Natural History of Rotator Cuff Tears

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University Hospital of Patras
Key points

• Prevalence and risk factors for rotator cuff tearing
• Natural history of asymptomatic and symptomatic tears
• Potential for healing after rotator cuff repair
• Indications-timing of operative and conservative treatment
• The role of arthroscopic treatment
Prevalence – Cadaveric studies

- Cadaver and autopsy dissections 5% to 40%
- **Neer** full-thickness tears 5% in 500 cadavers
- **Lehman** full-thickness tears 17% in 235 cadavers
- **Yamanaka** supraspinatus full-thickness 7%
  partial-thickness 13% in 249 cadavers

Bursal sided (2.4%)
intratendinous (7.2%)
articular sided (3.6%)

*Neer CS, Clin Orthop 1983*
Prevalence – MRI & US studies

MRI

• Sher et al 34% overall prevalence in asymptomatic pt (15% full thickness and 20% partial thickness)

Ultrasound

• Tempelhof et al 23% prevalence of full-thickness tears in asymptomatic individuals (51% > 80 years)

• Cuff tearing increased with age

• Bilateral intact cuffs  48  
  Unilateral cuff tear  58  
  Bilateral cuff tear  67  

• Prevalence of tear from 35% to 50% in pt > 66 years
212 asymptomatic individuals (18-85 years)

6% complete rupture of SSP (mean: 67 years)

All patients reported no functional deficits, although strength was significantly lower in the tear group.
RC tears were present in 20.7% / 683 pt

36% tear in symptomatic pt
16.9% in asymptomatic

RC tearing associated with increasing age (25.6% in their 60s → up to 50% in their 80s)
An asymptomatic rotator cuff tear is associated with a clinically insignificant loss of shoulder function.

Clinically detectable differences in shoulder function may indicate an “at-risk” asymptomatic tear.

Hand dominance appears to be an important risk factor for pain.
Risk factors

- Increasing patient age
- Smoking
- Hypertension
- Hypercholesterolemia
- Family history
Smoking

Smoking has not only been shown to increase the risk for rotator cuff tearing but also:

- increased tear size
- limited healing ability after repair
- poorer clinical outcomes after surgical repair
The impact of preoperative smoking habit on rotator cuff tear: cigarette smoking influences rotator cuff tear sizes

Stefano Carbone, MDa,*, Stefano Gumina, MD, PhDa, Valerio Arceri, MDa, Vincenzo Campagna, MDb, Corrado Fagnani, MDC, Franco Postacchini, MDD, PhDa

<table>
<thead>
<tr>
<th>Type of tear</th>
<th>Average</th>
<th>Standard deviation</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>Type I</td>
<td>14.63</td>
<td>5.55</td>
<td>22</td>
</tr>
<tr>
<td>Type II</td>
<td>19.88</td>
<td>9.03</td>
<td>72</td>
</tr>
<tr>
<td>Type III</td>
<td>20.32</td>
<td>10.94</td>
<td>27</td>
</tr>
<tr>
<td>Type IV</td>
<td>23.88</td>
<td>6.85</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>19.40</td>
<td>9.07</td>
<td>131</td>
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Table I Distribution of different types of rotator cuff tear between smoking and nonsmoking patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type of tear</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Total</th>
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<tbody>
<tr>
<td>Nonsmokers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>No.</td>
<td>73</td>
<td>142</td>
<td>47</td>
<td>15</td>
<td>277</td>
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</tr>
<tr>
<td>% of total</td>
<td>17.9</td>
<td>34.8</td>
<td>11.5</td>
<td>3.7</td>
<td>67.9</td>
<td></td>
</tr>
<tr>
<td>Smokers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>22</td>
<td>72</td>
<td>27</td>
<td>10</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td>% of total</td>
<td>5.4</td>
<td>17.6</td>
<td>6.6</td>
<td>2.5</td>
<td>32.1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>214</td>
<td>74</td>
<td>25</td>
<td>408</td>
<td></td>
</tr>
<tr>
<td>% of total</td>
<td>23.5</td>
<td>52.5</td>
<td>18.1</td>
<td>6.1</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

* Corresponding author.
Hypertension was associated with a **2-fold higher risk** of tear occurrence.

- 2 times more likely to experience large tear and 4 times massive tear.

- Mean duration of antihypertensive therapy significantly increased from small tear (1.08 years) to large tear (3.20 years) to massive tear (6.34 years).
Hypercholesterolemia

The Effect of Hypercholesterolemia on Rotator Cuff Disease

Joseph A. Abboud MD, Jae S. Kim MS

Lipid profiles in 80 patients with full-thickness RC tears and 80 controls with shoulder pain but normal RC

Total cholesterol, triglycerides, and LDL concentrations of patients with RC tears were all significantly higher

**64%** of patients with a tear had an elevated serum cholesterol (> 240 mg/dL) compared with 28% in the control group.
129 siblings were retrospectively evaluated in a cohort of 205 patients diagnosed as having full-thickness RC tears by ultrasound.

Using the spouses of the patients as a control group, the relative risk of full-thickness tears in siblings compared with controls was 2.42.

Evaluation of the same population 5 years later showed that siblings were more likely to have had a progression of tear size (62.9% in siblings vs 22.1% in controls).
In a group of **3091 patients**, the relative risk of rotator cuff disease in the relatives of patients diagnosed with cuff disease before age 40 years was significantly elevated for both 2\textsuperscript{nd} degree and 3\textsuperscript{rd} degree relatives.
51% of the patients with a previously asymptomatic tear developed symptoms over an average of 2.8 years.

50% of the newly symptomatic tears progressed in size whereas only 20% of the tears that remained asymptomatic progressed in size.

There was no evidence of tendon healing or decrease in tear size.
They compared 34 patients who became symptomatic (~2 years after the initial evaluation) to 35 patients who remained asymptomatic.

RC tears in the symptom development group were significantly larger than those in the group that remained asymptomatic.

Also, tear enlargement was more common in the group that became symptomatic (23%) compared with those who remained asymptomatic (4%).
Why some tears become symptomatic?

**Burkhart** proposed the theory that normal glenohumeral kinematics can be preserved in the setting of a rotator cuff tear as long as the cuff’s force couples are maintained.

Tear size is less important than tear location in terms of force couple and kinematic preservation.

The symptomatic and asymptomatic groups showed progressive superior translation of the humeral head on the glenoid with increasing arm elevation. The normal group, in contrast, maintained a constant center of rotation along the geometric center of the glenoid.
Proximal humeral migration correlates with RC tear size. Tears extending into the infraspinatus tendon are associated with greater humeral migration than is seen with isolated supraspinatus tears.

For full-thickness symptomatic tears of > 175 mm², both pain and tear area were found to have a significant effect on migration.

Multivariate analysis showed that tear size was the strongest predictor of migration in symptomatic shoulders.
Patients with asymptomatic RC tears had significantly greater subscapularis activity during internal rotation activities and less upper trapezius activation during carrying activities than symptomatic patients.

Also, symptomatic patients had significantly greater supraspinatus, infraspinatus, and upper trapezius muscle activation with shoulder elevation tasks than asymptomatic patients.
Why some tears become symptomatic?

- Larger tears are more likely to develop symptoms and that development of pain correlates with tear enlargement.

- Abnormal glenohumeral kinematic function cannot independently explain the presence of symptoms and altered kinematics is probably most influenced by tear size.

- Patients with symptomatic tears continue to fire the torn muscles and attempt to overcompensate with scapular stabilizers compared with asymptomatic patients who use the remainder of the intact cuff.
### Natural History - Symptomatic Full-Thickness Tears

<table>
<thead>
<tr>
<th>Author</th>
<th>Patients</th>
<th>Average Fup</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golberg et al</td>
<td>46</td>
<td>2.5 years</td>
<td>59%</td>
</tr>
<tr>
<td>Bokor et al</td>
<td>53</td>
<td>7.6 years</td>
<td>74% (56% good UCLA scale)</td>
</tr>
<tr>
<td>Hawkins et al</td>
<td>33</td>
<td>3.8 years</td>
<td>58%</td>
</tr>
</tbody>
</table>

Although non-operative treatment can be effective, information regarding who fails conservative treatment and who likely benefits from surgical repair is required to maximize outcomes.

Natural History - Symptomatic Large Full-Thickness Tears

<table>
<thead>
<tr>
<th>Author</th>
<th>Patients</th>
<th>Average Fup</th>
<th>Size progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maman et al</td>
<td>33</td>
<td>24 months</td>
<td>52% (tear progression &gt; 18 months/age&gt; 60 and fatty infiltration tear progression)</td>
</tr>
<tr>
<td>Safran et al</td>
<td>51(&lt;60)</td>
<td>29 months</td>
<td>50% (&gt; 5mm), pain was correlated with tear progression</td>
</tr>
</tbody>
</table>

... there is a significant risk for tear progression in non-operatively treated **symptomatic** large full-thickness tears with approximately 50% progressing at an average of 2 years.

Early surgical treatment can be considered in young patients

If tears are to be monitored, then imaging should be performed at 1.5 years or if the shoulder becomes increasingly painful
24 patients (~ 54 years old) isolated full-thickness SSP tears
initial tear size was 1.6 cm
3.5 years’ average follow-up
25% had tear progression

no increase in fatty degeneration of the SSP beyond stage 2
tear progression did not affect the reparability of these tears
Natural History - Symptomatic Full-Thickness Tears

In small (<1–1.5 cm) full-thickness tears, initial observation is reasonable even in young patients, due to a low risk for tear progression (25%).

In larger tears, as shown by Maman et al and Safran et al, there is a higher risk (approximately 50%) for tear enlargement.
30 asymptomatic partial-thickness tears.

2-years' follow-up

10/30 became symptomatic.

40% of symptomatic progressed to a full-thickness tear

Pain was highly correlated with tear progression
Natural History - **Symptomatic Partial-Thickness Tears**

30 patients with symptomatic partial-thickness tear

24 months follow up with an MRI

10% of progressed in size (>5 mm),

(which is significantly less than the 50% progression reported in the same study for symptomatic full-thickness tears)

Tear location had no affect on tear progression.

Initial non-operative treatment is reasonable due to a decreased risk for tear progression.
Spontaneous Tendon Healing – Animal models

There is limited if any spontaneous rotator cuff healing in animal models.


Spontaneous Tendon Healing – clinical cases

Arthroscopic or open debridement of tears and acromioplasty will not result in spontaneous tendon healing

**Weber SC:** none of pt treated with arthroscopic debridement and acromioplasty for partial-thickness tears had evidence of healing at 2\(^{nd}\) look scope

**Kartus et al:** no evidence of tendon healing *(by US)* at 101 m postoperatively in 26 patients treated with arthroscopic acromioplasty for partial thickness rotator cuff tears. (35% progressed to full tears)

**Massoud et al:** no patients who underwent revision surgery at an 13.7 months after open decompression for small and medium-sized tears had evidence of healing and 40% progressed to full tears
In a rat supraspinatus tendon repair model, repair sites revealed a **poor healing response** with only partial recreation of the original tendon insertion site by 8 weeks.

Biomechanical properties of repaired supraspinatus rat tendons were **inferior at 8 weeks after repair** compared with uninjured tendon sites.

Tendon Healing After Repair—clinical studies


The results of open rotator cuff repair for chronic tears do not deteriorate with time (ten year)

ORIGINAL ARTICLES

Mini-incision rotator cuff repair: A longitudinal assessment with no deterioration of result up to nine years

Homan Zandi, FRACS,1,2 Jennifer A. Coghlan, BA, FRCNA,1,2 and Simon N. Bell, FRACS1,2. Melbourne and Brighton, Australia

there is no deterioration in the results of mini-incision cuff repair in up to 9 years’ follow-up
Single-tendon and 2-tendon re-tear rates have been reported as 29% and up to 94%, respectively, despite excellent clinical outcomes.

Failure of tendon healing does not preclude an excellent result, although improved results have been correlated with intact repairs.

Biologic & patient related factors affecting healing

- Patient age: > 60
- Tear size: > tears
- Tear chronicity: > 24 m
- Muscle atrophy: > grade 2
Patient age

Boileau et al reported 43% healing in patients over 65 as opposed to 86% healing under age 65 in single tendon tears fixed arthroscopically.

Tashjian et al determined the average age of unhealed repairs after double-row repair was in the early 60s compared with those that healed was in the mid-50s.


Tear size

Prospective evaluation of arthroscopic rotator cuff repairs at 5 years: part II—prognostic factors for clinical and radiographic outcomes

Lawrence V. Gulotta, MD*, Shane J. Nho, MD, Christopher C. Dodson, MD, Ronald S. Adler, MD, PhD, David W. Altchek, MD, John D. MacGillivray, MD, for the HSS Arthroscopic Rotator Cuff Registry

.....those who were satisfied at earlier time points continued to have excellent functional scores at 5 years.

The presence of a radiographic defect at the repair site at 5 years was predicted by older age, **increasing tear size**, concomitant biceps, and AC joint procedures
The factors affecting tendon healing were the patient’s age, the size and extent of the tear, and the presence of **fatty degeneration** in the rotator cuff muscle.
Higher degrees of muscular atrophy and fatty infiltration preoperatively are associated with recurrence of the tear as well as progression of fatty infiltration and muscular atrophy and an inferior clinical result.
Inter-Rater Agreement of the Goutallier, Patte, and Warner Classification Scores Using Preoperative Magnetic Resonance Imaging in Patients With Rotator Cuff Tears

Julienne Lippe, M.D., Jeffrey T. Spang, M.D., Robin R. Leger, R.N., Ph.D., Robert A. Arciero, M.D., Augustus D. Mazzocca, M.D., and Kevin P. Shea, M.D.

**Table 2. Interobserver Agreement for Full-Thickness Rotator Cuff Tears**

<table>
<thead>
<tr>
<th>Classification System</th>
<th>$\kappa$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendon retraction in frontal plane (Patte)</td>
<td>0.58</td>
</tr>
<tr>
<td>Supraspinatus fatty infiltration, dichotomized (Goutallier)</td>
<td>0.53</td>
</tr>
<tr>
<td>Supraspinatus fatty infiltration, nondichotomized (Goutallier)</td>
<td>0.41</td>
</tr>
<tr>
<td>Supraspinatus atrophy</td>
<td>0.25</td>
</tr>
<tr>
<td>Infraspinatus atrophy</td>
<td>&lt;0.37</td>
</tr>
</tbody>
</table>

**Note.** The $\kappa$ statistic is a measure of interobserver reliability. Further description is given in the Methods section.
Indications & timing of surgical repair

The natural history of rotator cuff disease has demonstrated that there are several potential significant risks associated with non-operative treatment.

These risks include:
- a relative lack of spontaneous healing,
- tear progression over time,
- muscle fatty degeneration,
- tendon retraction,
- difficulty with tendon mobilization and
- potential for arthritis
# Epidemiology, Natural History, and Indications for Treatment of Rotator Cuff Tears

Robert Z. Tashjian, MD*

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**Box 1**

**Treatment algorithm for rotator cuff disease**

- **Group I**—initial nonoperative treatment
  - Tendonitis
  - Partial-thickness tears (except maybe larger bursal-sided tears)
  - Maybe small (<1 cm) full-thickness tears
- **Group II**—consider early surgical repair
  - All acute tears full-thickness (except maybe small [<1 cm] tears)
  - All chronic full-thickness tears in a young (<65) age group (except maybe small [<1 cm] tears)
- **Group III**—initial nonoperative treatment
  - All chronic full-thickness tears in an older (>65 or 70) age group
  - Irreparable tears (based on tear size, retraction, muscle quality, and migration)
**Group I—Rotator Cuff Tendonitis, Partial-Thickness Tears (Except Larger Bursal-Sided Tears), and Small (<1–1.5 cm) Full-Thickness Tears**

Prolonged physical therapy and nonoperative treatment should be considered in group I.

There is limited risk for the development of irreversible, chronic changes, such as fatty infiltration, tendon retraction, or glenohumeral arthritis with this treatment regimen.
11 randomized, controlled trials (level 1 and 2) evaluating the effect of exercise in the treatment of impingement were identified.

... the data demonstrate that exercise has statistically and clinically significant effects on pain reduction and improving function, but not on range of motion or strength.
We conclude that after 2.5 years of follow-up, both arthroscopic surgery and supervised exercises are better treatments than placebo. The difference between the 2 active treatments was not significant.
Then who should be operated on?

In view of our findings, we are now more reluctant to recommend surgery in cases with stage II impingement.

There is a need for larger scale studies with sufficient numbers of participants.
**Group I**—Rotator Cuff Tendonitis, **Partial-Thickness Tears (Except Larger Bursal-Sided Tears)**, and **Small (<1–1.5 cm) Full-Thickness Tears**

Although healing has not been shown to occur without repair, significant improvements in functional outcomes have been shown with conservative treatment.

Similarly, there has been shown to be a slow, small risk for tear progression.

*Kartus J, Arthroscopy 2006;22:44–9
The clinical outcome among patients with partial-thickness RC tear (>50% of the tendon, grade 1 and 2) is not significantly different from that among patients without partial-thickness rotator cuff tears.

Patients with grade 2B (bursal-side) partial-thickness tears had a higher failure rate (38%) than did patients with grade 2A (articular-side) partial-thickness tears (5%).
Low rate of tear progression for small (<1 cm–1.5 cm) full-thickness tears.
If observation is performed, then an MRI should be performed at 12 to 18 months from evaluation or if symptoms progress to monitor for tear progression.
**Group II** - Any Acute **Full-Thickness Tear** or Any Chronic Full-Thickness Tear in a Young (<65-Year-Old) Age Group (Except Possibly Small [<1–1.5 cm] Full-Thickness Tears)

Early surgical intervention is warranted in this category due to significant risks for irreversible changes with non-operative treatment and a high likelihood of healing if repair is performed.
Early operative fixation?

Patients younger than 50 years old with acute rotator cuff tears should undergo early operative fixation or at least within 3 weeks for maximal restoration of shoulder function, specifically improved shoulder abduction.

no significant differences in tendon healing, pain, shoulder elevation, or functional outcomes occur if an acute tear was fixed within 3 months of injury compared with within 3 weeks.

patients with acute tears fixed after 4 months had worse American Shoulder and Elbow Surgeons scores, active forward elevation, and satisfaction than if fixed before 4 months.
Group II - Any Acute Full-Thickness Tear or Any **Chronic Full-Thickness Tear** in a Young (<65-Year-Old) Age Group (Except Possibly Small [<1–1.5 cm] Full-Thickness Tears)

All young (<65 years old) patients with substantial (>1–1.5 cm) full-thickness tears without significant muscle deterioration can also be considered for early surgical repair.

Based on natural history\(^1,2\) there is a significant risk tear progression in this group (tear extension, fatty changes and tendon retraction)

Group III - Chronic Full-thickness Tears in Older Patients (>65 or 70) or Irreparable Tears with Significant Irreversible Changes Present

Only 43% of patients over age 65 treated with arthroscopic rotator cuff repair of a full thickness supraspinatus tear had evidence of healing at 18 months postoperatively compared with 86% of patients under age 65.
**Group III - Chronic Full-thickness Tears** in Older Patients (>65 or 70) or Irreparable Tears with SignificantIrreversible Changes Present

High rate of recurrent defects
Mean 25-month follow-up demonstrated excellent pain relief and improvement in the ability to perform the activities of daily living, despite the structural failures.
Group III - Chronic Full-thickness Tears in Older Patients (>65 or 70) or Irreparable Tears with Significant Irreversible Changes Present

In the setting of large or massive tears with chronic irreversible changes to the rotator cuff muscle, the risks of non-operative treatment are small because most of these injuries are irreparable.

Several factors have been identified on imaging studies that correlate with irreparability
- Tears greater than 4 cm in width and length
- Severe fatty infiltration of the SSP (grade 3 or 4) and IFS
- Static superior humeral head migration on plain radiographs
- Reduced acromiohumeral index
The rotator cuff normally provides stability by compression of the humeral head into the glenoid, whereas rotator cuff disruption compromises concavity compression and alters glenohumeral load structure and direction.
“Seein’ is believin’!” and arthroscopy allows direct visualization of the entire rotator cuff from anterior subscapularis to posterior teres minor in one single “view”
- decreased surgical morbidity,
- improved rehabilitation,
- ability to identify and treat associated pathology
- allows visualization of the tear size, retraction, and tissue quality
- releases can also be performed, facilitating low-tension repairs.

The final factor in the argument for an arthroscopic approach is that of patient preference.
Initial nonoperative care can be safely undertaken in:

- in older patients (>70 years old) with chronic tears
- patients with irreparable rotator cuff tears with irreversible changes,
- patients of any age with small (<1 cm) full-thickness tears or in
- patients with partial-thickness tears

Early surgical treatment can be considered in

significant (>1 cm–1.5 cm) acute tears or young patients with full-thickness tears who have a significant risk for the development of irreparable rotator cuff changes.