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Asymptomatic Rotator Cuff Tears

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Abstract

- Asymptomatic rotator cuff tears (RCTs) are prevalent in the general population; they are positively associated with age and are common in the contralateral shoulder of individuals who are being treated for shoulder pain or a symptomatic RCT.
- Asymptomatic RCTs are likely to become symptomatic over time, corresponding with decreased patient-reported function, strength, and range of motion.
- Previous studies have largely reported inconsistent findings regarding patient-reported outcomes, strength, range of motion, and kinematics in individuals with asymptomatic RCTs.
- Future research would benefit from characterizing any functional alteration that is associated with asymptomatic rotator cuff pathology, including determining whether such alterations are detrimental or compensatory and understanding the mechanism by which an asymptomatic RCT becomes symptomatic.

Rotator cuff tears (RCTs) are common, affecting approximately 40% of the population who are >60 years of age^{1–3} and substantially impacting an individual's function^{4,5}.

Approximately 250,000 rotator cuff repairs are performed annually in the United States⁶, accounting for \$3 to \$5 billion per year in medical costs, Workers' Compensation benefits, and lost productivity^{7,8}. The rotator cuff has received considerable research attention over the last 30 to 40 years (Fig. 1), and these efforts have contributed greatly to our knowledge regarding the spectrum of rotator cuff pathology. For example, previous research has documented RCT risk factors^{3,9–12}, natural history^{13–17}, clinical imaging considerations¹⁸, and outcomes of nonsurgical^{19–21} and surgical^{22–24} interventions. Despite an increase over time in our understanding of the healthy and the pathologic rotator cuff and the advances in surgical repair techniques, a recent review by McElvany et al. concluded that clinical outcomes after rotator cuff repair have not improved appreciably over the last 30 years²⁵. Specifically, the authors concluded that approximately 25% of rotator cuff repairs in a typical study failed to remain intact, and that improvements in patient-reported outcomes

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were <75% of the possible maximum improvement²⁵. These findings indicate that, despite the substantial volume of research that has focused on rotator cuff pathology, postsurgical outcomes following rotator cuff repair remain suboptimal.

In addition to suboptimal clinical outcomes, the etiology of RCTs is still not fully understood. One issue that confounds our understanding of rotator cuff pathology is that chronic RCTs initially may be asymptomatic and may remain asymptomatic for an unknown and likely highly variable period of time. Furthermore, clinical evidence suggests that individuals with an asymptomatic RCT may be capable of a high level of shoulder function^{14–16,20,26–28}. Therefore, if outcomes after surgical repair have not improved markedly over the last 30 or more years and a high level of shoulder function can be achieved in spite of an asymptomatic RCT, then perhaps an alternative strategy for addressing this long-standing clinical problem may involve (1) identifying rotator cuff pathology when an individual is still asymptomatic and has acceptable shoulder function and (2) intervening with exercises that are designed to ensure that the RCT remains asymptomatic while maintaining or improving shoulder function. Unfortunately, far less is known about asymptomatic RCTs compared with symptomatic tears. Thus, the primary objective of this article is to summarize what is currently known about asymptomatic RCTs, with specific focus on the prevalence, patient-reported outcomes, shoulder function, and natural history. Opportunities for future research also are suggested.

Prevalence of Asymptomatic RCTs

The prevalence of asymptomatic partial-thickness and full-thickness RCTs has been reported to range from 8% to 40% and from 0% to 46%, respectively^{1,10,26,28–37} (Table I). In general, the prevalence of asymptomatic RCTs increases with age^{1,26,28,31,32,34,35,38,39}, and individuals with an asymptomatic full-thickness RCT tend to be older than those with a partial-thickness RCT^{31,34,40}. The wide range of reported prevalence is likely due to several factors. First, the characteristics of the subject populations from which the data were acquired certainly influenced the reported prevalence rate. For example, some studies reported rates of asymptomatic RCTs in individuals with a contralateral symptomatic^{10,37,40} or postsurgical shoulder³³. Not surprisingly, the prevalence of an asymptomatic RCT in these populations is much higher than in the general population. Other unique subject populations include Ironman triathletes⁴¹, post-menopausal women²⁹, and individuals living in specific geographical regions^{31,39}. While studies in specific populations help to expand the description of prevalences, it can be challenging to reconcile the reported prevalences among the various studies.

The clinical imaging modality that is used to assess the rotator cuff (i.e., magnetic resonance imaging [MRI] or ultrasonography) also may influence the reported prevalence of RCTs. Although several studies have described the diagnostic accuracy of ultrasonography and MRI^{18,42,43}, the precision with which these modalities can differentiate the various stages of pathology varies. For example, some studies that utilized ultrasonography reported the prevalence of only full-thickness RCTs and acknowledged a limited ability to identify partial-thickness tears^{26,28,35,39}. Given that the diagnostic accuracy of both MRI and ultrasonography depends on the quality of the images, advances in imaging technology over

the time period of the studies that are included in this review also could help to explain the variability of prevalence. Furthermore, studies often used different or unspecified criteria for how the presence, absence, or severity of an RCT was identified.

Collectively, these previous studies indicate that asymptomatic RCTs are prevalent in the general population (Table I), that the risk of asymptomatic RCTs increases with age^{1,26,28,31,32,34,35,38,39}, and that there is a high likelihood that patients who are being treated for shoulder pain or an RCT have an asymptomatic tear in the contralateral shoulder^{10,33,37,40}. Advances in clinical imaging technology over the past 30 to 40 years have markedly improved the precision with which the various stages of rotator cuff pathology can be discriminated, and more recent studies have tended to report a lower prevalence than older studies. However, asymptomatic RCTs remain a common finding.

Characteristics of Individuals with Asymptomatic RCTs

Patient-Reported Outcomes

Several studies have compared subjective measures of shoulder function (i.e., patient-reported outcomes) between individuals with an asymptomatic RCT and control subjects with an intact rotator cuff. However, the results often are conflicting. For example, compared with individuals with an intact rotator cuff, individuals with an asymptomatic RCT have reported a lower total Constant score²⁸, a lower Simple Shoulder Test (SST) score⁴⁴, and a lower reported ability to lift 3.6 kg (8 lb) to shoulder level⁴⁴. In contrast, other studies have reported no significant difference in patient-reported outcomes of function between individuals with an intact rotator cuff and those with an asymptomatic RCT^{20,26,28,45}. For example, Moosmayer et al. reported small but not significant differences in the American Shoulder and Elbow Surgeons (ASES) shoulder score between individuals with an intact rotator cuff and those with an asymptomatic full-thickness RCT²⁶. Baumer et al. also failed to detect any significant difference in the Western Ontario Rotator Cuff (WORC) scores between similar subject populations²⁰. Keener et al. reported that individuals with an asymptomatic RCT had lower ASES and SST scores than those with an intact rotator cuff, but concluded that the differences were “not clinically relevant.”⁴⁵ These conflicting reports suggest that asymptomatic RCTs may not substantially impact shoulder function. However, the patient-reported functional outcomes may be confounded by the status of the contralateral shoulder and other upper-extremity joints. Furthermore, if functional deficits do in fact exist in individuals with asymptomatic RCTs, the conflicting results of these studies suggest that conventional patient-reported outcomes (e.g., WORC, ASES, Constant, and SST scores) may not have sufficient precision to reliably detect these differences. As such, conventional patient-reported outcomes alone may have limited use in helping to identify asymptomatic RCTs.

Shoulder Strength

Several studies have compared shoulder strength between individuals with an asymptomatic RCT and those with an intact rotator cuff^{9,20,26,28,32,45}. Some studies have reported deficits in shoulder strength in individuals with an asymptomatic RCT, but the findings have been inconsistent. For example, Kim et al. reported that the ratio of abduction strength to external

rotation strength was lower in individuals with a full-thickness RCT³². In particular, decreased abduction strength was especially pronounced in individuals with a large or massive full-thickness RCT. Additionally, it has been reported that individuals with an asymptomatic RCT have lower elevation (i.e., flexion and/or abduction) strength compared with individuals with an intact rotator cuff^{20,26,28}. Similarly, Yamamoto et al. reported that 17% of individuals with an asymptomatic RCT had weakness in abduction, while 12% had weakness in external rotation⁹. In contrast, several studies have reported no difference in external rotation or abduction strength between individuals with an asymptomatic RCT and control subjects with an intact rotator cuff^{15,26,45}. Collectively, these findings suggest that measures of shoulder strength may not be substantially altered in the presence of an asymptomatic RCT; therefore, strength may not be the most reliable predictor of rotator cuff integrity.

The inconsistent findings regarding shoulder strength may be due to factors such as measurement methods and RCT morphology. Strength was generally assessed using a handheld dynamometer, and it is possible that isokinetic devices (e.g., from Biodex or Baltimore Therapeutic Equipment) may provide a more controlled and therefore sensitive assessment. This premise is supported by the findings of Baumer et al.²⁰; with use of a Biodex device, they found reduced strength in individuals with asymptomatic RCTs. Additionally, RCT morphology may impact shoulder strength. Specifically, larger RCTs appear to result in larger reductions in shoulder strength^{32,35}, and the results of cadaveric studies suggest that cable involvement may impact load transfer and, therefore, strength^{46,47}.

Range of Motion

Similar to measures of shoulder strength, previous research has not reached a consensus regarding how asymptomatic RCTs influence gross shoulder range of motion. Kelly et al. reported that individuals with an asymptomatic RCT had approximately 6° less scapular-plane elevation than individuals without rotator cuff pathology⁴⁸. In contrast, it has been reported that individuals with an asymptomatic RCT have greater forward elevation and external rotation range of motion than healthy control subjects⁴⁵. However, for both studies, the magnitude of these reported range-of-motion differences was no more than approximately 5° to 10°, so it is unclear if these differences are clinically meaningful. Not surprisingly, several studies have reported no difference in internal rotation, external rotation, abduction, and elevation range of motion between individuals with an intact rotator cuff and those with an asymptomatic RCT^{20,26,45,49}. Clearly, the relationship between asymptomatic rotator cuff pathology and gross shoulder range of motion is not yet fully understood.

Joint Kinematics

Studies investigating differences in joint kinematics that are associated with asymptomatic RCTs have reported inconsistent findings, but some of these inconsistencies may be attributable to the specific measurement method. Studies that have relied on 2-dimensional static radiographs have reported mixed findings in proximal humeral migration (i.e., superior/inferior position or translation of the humerus relative to the glenoid) when comparing individuals with an asymptomatic RCT to those with an intact rotator cuff^{15,40,50}.

For example, Yamaguchi et al. reported that individuals with RCTs, regardless of symptom status, had significantly increased superior migration⁵⁰. Specifically, the humerus of individuals with RCTs tended to migrate superiorly during shoulder elevation, whereas in individuals with an intact rotator cuff, the humerus tended to migrate inferiorly. Similarly, Keener et al. reported greater superior migration of the humerus with asymptomatic RCTs that involved the supraspinatus and infraspinatus (or infraspinatus only) (mean and standard deviation [SD], 0.5 ± 1.0 mm) compared with tears that involved the supraspinatus only (mean and SD, -0.4 ± 1.3 mm)⁴⁰. However, the mean difference in superior humeral migration between these 2 subject groups was <1 mm, which may be within the measurement uncertainty of this technique⁴⁰. In contrast, Kijima et al. measured joint motion with dynamic fluoroscopy and reported no difference in kinematics between individuals with an intact rotator cuff and individuals with an asymptomatic tear⁴⁹. However, this lack of difference in joint kinematics was likely due, at least in part, to a small sample size and relatively high variability between the subjects.

More recent work investigating glenohumeral kinematics in individuals with asymptomatic rotator cuff pathology has been performed with high accuracy using a biplane radiographic system⁵¹. Baumer et al. performed a dynamic analysis of in vivo joint kinematics and reported that the humerus of individuals with asymptomatic rotator cuff pathology was positioned more inferiorly on the glenoid compared with control subjects with an intact rotator cuff²⁰. Although this finding seems difficult to reconcile with the clinical dogma that the humerus appears high on the glenoid on conventional static radiographs, the finding may reflect differences in joint mechanics under static and dynamic conditions. The authors also reported that individuals with asymptomatic rotator cuff pathology had a longer path of glenohumeral joint contact, which may indicate that subtle deficits in muscle function are associated with asymptomatic rotator cuff pathology.

Muscle Activity Patterns

There appears to be relatively little information available on muscle activity patterns in individuals with an asymptomatic RCT. Kelly et al. conducted electromyography (EMG) analysis on individuals with an intact rotator cuff, patients with an asymptomatic RCT, and patients with a symptomatic tear. The study generally reported increased supraspinatus EMG activity in both symptomatic and asymptomatic individuals with an RCT compared with control subjects⁴⁸.

Summary

In summary, studies have largely reported inconsistent findings regarding patient-reported outcomes, strength, range of motion, and kinematics in individuals with asymptomatic RCTs. Consequently, the extent to which an asymptomatic RCT impacts shoulder function remains unclear. If an asymptomatic RCT does indeed alter shoulder function, it appears that conventional clinical assessment tools may not have the necessary sensitivity to detect these alterations and, therefore, may be of limited diagnostic value when used in isolation.

Natural History of Asymptomatic RCTs

Several studies have documented the natural history of asymptomatic RCTs by longitudinally assessing tissue characteristics (e.g., tear size) using ultrasonography, objective measures of shoulder function (e.g., strength), patient-reported outcomes, and symptom status^{13–17,52}. Most of these studies followed individuals with confirmed full-thickness tears^{13,16,17}, citing the ability of ultrasonography to measure tear characteristics more accurately in full-thickness tears compared with partial-thickness tears. However, 2 ultrasound studies followed individuals with partial-thickness tears^{14,15}. Collectively, these studies provide useful information regarding risk factors for tear enlargement, symptom development, and functional decline. Although some natural history studies included individuals with a symptomatic contralateral shoulder^{13,15,53}, their conclusions are not substantially different from other studies involving individuals without contralateral shoulder pain¹⁶.

Risk of Enlargement

Enlargement of asymptomatic RCTs is common and typically observed within 3 years of tear identification^{13,14,16,17}. Compared with partial-thickness tears, full-thickness tears tended to be at higher risk for enlargement over time ($p = 0.07$, hazard ratio [HR]: 1.53)¹⁴. In particular, studies have reported that 38% to 61% of individuals with full-thickness asymptomatic tears^{13,16,17} and 44% of individuals with partial-thickness tears¹⁴ experienced enlargement within 3 years from the beginning of observation. However, without knowing the duration of time between the onset of the tear and the beginning of the observation period, the rate of tear progression is difficult to determine.

Previous studies also have reported the impact of various factors on the risk of tear enlargement, including shoulder dominance, physical activity, rotator cuff cable involvement, and the extent of muscle degeneration. Specifically, RCTs in the dominant shoulder are at a higher risk for enlargement^{14,53}. However, a higher level of shoulder activity does not appear to be associated with a higher risk of enlargement⁵³. Furthermore, tears involving the rotator cuff cable tend to have a higher frequency of enlargement than cable-intact tears ($p = 0.09$; 67% versus 52%, respectively)¹³. However, this finding may be confounded by cable-disrupted tears that are larger at baseline than cable-intact tears. Thus, it is difficult to know whether the higher risk of enlargement in cable-disrupted tears reflects a deficit in the theorized stress-shielding function of the cable or if cable-disrupted tears were simply more chronic at the onset of observation and more likely to progress. Additionally, supraspinatus muscle degeneration has been reported to influence the risk of tear enlargement, even in small tears¹⁴. In contrast, age, sex, and smoking status have not been found to be significantly associated with tear progression¹⁴.

Development of Pain

The eventual development of pain is common in individuals with a documented partial-thickness or full-thickness RCT. Specifically, 23% to 51% of individuals with an initially asymptomatic RCT become symptomatic, typically within 1.5 to 3.0 years from the beginning of the observation period^{14–17}. However, it is currently impossible to know when

a degenerative RCT begins, making both chronicity and long-term survivorship unclear. Nevertheless, individuals whose shoulder became symptomatic were more likely to have tear enlargement than those who remained asymptomatic^{14–16}. In particular, an enlargement of tear width appears to be more strongly related to the development of symptoms than an enlargement of tear retraction^{15,16}. However, 37% to 77% of individuals who developed symptoms did not have significant enlargement^{14–17}, suggesting that the alterations in tear characteristics cannot fully explain symptom development. These findings further emphasize that symptom development in the presence of an RCT is a complex and multifactorial process that is not yet fully understood.

The development of shoulder pain in the presence of a previously asymptomatic RCT has been associated with a decline in patient-reported function^{14–17}. In general, individuals who became symptomatic had reduced shoulder flexion and/or abduction range of motion compared with those who remained asymptomatic^{14–16}. A decline in internal and/or external rotation range of motion was less consistently observed, with some studies reporting a reduction^{14,15} and others showing no difference¹⁶.

Summary

Collectively, these natural history studies suggest that asymptomatic RCTs are likely to become symptomatic over time^{14–17}; also, as individuals become symptomatic, they typically report worse patient-reported outcome scores^{14–17}. In addition, RCTs that become symptomatic may be associated with functional deficits such as decreased strength^{14,16} and range of motion^{14–16}, but alterations in glenohumeral or scapulothoracic kinematics may be subtle and/or not detectable¹⁶.

Opportunities for Future Research

This literature review has summarized the relatively few but valuable studies that have investigated asymptomatic rotator cuff pathology. Although much has been learned, many questions remain that require more research to improve the management of rotator cuff pathology across the spectrums of tissue integrity and symptom status. As previously suggested, an alternative strategy for dealing with this long-standing clinical problem may be to identify rotator cuff pathology while it is asymptomatic and then initiate exercises designed to maintain acceptable shoulder function and prevent the pathology from becoming symptomatic. To that end, this approach provides a number of opportunities for future research.

First, future research should fully characterize any functional alteration that is associated with asymptomatic rotator cuff pathology. Previous research efforts have identified some alteration in strength, kinematics, and range of motion that are associated with asymptomatic rotator cuff pathology, but these findings collectively have been largely inconclusive. However, it remains plausible that asymptomatic rotator cuff pathology would be manifested through specific functional alterations, and, therefore, future efforts should identify the testing conditions and measurement techniques that are required to consistently elicit these alterations. It may be that identifying functional alterations that are associated with asymptomatic rotator cuff pathology requires shoulder function to be measured with greater

accuracy and/or under more challenging testing conditions than what has been done previously. Alternatively, it is possible that unconventional measures of strength, kinematics, or range of motion may be necessary in order to differentiate individuals with asymptomatic rotator cuff pathology from those with a healthy intact rotator cuff. For example, perhaps descriptions of joint motion (i.e., displacement) may be more sensitive to differences than absolute joint positions. Future research should rigorously identify the testing methods, conditions, and outcomes that are required to identify individuals with asymptomatic rotator cuff pathology.

Second, if asymptomatic rotator cuff pathology can be linked to specific functional alterations, then future research should determine whether the alterations are detrimental or compensatory. For example, there is evidence to suggest that RCTs are associated with altered scapular motion in the form of increased upward rotation^{54–56}. However, this finding does not necessarily imply that increased scapular upward rotation is an appropriate target for intervention because it may be a compensatory strategy for maintaining humerothoracic elevation because of decreased glenohumeral elevation. Consequently, future efforts should seek to correctly identify the targets that are most appropriate for early clinical intervention. For example, superior glenohumeral migration is thought to be detrimental for shoulder health but could be the result of insufficient rotator cuff muscle function (e.g., due to reduced strength and/or impaired motor control) or restricted glenohumeral joint mobility (e.g., due to glenohumeral osteoarthritis). Despite the same functional alteration (superior humeral head migration), clinical interventions (strengthening versus motor control training versus joint mobilization) could be disparate depending on the underlying cause. Finally, future studies should assess the extent to which early clinical intervention for the management of RCTs improves the long-term outcomes.

Third, future research efforts should focus on understanding the etiological factors that underlie rotator cuff pathology because the efficacy of early clinical intervention is likely dependent on this knowledge. Given that overuse is thought to be an important factor in the etiology of RCTs, concern may arise whether early exercise intervention is appropriate. This premise is supported by higher rates of tear progression and/or symptom development in dominant shoulders with asymptomatic RCTs^{14,15,53}. However, shoulder activity level does not appear to be a predictor of tear enlargement^{53,57,58}. This suggests that an RCT should not necessarily preclude an individual from performing exercise. However, more research is clearly needed to better understand the etiology of RCTs.

Fourth, future research efforts should focus on understanding the pain mechanisms that are associated with RCTs. Given the prevalence of asymptomatic RCTs, it is possible that other structures (e.g., subacromial bursa, biceps tendon) serve as the primary pain generators in symptomatic individuals. Furthermore, the prevalence of asymptomatic RCTs suggests that the nociceptive theory of pain cannot fully explain the relationship between pain and pathology. An alternative pain theory, central sensitization, suggests that pain may be mediated by central (i.e., neurological) mechanisms in addition to or independent from mechanical stimuli. Evidence of central sensitization has been found in individuals with shoulder pain^{59–61}. Additionally, clinical practice would benefit from research into the role of genetic and biopsychosocial factors in an individual's pain experience.

Fifth, the influence of RCT morphology (e.g., size, location, and cable involvement) and concomitant conditions (e.g., glenohumeral osteoarthritis) on factors such as shoulder strength, range of motion, and patient-reported outcomes is another opportunity for future research. The results of this research might help to identify individuals who are most susceptible to declining shoulder function and, therefore, most appropriate for early intervention.

Another intriguing opportunity for future research is developing and validating a home-based test for detecting asymptomatic rotator cuff pathology. A number of previous studies have described tests of upper-extremity function, and these tests are typically scored by documenting the time that is required for an individual to complete a standardized activity^{62–67}. While some of these tests have been shown to discriminate between healthy control subjects and patients with shoulder pain, it is unknown whether the tests can discriminate between asymptomatic individuals with intact rotator cuffs and those with torn rotator cuffs. Consequently, future research efforts should assess the extent to which existing functional tests can identify individuals with asymptomatic rotator cuff pathology or should develop and rigorously validate new functional tests.

Overview

Compared with symptomatic RCTs, relatively few studies have investigated asymptomatic rotator cuff pathology. The studies described herein indicate that asymptomatic RCTs are common, their prevalence increases with age, and there is a high likelihood that patients who are being treated for shoulder pain or an RCT have an asymptomatic tear in their contralateral shoulder. Unfortunately, conventional patient-reported outcomes (e.g., WORC or ASES scores) likely do not have sufficient precision to reliably identify the presence of an asymptomatic RCT. Similarly, functional measures (specifically, measures of strength, joint motion, and range of motion) and EMG also appear to have a limited ability to discriminate between individuals with an asymptomatic RCT and those with a healthy intact rotator cuff. Asymptomatic RCTs are likely to enlarge over the course of several years, but the development of symptoms is not understood.

An alternative approach to the long-standing clinical issue of rotator cuff pathology could involve identifying pathology (perhaps through a home-based test of shoulder function) when an individual is asymptomatic and then intervening with exercises that are designed to ensure that an asymptomatic RCT remains asymptomatic while maintaining the individual's shoulder function. If a home-based test was available that reliably identified the presence of asymptomatic rotator cuff pathology, then it is possible that early intervention could help to avoid the clinical sequelae that begin with symptom development and end with compromised shoulder function after surgical repair. Large-scale implementation of this approach could substantially reduce the number of patients seeking conventional clinical intervention for symptomatic rotator cuff pathology. However, development and validation of this proposed approach will require considerable research efforts.

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Fig. 1.
The number of published rotator cuff articles (PubMed search: “rotator cuff”; English language only) has risen dramatically over the past 50 years.

TABLE I

Summary of Studies Reporting Asymptomatic RCT Prevalence*

Study	Sample Characteristics	Prevalence	
		Partial-Thickness RCT	Full-Thickness RCT
Ultrasound studies			
Milgrom et al. ¹ (1995) [‡]	N = 90 (43 M, 47 F); age range, 30–99 yr	36%	36%
Tempelhof et al. ³⁵ (1999)	N = 411 (191 M, 220 F); age, >50 yr	NR	23%
Worland et al. ⁶⁸ (2003) [‡]	N = 59 (29 M, 30 F); age, 40 yr	NR	34%
Schibany et al. ²⁸ (2004) [§]	N = 212 (108 M, 104 F); age range, 18–85 yr; dominant shoulders	NR	6%
Yamaguchi et al. ³⁷ (2006)	N = 376; mean age, 63 yr; subjects receiving treatment for contralateral symptoms	21%	36%
Kim et al. ³² (2009) [‡]	N = 237 (144 M, 93 F); age, >40 yr	8%	11%
Keener et al. ⁴⁰ (2009) [#]	N = 98 (54 M, 44 F); mean age, 61 yr; subjects receiving treatment for contralateral symptoms	30%	46%
Moosmayer et al. ²⁶ (2009) [§]	N = 420 (206 M, 214 F); age, >50yr	NR	8%
Yamamoto et al. ³ (2010) [‡]	N = 1,366 shoulders from 683 subjects (229 M, 454 F); mean age, 57.9 yr (range, 22–87 yr)	NR	17%
Girish et al. ³⁰ (2011)	N = 51 (51 M); mean age, 56 yr (range, 40–70 yr)	24%	10%
Abate et al. ²⁹ (2014) [‡]	N = 464 shoulders from 232 subjects (232 F); age, 44 yr (mean, 52 yr)	NR	6%
Minagawa et al. ³⁹ (2013) [‡]	N = 664 (242 M, 422 F); age range, 20–87 yr; subjects from a single Japanese village	NR	14%
Roetal. ³³ (2015) [#]	N = 140 (60 M, 80 F); mean age, 60 yr (range, 39–83 yr); subjects had contralateral rotator cuff repair	19%	19%
Jeong et al. ³¹ (2017) [‡]	N = 486 (144 M, 342 F); age, 40 yr; Korean population	17%	5%
MRI studies			
Miniati et al. ⁶⁹ (1995) [‡]	N = 30 shoulders from 20 subjects (11 M, 19 F); mean age, 29 yr (range, 17–49 yr)	23%	0%
Sher et al. ³⁴ (1995)	N = 96 (47 M, 49 F); mean age, 53 yr (range, 19–88 yr); dominant shoulders	20%	15%
Needell et al. ³⁸ (1996)	N = 100 (49 M, 51 F); mean age, 54 yr (range, 19–88 yr); dominant shoulders	22%	14%
Reuter et al. ⁴¹ (2008)	N = 7 (5 M, 2 F); mean age, 35 yr (range, 29–62 yr); dominant shoulders of Ironman triathletes	29%	NR
Gill et al. ⁷⁰ (2014)	N = 30 (12 M, 18 F); mean age, 65 yr (range, 56–74 yr)	40%	20%

* RCT = rotator cuff tear, M = male, F = female, NR = not reported, and MRI = magnetic resonance imaging.

[‡]Prevalence was estimated from a figure.[#]Included both shoulders of an individual.

Rotator cuff tear was identified by ultrasonography and verified by MRI.

Subjects had contralateral shoulder pain or rotator cuff repair.

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