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Determining the rate of full-thickness progression in partial-thickness rotator cuff tears: a systematic review

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Background: Partial-thickness rotator cuff tears are likely at least as common as full-thickness rotator cuff tears, and it is critical for surgeons to have knowledge of the tear progression rate of partial-thickness rotator cuff tears when determining surgical or nonsurgical treatment. However, a systematic review investigating the rate of tear progression of partial-thickness rotator cuff tears has not been performed. Therefore, the purpose of this study was to systematically review the literature and determine the rate of full-thickness progression in nonoperatively treated partial-thickness rotator cuff tears.

Methods: A systematic review of the literature was performed following the PRISMA guidelines and checklist using the PubMed, MEDLINE, and Cochrane Library databases. English-language studies of Level I through IV evidence examining partial-thickness rotator cuff tears with description of the change in tear size were included. Studies using imaging modalities other than magnetic resonance imaging (MRI) or ultrasonography (US) for serial imaging and studies without description of the number of tears that progressed to full-thickness tears were excluded. The primary outcome was to determine the per-month progression rate from a partial-thickness tear to a full-thickness tear confirmed on either MRI or US. The progression rates, which were divided into 3 groups—symptomatic, asymptomatic and combined (asymptomatic + symptomatic)—were calculated using a random effects model with binomial within-study variance.

Results: Four studies were included, and 257 tears were analyzed statistically for tear progression. The average follow-up was 34 months (standard deviation, 19 months). The overall rate of progression to a full-thickness tear was 0.26% per month (95% confidence interval [CI], 0.15%-0.36% per month). In the symptomatic and asymptomatic groups, the rates were 0.22% per month (95% CI, 0.09%-0.34% per month) and 0.32% per month (95% CI, 0.15%-0.49% per month), respectively, which showed no significant difference (P =.341).

Conclusions: This study demonstrated that partial-thickness tears progress to full-thickness tears over time but at a relatively low rate at short- to intermediate-term follow-up. There was no significant difference in the per-month rates of full-thickness progression between symptomatic and asymptomatic tears.

Institutional review board approval was not required for this systematic review.

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Level of evidence: Level IV; Systematic Review

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The prevalence of partial-thickness rotator cuff tears (PT-RCTs) has been reported in cadaveric and imaging studies to be 13%-32%.[4,15,23,24] Thus, PT-RCTs are likely at least as common as full-thickness rotator cuff tears (FT-RCTs). Despite a recent interest in the study of PT-RCTs, the majority of studies have focused on surgical outcome or technique.[6,21] In addition, the number of published studies of PT-RCTs is less than those of FT-RCTs. Although the natural history of RCTs continues to be the defined,[1,3,8] the majority of data is on FT-RCTs. This lack of data on the natural history of PT-RCTs has led to debate over optimal treatment. When determining surgical or nonsurgical treatment, it is critical for surgeons to have a knowledge of the tear progression rate of PT-RCTs.

Previous studies have suggested that PT-RCTs appear to have a relatively low risk of tear progression compared with FT-RCTs.[18,22] However, the differences between progression of symptomatic vs. asymptomatic PT-RCTs remains unclear. To our knowledge, a systematic review investigating the rate of tear progression of PT-RCTs has not been performed.

The purpose of this study was therefore to systematically review the literature on the tear progression of PT-RCTs. In particular, we focused on the progression rate from a partial-thickness tear to a full-thickness tear. It was hypothesized that PT-RCTs would demonstrate a measurable rate of progression to full-thickness tears over time. We also hypothesized there would be no significant difference in the rates of tear progression between symptomatic and asymptomatic tears. In addition, the rate would be less than that of tear progression of FT-RCTs in the published literature.

Materials and methods

Systematic review

A systematic literature review was performed in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and checklist.[19] A thorough literature search was performed using the following databases: PubMed, MEDLINE, and Cochrane Library. The following terms in the title and abstract were used for the search: (''rotator cuff'' OR ''rotator cuff tear'') AND (''partial thickness'' OR ''articular side'' OR ''joint side'' OR ''bursal side''). Studies were systematically reviewed if they met the following inclusion criteria: (1) English-language studies, (2) Level I through IV clinical studies of chronic or degenerative RCTs including partial-thickness tears, (3) inclusion of a nonoperatively treated group, (4) patients aged 18 years or older, (5) mean study follow-up period of at least 1 year, (6) follow-up consisting of serial imaging, and (7) studies with description of the change of tear size. The exclusion criteria included (1) acute RCTs, (2) surgical intervention performed before serial imaging, (3) studies using imaging modalities other than magnetic resonance imaging (MRI) or ultrasound (US) for serial imaging, and (4) studies without description of the rate of progression to a full-thickness tear. Studies examining the same study population were included only once. This search was independently conducted by 2 investigators, each reviewing the abstract of each publication, and in cases where the abstract screening was inconclusive, full-text articles were reviewed. References of included manuscripts were manually searched to identify additional studies for review. The final literature search was conducted on March 20, 2020.

Quality assessment

A level of evidence was assigned to each study by 2 independent investigators using the *Journal of Bone and Joint Surgery*'s tool for prognostic studies.[30] Because of the observational nature of this study, the risk of bias in each study was assessed using a tool to assess risk of bias in longitudinal symptom research studies aimed at the general population from McMaster University.[29] The risk of bias is categorized into 3 sections in this tool: the representativeness of the source population, accuracy of outcome assessment, and completeness of data. This tool has previously been used in another natural history study.[12]

Outcome measures

The primary outcome was to determine the per-month progression rate from a partial-thickness tear to a full-thickness tear confirmed on either follow-up MRI or US irrespective of the anatomic location of each partial-thickness tear (ie, bursal surface, articular surface, or insubstance). The progression rates were calculated based on 3 groups: symptomatic, asymptomatic, and combined (asymptomatic + symptomatic).

Statistical analysis

Rates of progression were analyzed using a random effects model with binomial within-study variance. The combined outcomes were estimated via least squares means and were compared between groups. On the combined data, additional random effects models were used to fit a linear trend in the tear progression rates vs. follow-up months.

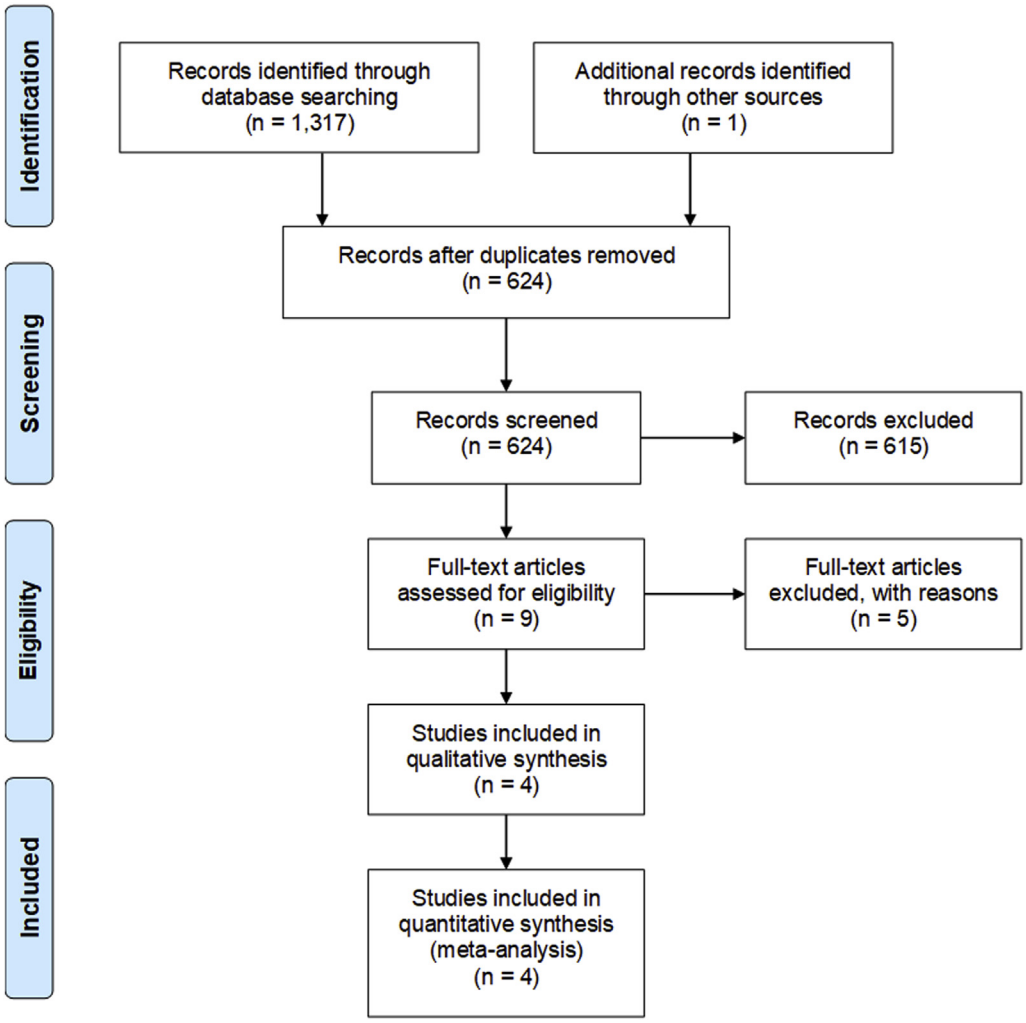

Figure 1 Systematic review algorithm using Preferred Items for Systematic Reviews and Meta-analyses (PRISMA).

Results

Literature search

Of the 624 articles identified by the initial literature search, only 9 articles met the inclusion criteria and were selected for full-text review. Five articles were excluded: 1 used arthrography and 3 had no description of progression to a full-thickness tear. As 2 articles used the same population, the one that had shorter follow-up and smaller number of patients was excluded. In total, 4 articles satisfied all inclusion and exclusion criteria and reported sufficient data for statistical analysis (Fig. 1).

Quality assessment

The levels of evidence ranged from II to IV, including a prospective longitudinal study and a retrospective study (Table I). The risk-of-bias assessment is summarized in Fig. 2. All 4 articles had a high risk of bias with sample populations that were not representative of the general population.

Demographic characteristics

The symptomatic group consisted of 3 studies, whereas only 1 study was available for the asymptomatic group. In total, 257 tears were included for the primary outcome with 201 tears in the symptomatic group and 56 tears in the asymptomatic group. Each article clearly documented the number of initial partial-thickness tears that progressed to full-thickness tears (Table I). The mean ages were 63 years in the symptomatic group and 60 years in the asymptomatic group (Table I).

Progression rate to a full-thickness tear

Of the 201 symptomatic partial-thickness tears, 5.3% progressed to full-thickness tears during a mean follow-up

Table I Studies and tear progression detail

Authors	Study type	Level of evidence	Imaging modality	Mean age (yr)	Mean follow-up (mo)	No. of tears	No. of progression to a full-thickness tear
Symptomatic tears							
Kong et al[11]	Retrospective cohort	IV	MRI	62	20	81	3
Lo et al[14]	Prospective cohort	II	MRI or MRA	53	46	37	3
Yamamoto et al[31]	Prospective cohort	III	MRI	67*	19	83	6
Subtotal or mean				63	28 (SD, 15)	201	12
Asymptomatic tears							
Keener et al[7]	Prospective cohort	II	US	59	61	56	11
Total or mean				62	34 (SD, 19)	257	23

MRI, magnetic resonance imaging; *MRA*, magnetic resonance arthrography; *US*, ultrasound; *SD*, standard deviation
* The mean age included some full-thickness tears.

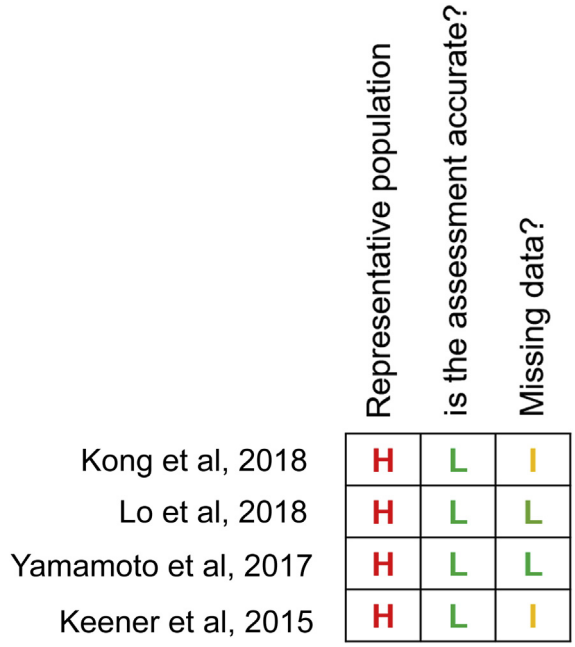

Figure 2 The summary of risk of bias in each included study by reviewers' judgments. *Green* indicates low risk; *yellow*, intermediate risk; and *red*, high risk.

period of 28 months compared with 19.6% at 61 months in the 56 asymptomatic partial-thickness tears. The average percentage progressions per month in the symptomatic and asymptomatic groups were 0.22% per month (95% confidence interval [CI], 0.09%-0.34% per month) and 0.32% per month (95% CI, 0.15%-0.49% per month), respectively. Although there was a statistically significant between-group difference in overall progression rates at 14.3% (95% CI, 3.4%-25.2%; $P = .010$), the difference in per-month rates showed no significant difference at 0.10% (95% CI, –0.11% to 0.31%; $P = .341$). When the symptomatic and asymptomatic groups were combined, the overall rate of tear progression was 8.4% (95% CI, 2.6%-14.1%) at 34 months, resulting in an overall percentage progression per month of 0.26% per month (95% CI, 0.15%-0.36% per month). A trend line included on a scatter plot of percentage tear progression vs. mean follow-up time is shown in Fig. 3. The slope coefficient ± standard error in the simplified linear trend model was 0.26 ± 0.05. The intercept was tested against 0 and dropped as there was no significant difference.

Discussion

This study demonstrated measurable rates of tear progression from a partial-thickness tear to a full-thickness tear. Consistent with the hypothesis, no significant difference was detected in those rates between the symptomatic and asymptomatic tears when examined by month.

When determining the progression of PT-RCTs, a number of factors may also be considered including anatomic location, tendon involvement, presence of delamination, tear size, and depth. While there may have been value in stratifying patients into various subcategories, this would have proven difficult because of the number of patients available. Furthermore, the interobserver reliability of MRI in determining the depth and size of a PT-RCT has been questioned.[25]

Despite this, a number of studies have previously evaluated the progression of PT-RCTs utilizing small size changes, and the definition of progression is variable. Although some have defined tear progression as an increase in size in any dimension of >5 mm,[7,17] others have defined tear progression as an increase in size as small as >2 mm.[9,31] Furthermore, other authors have included a change of tendon thickness or area of the tear in the rate of tear progression.[2,11,14,32]

When reviewing the literature, the vast majority of studies of PT-RCTs have used MRI or US in determining tear progression.[2,7,9,11,14,16,17,31] The diagnostic accuracy of MRI and US are relatively similar when detecting partial-

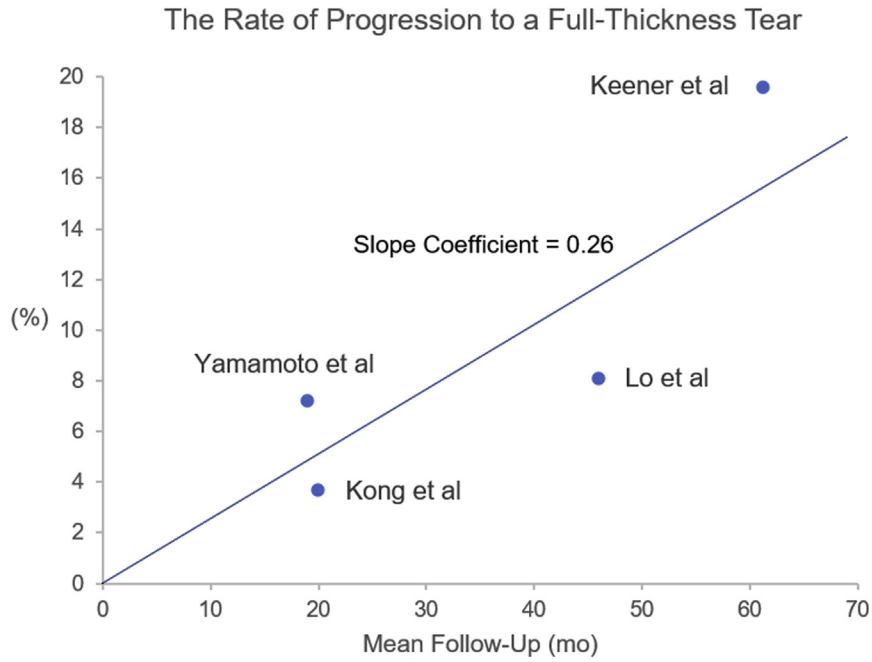

Figure 3 Correlation of the percentage of the full-thickness progression of a partial-thickness tear and mean follow-up expressed as a month for each included study and a trend line with slope coefficient = 0.255.

vs. full-thickness tears of the rotator cuff.[5,20,27,28] However, the diagnostic accuracy of detecting small changes (eg, >2 mm or >5 mm) in PT-RCTs remains unclear. For these reasons, in the current systematic review we defined tear progression as conversion to an FT-RCT. This definition of tear progression should be more accurate than other more subtle changes that may be marred by variability in both intraobserver and interobserver reliability. Furthermore, it is the senior authors' clinical experience that most patients have concerns regarding the potential of progression to a full-thickness tear where the risk of tendon retraction, muscle atrophy, and fatty infiltration may increase.[22]

In the current study, we compared the rate of progression of both symptomatic and asymptomatic PT-RCTs. Although the number of available studies was significantly low, statistical comparison was possible because of the availability of study-specific variances to the model. Overall, there was a significant difference in the rates of progression to a full-thickness tear between these groups. However, when the follow-up interval was considered, there was no significant difference in the per-month rate. This suggests that both symptomatic and asymptomatic PT-RCTs progress at similar rates. Although this conclusion should be confirmed by further studies, this is similarly reported by a systematic review of progression of FT-RCTs where the rate of tear progression was not significantly different between symptomatic and asymptomatic FT-RCTs.[12]

Although the definition of tear progression was different in each study, the rate of tear progression of PT-RCTs (0.26% per month) does seem to be less than that of FT-RCTs (0.91% per month).[12] This is supported by a study by Kim et al[9] on the progression of both PT-RCTs and FT-RCTs. They determined that FT-RCTs (82.4%) were more likely to progress than PT-RCTs (26.1%) over a follow-up period of 6-100 months.[9]

Most authors agree that the majority of PT-RCTs may be initially treated nonoperatively[26] with successful treatment reported in some studies.[10,13,14] The results of this study further improve our understanding of the ''natural history'' of PT-RCTs. We hope this information will allow us to properly counsel patients when considering investigations, follow-up, and operative vs. nonoperative treatment. This is particularly relevant during nonoperative treatment where, in the authors' experience, the patient question of tear progression inevitably occurs. Furthermore, the relatively low rate of progression to full-thickness defects supports the current scientific literature.

This study had several limitations. First, only a small number of studies were available for review, and only 4 studies were included after final review. Although this was in part related to the paucity of literature, it was also related to our strict definition of tear progression. Further well-designed studies are required to both increase the number of PT-RCTs followed for tear progression and investigate other factors (other symptoms) that may be associated with tear progression.

Second, the demographic patient data was limited to age because of inconsistent reporting between studies. On average, asymptomatic tears had younger age. Although

these data were from only 1 study,[7] it may have introduced some age-related bias in the current study. Furthermore, other variables not assessed in the current study such as occupation, sports activity, and medical comorbidities may also affect tear progression.

Third, there were a number of biases in the studies that may have affected the results, including sample population bias. In addition, the nonoperative treatment that was performed in symptomatic PT-RCTs studies was not standardized.[11,14,31]

Fourth, the location and side of PT-RCTs were not universally analyzed. Although the tendons involved were most commonly the supraspinatus and infraspinatus tendon, the included studies did not describe which tendon actually progressed to a full-thickness tear.

Fifth, the definition of a symptomatic PT-RCT was not clearly defined in all studies (ie, pain, weakness, decreased function). One study defined symptomatic PT-RCTs as a minimum duration of "symptoms" for 3 months,[14] another as a painful RCT at the initial visit,[31] and further, another study only stated symptomatic rotator cuff tear.[11] Therefore, the frequency, type, and severity of symptoms may be heterogeneous between studies. In contrast, patients included in the asymptomatic group were derived from patients with contralateral symptomatic RCTs who had underwent bilateral shoulder US.[7] Therefore, these results may differ from patients with bilateral asymptomatic shoulders. Results may also differ from those in subjects with unilateral disease.

Finally, a linear model was assumed in determining the rate of tear progression but, overall, this is likely an oversimplification of failure over time. However, without individual patient data, it is unclear what the survivorship curve of progression to a full-thickness tear may be.

Conclusion

This study demonstrated that PT-RCTs progress to FT-RCTs over time but at a relatively low rate at short- to intermediate-term follow-up. There was no significant difference in the per-month rates of full-thickness progression between symptomatic and asymptomatic tears.

Disclaimer

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