Washington University School of Medicine
Digital Commons@Becker

Open Access Publications

5-1-2010

Location and initiation of degenerative rotator cuff tears: An analysis of three hundred and sixty shoulders

H. Mike Kim
Washington University School of Medicine in St. Louis

Nirvikar Dahiya
Washington University School of Medicine in St. Louis

Sharlene A. Teefey
Washington University School of Medicine in St. Louis

William D. Middleton
Washington University School of Medicine in St. Louis

Georgia Stobbs
Washington University School of Medicine in St. Louis

See next page for additional authors

Follow this and additional works at: http://digitalcommons.wustl.edu/open_access_pubs

Part of the Medicine and Health Sciences Commons

Authors

H. Mike Kim, Nirvikar Dahiya, Sharlene A. Teefey, William D. Middleton, Georgia Stobbs, Karen Steger-May, Ken Yamaguchi, and Jay D. Keener

Location and Initiation of Degenerative Rotator Cuff Tears

An Analysis of Three Hundred and Sixty Shoulders

By H. Mike Kim, MD, Nirvikar Dahiya, MD, Sharlene A. Teefey, MD, William D. Middleton, MD,
Georgia Stobbs, RN, Karen Steger-May, MA, Ken Yamaguchi, MD, and Jay D. Keener, MD

Investigation performed at the Department of Orthopaedic Surgery, Washington University School of Medicine, St. Louis, Missouri

Background: It has been theorized that degenerative rotator cuff tears most commonly involve the supraspinatus tendon, initiating at the anterior portion of the supraspinatus insertion and propagating posteriorly. The purposes of this study were to determine the most common location of degenerative rotator cuff tears and to examine tear location patterns associated with various tear sizes.

Methods: Ultrasonograms of 360 shoulders with either a full-thickness rotator cuff tear (272) or a partial-thickness rotator cuff tear (eighty-eight) were obtained to measure the width and length of the tear and the distance from the biceps tendon to the anterior margin of the tear. Tears were grouped on the basis of their size (anteroposterior width) and extent (partial or full-thickness). Each tear was represented numerically as a column of consecutive numbers representing the tear width and distance posterior to the biceps tendon. All tears were pooled to graphically represent the width and location of the tears within groups. Frequency histograms of the pooled data were generated, and the mode was determined for each histogram representing various tear groups.

Results: The mean age (and standard deviation) of the 233 subjects (360 shoulders) was 64.7 ± 10.2 years. The mean width and length of the tears were 16.3 ± 12.1 mm and 17.0 ± 13.0 mm, respectively. The mean distance from the biceps tendon to the anterior tear margin was 7.8 ± 5.7 mm (range, 0 to 26 mm). Histograms of the various tear groups invariably showed the location of 15 to 16 mm posterior to the biceps tendon to be the most commonly torn location within the posterior cuff tendons. The histograms of small tears (a width of <10 mm) and partial-thickness tears showed similar distributions of tear locations, indicating that the region approximately 15 mm posterior to the biceps tendon may be where rotator cuff tears most commonly initiate.

Conclusions: Degenerative rotator cuff tears most commonly involve a posterior location, near the junction of the supraspinatus and infraspinatus. The patterns of tear location across multiple tear sizes suggest that degenerative cuff tears may initiate in a region 13 to 17 mm posterior to the biceps tendon.

Clinical Relevance: The findings of this study speak to the specific location of the most common type of rotator cuff lesions, degenerative rotator cuff tears.

Understanding the common locations and points of initiation of degenerative rotator cuff tears is fundamental to understanding the pathogenesis of rotator cuff disease. Until now, little attention has been directed toward defining these important concepts. Several previous authors have stated that degenerative rotator cuff tears most commonly involve the supraspinatus tendon, typically beginning at the anterior portion of the supraspinatus insertion near the biceps

tendon and propagating posteriorly[1-6]. It has also been theorized that a rotator cuff tendon gradually tears at its humeral insertion from the articular surface to the bursal surface, progressing in a continuum from a partial-thickness tear to a full-thickness tear[1-3,7,8]. However, recent studies have shown that rotator cuff tears can be isolated to or propagate from the infraspinatus tendon[9,10]. In addition, fatty degeneration of the infraspinatus muscle has been reported with presumed isolated supraspinatus tendon tears[11]. These seemingly conflicting findings combined with recent anatomical descriptions of the rotator cuff insertion[12,13] challenge our conventional theories regarding the initiation and propagation of rotator cuff tears. An improved understanding of the location and initiation of degenerative rotator cuff tears may serve as a foundation for further research regarding the pathogenesis of these tears and help to direct surgical strategies for patients with painful rotator cuff tears.

The purposes of this study were (1) to determine the most common location of degenerative rotator cuff tears and (2) to examine tear location patterns for various tear sizes. To this end, ultrasonograms of the shoulders of a large number of patients with a rotator cuff tear were examined in order to localize and graphically represent the cuff tears.

Materials and Methods

Study Subjects

Ultrasonograms of both shoulders of 262 patients were reviewed for this study after approval by our institutional review board. The subjects of this study represent all eligible subjects in an ongoing National Institutes of Health-funded prospective cohort study in which standardized bilateral assessment of shoulder function is performed and shoulder ultrasonograms and radiographs are made annually to study the natural history of asymptomatic rotator cuff tears. To be included in the prospective cohort study, patients had to have (1) presented for bilateral shoulder ultrasonography at our institution for investigation of unilateral shoulder pain, (2) been discovered to have a rotator cuff tear (either full or partial-thickness) in the asymptomatic contralateral shoulder, (3) been verified as being asymptomatic in one shoulder at the initiation of the study, and (4) had no history of recognized trauma (a fall, motor-vehicle accident, heavy-lifting episode, or shoulder dislocation) to either shoulder and remained free of injury for the duration of the study. Exclusion criteria were (1) any "significant pain" in the asymptomatic shoulder, (2) a history of trauma to either shoulder, (3) inflammatory arthropathy, (4) a history of seeking medical attention for other problems in the asymptomatic shoulder (such as instability or arthritis), (5) use of the upper extremity for weight-bearing, and (6) a very small partial-thickness tear (<5 mm) in the asymptomatic shoulder. The definition of "significant pain" for the prospective cohort study included (1) any pain rated as >3 on a 10-point visual analog pain scale that had lasted for more than one week, (2) any pain considered to be greater than that normally experienced as part of daily living, (3) any pain requiring the use of medications such as narcotics or nonsteroidal anti-inflammatory drugs, and (4) any pain that prompted a visit to a physician for evaluation.

Initial ultrasonograms of both the symptomatic and the asymptomatic shoulder of all subjects were reviewed, and they were included in the present study if (1) no previous rotator cuff surgery had been performed on either shoulder, (2) the width and length of the rotator cuff tear (when one was present) had been measured and recorded in the ultrasonography report, (3) ultrasound images demonstrating the width and length of the tear were available for review, (4) either the biceps tendon or the bicipital groove was clearly visible on the transverse view, and (5) the biceps tendon was located in the groove without subluxation or dislocation when the bicipital groove was not visible.

Shoulder Ultrasonography

All ultrasonography examinations were performed in real time with use of one of three different sonographic machines (ATL HDI 5000 [Philips Healthcare, Andover, Massachusetts], Elegra [Siemens Healthcare, Malvern, Pennsylvania], and Antares [Siemens Healthcare]) and high-frequency linear transducers (7.5 to 13 MHz) by one of three radiologists who had more than ten years of experience in musculoskeletal ultrasonography. All of the patients underwent standardized ultrasonography of both shoulders as previously described[14-17]. The accuracy of this modality at our institution has been validated in previous studies[14-17]. Four tear characteristics were either measured directly or calculated: (1) the width of the tear, (2) the length of the tear, (3) the distance from the biceps tendon to the anterior margin of the tear, and (4) the distance from the biceps tendon to the posterior margin of the tear. The maximum anteroposterior dimension of the tear was measured on transverse views (perpendicular to the long axis of the rotator cuff) and designated as the width of the tear (Fig. 1). When the width of a tear was too large to measure with one straight line over the convex humeral head, more than one straight line was drawn and the sum of the lengths of the lines was calculated to obtain the tear width. The maximum degree of retraction (i.e., the mediolateral length of the tear) was measured on longitudinal views (parallel to the long axis of the cuff) and designated as the length of the tear. The tear length was measured from the edge of the tear to the lateral aspect of the greater tuberosity. All tears were measured with a standard digital measuring tool in real time during the ultrasonography examination. When a tear was too large to measure on any of the two views, it was assigned a fixed value of 50 mm and designated as a massive tear. The images that showed the maximum anteroposterior diameter and maximum mediolateral diameter of each tear were saved in the Picture Archiving and Communication System (PACS) for measurement of the tear location. The tear location was determined by measuring the anteroposterior distance from the posterior margin of the biceps tendon to the anterior margin of the cuff tear on transverse views with use of digital radiography-viewing software (Fig. 2). This measurement was designated as the distance from the anterior margin of the tear to the biceps tendon. The distance from the biceps was measured by a radiologist (N.D.) and an
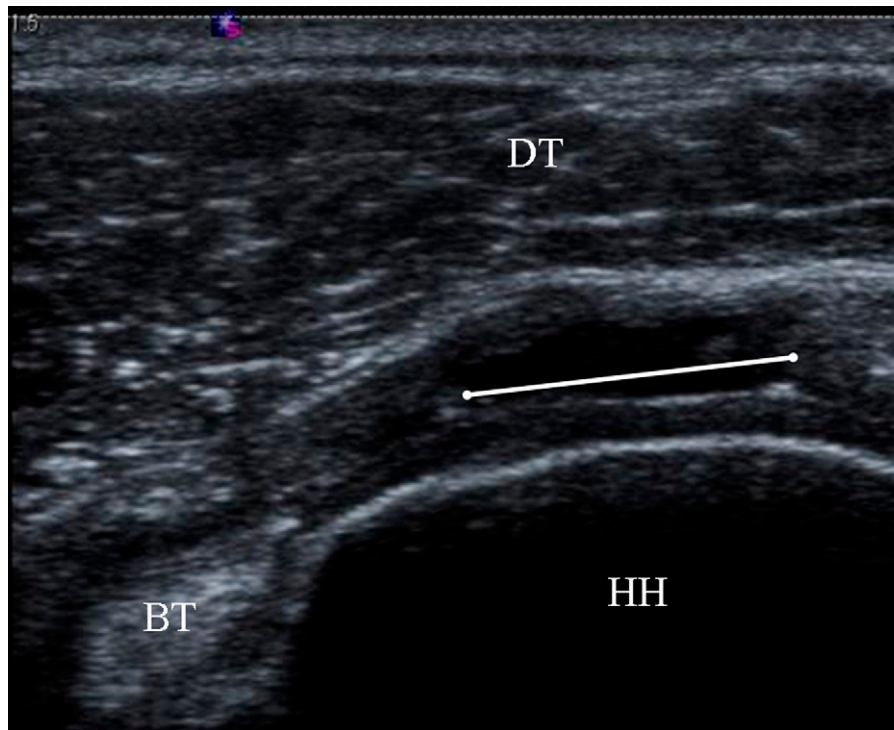
Fig. 1

Measurement of the width of a fluid-filled full-thickness tear in the transverse plane. The width (white line) was defined as the distance between the anterior and posterior torn tendon ends. BT = biceps tendon, HH = humeral head, DT = deltoid muscle.

orthopaedic surgeon (H.M.K.) and determined by concordance between these two investigators. The sum of the distance from the biceps to the anterior tear margin and the width of each tear was calculated and designated as the distance of the posterior margin of the tear to the biceps tendon (Fig. 2).

Numerical Representation of Size and Location of Rotator Cuff Tears

Tears were grouped according to their size (anteroposterior width) or extent (full-thickness or partial-thickness). To visualize their spatial distribution, each tear was plotted on a
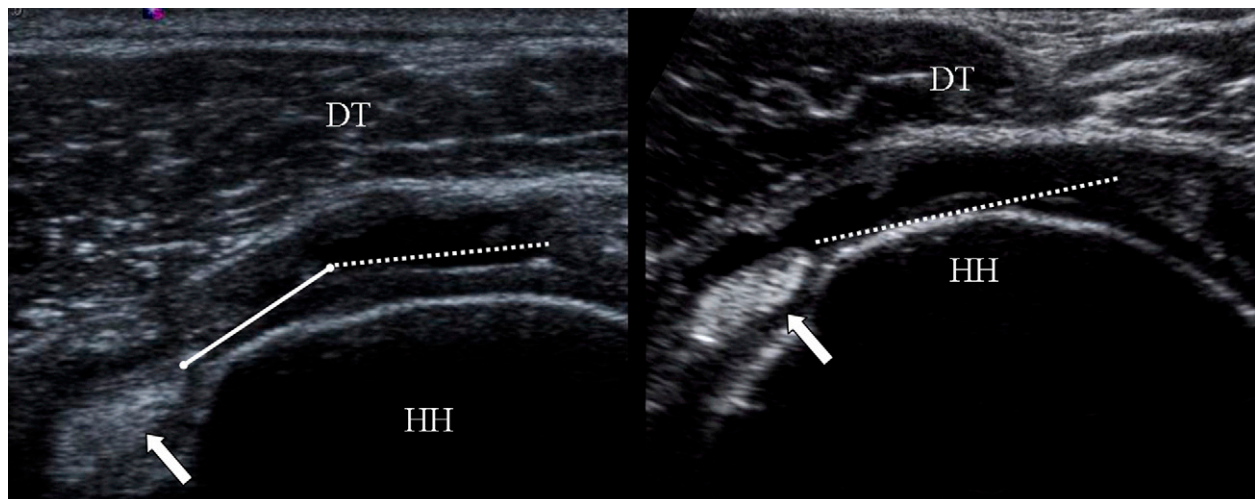
Fig. 2

Measurement of the distance from the biceps tendon to the anterior margin of a tear in the transverse plane. A tear (dotted line) with an anterior margin that has a measurable distance (solid line) from the biceps (arrow) is shown on the left. The distance from the biceps to a fluid-filled full-thickness tear (dotted line) that extends up to the biceps tendon (arrow) is not measurable, as the rotator interval is disrupted (shown on the right). HH = humeral head, DT = deltoid muscle.

spreadsheet. The distances (in millimeters) from the biceps tendon to the anterior and posterior margins of each tear were first rounded up or down to the nearest whole number. The tear size as measured from its anterior margin to its posterior margin was then entered into a column of the spreadsheet in such a way that 1 mm was assigned to one cell. For example, a tear that had an anterior margin that was 10 mm posterior to the biceps tendon and a width of 20 mm—and thus had a posterior margin that was 30 mm posterior to the biceps tendon—was plotted as a column of twenty-one cells (millimeters) starting with ten at the top and ending with thirty at the bottom. Plotting the data in this manner provided a numerical representation of both the tear size and the tear location as referenced from the biceps tendon. The column of cells was then entered into a data table of statistical software and pooled with those for other tears. Each of these columns represented the size (anteroposterior width) and location of the tear as referenced from the biceps tendon. The mode(s)—the most common whole number(s)—were obtained to determine the most common tear location within the posterior part of the rotator cuff. Frequency histograms of these columns were generated to visualize the distribution of the tears. Data on full-thickness and partial-thickness tears of <10 mm in width were grouped separately and designated as small full-thickness tears and small partial-thickness tears.

Statistical Methods

Each shoulder of a given subject was treated as an independent observation rather than the two shoulders being considered as a single pair. Symptomatic and asymptomatic tears were pooled together rather than grouped separately. Normality testing of the data for the three tear variables (i.e., width, length, and distance from the biceps tendon to the anterior tear margin) was performed for each tear group with use of the one-sample Kolmogorov-Smirnov test. This test demonstrated that the data for all three variables had a distribution that was significantly different from the normal Gaussian distribution ($p < 0.05$). Therefore, statistical comparisons of these variables were performed with use of the Mann-Whitney U test. The correlation between these variables was evaluated with use of Spearman rank correlation. Significance was set at $p < 0.05$. The data are shown as the mean and one standard deviation.

Source of Funding

Results

Study Subjects and Tear Types

Of 524 shoulders in 262 patients, 451 had either a partial-thickness or a full-thickness tear and seventy-three had an intact rotator cuff. Of the 451 shoulders with a cuff tear, 360 were in a total of 233 patients (106 patients with unilateral studies and 127 with bilateral studies) who were found to meet the inclusion criteria, including having complete data regarding the tear width, the tear length, and the distance from the biceps tendon to the anterior margin of the tear. Of the 360 shoulders, 180 were symptomatic and 180 were asymptomatic. Ninety-one of the original 451 shoulders were excluded because (1) rotator cuff surgery had been performed prior to the study (eleven shoulders), (2) there were no ultrasound images demonstrating the tear width and length (four shoulders), (3) the biceps tendon was torn with no visible bicipital groove (twelve shoulders), (4) the biceps tendon was dislocated or subluxated with no visible bicipital groove (eight shoulders), (5) the biceps tendon or bicipital groove was not included on the ultrasound images (fifty-five shoulders), or (6) there was a midsubstance rotator cuff tear (one shoulder).

The mean age of the 233 subjects was 64.7 ± 10.2 years (range, thirty-six to ninety years). There were 135 men and ninety-eight women. The twenty-eight patients (eighteen men and ten women) with an identified rotator cuff tear who were excluded from this study had a mean age of 65.4 ± 12.6 years (range, forty-five to eighty-four years). Of the 360 shoulders, 272 had a full-thickness tear and eighty-eight had a partial-thickness tear.

Rotator Cuff Tear Characteristics

The mean width and length of the 360 tears were 16.3 ± 12.1 mm and 17.0 ± 13.0 mm, respectively. The mean width and length of the 272 full-thickness tears were 18.5 ± 12.9 mm and 20.1 ± 13.4 mm, respectively. The mean width and length of the eighty-eight partial-thickness tears were 9.3 ± 3.9 mm and 6.9 ± 2.5 mm, respectively, which were significantly smaller than those of the full-thickness tears ($p < 0.05$). Of the 272 full-thickness tears, eighty-two were small (a width of <10 mm), 136 were medium-sized (a width of 10 to <30 mm), thirty-eight were large (a width of 30 to <50 mm), and sixteen were massive (a width of ≥50 mm). Of the eighty-eight partial-thickness tears, fifty-eight were small, thirty were medium-sized, and none were wider than 30 mm.

The mean distance from the biceps tendon to the anterior margin of the tear was 7.8 ± 5.7 mm (range, 0 to 26 mm). The mean distance from the biceps tendon to the full-thickness tears (7.3 ± 6.1 mm) was significantly shorter than that between the biceps tendon and the partial-thickness tears (9.3 ± 4.0 mm) ($p < 0.05$). Ninety (33%) of the 272 full-thickness tears were at a distance of 0 mm from the biceps tendon, whereas only one (1%) of the eighty-eight partial-thickness tears was at such a distance from the biceps tendon.

There was a significant correlation between the width and length of the full-thickness tears (Spearman rho [ρ] = 0.850, $p < 0.05$). There was also a significant linear relationship between the width of the full-thickness tears and the distance of their anterior margin from the biceps (ρ = −0.704, $p < 0.05$). A significant relationship was observed between the width and length of the partial-thickness tears (ρ = 0.370, $p < 0.05$) but not between the width of the partial-thickness tears and their distance from the biceps (ρ = −0.073, $p = 0.499$).
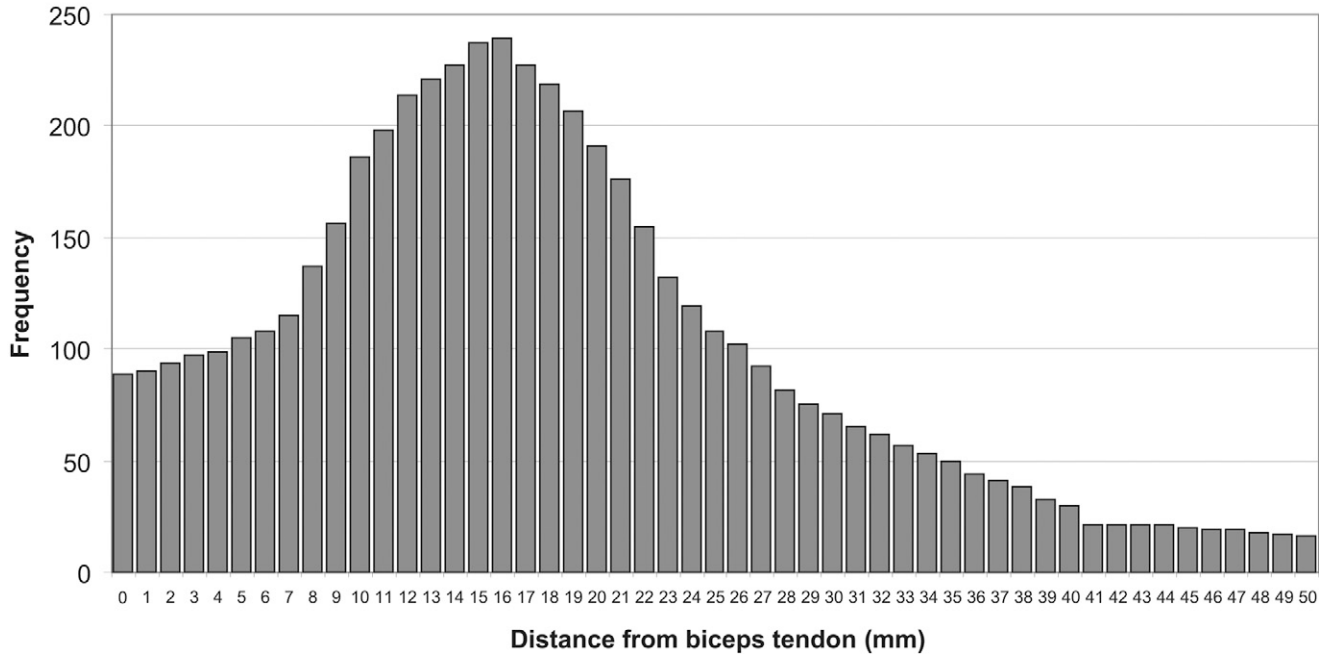
All full-thickness tears (N=272)

Fig. 3-A

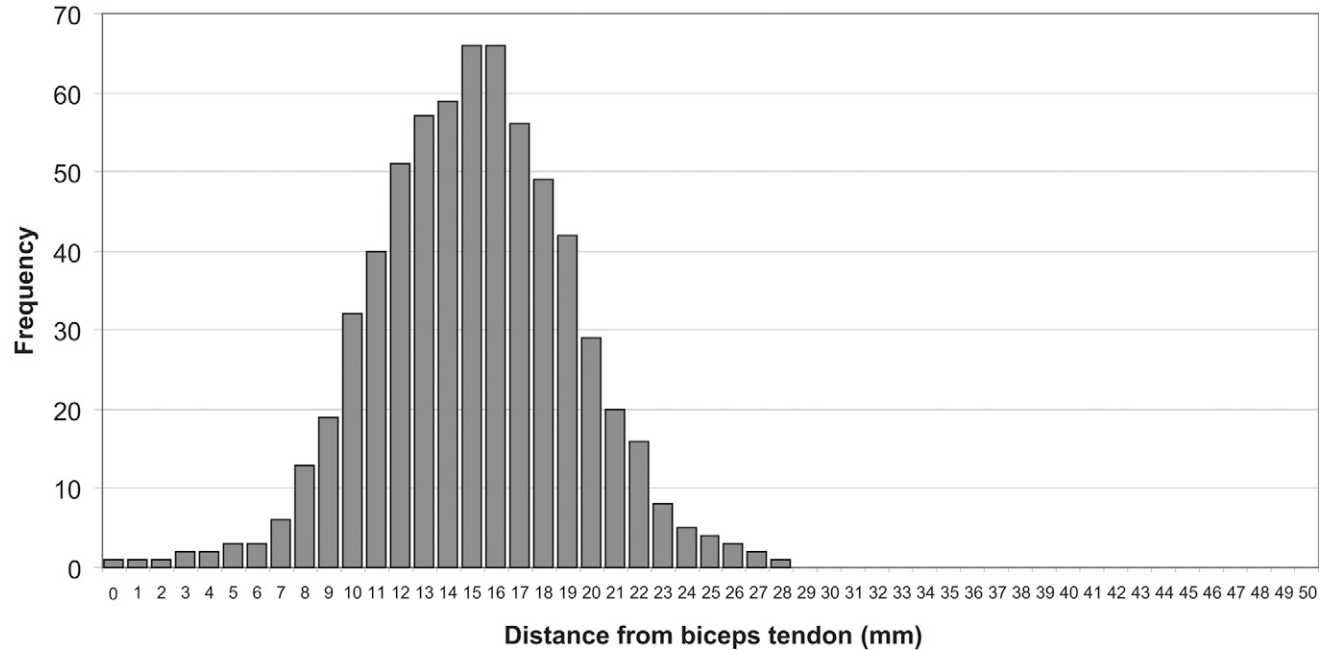## Small full-thickness tears (N=82)

Fig. 3-B

Fig. 3-A A histogram of all full-thickness tears shows a unimodal distribution. The most common location (i.e., the mode) is 16 mm posterior to the biceps, and the second most common location is 15 mm posterior to the biceps. The frequency represents the number of tears that involve a given location within the rotator cuff tendon. The location is shown as the distance in millimeters from the intra-articular portion of the biceps tendon. **Fig. 3-B** A histogram of the small full-thickness tears shows a unimodal distribution. The most common locations are 15 and 16 mm posterior to the biceps. The frequency represents the number of tears that involve a given location within the rotator cuff tendon. The location is shown as the distance in millimeters from the intra-articular portion of the biceps tendon.

All partial-thickness tears (N=88)

Fig. 4

A histogram of all partial-thickness tears shows a unimodal distribution. The most common locations are 13, 14, and 15 mm posterior to the biceps. The frequency represents the number of tears that involve a given location within the rotator cuff tendon. The location is shown as the distance in millimeters from the intra-articular portion of the biceps tendon.
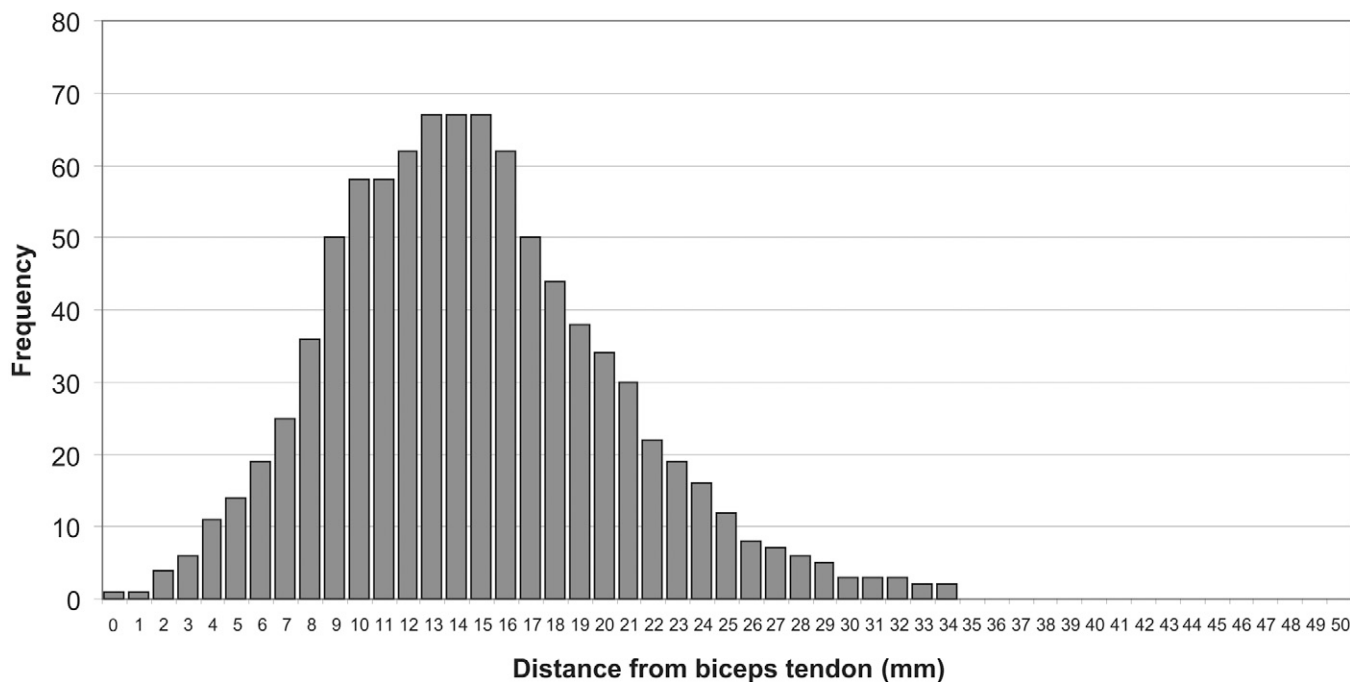
Analysis of Tear Location

When all 272 full-thickness tears were plotted in a histogram, a unimodal distribution was noted, with the mode (the most frequent whole number) located 16 mm posterior to the biceps tendon. The second most frequent tear location was 15 mm posterior to the biceps tendon (Fig. 3-A). In other words, the location within the posterior part of the rotator cuff that was 16 mm posterior to the biceps tendon was found to be the most common site of full-thickness tears (87.9% [239] of the 272 full-thickness tears involving this region), and 15 mm posterior to the biceps tendon was the second most commonly torn site (87.1% [237] of the 272 full-thickness tears involving this region). Conversely, 12.1% and 12.9% of all shoulders with a full-thickness tear had an intact rotator cuff insertion at 16 mm and 15 mm, respectively, posterior to the biceps tendon. When only the eighty-two small full-thickness tears (<10 mm in width) were plotted, the histogram also showed a unimodal distribution, and the two most frequent tear locations were in a similar region within the posterior rotator cuff, 15 and 16 mm posterior to the biceps tendon (Fig. 3-B). Sixty-eight (83%) of the eighty-two small full-thickness tears were found to involve this region of the posterior part of the cuff.

When all eighty-eight partial-thickness tears were plotted, the histogram showed a unimodal distribution, and there were three consecutive values with equal frequency (13, 14, and 15 mm posterior to the biceps tendon) (Fig. 4). Sixty-seven

(76%) of the eighty-eight partial-thickness tears involved the locations at 13 to 15 mm posterior to the biceps tendon. When only the fifty-eight partial-thickness tears that were <10 mm wide were plotted, the histogram again showed a unimodal distribution, with the mode being 15 mm. Forty-one (71%) of the fifty-seven small partial-thickness tears involved the location 15 mm posterior to the biceps tendon.

Discussion

Understanding the common location and initiation of rotator cuff tears is a fundamental step toward revealing the pathogenesis and progression of these tears. To our knowledge, we are the first to systematically investigate the location of degenerative rotator cuff tears in living subjects. Our results suggest that rotator cuff tears most commonly involve a location that is more posterior (approximately 15 mm posterior to the biceps tendon) than has been traditionally thought. This area was the most common location of both small full-thickness tears (83%) and small partial-thickness tears (72%). Additionally, the histograms for these small tears had a similar unimodal distribution, suggesting that the most common region for these small tears may be the location where degenerative rotator cuff tears commonly initiate. If this point-location of 15 mm posterior to the biceps tendon is expanded in both the anterior and the posterior direction to include a range of 13 to 17 mm posterior to the biceps tendon, then 93% of all full-

thickness tears and 89% of all small full-thickness tears were found to involve this region of the posterior part of the rotator cuff. We believe that the similarity between the pattern of locations of the small tears and that of all tears collectively provides evidence that most degenerative cuff tears initiate from a region near the junction of the supraspinatus and infraspinatus tendons. These findings contradict the concept that degenerative tears typically start from the anterior portion of the supraspinatus insertion near the biceps tendon and propagate posteriorly[1-6]. If this were the case, the data would have resulted in a histogram with a peak near the 0-mm location and a downslope posteriorly, meaning that the most commonly torn area would have been an anterior location near the biceps tendon and the frequency of involvement would have gradually decreased posteriorly.

The possibility of bifocal or multifocal tear locations should be considered when interpreting these data. Examining the distribution pattern of smaller degenerative tears may allow a better assessment of the possibility of the existence of two or more common sites of initiation of rotator cuff tears. However, the histograms of the smaller full-thickness and partial-thickness tears showed a pattern of tear location that was similar to that demonstrated by the histogram of all tears collectively. The modes of these histograms involved the same region in the posterior part of the rotator cuff, between 13 and 17 mm posterior to the biceps tendon. Additional evidence arguing against multifocal sites of tear location and initiation is provided by the

shapes of the histograms. In all histograms, there were strong tear-location peaks between 13 and 17 mm posterior to the biceps tendon with a rapid decline both anteriorly and posteriorly from this region. The presence of a bifocal or multifocal pattern of tear location would have resulted in either multiple separate regional modes or flatter histograms, particularly in the analysis of the smaller tears.

The most frequent location of rotator cuff tears found in the present study can be regarded either as the junction between the insertions of the supraspinatus and infraspinatus tendons or as being purely within the infraspinatus tendon, depending on which anatomical definition is used. A recent anatomical study by Mochizuki et al.[13] demonstrated that only the most anterior 1.3 mm of the rotator cuff footprint is purely occupied by the supraspinatus tendon. From this point, the next 11.3 mm of the tendon insertion, on the average, comprises the supraspinatus medially and the infraspinatus laterally. The remaining posterior part of the cuff insertion consists only of the infraspinatus tendon. According to that study, a tear location of 13 to 17 mm posterior to the biceps tendon would lie predominantly within the infraspinatus insertion. According to the anatomical study by Minagawa et al.[12], the location of 13 to 17 mm posterior to the biceps tendon would lie at the junction of the supraspinatus and infraspinatus tendons. On the other hand, according to the conventional anatomical definitions[18,19], the location 13 to 17 mm posterior to the biceps tendon would be regarded as purely within the supraspinatus tendon. Findings
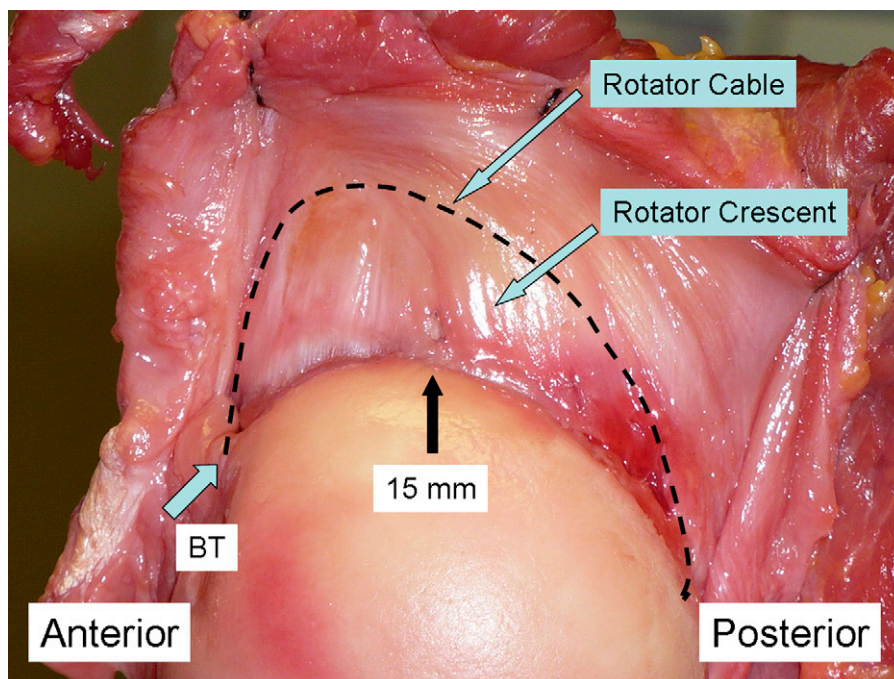
Fig. 5

A cadaver shoulder specimen showing the articular surface of the rotator cuff and the humeral head. The rotator cable (curved dashed line) spans from the biceps tendon (BT) to the inferior border of the infraspinatus. Distal to the rotator cable is the rotator crescent. In this specimen, a mild degenerative change (a small defect in the synovium, black arrow) is seen on the articular surface of the rotator cuff at a location approximately 15 mm posterior to the biceps tendon.

from the present study, in concert with those from recent anatomical studies[12,13], may help to explain why some presumed isolated supraspinatus tears are associated with degenerative changes of the infraspinatus muscle[11].

Presently, it is not clear why degenerative rotator cuff tears are commonly located within this region of the posterior part of the rotator cuff. One theoretical explanation for this finding relates to the "rotator crescent" concept[20]. The location of 15 mm posterior to the biceps tendon within the posterior rotator cuff insertion is approximately at the midpoint between the biceps tendon and the inferior border of the infraspinatus insertion[12,13,20,21]. According to Burkhart et al.[20], the area from the biceps tendon to the inferior border of the infraspinatus tendon spans the rotator crescent, the margin of which is outlined by arch-shaped thick bundles of fibers called the "rotator cable." They theorized that the rotator cable shields the rotator crescent from stress through a "suspension bridge" configuration. They hypothesized that, as people age, there is progressive thinning of the crescent due to relative avascularity of this region and increasing reliance on the cable, with a crescent-dominant cuff eventually evolving into a cable-dominant cuff. The location within the cuff of 15 mm posterior to the biceps tendon is approximately at the center of the rotator crescent. This region may undergo more pronounced degenerative changes with age than other regions of the cuff insertion and thus be more vulnerable to tear formation (Fig. 5).

Some limitations should be considered when interpreting the results of the present study. The ideal method for investigating the initiation and propagation of rotator cuff tears is a longitudinal analysis of tears from the time of their initiation, which was not possible in the present study. In the present study, each cuff tear was considered to represent a different stage of the disease. We consider this approach to be valid, assuming that most degenerative cuff tears begin as a small defect and then enlarge. However, the definitive pattern of tear propagation cannot be determined with the methodology used in the present study and should be investigated further with longitudinal studies. A previous study demonstrated that ultrasonography is accurate for the measurement of the width of full-thickness cuff tears (87%) but less accurate for the measurement of the width of partial-thickness tears (54%)[16]. This lower accuracy may have led to errors in the collection of the data on the partial-thickness tears. However, given the fact that the data for the full-thickness tears mirrored that for the partial-thickness tears and that identifying the location of full-thickness tears is probably of equal importance in determining the location and initiation of rotator cuff tears in general, it was presumed that our findings are valid. In addition, given the selected study population, our findings are applicable primarily to degenerative tears rather than to tears with a traumatic onset. Finally, our analysis of tear location did not differentiate between symptomatic and asymptomatic shoulders. We chose to initially examine data from both painful and asymptomatic shoulders as a group. Additional studies to distinguish tear locations between these groups may be warranted.

The strengths of this study include the use of a standardized and validated modality for imaging rotator cuff morphology. In addition, a large number of subjects were available for the data analysis. Finally, a novel method for representing the size and location of cuff tears enabled us to better describe the pattern of rotator cuff tear locations across multiple tear sizes.

In conclusion, the findings of the present study suggest that degenerative rotator cuff tears most commonly involve a region 13 to 17 mm posterior to the biceps tendon. The results of this study also suggest that this region may be the common site of initiation of degenerative rotator cuff tears. This location can be regarded as either the junction between the supraspinatus and infraspinatus or being purely within the infraspinatus tendon. This location also corresponds approximately to the center of the rotator crescent, an area that may be more vulnerable to degenerative changes than other areas within the posterior part of the cuff. Findings from this study may explain why fatty degeneration of the infraspinatus is seen in some patients with a presumed isolated tear of the supraspinatus tendon. This study highlights the importance of assessing the integrity of, and potentially repairing, a torn infraspinatus tendon in a shoulder with a presumed isolated supraspinatus tear. The results of this study have identified a potential area of future research to further define initiation and propagation of rotator cuff tears as related to rotator cuff anatomy. ∎

H. Mike Kim, MD
Georgia Stobbs, RN
Ken Yamaguchi, MD
Jay D. Keener, MD
Shoulder and Elbow Service,
Department of Orthopaedic Surgery,
Washington University School of Medicine,
1 Barnes-Jewish Hospital Plaza, 11300 West Pavilion,
Campus Box 8233, St. Louis, MO 63110.
E-mail address for J.D. Keener: keenerj@wudosis.wustl.edu

Nirvikar Dahiya, MD
Sharlene A. Teefey, MD
William D. Middleton, MD
Mallinckrodt Institute of Radiology, Washington University School of Medicine, 510 South Kingshighway Boulevard,
St. Louis, MO 63110

Karen Steger-May, MA
Division of Biostatistics, Washington University School of Medicine,
660 South Euclid Avenue, Box 8067, St. Louis, MO 63110-1093

References

1. Matsen III FA, Arntz CT, Lippitt SB. Rotator cuff. In: The shoulder. Rockwood CA, Matsen III FA, editors. Philadelphia: W.B. Saunders; 1998.

2. Codman EA. The shoulder. Boston: Norman Publishing; 1934.

3. Codman EA, Akerson IB. The pathology associated with rupture of the supraspinatus tendon. Ann Surg. 1931;93:348-59.

4. Keyes EL. Observations on rupture of the supraspinatus tendon: based upon a study of seventy-three cadavers. Ann Surg. 1933;97:849-56.

5. Hijioka A, Suzuki K, Nakamura T, Hojo T. Degenerative change and rotator cuff tears. An anatomical study in 160 shoulders of 80 cadavers. Arch Orthop Trauma Surg. 1993;112:61-4.

6. Lehman C, Cuomo F, Kummer FJ, Zuckerman JD. The incidence of full thickness rotator cuff tears in a large cadaveric population. Bull Hosp Jt Dis. 1995;54:30-1.

7. Cotton RE, Rideout DF. Tears of the humeral rotator cuff; a radiological and pathological necropsy survey. J Bone Joint Surg Br. 1964;46:314-28.

8. McLaughlin HL. Lesions of the musculotendinous cuff of the shoulder. The exposure and treatment of tears with retraction. 1944. Clin Orthop Relat Res. 1994;304:3-9.

9. Shimizu T, Itoi E, Minagawa H, Pradhan RL, Wakabayashi I, Sato K. Atrophy of the rotator cuff muscles and site of cuff tears. Acta Orthop Scand. 2002;73:40-3.

10. Wening JD, Hollis RF, Hughes RE, Kuhn JE. Quantitative morphology of full thickness rotator cuff tears. Clin Anat. 2002;15:18-22.

11. Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. Clin Orthop Relat Res. 1994;304:78-83.

12. Minagawa H, Itoi E, Konno N, Kido T, Sano A, Urayama M, Sato K. Humeral attachment of the supraspinatus and infraspinatus tendons: an anatomic study. Arthroscopy. 1998;14:302-6.

13. Mochizuki T, Sugaya H, Uomizu M, Maeda K, Matsuki K, Sekiya I, Muneta T, Akita K. Humeral insertion of the supraspinatus and infraspinatus. New anatomical findings regarding the footprint of the rotator cuff. J Bone Joint Surg Am. 2008;90:962-9.

14. Middleton WD, Teefey SA, Yamaguchi K. Sonography of the rotator cuff: analysis of interobserver variability. AJR Am J Roentgenol. 2004;183:1465-8.

15. Teefey SA, Hasan SA, Middleton WD, Patel M, Wright RW, Yamaguchi K. Ultrasonography of the rotator cuff. A comparison of ultrasonographic and arthroscopic findings in one hundred consecutive cases. J Bone Joint Surg Am. 2000; 82:498-504.

16. Teefey SA, Middleton WD, Payne WT, Yamaguchi K. Detection and measurement of rotator cuff tears with sonography: analysis of diagnostic errors. AJR Am J Roentgenol. 2005;184:1768-73.

17. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am. 2004;86:708-16.

18. Ruotolo C, Fow JE, Nottage WM. The supraspinatus footprint: an anatomic study of the supraspinatus insertion. Arthroscopy. 2004;20:246-9.

19. Curtis AS, Burbank KM, Tierney JJ, Scheller AD, Curran AR. The insertional footprint of the rotator cuff: an anatomic study. Arthroscopy. 2006;22:609.e1.

20. Burkhart SS, Esch JC, Jolson RS. The rotator crescent and rotator cable: an anatomic description of the shoulder's "suspension bridge". Arthroscopy. 1993;9:611-6.

21. Dugas JR, Campbell DA, Warren RF, Robie BH, Millett PJ. Anatomy and dimensions of rotator cuff insertions. J Shoulder Elbow Surg. 2002;11:498-503.