Long-term results of arthroscopic and mini-open repair of small- to medium-size full-thickness rotator cuff tears

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Abstract

Background: This retrospective cohort study evaluated functional outcome and structural integrity after arthroscopic or mini-open repair of small- to medium-size rotator cuff tears assessed at long-term follow-up.

Methods: All patients operated between 2001 and 2004 were invited to participate. Functional outcome was measured by Constant–Murley Score, Disability of Arm, Shoulder and Hand and Oxford Shoulder Score. Quality of life was assessed with EuroQol Health 5 Dimension. Patient satisfaction was assessed in terms of pain and overall result. Structural integrity of the rotator cuff repair was determined using ultrasound.

Results: Of the eligible 62 patients, 44 patients were available for follow-up. After a mean of 11.3 years, 76% of the patients had good to excellent functional outcome on the Constant–Murley Score (median 82, range 29–95). The majority of patients reported good results on both Disability of Arm, Shoulder and Hand and Oxford Shoulder Score (median Disability of Arm, Shoulder and Hand 5.0, range 1.0–54; median Oxford Shoulder Score 19, range 13–39). The quality of life was also good (mean EuroQol Health 5 Dimension utility score 0.88, standard deviation 0.12). Eighty per cent was satisfied with the overall result. Ultrasound examination revealed structural integrity in 76% of all cases.

Conclusion: This study shows that functional outcome is good and structural integrity is high for the majority of patients 11.3 years after repair of small- to medium-size rotator cuff lesions.

Keywords

rotator cuff repair, satisfaction, ultrasound, functional outcome, long-term results, quality of life

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Introduction

The purpose of repairing a rotator cuff tear is to decrease pain and to improve shoulder function. With the evolution of arthroscopic instruments and techniques, rotator cuff repair evolved from an open procedure to a mini-open and eventually a full arthroscopic procedure. Studies comparing mini-open and arthroscopic repair concluded that there was no significant difference in outcome between both surgical techniques.^{1,2} Being a less invasive technique, arthroscopic methods are nowadays considered standard care in repair of rotator cuff tears. The reported advantages of an arthroscopic procedure include less post-

operative pain, shorter length of hospital stay, less wound complications and earlier return to work and sports.³ On the other hand, arthroscopic procedures are technically demanding and are accompanied with higher costs.⁴ Previous studies showed that short-term

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results (1–2 years of follow-up) and medium-term results (five years of follow-up) of both mini-open and full arthroscopic rotator cuff repair are good, regarding range of motion, function, pain and strength of the shoulder.^{5–9} However, re-tear rates of 7% to even 69% have been reported.¹⁰ Some reports suggest that rotator cuff insufficiency is a risk factor for developing cuff arthropathy and could lead to the indication for reversed shoulder arthroplasty.¹¹ Achieving a durable rotator cuff repair potentially may avoid the need to perform tendon transfers or reversed arthroplasty. In literature there is a lack of literature reporting the long-term results of repair of these small- to medium-size rotator cuff lesions.^{12,13} Therefore, the aim of the current study is to gain more insight in the long-term functional outcome of arthroscopic (or arthroscopic assisted mini-open) repair of small- to medium-size rotator cuff lesions. We hypothesized that rotator cuff repair of small- to medium-size lesions will fail and produce unfavourable outcome scores and patients will become unsatisfied.

Methods

This single centre retrospective cohort study has been performed according to the declaration of Helsinki and amendments and approved by the institutional Medical Ethical Committee.

All patients, older than 50 years who were diagnosed with a small- to medium-size traumatic or non-traumatic rotator cuff tear and who underwent either arthroscopic or arthroscopic-assisted mini-open rotator cuff repair between January 2001 and December 2004 in our centre, were invited to participate in this study. These patients were operated by one of two surgeons. In all tears at least, the supraspinatus tendon was involved. Patients with a full-thickness tear of the supraspinatus with involvement of only the anterior part of the supraspinatus tendon (not extending in other tendons) were classified as having a partial tendon size or small-size lesion. Rotator cuff tears comprising at least the entire footprint of the supraspinatus and partial involvement of infraspinatus or subscapularis were classified as medium-size lesions. Patients were excluded when treated with only a debridement for a partial thickness supraspinatus tear, as well as patients with significant concomitant lesions of the subscapularis tendon requiring surgical repair, or in case only partial rotator cuff repair could be achieved. Rotator cuff tears comprising both supraspinatus and the entire infraspinatus or subscapularis tendon were regarded as large size tears and therefore excluded. Other exclusion criteria were inadequate knowledge of Dutch language, ipsilateral shoulder injury such as fractures or acromioclavicular separation, shoulder

dislocation or neurological conditions influencing upper limb or not signing informed consent.

Surgical technique

All patients underwent arthroscopic evaluation and subsequently either arthroscopic repair or arthroscopic assisted mini-open rotator cuff repair in the lateral decubitus position. The edges of the rotator cuff lesions were debrided together with the footprint of the rotator cuff on the greater tubercle. Rotator cuff repair was performed using one anchor in case of small lesions or two anchors for medium-size lesions for medial row fixation. Additional lateral row fixation was performed in case reconstruction of the footprint could not be achieved. Subacromial decompression was performed when a subacromial bone spur was encountered. If necessary, tenotomy or tenodesis of the long head biceps tendon was performed depending on preoperative informed consent.

Two weeks post-operatively, patients visited the outpatient clinic and started physiotherapy subsequently. During the first six weeks after surgery all patients used a shoulder immobilizer and motion was restricted to passive mobilization up to 90° abduction and elevation. After six weeks, active motion was gradually promoted initiating strengthening exercises after four months.

Outcome assessment

To evaluate the clinical long-term outcome, participants were physically examined and subsequently underwent ultrasound examination of the shoulder. In addition, subjects were asked to fill out questionnaires and patient-reported outcome measures (PROMs). In case of a bilateral rotator cuff repair, data were collected only from the first operated shoulder. Participants who were not willing to visit the outpatient clinic completed and returned questionnaires and PROMS only. In case of missing data, these were retrieved by subsequent telephone enquiry.

The Constant–Murley Score (CMS)¹⁴ was used to assess the function of the shoulder by patient-reported subjective findings and by physically assessing the degree of strength and range of motion (elevation, abduction, internal and external rotation) of the shoulder. Both raw total CMS was calculated (0–100), as well as the age- and gender-adjusted percentage thereof, according to Katolik et al.¹⁵ A CMS score higher than 70 was classified as good, higher than 85 as excellent.

PROMs were assessed by the Disability of Arm, Shoulder and Hand (DASH),¹⁶ the Oxford Shoulder Score (OSS),¹⁷ the EuroQol Health 5 Dimensions (EQ5D3L) and a patient satisfaction questionnaire.^{18,19} The DASH is a self-report questionnaire (scale 0–100)

designed to measure physical function and symptoms in patients with musculoskeletal disorders of the upper limb. A higher score indicates a greater disability.

The OSS (scale 12–60) is a self-report questionnaire focussing on shoulder complaints experienced in the past six months, three months and four weeks.

The EQ5D3L is a self-report questionnaire, which measures the health-related quality of life. It has two scores: the EQ5D3L utility score (−0.59 to 1) and the EQ VAS based on visual analogue scale (VAS, 0–100) where the endpoints are labelled ‘best imaginable health state (100)’ and ‘worst imaginable health state (0)’.^{18,19} Patient satisfaction was assessed using four questions concerning the reduction of pain, general satisfaction with the overall result, whether the subject would repeat the operation and if they would recommend it to others. The questions were scored on a five-point scale (Completely Agree, Agree, Neutral, Disagree, Completely Disagree). For the analysis, answers were dichotomized to ‘Agree’ or ‘Neutral or Disagree’.

The self-report part of the CMS and all other PROMs were filled out either using QuestManager Software (Vital Health, Ede, Netherlands) or on paper if that was preferred by the subject.

Ultrasound examination of the integrity of the rotator cuff was performed with dedicated equipment (Philips iU22, linear array, 12 MHz transducer) by two experienced musculoskeletal radiologists. Radiologists were blinded for the specific surgical procedures that subjects had undergone. A standardized ultrasound examination of the rotator cuff was performed.²⁰ The rotator cuff was classified as either ‘intact’, or ‘full-thickness rupture’ for each separate rotator cuff tendon.

Statistical analysis

Microsoft Office Excel 2003 (Microsoft, Redmond, US) was used for data entry and SPSS 20.0 (IBM Inc., NY, US) for statistical analyses. Descriptive statistics were used to evaluate the CMS, DASH, OSS, EQ5D3L, patient satisfaction scores, and the data obtained by ultrasound at follow-up. The CMS, DASH, OSS scores, EQ5D3L Utility score and EQ VAS were non-normally distributed continuous variables and are presented as median and range. The patient satisfaction data were dichotomized and are presented as frequencies and percentages. The data obtained by ultrasound were nominal and are presented as frequencies and percentages. Three subgroup analyses were performed, to compare the outcomes between patients: (1) with and without a preoperative full-size supraspinatus tendon tear, (2) with and without a re-repair and (3) with and without an intact rotator cuff at long-term follow-up. The Mann–Whitney U test was used to compare the CMS, DASH, OSS, EQ5D3L Utility and VAS

scores. The Chi-square test was used to compare the patient satisfaction. *P*-value lower than 0.05 was considered significant.

Results

Sixty-five patients underwent arthroscopic or arthroscopic-assisted mini-open rotator cuff repair of small- to medium-size lesions between January 2001 and December 2004. Three patients were deceased. Therefore, our potential cohort consisted of 62 patients. Nine patients were lost to follow-up, six refused to participate and three refused because of medical conditions not related to the shoulder.

The remaining 44 patients were enrolled in the study. Of these, six patients were not willing to visit the outpatient clinic and only filled out the PROMs. The remaining 38 patients did visit the outpatient clinic and completed all outcome measures and subsequently underwent ultrasonographic to assess integrity of the rotator cuff repair.

The patient characteristics are shown in Table 1. Mean follow-up was 11.3 years. The majority was male; most of the patients had been operated on their

Table 1. Patient and surgical characteristics.

		Patients (n = 44)
Age at follow-up, years (mean ± SD)		66.8 ± 8.4
Age at time of surgery, years (mean ± SD)		55.1 ± 9.0
Follow-up, years (mean ± SD)		11.3 ± 1.8
Gender	Male	29 (66%)
	Female	15 (34%)
Affected shoulder	Right	32 (73%)
	Left	12 (27%)
Diabetes (n = 40)		3 (8%)
Smoking (n = 40)		10 (25%)
Dominant arm	Right	38 (86%)
	Left	6 (14%)
Interval symptoms to operation (eight missing)	<6 months	5 (17%)
	6–12 months	7 (19%)
	>12 months	23 (64%)
Surgical technique	Arthroscopic repair	17 (39%)
	Mini-open repair	27 (61%)

right shoulder, which was the dominant side, in most cases. Arthroscopic repairs and mini-open repairs were almost equally performed.

Information about rotator cuff tear characteristics is presented in Figure 1. The supraspinatus tendon was always involved. In 12 out of 44 cases only the anterior part of the supraspinatus was involved, classified as partial tendon size lesions. The majority of patients had a full-size tear of at least the supraspinatus tendon (73%) which in some cases extended partially in the infraspinatus tendon or subscapularis tendon.

Long-term functional outcome – Total group

CMSs were obtained in 38 patients. The median CMS was good (82 points). Out of all, 29 patients (76%) had a good to excellent CMS (range 80–100); a moderate score was seen in five (13%) with scores ranging from 56 to 70 points and four patients (11%) had a poor CMS with CMS between 0 and 55 points. When corrected for age, the overall median score was 94%.

The majority of patients reported good functional outcome on both DASH (median score of 5.0) and OSS (median score of 19). The quality of life was also good with a median EQ5D3L utility score of 0.85 and a median EQ5D3L VAS score of 82.

With regard to patient satisfaction, the vast majority of patients (80–82%) was satisfied with the results, both in terms of pain reduction and results. The same majority would also have this operation performed again or would recommend it to others.

Long-term integrity of the rotator cuff

Next to assessment of functional outcome, 38 patients also underwent an ultrasound examination at the

outpatient clinic at an average period of 11.3 years' follow-up. An intact repair of the supraspinatus tendon was confirmed in 32 patients (84%). In this group, there were three patients who had undergone a re-repair, leaving 29 patients (76%) with an intact primary rotator cuff repair since the index procedure, or a 24% re-rupture rate in the group of patients who underwent ultrasound examination.

At follow-up, a recurrent tear was observed in six patients (16%). Two of these (5%) had a recurrent partial tendon size tear. Three had a recurrent full-size tear of the supraspinatus tendon and now also showed a full-size tear of the infraspinatus tendon. In one case all three rotator cuff tendons were ruptured.

Four of these patients had not received secondary surgery. The other two patients had meanwhile undergone secondary surgery. One had undergone a re-repair and now showed a re-tear extending in all three muscles. The other patient had undergone a transposition of the m. latissimus dorsi, after undergoing a re-repair of the rotator cuff. In this case, the ultrasonographic findings were consistent with the indication to perform the transposition, i.e. a full-size tear of both supraspinatus and infraspinatus tendon.

Long-term functional outcome – Subgroups

Three subgroup analyses were performed.

Subgroup 1: Small- versus medium-size tears. Patients with preoperatively confirmed full tendon size tears consistently scored worse on all functional outcome measures (CMS, DASH, OSS) at follow-up compared to partial tendon size lesions, but this only reached statistical significance with regard to the raw CMS score. Their perceived quality of life was not significantly different. Both groups were equally satisfied: an overall 80% would undergo this procedure again or would recommend it to others.

Since the initial time of surgery, eight patients (18%) had undergone a secondary operation of the shoulder. In four of these, a recurrent rotator cuff tear was confirmed during arthroscopy for which a re-repair ('redo') was performed.

In the other four patients, re-repair was not performed. One patient was inspected arthroscopically, but revealed an intact rotator cuff. Two patients had an irreparable rotator cuff rupture and were treated with biceps tenotomy. The fourth patient first underwent partial repair for insufficiency of the posterosuperior rotator cuff and subsequently a latissimus dorsi transfer was done because of ongoing pain and loss of function. Five patients had undergone rotator cuff repair on the contralateral side as well. These shoulders were not included in the analysis.

Figure 1. Rotator cuff tear characteristics. ISP: infraspinatus; SSc: subscapularis; SSP: supraspinatus.

Table 2. Small versus medium size tears (subgroup 1).

Outcome score		Subgroup 1		
		Tear type		p-value
		Partial SSP size (small size) (n = 12)	Full SSP size (medium size) (n = 26)	
CMS median (IQR)	Raw score	91 (79–93)	79 (69–86)	0.045
	Age-adjusted score	101 (83–105)	89 (75–100)	0.100
DASH median (IQR)		2.5 (0.0–8.3)	7.5 (1.7–23)	0.131
OSS median (IQR)		16 (15–30)	21 (16–25)	0.427
EQ5D3L (IQR)	Utility score	1.0	0.84	0.224
	VAS	85	80	0.214
Satisfaction	Reducing pain	83%	81%	1.0
(Agree: Disagree)	Satisfying results	83%	78%	1.0
	Repeat surgery	75%	81%	0.687
	Recommendation	83%	81%	1.0

CMS: Constant–Murley Score; DASH: Disability of Arm, Shoulder and Hand; EQ5D3L: EuroQol Health 5 Dimensions; IQR: interquartile range; SSP: supraspinatus; VAS: visual analogue scale.

In subgroup 2 we compared the results of patients who underwent re-repair with patients who did not undergo any secondary surgery.

Subgroup 2: No versus yes re-do rotator cuff repair. Patients who had undergone a re-do rotator cuff repair consistently scored worse on all functional outcome measures (CMS, DASH, OSS), reaching statistical significance for the DASH and EQ5D3L scores. Furthermore, they were significantly less satisfied with the results of surgery in terms of pain reduction. Three out of four patients who had undergone re-do rotator cuff repair were available for ultrasound examination at follow-up. Two of these revealed an intact rotator cuff. The CMS in the patient with an intact repair was 76 compared to 29 in the patient with a re-tear.

Subgroup 3: Intact versus re-rupture. Patients with an intact rotator cuff tear at follow-up scored significantly better on the CMS ($p=0.01$) and age/gender-adjusted score ($p=0.01$). These patients also scored significantly better on DASH and OSS. The perceived quality of life was also scored better but this did not reach

statistical significance. Furthermore, they showed significantly better results in terms of satisfying pain reduction and functional results. Although only 50% of the patients with a re-rupture would have this operation performed again, or would recommend it to others, as compared to 85–91% of the patients with a long-term intact supraspinatus tendon, this did not reach statistical significance.

Two subjects in the group with an intact rotator cuff repair at follow-up had meanwhile undergone a re-do rotator cuff repair. There were no significant differences in all functional outcome scores between these patients and patients with intact repair at follow-up.

Discussion

The purpose of this study was to assess the long-term results of arthroscopic and arthroscopic-assisted mini-open repair of small- to medium-size rotator cuff lesions. The most important finding of our study was that after 11 years, 80% of these patients perceived a very good functional outcome of their arm had a good quality of life and were satisfied with the result of the

Table 3. No versus yes re-do rotator cuff repair (subgroup 2).

Outcome score		Subgroup 2		
		Re-do rotator cuff repair		
		Yes (n = 4)	No (n = 36)	p-value
CMS median (IQR)	Raw score	73 ^a (51–76)	85 ^b (75–92)	0.096
	Age-adjusted score	76 ^a (55–86)	98 ^b (83–101)	0.124
DASH median (IQR)		33 (15–44)	4 (0.8–13)	0.025
OSS median (IQR)		26 (20–30)	18 (16–23)	0.176
EQ5D3L (IQR)	Utility score	0.79 (0.7–0.9)	1.0 (0.8–1.0)	0.047
	VAS	70 (62–78)	85 (76–94)	0.47
Satisfaction	Reducing pain	25%	89%	0.013
	Satisfying results	50%	86%	0.134
	Repeat surgery	75%	81%	1,000
	Recommendation	75%	86%	0.493

CMS: Constant–Murley Score; DASH: Disability of Arm, Shoulder and Hand; EQ5D3L: EuroQol Health 5 Dimensions; IQR: interquartile range; VAS: visual analogue scale.

^aThree out of four patients were available for CMS.

^bThirty-two out of 36 patients were available for CMS.

repair. In addition, patients showed healing of the repair in 76% of primary rotator cuff repairs and in 84% of cases when re-repairs are included as well. In our cohort, the re-repair rate was 9%. These patients reported a significantly worse outcome and were significantly less satisfied with the result than patients with a successful primary repair. There were 33 patients who did not undergo any re-surgical intervention or revealed a re-rupture on ultrasound at follow-up and can be identified as a successful primary rotator cuff repair in our cohort of 44 subjects, identifying a 25% failure rate of primary rotator cuff repairs.

There are some limitations to this study. First, 29% of patients did not sign informed consent, which may lead to selection bias. On the other hand, it is not unexpected that a considerable number of patients get lost to follow-up after more than 10 years' follow-up. Second, assessment of size and quality of rotator cuff lesions in all patients was not possible because preoperative MRI was not always available. Characterization of the rotator cuff lesion was possible

and was performed using the available preoperative ultrasound and operative reports. Third, not all rotator cuff lesions were completely similar with regard to size. Therefore, a subgroup analysis was performed comparing patients with a partial tendon size and full-size tendon lesions. Not all patients who underwent re-operation also underwent ultrasound and in case of a re-operation, not all patients underwent a re-do rotator cuff repair. This may be burdensome with regard to recalculating the number in the tables.

In all patients there was at least a full-thickness tear of the supraspinatus tendon. Some of these were not full size and other lesions partially extended into the subscapularis or into the infraspinatus tendon. By excluding subscapularis lesions that warranted repair and lesions of both the entire supraspinatus and infraspinatus tendon, only small- to medium-size rotator cuff lesions were selected.

The functional outcome defined as CMS 11years after arthroscopic and mini-open rotator cuff repair in our study revealed a median CMS of 82. Of all patients

Table 4. Ultrasonographic findings (subgroup 3).

Outcome score		Subgroup 3		
		Ultrasonographic findings		
		Intact (n = 32)	Re-rupture (n = 6)	p-value
CMS median (IQR)	Raw score	84 (76–91)	63 (45–69)	0.01
	Age-adjusted score	96 (82–101)	71 (52–78)	0.01
DASH median (IQR)		38 (19–44)	3.3 (0.8–12)	0.03
OSS median (IQR)		18 (16–23)	29 (24–34)	0.03
EQ5D3L (IQR)	Utility score	1.0 (0.84–1.0)	0.71 (0.69–0.86)	0.07
	VAS	82 (70–93)	72 (58–85)	0.28
Satisfaction	Reducing pain	91%	25%	0.01
	Satisfying results	91%	25%	0.01
	Repeat surgery	85%	50%	0.15
	Recommendation	91%	50%	0.08

CMS: Constant–Murley Score; DASH: Disability of Arm, Shoulder and Hand; EQ5D3L: EuroQol Health 5 Dimensions; IQR: interquartile range; VAS: visual analogue scale.

87% had a good to excellent CMS score. This is comparable to the study of Kluger et al.²¹ who found CMS score of 86 points after seven years' follow-up. Similar to our study Kluger et al. found a re-rupture rate of 33%. Heuberger et al.²² performed a long-term MRI controlled study after two and 10 years following single row arthroscopic repair of small- to medium-size lesions and found an overall re-rupture rate of 42% at two years and 50% at final follow-up. Their CMS was 87.8 at two-year follow-up and 77.5 at final follow-up, which is also comparable to our results. The authors concluded that despite high re-tear rates good clinical long-term results can be achieved. Levy et al.⁸ showed a mean CMS of 85 in 102 patients, three years after arthroscopic repair. Gulotta et al.⁶ measured functional outcome after five years using the American Shoulder and Elbow Surgeons score (ASES) and also showed a good functional outcome.

There are several studies that measured the patient-reported outcome after arthroscopic (mini-open) rotator cuff repair beyond five years of follow-up, but these studies used different yet comparable scoring systems.

Wolf et al.⁹ reported good to excellent functional outcomes using a modified University of California, Los Angeles (UCLA) with a follow-up of 4–10 years. Denard et al.²³ reported functional outcome after eight years using ASES and UCLA scores and showed in 78% of 107 patients good to excellent outcome. Marrero et al.²⁴ reported good to excellent functional outcomes using UCLA and in 88% of 48 patients at 12 years' follow-up.

The long-term results of our study are comparable to the midterm outcome as well as to the long-term outcome reported in the study of Marrero et al.,²⁴ which suggests that the functional outcome remains stable on the long term. Spennacchio et al.¹² performed a comprehensive literature review to evaluate the outcome of arthroscopic rotator cuff repairs beyond at least five years of follow-up, including the previously discussed studies. Their main conclusion was that arthroscopic procedures of the rotator cuff result in a good outcome.

To our knowledge, there are no long-term follow-up studies after arthroscopic rotator cuff repair that used the DASH, OSS or the EQ5D3L, so it was not possible

to compare these results to the currently available literature.

Hunsaker et al.²⁵ have studied the DASH score in the American general population without arm complaints/pathology. They found a mean score of 10.1 ± 14.7 measured in 1706 people. Clarke et al.²⁶ evaluated the normative value of the DASH in a young, active population without shoulder symptoms, finding a mean score of 1.85 ± 6.0 in 192 people. Aasheim and Finsen²⁷ researched the normative DASH value in the general population in Norway. They found a mean score of five in 1000 people. The mean scores were increasing with age, ranging from 5 in women aged 20–29 years, to 18 aged 60–69, and 36 for those over 80 years old (respectively, scores of 5, 11 and 22 in men).

Considering a mean age of 67 years ± 8.4 at long-term follow-up in our study, our median DASH score of 5.0 (± 15) 10 years after arthroscopic rotator cuff repairs are comparable or even better than the DASH scores found in the general population of the USA and Norway.

Younis et al.²⁸ investigated the normative values of the OSS in an asymptomatic population of the UK. They found a mean score of 15 in 100 people. In our study, the median OSS score was 19 at 11.3 years' follow-up which is only slightly different.

Aasheim and Finsen²⁷ described the normative value of EQ5D3L scores in 2280 people of the general population in the Netherlands. In the EQ5D3L utility score they found a mean of 0.87 ± 0.18 . A mean of 0.85 ± 0.11 in the EQ5D3L utility score was found. These mean scores are comparable. An EQ5D3L VAS mean of 82 ± 15 was found. The normative value in the EQ5D3L VAS in the study of Aasheim and Finsen²⁷ reveals a mean of 77.7 ± 15.2 . The patients in our study scored their own self-rated health as high compared to the normative value found in the Netherlands.

As MRI has a higher disutility and ultrasound has been shown to be almost as accurate, the integrity of the rotator cuff repair was assessed by ultrasound.

In our study a healing rate of 76% was found in patients with primary rotator cuff repair after 11.3 years on ultrasound, which is comparable to previous studies. Gulotta et al.⁶ reported a healing rate of 81% in 106 patients after five years of follow-up and Levy et al.⁸ reported a healing rate of 81% in 102 patients after three years of follow-up, both after an arthroscopic rotator cuff repair.

Since literature reveals no difference in functional outcome between both techniques, patients who were operated with either arthroscopic or arthroscopic-assisted mini-open repair were included.²⁹ With regard to mini-open rotator cuff repair, Bell et al.¹³ reported sustainable results after an average of 15 years' follow-up. However, in their series no

radiographic imaging was used to assess cuff integrity. Probably due to similar issues with long-term studies, they also had a considerable loss to follow-up of 38%.

Consistent with previous findings^{30,31} significantly higher median CMSs after repair of small-size tears were observed, confirming the theory that repair of smaller rotator cuff tears results in better outcome.

With an average of 11.3 years, our study has a substantial longer follow-up time compared to most previous studies. By measuring clinical outcomes using the CMS, as well as patient reported outcomes this study also provides ultrasonographic insight in the structural integrity of the rotator cuff, functional outcome and the results as experienced by the patient. Additional subgroup analyses were performed and reported the long-term differences in outcome between (1) preoperative small and medium rotator cuff lesion, (2) intact and re-repaired rotator cuff lesions and (3) an ultrasonographic intact versus re-ruptured rotator cuff repair.

Conclusion

The results of our study performed 11 years after arthroscopic or arthroscopic-assisted mini-open rotator cuff repair reveal a good to excellent functional outcome, a high healing rate of the rotator cuff and satisfying results reported by the majority of the patients. Patients with failure of rotator cuff repair perform worse and are less satisfied than patients with a successful primary repair.

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Ethical Review and Patient Consent

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