Acta Orthop Scand 55, 52–56, 1984

Ruptures of the supraspinatus tendon

Cadaver dissection

Ninety-nine shoulders from 50 deceased with an average age of 73 years were dissected. There was a significant decrease in the thickness of the supraspinatus tendons with full thickness ruptures but not in partial ruptures. A highly significant increase in the length of the extramuscular supraspinatus tendon in shoulders with partial or full thickness supraspinatus ruptures was found. However, the total length of the supraspinatus aponeurosis was the same in shoulders with ruptures as in normal shoulders of the same age. This might indicate that the increase in length of the extramuscular portion of the tendon in ruptures is not caused by elongation of the tendon but is the result of muscular decay.

Key words: aging; shoulder joint; tendons.

Claes J. Petersson

University of Lund, Department of Orthopaedic Surgery at Malmö General Hospital, S-214 01 Malmö, Sweden

Codman & Akerson (1931) and Codman (1934, 1937) were among the first to recognize the prevalence and importance of ruptures of the supraspinatus tendon. They thought that tendon ruptures were the result of direct trauma, contrary to Meyer (1931), who argued his theory of attrition as the main cause of degeneration and rupture of the rotator cuff and the long biceps tendon. Skinner (1937) examined 100 shoulders and considered the change with age of the lateral portion of the supraspinatus muscle – from muscle fibres to a wide aponeurosis – to be of crucial importance for the development of tendon rupture. Lindblom (1939) and Wilson & Duff (1943), however, were not able to confirm these results in their dissection studies. They considered ruptures of the supraspinatus tendons to be due to trauma to degenerated tissues. Keyes (1935) in an extensive dissection study did not find any association between supraspinatus tendon ruptures and atrophy of the supraspinatus muscle itself. He considered age, long use and trauma to be the chief causative factors of supraspinatus tendon lesions.

The purpose of the second part of the present investigation was to measure the length and thickness of the tendinous portions of the supraspinatus, infraspinatus and subscapularis muscles in shoulders without macroscopic evidence of rotator cuff lesions and in shoulders with partial or full thickness ruptures of the supraspinatus tendon.

Material and methods

Two series of shoulder dissections were performed at the Department of Pathology at the Malmö General Hospital. The second series was carried out as a result of tentative findings in the first.

Each series consisted of 25 randomly selected cadavers, with histories of malignant or cardiovascular disease. Information about shoulder disability during life-time was extracted from the case reports.

The *first series* consisted of 15 men and 10 women with an average age of 73 (43–91) years. At dissection the deltoid muscle was excised from the clavicle and the acromion. After excision of the coraco-acromial ligament, the acromion and the lateral end of the clavicle were divided perpendicularly to the acromioclavicular joint in the frontal plane. Partial and full thickness ruptures of the cuff were registered. The supraspinatus tendon and muscle were then incised and divided in line with the divided acromion and the clavicle and the anterior part of the muscle-tendon preparation was excised. The thickness of the supraspinatus was measured with a ruler at the lateral edge of the acromion and below the midpoint of the acromion, according to Figure 1.

The *second series* consisted of 13 men and 12 women with an average age of 74 (41–93) years. The deltoid muscle, the acromion and the lateral part of

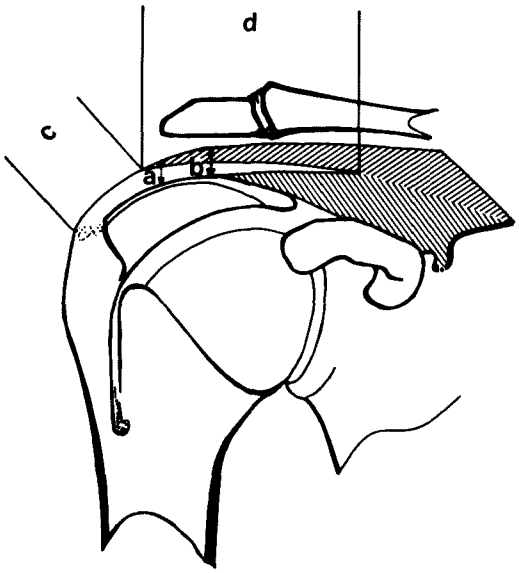

Figure 1. Schematic drawing of the sites of measurement in the two dissection series.
a and b indicate the sites of measuring of the thickness of the supraspinatus tendon.
c indicates the extramuscular tendon portion and d indicates the length of the intramuscular aponeurosis.

the clavicle were excised, thus visualizing the whole rotator cuff. After registration of partial or full thickness ruptures of the rotator cuff, the length of the tendon of the infraspinatus, the supraspinatus and the subscapular muscles was measured with a ruler and the shortest distance between the fleshy muscle fibres and the tendon insertion of each muscle was registered.

Finally, the supraspinatus tendon and muscle were bisected longitudinally in the frontal plane, exposing the intramuscular part of the aponeurosis. The length of the aponeurosis covered by muscle fibres was measured with a ruler according to Figure 1. The coefficient of variation of repeated measurement was 12 per cent in the first series and 11 per cent in the second series.

Results

In the *first dissection series,* 32 shoulders turned out to have macroscopically normal supraspinatus tendons. Circumscript degeneration with partial, non-perforating rupture of the supraspinatus tendon was observed in nine shoulders. In six shoulders the partial ruptures were located on the internal, articular surface of the tendon with wearing away of the capsule and more or less pronounced fraying of the tendon (Figure 2). In three shoulders partial ruptures with fibrillation were found on the external, bursal aspect of the supraspinatus tendon. Partial ruptures were encountered bilaterally in two shoulders.

Full-thickness rupture of the supraspinatus tendon was found in nine shoulders and they were registered bilaterally in three subjects. In two cases full-thickness rupture of the supraspinatus tendon of one shoulder was combined with partial rupture of the other one. In two shoulders, the full-thickness supraspinatus tendon ruptures were total, comprising the whole tendon and leaving a cuff defect from the infraspinatus to the subscapularis tendons (Figure 3). No supraspinatus tendon tissue was left to be measured. Also, in these shoulders both the subscapularis and the infraspinatus tendons presented degenerative changes with internal, non-perforating ruptures. In the remainder of the shoulders with full-thickness ruptures of the supraspinatus tendon the tears were circumscript, limited to part of the tendon and with well-defined edges (Figure 4). No isolated full-thickness ruptures of the infraspinatus or subscapularis tendons were observed.

The normal supraspinatus tendons turned out to have a typical and constant cross-section configuration. At about the level of the lateral acromial edge the lateral tendon portion was replaced by a "sandwich" construction – a central tendon plate with muscle fibres on both sides. Thus, in normal tendons at both measuring sites, the thickness of the mixed tendon with muscle fibres and aponeurosis was measured. In shoulders with partial or full-thickness ruptures there was frequently a lengthening of the extramuscular tendon portion. There was no obvious or significant relationship between age and thickness of the supraspinatus tendon in either measuring site. Those subjects who had partial ruptures did not deviate from normal, whereas those with full-thickness rupture had a significantly thinner supraspinatus tendon at the level of the lateral edge of the acromion. Also, in the

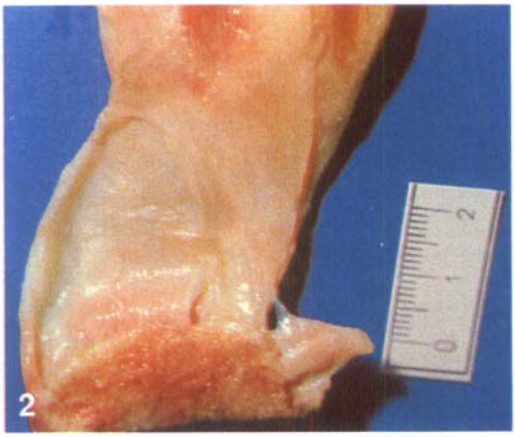

Figure 2. The right supraspinatus tendon from an 81-year-old woman. Partial rupture on the internal articular surface of the tendon. A defect in the capsule can be seen and some fibrillation of the tendon.

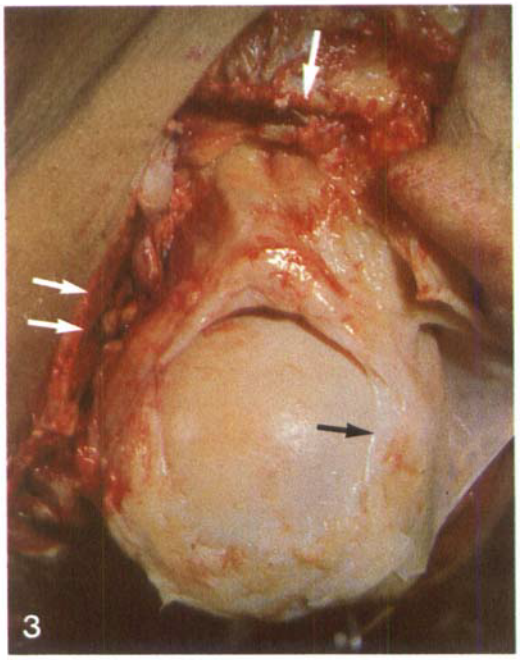

Figure 3. Total supraspinatus tendon rupture in the right shoulder of a 78-year-old man. Double white arrows at the base of the resected acromion. Single white arrow indicating the end of the divided clavicle. Black arrow at the flattened dislocated long biceps tendon.

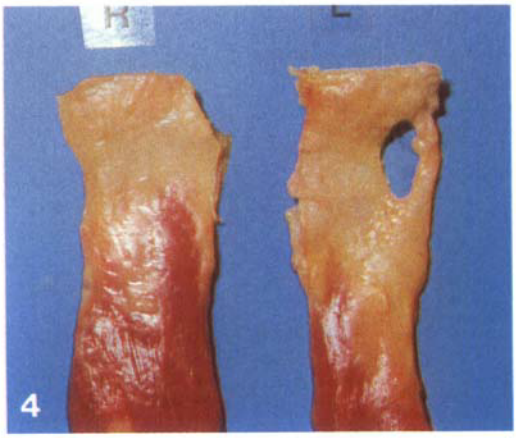

Figure 4. The supraspinatus muscles of an 89-year-old man. On the left side is a small rupture with clear cut edges. There is an increase in length of the ruptured tendon.

measuring site below the midpoint of the acromion a significant decrease in thickness was found, but only for full-thickness ruptures.

The frequent finding of a lengthening of the extramuscular tendinous portion of the supraspinatus muscle in subjects with ruptures was the reason for the second modified dissection series in which 49 shoulders were studied. Thirty-five shoulders turned out to have macroscopically normal rotator cuff tendons. Nine supraspinatus tendons had partial ruptures of which five were located on the internal tendon surface and four were external. One woman, 81 years old, had partial internal rupture bilaterally and another woman of the same age had external rupture in her right shoulder and internal rupture in her left. Five supraspinatus tendons had full-thickness ruptures, one of which was total and not possible to measure. No full thickness ruptures were found in the infraspinatus or subscapularis tendons.

The length of the extramuscular tendon portion was significantly greater in rupture cases – full thickness as well as partial – than in controls, also accounting for the age factor. There was a significant increase in the length of the extramuscular tendon with increasing age. The total length of the supraspinatus aponeurosis, intra- plus extramuscular, did not change with age and was not related to rupture.

The infraspinatus tendons and the tendons of the subscapularis muscles did not follow this pattern of change – there was no age relationship nor was there any relation between supraspinatus tendon ruptures and the extramuscular portions of these tendons. Interaction of sex did not influence the findings, even if the tendons were slightly longer in men than in women.

Discussion

The results of the present investigation indicate that a circumscript, completely ruptured supraspinatus tendon is decreased in thickness. Since the supraspinatus tendon serves as the most important structural spacer of the subacromial space, this might explain the reduction of the subacromial space in shoulders with supraspinatus tendon ruptures observed radiographically (Golding 1962, Cotton & Rideout 1964, Weiner & Macnab 1970). The thickness of the supraspinatus tendons with partial ruptures did not deviate from that of normal tendons of the same age. This suggests that no roentgenographic changes are to be expected in the subacromial space in patients with partial supraspinatus tendon ruptures.

Petersson & Redlund-Johnell (1983) found a significantly narrower subacromial space in women than in men in normal radiographs. They also found a slight decrease of the subacromial space in elderly men. In the present study no relationship between the thickness of the supraspinatus tendon and age or sex was found.

These results strongly suggest that in supraspinatus tendon ruptures – partial as well as full-thickness – there is an increase in the length of the extramuscular tendon portion. The muscle fibres covering the central aponeurosis are retracted medially, denuding more tendon tissue. In no case did the edges of the rupture reach fleshy muscle fibres. As the total length of the intra- and extramuscular supraspinatus aponeurosis was the same in normal shoulders as in shoulders with partial or full-thickness ruptures, it seems less probable that the increased length of the tendons in the rupture group is a mere elongation of the tendon as proposed by Wilson & Duff (1943). It seems more likely that degeneration of the muscle fibres covering the aponeurosis has preceded the rupture.

In the present investigation no full-thickness ruptures were found in the infraspinatus or subscapularis tendons. The length of these tendons was the same irrespective of the condition of the supraspinatus tendon or the age of the deceased. There is one conspicuous anatomical difference between the supraspinatus muscle on one hand and the infraspinatus and subscapularis muscles on the other: the supraspinatus has limited space to slide between the caput humeri and the acromion and the very tight coracoacromial ligament. Normally, it slides freely in abduction but in the elderly, bony osteophytes of the acromion (Neer 1972) or of the acromioclavicular joint (Petersson &

Gentz 1983) might impinge on the supraspinatus muscle. Possibly pressure, ischaemia and subnutrition are the causes of the decay of the muscle fibres.

Acknowledgement

Financial support was obtained from Herman Järnhardt Foundation.

References

Codman, E. A. & Akerson, I. B. (1931) The pathology associated with rupture of the supraspinatus tendon. *Ann. Surg.* **93**, 348–359.

Codman, E. A. (1934) Rupture of the supraspinatus tendon and other lesions in or about the subacromial bursa. In: *The shoulder.* 2nd ed. Thomas Todd Company, Boston, Massachusetts.

Codman, E. A. (1937) Rupture of the supraspinatus – 1834 to 1934. *J. Bone Joint Surg.* **19**, 643–652.

Cotton, R. E. & Rideout, D. F. (1964) Tears of the humeral rotator cuff. *J. Bone Joint Surg.* **46**-B, 314–328.

Golding, F. C. (1962) The shoulder – the forgotten joint. *Br. J. Radiol.* **35**, 149–158.

Keyes, E. L. (1935) Anatomical observations on senile changes in the shoulder. *J. Bone Joint Surg.* **17**, 953–960.

Lindblom, K. (1939) On pathogenesis of ruptures of the tendon aponeurosis of the shoulder joint. *Acta Radiol.* **20**, 563–577.

Meyer, A. W. (1931) The minuter anatomy of attrition lesions. *J. Bone Joint Surg.* **13**-A, 341–360.

Neer, C. S. (1972) Anterior acromioplasty for the chronic impingement syndrome in the shoulder. *J. Bone Joint Surg.* **54**-A, 41–50.

Petersson, C. J. & Gentz, C. F. (1983) Ruptures of the supraspinatus tendon. The significance of distally pointing acromioclavicular osteophytes. *Clin. Orthop.* **174**, 143–148.

Petersson, C. J. & Redlund-Johnell, I. (1983) The subacromial space in normal shoulder radiographs. *Acta Orthop. Scand.* **55**, 57–58.

Skinner, H. A. (1937) Anatomical considerations relative to rupture of the supraspinatus tendon. *J. Bone Joint Surg.* **19**, 137–151.

Weiner, D. S. & Macnab, I. (1970) Superior migration of the humeral head. A radiological aid in the diagnosis of tears of the rotator cuff. *J. Bone Joint Surg.* **52**-B, 524–527.

Wilson, C. L. & Duff, G. L. (1943) Pathologic study of degeneration and rupture of the supraspinatus tendon. *Arch. Surg.* **47**, 121–135.