# Cost-effectiveness of rotator cuff treatments

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**ABSTRACT**

**Purpose:** Rotator cuff tear (RCT) is a common injury in adults over 50, causing significant pain and functional impairment. This review compares the cost-effectiveness of various surgical and non-surgical RCT treatment options.

**Methods:** A systematic review was conducted, including cost analyses, randomized controlled trials, and feasibility studies published up to October 2023. Participants had clinically diagnosed RCT confirmed by magnetic resonance imaging. Both conservative and surgical treatments were included. Outcomes measured were cost-effectiveness parameters, like incremental cost-effectiveness ratios or quality-adjusted life years (QALYs), and clinical effectiveness.

**Results:** The review included 26 studies involving 174,335 patients aged 16 to 88. Surgical interventions, particularly arthroscopic rotator cuff repair (aRCR) and reverse total shoulder arthroplasty (RTSA), were mainly evaluated. Double-row repairs, although more costly, provided better outcomes and tendon healing. Non-operative treatments, while initially cheaper, resulted in lower QALY gains. Delayed surgery led to higher costs and less favorable outcomes. Methodological quality varied, with significant bias due to small sample sizes and short follow-ups.

**Conclusions:** Both surgical and conservative treatments have benefits, but cost-effectiveness varies. aRCR is cost-effective, especially in terms of QALYs gained. RTSA, despite higher initial costs, offers significant QALY gains for severe cases. Non-operative treatments yield lower QALY gains compared with surgery. Delayed surgery increases overall costs and reduces cost-effectiveness due to prolonged pain management and rehabilitation needs. High-quality, long-term studies are needed to reach definitive conclusions.

**KEYWORDS**

Rotator cuff, cost-effectiveness, ICER, QALY, cost-effective, conservative, surgical.

## Introduction

The prevalence of rotator cuff rear (RCT) injuries, particularly in adults over the age of 50, ranges from 15% to 30% [1] . The etiology of RCT is multifactorial, involving intrinsic factors such as tendon degeneration, and extrinsic factors including mechanical compression and trauma [1-3]. These tears often lead to significant pain, shoulder weakness, and functional impairment, substantially affecting patients' quality of life and their ability to perform daily activities [4].

Management options for RCT vary widely, ranging from conservative treatments to surgical interventions [5,6]. Conservative management includes rest, physiotherapy, exercises, and analgesics, aimed at reducing pain and improving shoulder function without surgery [7]. Surgical treatments are diverse, including arthroscopic rotator cuff repair (aRCR), open repair, shoulder hemiarthroplasty (SH), total shoulder replacement (ATSA), and reverse total shoulder arthroplasty (RTSA) [8]. Each of these surgical options has distinct indications, potential benefits, and associated risks [9-11].

The economic burden of RCT on the healthcare system is substantial, driven by both direct costs of treatment and indirect costs related to loss of productivity and long-term disability [12-14]. Studies have shown that the direct medical costs associated with RCT include expenses for diagnostic imaging, physician

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consultations, physical therapy, surgical procedures, and postoperative rehabilitation [15]. Indirect costs are equally significant, encompassing loss of income due to decreased work productivity, long-term disability, and the need for ongoing care and support [15]. A comprehensive understanding of these costs is crucial for developing effective healthcare policies and strategies that can alleviate the financial strain on both patients and healthcare systems.

With healthcare systems globally striving to balance cost containment with the delivery of high-quality care, understanding the cost-effectiveness of various treatment options for RCT is essential. Cost-effectiveness analysis provides valuable insights into which treatments offer the best value for money, thereby informing clinical decision-making and policy development. This type of analysis evaluates the relative costs and outcomes of different interventions, considering factors such as quality-adjusted life years (QALYs), incremental cost-effectiveness ratios (ICERs), and overall healthcare expenditure [15]. ICER and QALY are critical metrics used in health economics to assess the cost-effectiveness of medical interventions. ICER is the ratio of the difference in costs between two interventions to the difference in their effectiveness, typically measured in QALYs [15]. QALY, on the other hand, combines both the quantity and quality of life, reflecting the years of life gained from an intervention adjusted for the patient's health-related quality of life during those years. A QALY value of 1 equates to one year in perfect health, whereas a value less than 1 indicates a year lived in a less-than-perfect health state [15].

By identifying the most efficient and effective treatment strategies, cost-effectiveness analysis helps ensure that limited healthcare resources are used optimally to achieve the best possible patient outcomes.

This systematic review aims to compare the cost-effectiveness of different rotator cuff repair techniques and non-surgical interventions. By evaluating existing evidence, the objective is to identify the most efficient and effective treatment strategies able to reduce healthcare expenditure while improving patient outcomes. This review will inform healthcare providers, patients, and policymakers about the economic and clinical benefits of various RCT management options, ultimately contributing to more sustainable healthcare practices.

## Methods

### Eligibility criteria and search strategy

A comprehensive literature search was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) protocol to identify studies evaluating the cost-effectiveness of various interventions for RCT. The search strategy was designed using the Population, Intervention, Comparison, Outcome (PICO) framework.

Studies were included if they met the following criteria:

- **Study design:** Original studies including cost analyses, randomized controlled trials, prospective studies, retrospective analyses, and feasibility studies.
- **Language:** Articles published in English.
- **Publication period:** Articles published from the inception of the databases to October 2023.
- **Participants:** Patients clinically diagnosed with RCT, with no history of shoulder instability or fractures of the glenoid or tuberosities, confirmed by magnetic resonance imaging.
- **Interventions:** Studies examining both conservative treatments (e.g., rest, physiotherapy, exercise, analgesics) and surgical treatments (e.g., arthroscopic rotator cuff repair, SH, RTSA, ATSA).
- **Outcomes:** Primary outcomes included cost-effectiveness measures such as ICERs and QALYs. Secondary outcomes included clinical effectiveness and patient satisfaction.

Exclusion criteria were:

- Reviews, books, and protocol studies.
- Patients with inflammatory joint disease, previous shoulder surgery, labral pathologies amenable to surgical repair, degenerative arthritis of the glenohumeral joint, or symptomatic arthritis of the acromioclavicular joint.

A systematic search was conducted in the Medline, Scopus, Cochrane, CINAHL, and Embase databases. Keywords were combined using Boolean operators "AND" and "OR". The following MeSH terms and free text keywords were used: "shoulder", "rotator cuff tear", "injury", "costs", "effectiveness", "surgery", "arthroscopy", "conservative treatment", "orthopedic", "QALY", "ICER".

### Study selection and data collection

In October 2023, two independent reviewers (S.F. and L.G.) screened titles, abstracts, and full texts of studies for eligibility. Disagreements were resolved through discussion. Data extraction was performed independently by the reviewers using a standardized form to collect relevant data on study characteristics, interventions, outcomes, and cost-effectiveness measures.

### Risk of bias assessment

The risk of bias for included studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS). The MINORS tool includes 12 items, each scored from 0 to 2, with a maximum score of 24 for non-comparative studies and 32 for comparative studies. Items include clearly stated aim, inclusion of consecutive patients, prospective data collection, appropriate endpoints, unbiased assessment, appropriate follow-up period, and adequate statistical analyses

### Data synthesis and analysis

Data were synthesized narratively and quantitatively where appropriate. Data on the study design, patient population size, length of follow-up, treatment administered, presence of RCTs, quantitative and qualitative outcome metrics, costs, ICERs and QALYs were extracted.

Categorical variables were reported as percentage frequencies. Continuous variables were reported as mean, minimum, and maximum values, and the standard deviation.

## Results

The selection process is illustrated in Figure 1. The search strategy yielded 138 articles. After duplicate removal and title, abstract and full-text review, 26 studies were evaluated for methodological quality and were eligible for the review [16].

### Study and patient characteristics

A total of 26 studies were included in this systematic review, evaluating the cost-effectiveness of various rotator cuff repair techniques and non-surgical interventions. The studies were published between 2010 and 2023, encompassing a diverse range of methodologies and patient populations. A total of 174,335 patients (cohorts ranging from 15 to 52,485) have been reviewed in this study (Table I).

The demographics of these studies were diverse, with patient ages ranging from 16 to 88 years and both male and female patients represented. 65% of the included studies reported patients between 40 and 60 years old.

The studies were divided into surgical treatment (85%) and conservative treatment (15%).

The studies included in the review used different follow-up periods, ranging from 1 to 5 years.

## Cost-effectiveness of surgical interventions

The included studies examined several surgical techniques for rotator cuff repair, including arthroscopic single-row and double-row repairs [17,18], open surgeries, and innovative methods like the InSpace™ balloon. Among the surgical treatments, the majority of subjects underwent aRCR (29%). The second most frequent treatment was RTSA (20%) (Table II).

Adla *et al*. (2010) found that arthroscopic repair and open surgery had different cost implications, with aRCR costing £8700 and open cuff repair £1950 [19].

Overall, double-row repairs, while generally more costly than single-row repairs, were associated with better functional outcomes and higher rates of tendon healing, potentially justifying the higher initial expenditure. Bisson *et al*. observed that although double-row repairs involve higher costs (ranging from $8,019 to $12,979) [20], they may offer superior long-term benefits compared with single-row repairs (where costs range from $7,572 to $10,663) [20, 21]. However, Genuario *et al*. (2012) found that double-row aRCR compared with single-row aRCR was cost-effective, reporting costs of $11,914 for double-row repair and $10,605 for single-row repair [22,23].

The ICER for double-row repair was $571,500 for tears <3 cm and $460,200 for tears ≥3 cm [22].

## Conservative management versus surgical treatment

When comparing conservative management with surgical treatment, studies consistently found that surgical intervention, particularly aRCR, provided better long-term outcomes. For example, Mather *et al*. (2013) [24] reported that non-operative treatment had a lower cost ($40,457) than aRCR ($19,366), but the QALYs gained were higher for aRCR (12.61 vs. 11.96).

This suggests that, despite its higher upfront costs, surgical treatment may offer better value over time due to improved patient outcomes and reduced disability (Table II).

## Quality-adjusted life years (QALYs) and incremental cost-effectiveness ratios (ICERs)

QALYs and ICERs were used to evaluate the value for money of different interventions.

Surgical interventions generally resulted in higher QALYs gained compared with conservative treatments, reflecting improved quality of life and functional outcomes. Coe *et al*. (2012) found that RTSA was more effective but more expensive than SH, with an incremental cost per QALY gained of $94,118 [25]. However, using a $100,000/QALY threshold, RTSA was deemed cost-effective. Castagna *et al*. (2018) reported incremental effectiveness, in terms of QALYs gained, of 0.050 for the InSpace balloon, 0.060 for partial RCR, and 0.040 for RTSA, with respective incremental costs of €522, €6985, and €6719 [8].

**Figure 1** Study selection process and screening according to the PRISMA flow chart [16].

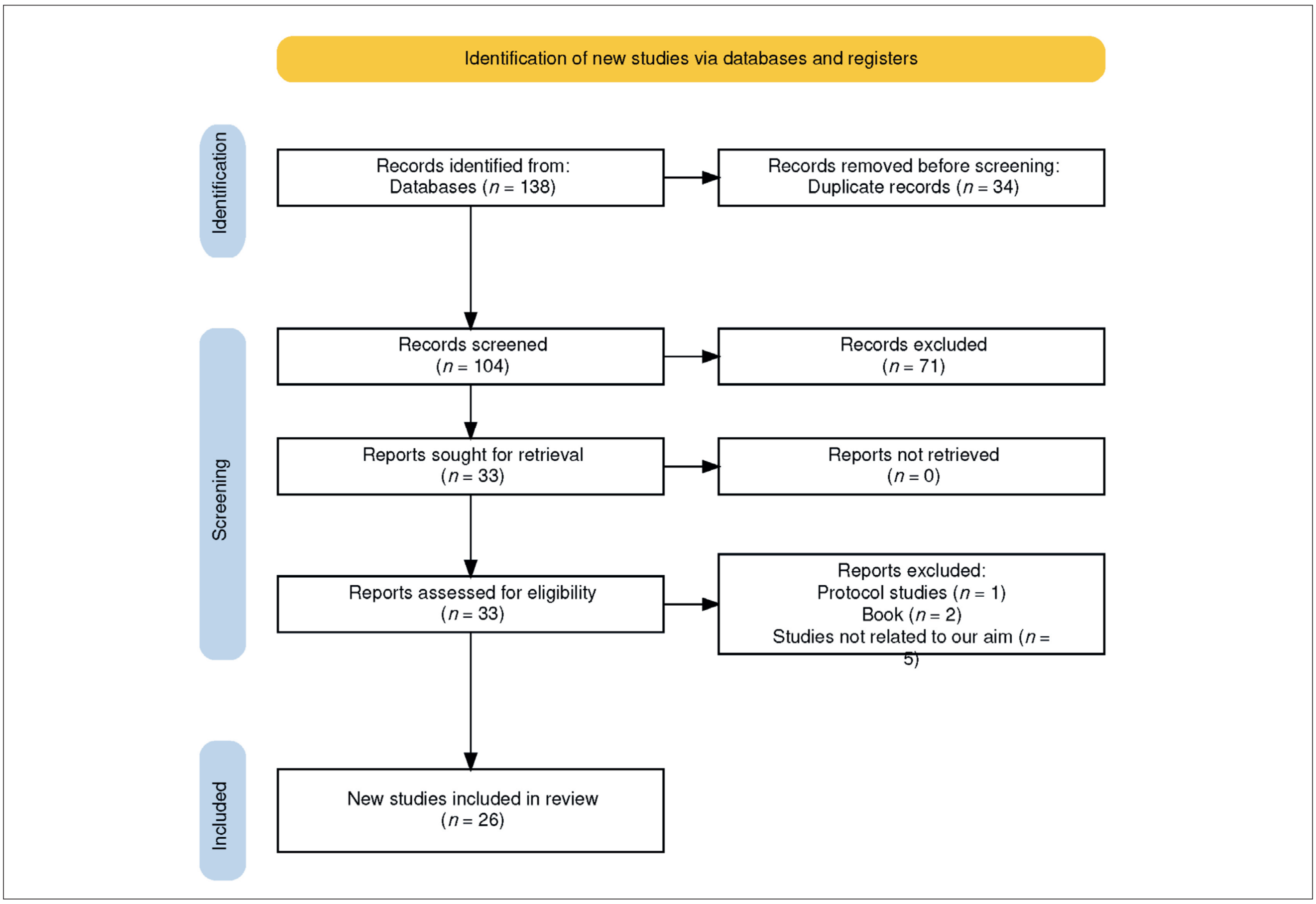

**Table I** Characteristics of the included studies.

| AUTHOR | STUDY DESIGN | NUMBER OF PATIENTS | PATIENTS (SEX) | | MEAN AGE IN YEARS ±SD (RANGE) | TREATMENT | FOLLOW-UP |
|---|---|---|---|---|---|---|---|
| Adla *et al.*, 2010 [19] | Prospective study | 26 (13 arthroscopic repairs; 13 open surgeries) | 18 (70%) | 8 (30%) | 54 ± 11.2<br>(34-78)<br>57 ± 8<br>(45-73) | Arthroscopic repair<br>Open surgery | 1 year |
| Arias-Buría *et al.*, 2018 [13] | Cost analysis | 50 (25 allocated to exercise alone; 25 allocated to exercise + TrP-DN) | 37 (74%) | 13 (26%) | 48 ± 5, exercise group<br>49 ± 4, TrP-DN + exercise group | Exercise alone<br>TrT-DN | 1 year |
| Bachman *et al.*, 2016 [21] | Prospective study | 15 (RTSA) | 110 (46%) | 129 (54%) | 67.9 ± 9.0 | RTSA | 1 year |
| Bisson *et al.*, 2012 [20] | Cost analysis | 17 (single row, size of lesion:<br><1 cm: 1<br>1-3 cm: 2<br>3-5 cm: 3<br>>5 cm: 4;<br>double row, size of lesion:<br><1 cm: 1<br>1-3 cm: 1<br>3-5 cm: 2<br>>5 cm: 3) | | | | aRCR with single-row and double-row fixation | 1 year |
| Castagna *et al.*, 2018 [8] | Comparative cost-effectiveness analysis | | | | | InSpace™<br>RTSA<br>Partial repair/ debridement<br>Non-operative care | 2 years |
| Coe *et al.*, 2012 [25] | Prospective study | 42 (16 RTSA; 26 SH) | 18 (43%) | 24 (57%) | RTSA 78.4<br>(61.9-87.7,<br>SH 72.2<br>(54.9-87.5 | SH<br>RTSA | RTSA 2 years<br>SH 5 years |
| Danninger *et al.*, 2015 [23] | Cost analysis | 27,201<br>(4198 GN; 23,003 G) | 15,308 (56%) | 11,893 (44%) | GN<br>58.39 ± 12.01<br>G<br>58.18 ± 12.35 | RCR with GN or G | |
| Dornan *et al.*, 2016 [38] | Cost analysis | | | | 45-85<br>years of age | ARCR<br>RTSA | 1 year |
| Genuario *et al.*, 2012 [22] | | 52,485 | 29,916 (57%) | 22,568 (43%) | 56 | RCR with single-row or double-row approach | 2 years |
| Grobet C. *et al.*, 2020 [37] | Prospective study | 153 (92 trauma-OP; 61 degen-OP) | 97 (63%) | 56 (37%) | 56.9 ± 8.2 | aRCR | 2 years |
| Hearnden *et al.*, 2008 [36] | Cost analysis | | | | >69; <70 | aRCR<br>ASD | aRCR<br>ASD |
| Huang *et al.*, 2017 [33] | Cost analysis | 90 (48 single row;<br>42 double row) | | | Any age | RCR with single-row or double-row fixation | 2 years |
| Kang *et al.*, 2016 [32] | Cost analysis | | | 100% female | 70 | SH<br>RTSA<br>AD-BT<br>PT | 1 year |
| Kose, 2008 [31] | Cost analysis | 50 (25 aRCR; 25 MORCR) | 11 (22%) | 39 (78%) | MORCR<br>62 ± 10.02<br>aRCR 55 ± 7.57 | MORCR<br>aRCR | MORCR 1 year and 6 months<br>ARCR 1 year and 9 months |
| Makhni *et al.*, 2016 [12] | Cost analysis | | | 65 ± 17.8 | | aRCR<br>RTSA<br>Non-operative treatment | 3 years |

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| AUTHOR | STUDY DESIGN | NUMBER OF PATIENTS | PATIENTS (SEX) | | MEAN AGE IN YEARS ±SD (RANGE) | TREATMENT | FOLLOW-UP |
|---|---|---|---|---|---|---|---|
| Mather *et al.*, 2010 [39] | Cost analysis | 484 | | | 64 (63-66) | TSR<br>SH | 1 year |
| Mather *et al.*, 2013 [24] | Cost analysis | | | | 56 ± 13.5 | RCR<br>Non-operative treatment | 1 year |
| Milne *et al.*, 1994 [30] | Cost analysis | Four groups of<br>50 patients each | 35 (70%)<br>38 (76%)<br>32 (64%)<br>27 (54%) | 15 (30%)<br>12 (24%)<br>18 (36%)<br>23 (46%) | 56 (35-84)<br>32 (16-59)<br>50 (28-88)<br>63 (27-87) | Group 1- RTSA<br>Group 2- open anterior instability repair<br>Group 3 - arthroscopic subacromial decompression<br>Group 4- shoulder arthroplasty | 1 year |
| Murphy *et al.*, 2016 [7] | Economic analysis | 273 (136 arthroscopic; 137 open surgery) | 81 (60%) arthroscopic<br>88 (64%) open | 55 (40%) arthroscopic<br>49 (36%) open | arthroscopic 62.9 ± 7.1<br>open ± 7.5 | Arthroscopic management<br>Open surgical management | 2 years |
| Nicholson *et al.*, 2019 [35] | Cost analysis | 92 | 51 (55%) | 41 (45%) | 59.9 ± 9.7<br>(41-78) | aRCR | 2 years |
| Parikh *et al.*, 2019 [15] | Cost analysis | 32 | 16 (50%) | 16 (50%) | 40-80 | SCOI | 1 year |
| Renfree *et al.*, 2013 [27] | Cost analysis | 30 | 14 (45%) | 16 (55%) | 74.1<br>(61.1-87.3) | RTSA | 2 years |
| Savoie *et al.*, 1995 [28] | Cost analysis | 50<br>(group 1: 34; group 2: 16) | | | | RCR | 1 year and 6 months |
| Skutek *et al.*, 2000 [29] | Cost analysis | 23 | 16 (70%) | 7 (30%) | 55.3 ± 10.5 | open RCR | 1 year and 6 months |
| Vitale *et al.*, 2007 [26] | Cost analysis | 87 | 47 (54%) | 40 (46%) | 62.5 ± 9.52<br>(40-83) | RCR | 1 year |
| Yeranosian *et al.*, 2013 [18] | Cost analysis | 92,688 | - | - | | preoperative evaluation | 90-day preoperative |
| | | | TOTAL: 35,105 | | | | |

**AD-BT**: arthroscopic debridement with biceps tenotomy; **aRCR**: arthroscopic rotator cuff repair; **ASD**: arthroscopic subacromial decompression; **G**: general anesthesia alone; **GN**: general anesthesia in addition to peripheral nerve blocks; **MORCR**: mini-open rotator cuff repair; **PT**: physical therapy; **RCR**: rotator cuff repair; **SCOI**: Southern California Orthopedic Institute technique; **RTSA**: reverse total shoulder arthroplasty; **SH**: shoulder hemiarthroplasty; **TrT-DN**: trigger point dry needling. **TSR**: total shoulder replacement; **trauma-OP**: traumatic rotator cuff tear patients; **degen-OP**: degenerative rotator cuff tear patients

**Table II** Summary of treatments and outcome results.

| AUTHOR | TREATMENT | TYPE OF DISEASE | ICER | OUTCOME | OUTCOME RESULTS |
|---|---|---|---|---|---|
| Adla et al., 2010 [19] | Arthroscopic repair<br>Open surgery | RCTs | | OSS<br>CMS<br>Cost £ | -25.5 ± 8.2 (arthroscopic group)<br>24.9 ± 6.7 (open group)<br>- 82 (arthroscopic group), 78 (open group)<br>Arthroscopic RCR £870<br>Open cuff repair £195 |
| Bisson et al., 2012 [20] | ARCR with single-row and double-row fixation | Ruptured RC | | Cost ($) | Single-row<br>size of lesion:<br><1 cm: $7,572– $8,347<br>1–3 cm: $8,019– $9,119<br>3–5 cm: $8,466– $9,891<br>>5 cm: $8,913– $10,663<br>Double-row<br>size of lesion:<br><1 cm: $8,019– $9,119<br>1–3 cm: $8,466– $9,891<br>3–5 cm: $9,360– $11,435<br>>5 cm: $10,254– $12,979 |

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| AUTHOR | TREATMENT | TYPE OF DISEASE | ICER | OUTCOME | OUTCOME RESULTS |
|---|---|---|---|---|---|
| Castagna *et al.*, 2018 [8] | InSpace™<br>RTSA<br>Partial repair/ debridement<br>Non-operative care | Irreparable RCTs | InSpace 10440<br>Aprcr 116417<br>RTSA 167975 | QALYs<br>Cost (€) | Incremental effectiveness QALYs:<br>InSpace 0.050<br>Aprcr 0.060<br>RTSA 0.040<br>Incremental cost:<br>InSpace €522<br>Aprcr €6985<br>RTSA €6719 |
| Coe *et al.*, 2012 [25] | SH<br>RTSA | CTA | RTSA was more effective but more expensive than SH for CTA, with an incremental cost per QALY gained of $94,118. Using $100,000/ QALY as a cut off, RTSA was cost-effective | Cost ($)<br>QALYs | Cost of RTSA $23,000.<br>Cost of SH $12,000.<br>QALYs<br>SH 6.334<br>RTSA 6.454 |
| Danninger *et al.*, 2015 [23] | RCR with GN or G | - | | Cost ($) | GN: $5370 (IQR 3941–7504)<br>G: $5440 (IQR 4016–7497) |
| Genuario *et al.*, 2012 [22] | aRCR with single- or double-row repair | RCTs | Double-row compared with single-row aRCR: $571,500 for RCTs of <3 cm and $460,200 for RCTs of ±3 cm | Cost ($) | Single row $10,605<br>Double row $11,914<br>Double-row repair seems to represent a cost-effective surgical alternative |
| Grobet C. *et al.*, 2020 [37] | aRCR | RCTs<br>of traumatic origin<br>Degenerative tears | All patients 24.924 CHF/ QALY (95% confidence interval, CI: 16.742–33.106)<br>Trauma-OP group:17.357 CHF/QALY (95% CI 10.951–23.763)<br>Degen-OP group: 36.474 CHF/QALY (95% CI 16.301 to 56.648) | EQ-5D | 0.26 aRCR |
| Hearnden *et al.*, 2008 [36] | ASD<br>aRCR | Degenerative tears | | Cost ($) | Cost of ASD $529<br>Cost of aRCR $1258 |
| Huang *et al.*, 2017 [33] | aRCR with single-row and double-row fixation | Full-thickness RCTs | | Cost ($)<br>QALYs | Cost:<br>single-row $1,641.61<br>double-row $2,104.59<br>QALYs:<br>single-row: 4.055<br>double-row: 4.073 |
| Kang *et al.*, 2016 [32] | PT<br>AD-BT<br>SH<br>RTSA | Massive irreparable RCTs | $4719 PT<br>$25,522 RTSA | QALYs<br>Cost (%) | QALYs:<br>AD-BT 6.69<br>PT 7.04<br>SH 7.35<br>RTSA 7.69<br>Cost:<br>AD-BT $6397<br>SH $30,774<br>RTSA $30,873<br>PT $7180 |
| Kose *et al.*, 2008 [31] | aRCR<br>MORCR | RC injuries | | CMS<br>UCLA score.<br>Cost ($) | MORCR:<br>CMS 79.56±13.65<br>UCLA 28.8±3.42<br>ARCR:<br>CMS 3.56±11.45<br>UCLA 29.76±4.5<br>Cost:<br>The difference in total costs was $2150 in favor of MORCR |
| Makhni *et al.*, 2016 [12] | aRCR<br>RTSA<br>Non-operative treatment | Large and massive RCTs | | Cost ($)<br>QALYs | Cost:<br>aRCR $22,300<br>RTSA $37,500<br>Non-operative $11,300<br>QALYs:<br>aRCR 11.73<br>RTSA 11.72<br>Non-operative treatment 11.02 |

continue >

| AUTHOR | TREATMENT | TYPE OF DISEASE | ICER | OUTCOME | OUTCOME RESULTS |
|---|---|---|---|---|---|
| Mather *et al.*, 2013 [24] | aRCR<br>Non-operative treatment | Full-thickness RCTs | | Cost ($)<br>QALYs | Cost: non-operative $40,457<br>aRCR $19,366<br>QALYs: Non-operative treatment: 11.96<br>aRCR: 12.61 |
| Murphy *et al.*, 2016 [7] | Arthroscopic management<br>Open management | RCTs | arthroscopic management was dominated by open management.<br>-£2845 (mean incremental cost per QALY gained) | Cost (£)<br>EQ-5D-3L<br>QALYs | Total cost over 24 mths: arthroscopic £2567<br>open £2699<br>EQ-5D-3L: arthroscopic 0.74<br>open 0.76<br>QALYs: arthroscopic 1.34<br>open 1.35 |
| Nicholson *et al.*, 2019 [35] | aRCR | RCTs | £5694.78/QALY | DASH<br>OSS<br>EQ-SD<br>Cost (£) | DASH: preoperative 47.6 vs. two-years 15.3<br>OSS: 26.5 vs. 40.5<br>EQ-SD: 0.86, two years postoperatively<br>Cost: £3646.94 per patient |
| Parikh *et al.*, 2019 [15] | SCOI | RCTs | | UCLA<br>CMS | UCLA score improved from preoperative 8.75 to postoperative 31.79.<br>CMS improved from preoperative 20.66 to postoperative 81.3. |
| Renfree *et al.*, 2013 [27] | RTSA | RC arthropathy | | EuroQol;<br>SF-6D<br>Cost ($)<br>QALY | EuroQol: preoperative: 0.75<br>postoperative: 0.81<br>SF-6D: preoperative: 0.59<br>postoperative: 0.66<br>Cost of humeral head replacement: $21,964<br>Cost of total knee arthroplasty: $13,995<br>Cost of RTSA: $21,536<br>QALYs: SF-6D preoperative 7.58<br>EQ-5D preoperative 8.10 |
| Savoie *et al.*, 1995 [28] | aRCR<br>Patients were divided into: Group I: managed by an orthopedic specialist<br>Group II: received medical care in house from the company physician | RCTs | | Cost ($) | Group 1: $25,871<br>(standard deviation $10,007).<br>Group 2: $100,911<br>(standard deviation $107,811) |
| Skutek *et al.*, 2000 [29] | Open aRCR | RC arthropathy | | CMS<br>ASES<br>DASH<br>SST | CMS: from 26.04 (preoperative) to 64.56<br>ASES: from 33.94 to 71.91<br>DASH from 49.58 to 21.62<br>SST: from 03.30 to 06.97 |
| Vitale *et al.*, 2007 [26] | aRCR | RCTs | | Cost ($)<br>HUI<br>EuroQol | Cost: $10,605.20<br>HUI preoperative: 0.803<br>HUI postoperative: 0.851<br>EuroQol preoperative: 0.563<br>EuroQol postoperative: 0.763 |
| Yeranosian *et al.*, 2013 [18] | preoperative evaluation | RCTs | | Cost ($) | $104,510.646 diagnostic imaging.<br>Injections $5,145,227<br>Outpatient visits $29,723,751.<br>PT, $13,844,270.<br>Preoperative studies, $6,792,245.<br>Miscellaneous $1,164,688 |

**AD-BT**: arthroscopic debridement with biceps tenotomy; **Aprcr:** arthroscopic partial rotator cuff repair; **aRCR:** arthroscopic rotator cuff repair; **ASD:** arthroscopic subacromial decompression; **ASES:** American Shoulder and Elbow Surgeons score; **CMS:** Constant-Murley Score; **CTA:** cuff tear arthroplasty; **DASH:** Disabilities of the Arm, Shoulder and Hand; **EuroQol/EQ-5D:** health-related quality of life; **G:** general anesthesia alone; **GN:** general anesthesia in addition to peripheral nerve blocks; **HUI:** Health Utilities Index; **ICER:** incremental cost-effectiveness ratio; **MORCR:** mini-open rotator cuff repair; **OSS:** Oxford Shoulder Score; **PT:** physical therapy; **QALYs:** quality-adjusted life years; **RC:** rotator cuff; **RCR:** rotator cuff repair; **RCT:** rotator cuff tear; **SCOI:** Southern California Orthopaedic Institute technique; **SF-6D:** Health State Utility Score, **SH:** shoulder hemiarthroplasty; **SST:** Simple Shoulder Test; **RTSA:** total reverse shoulder arthroplasty; **TrT-DN:** trigger point–dry needling. **TSR:** total shoulder replacement; **UCLA:** Shoulder Rating Scale;

## Economic impact of delayed surgery

The economic impact of delayed surgery was highlighted in several studies. For example, Murphy *et al*. (2016) found that delaying surgery could lead to higher costs and potentially less favorable outcomes [7]. They reported that the total cost over 24 months was £2567 for arthroscopic management and £2699 for open surgical management, with open surgery providing slightly better EQ-5D-3L scores (Table II).

## Risk of bias and study quality

The methodological quality of the included studies was variable, with MINORS scores ranging from 3 to 19. In particular, 10 (38.5%) of the included studies were determined to have a low risk of bias, while 16 (61.5%) were considered to have a high risk of bias. The quality assessment results are summarized in Table III.

Common sources of bias included small sample sizes, lack of blinding, and short follow-up periods. These factors potentially influenced the reported outcomes and cost-effectiveness estimates. High-quality studies with rigorous designs and longer follow-up are needed to provide more definitive conclusions regarding the cost-effectiveness of rotator cuff interventions.

## Discussion

This systematic review evaluated the cost-effectiveness of various treatments for RCT [26]. The primary findings suggest that both surgical and conservative interventions have unique economic and health benefits, but their cost-effectiveness varies significantly depending on the treatment method, severity of the tear, and healthcare system [27,28].

aRCR was frequently compared with open repair and RTSA. Multiple studies highlighted aRCR as a cost-effective option, especially in terms of QALYs [29]. For example, Genuario *et al*. (2012) found that double-row aRCR was more cost-effective than single-row aRCR for RCTs of varying sizes, with the cost per QALY gained for double-row repair being $571,500 for tears <3 cm versus $460,200 for tears ≥3 cm [22,30].

RTSA showed a higher initial cost but provided significant QALY gains, making it a viable option for severe cases. Coe *et al*. (2012) reported an incremental cost of $94,118 per QALY gained with RTSA versus hemiarthroplasty for cuff tear arthropathy, deeming RTSA cost-effective under the $100,000/QALY threshold [25].

This review also explored conservative management versus surgical treatment. Non-operative treatments, while less costly upfront, often resulted in lower QALY gains compared with surgical options. For instance, Castagna *et al*. (2018) reported that the InSpace™ device, despite its higher initial costs, offered a positive incremental effectiveness of 0.050 QALYs compared with non-operative care [8]. Mather *et al*. (2013) supported these findings, showing that aRCR was more cost-effective than non-operative treatment for full-thickness RCT, with costs of $19,366 for aRCR and $40,457 for non-operative treatment, and 12.61 QALYs gained for ARCR compared with 11.96 for non-operative treatment [24].

Delayed surgery was another critical factor affecting cost-effectiveness. Parikh *et al*. (2019) reported that delays in surgical intervention for RCT increased overall costs due to prolonged pain management and rehabilitation needs, thereby reducing the cost-effectiveness of eventual surgical repair [15,32]. The economic impact of delayed surgery was further emphasized by Murphy *et al*. (2016), who found that the total cost over 24 months amounted to £2567 for arthroscopic management and £2699 for open surgical management, with open surgery providing slightly better EQ-5D-3L scores [7,33].

The management of RCTs is increasingly requiring a surgical approach, resulting in a rise in healthcare spending associated with treatment of the condition. Numerous studies are currently being conducted to evaluate the potential advantages of conservative treatment over a surgical approach. While the healthcare costs are largely due to intervention and hospitalization, the economic burden of the rehabilitation period may be underestimated [12,20,34,35].

Studies focusing on untreated RCT have suggested that, in some cases, these tears may become irreparable if left unrepaired, emphasizing the need to consider surgical repair [19,24,36,37].

Studies have demonstrated that physical therapy and arthroscopic treatments can reduce pain and improve quality of life. However, surgical interventions such as SH and RTSA may result in improved functional outcomes [8,38-40].

## Limitations

This systematic review has several limitations. First, the included studies exhibited a high degree of heterogeneity in terms of patient populations, types of intervention, and outcome measures, which made direct comparisons challenging. The quality of the data was another significant concern, as some studies lacked robust economic evaluations or detailed cost data, potentially affecting the accuracy of cost-effectiveness estimates. Additionally, the economic evaluations were often specific to the healthcare systems in which they were conducted, which limits the generalizability of the findings to other regions or countries. Furthermore, many studies did not assess long-term outcomes beyond a few years post-intervention, even though such assessments are crucial for understanding the full economic impact of RCT treatments. Lastly, there is a possibility of publication bias, as studies with significant findings are more likely to be published, which could skew the overall conclusions of the review.

An analysis of the cost-effectiveness of various interventions for rotator cuff treatment revealed that SH and RTSA were the most cost-effective. However, due to the lack of standardized data, an accurate cost-effectiveness estimate is difficult to make. With increasing demand for effective treatments at lower cost, further research is needed to reduce costs and improve patient satisfaction.

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**Table III** MINORS scores of the included studies.

| AUTHOR | CLEARLY STATED AIM | INCLUSION OF CONSECUTIVE PATIENTS | PROSPECTIVE DATA COLLECTION | ENDPOINTS APPROPRIATE TO STUDY AIM | UNBIASED ASSESSMENT OF STUDY ENDPOINT | FOLLOW-UP PERIOD APPROPRIATE TO STUDY AIM | <5% LOST TO FOLLOW-UP | PROSPECTIVE CALCULATION OF STUDY SIZE | ADEQUATE CONTROL GROUP | CONTEMPORARY GROUP | BASELINE EQUIVALENCE OF GROUPS | ADEQUATE STATISTICAL ANALYSES | TOTAL SCORE (…/24) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adla et al., 2010 [19] | 2 | 2 | NA | 2 | 0 | 2 | 2 | 2 | NA | 2 | 2 | 0 | 16 |
| Arias-Buria et al., 2018 [13] | 2 | 2 | 0 | 2 | 2 | 2 | 1 | 2 | NA | 2 | 2 | 2 | 15 |
| Bachman et al., 2016 [21] | 2 | 2 | NA | 2 | 0 | 2 | 2 | 2 | NA | 2 | 1 | NA | 15 |
| Bisson et al., 2012 [20] | 2 | 2 | NA | 2 | 0 | 0 | 0 | 2 | NA | 2 | 2 | NA | 12 |
| Castagna et al., 2018 [8] | 2 | 0 | NA | 1 | 0 | 0 | 0 | 0 | NA | 0 | 0 | NA | 3 |
| Coe et al., 2012 [25] | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 0 | 2 | 1 | 2 | 17 |
| Danninger et al., 2015 [23] | 2 | 2 | 0 | 1 | 2 | 2 | 2 | 2 | NA | 2 | 0 | 2 | 17 |
| Dornan et al., 2016 [38] | 2 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 10 |
| Genuario et al., 2012 [22] | 2 | 2 | 0 | 1 | 1 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 14 |
| Grobet C. et al., 2020 [37] | 2 | 2 | NA | 2 | 2 | 2 | 1 | 2 | NA | 2 | 2 | 2 | 19 |
| Hearnden et al., 2008 [36] | 2 | 0 | NA | 1 | 0 | 2 | NA | 0 | NA | 2 | 0 | 0 | 7 |
| Huang et al., 2017 [33] | 2 | 2 | NA | 2 | 1 | 2 | 2 | 2 | NA | 2 | 2 | 0 | 17 |
| Kang et al., 2016 [32] | 2 | 0 | NA | 2 | 1 | 2 | 0 | 0 | NA | 2 | 0 | 2 | 11 |
| Kose et al., 2008 [31] | 2 | 2 | NA | 2 | 0 | 2 | 0 | 2 | NA | 2 | 2 | 2 | 16 |
| Makhni, 2016 [12] | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 10 |
| Mather, 2010 [39] | 2 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 2 | 14 |
| Mather, 2013 [24] | 2 | 0 | NA | 2 | 0 | 2 | 2 | 0 | NA | 2 | 0 | 2 | 12 |
| Milne C. et al., 1994 [30] | 1 | 2 | NA | 1 | 0 | 2 | 2 | 2 | NA | 2 | 2 | 0 | 14 |
| Murphy J. et al., 2016 [7] | 2 | 2 | NA | 2 | 2 | 2 | 2 | 2 | NA | 2 | 2 | 0 | 18 |
| Nicholson et al., 2019 [35] | 2 | 2 | NA | 2 | 1 | 2 | 0 | 2 | NA | 2 | 0 | 0 | 13 |
| Parikh et al., 2019 [15] | 2 | 2 | NA | 2 | 0 | 2 | 2 | 2 | NA | 0 | 2 | 0 | 14 |
| Renfree et al., 2013 [27] | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | 16 |
| Savoie et al., 1995 [28] | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 0 | 18 |
| Skutek et al., 2000 [29] | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 18 |
| Vitale et al., 2007 [26] | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 2 | 0 | 0 | 2 | 0 | 14 |
| Yeranosian et al., 2013 [18] | 2 | 0 | 0 | 2 | 0 | 2 | 2 | 2 | 0 | 2 | 0 | 2 | 14 |

NA: not applicable

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