large number of patients found no difference in mid-term outcome between arthroscopic, mini-open or open RCR. It showed that there was no difference in pain or functional outcome scores between the three groups at 24 months; however, the open group had marginally higher pain scores at 6 months. Surgical approach in RCR should be based on the surgeon's ability to achieve optimal repair in an individual patient.

Conflicts of interest

None declared.

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