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Dead men and radiologists don't lie: a review of cadaveric and radiological studies of rotator cuff tear prevalence

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ABSTRACT

INTRODUCTION Rotator cuff tears are a common pathology, with a varied prevalence reported.

PATIENTS AND METHODS A literature review was undertaken to determine the cadaveric and radiological (ultrasonography and magnetic resonance imaging [MRI]) prevalence of rotator cuff tear. The radiological studies were subdivided into symptomatic and asymptomatic subjects.

RESULTS Cadaveric rotator cuff tears were found in 4629 shoulders of which only 2553 met the inclusion criteria. The prevalence of full-thickness tears was 11.75% and partial thickness 18.49% (total tears 30.24%). The total tear rate in ultrasound asymptomatic was 38.9% and ultrasound symptomatic 41.4%. The total rate in MRI asymptomatic was 26.2% whilst MRI symptomatic was 49.4%.

DISCUSSION The unselected cadaveric population should contain both symptomatic and asymptomatic subjects. A prevalence of tears between the symptomatic and asymptomatic radiological groups would be expected. However, apart from the MRI asymptomatic group, the radiological prevalence of rotator cuff tears exceeds the cadaveric.

CONCLUSIONS Rotator cuff tears are frequently asymptomatic. Tears demonstrated during radiological investigation of the shoulder may be asymptomatic. It is important to correlate radiological and clinical findings in the shoulder.

KEYWORDS
Prevalence – Rotator cuff tears

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Rotator cuff tears are a common problem causing significant morbidity in terms of pain, activity limitation and sleep disturbance. A wide variation in the prevalence of cuff tears have been reported in cadaveric and radiological studies; as with other tendon failure, it is likely that this increases with age.[1]

The population in cadaveric studies tends to be older than the general population; consequently, a higher prevalence of cuff tears is likely. Furthermore, as no clinical data are available for the cadaveric population, it is reasonable to assume that, as in any large sample, some had symptomatic shoulders. The prevalence of rotator cuff tear in asymptomatic subjects determined by magnetic resonance imaging (MRI) and ultrasonography should be lower than the cadaveric population. Conversely, the radiological prevalence of rotator cuff tears in a population with symptomatic shoulders should be higher. This study reviewed the literature in an attempt to test this hypothesis.

Patients and Methods

A Medline search was performed using the key words: rotator cuff tear, prevalence, cadaver, MRI and ultrasound. The search was widened using references from these articles. All publications up to the time of the search were used.

The results were split into the following categories: cadaveric studies, ultrasound studies and MRI studies. The radiological studies were further categorised into asymptomatic and symptomatic.

Data were collected on the total number of shoulders, the mean age of the group, the sex distribution, the number

of full-thickness tears (FTTs) and partial thickness tears (PTTs). In articles that did not differentiate between the FTTs and PTTs, the total number of cuff tears was used. FTTs were defined as complete tears through the supraspinatus tendon. PTTs included bursal side tears, intratendinous tears and joint side tears. Data from articles where the pathology in patient groups had been preselected, for example all partial cuff tears,[2] were excluded from analysis.

In the radiological studies, asymptomatic patient groups had a clinical history and examination that revealed no significant symptoms or signs in the shoulder. Symptomatic patient groups had a history of shoulder pain with a number of diagnoses (tendonitis, cuff pathology, frozen shoulder, calcification or unspecified).

Results

The total number of cadaveric studies was 30, ranging from Smith[3] in 1834 to Jiang *et al.*[4] in 2002. There are many studies relating to ultrasound and MRI use. For the purposes of this review, 11 ultrasound studies were

Table 1 Cadaveric prevalence of rotator cuff tears

Author(s)	Year	Shoulders	Age (mean)	Male	Female	FTT	PTT
Smith[3]	1834	80				7	0
Keyes[7]	1933	73				10	Excl
Codman[8]	1934	200		144	56	33	31
Keyes[9]	1935	192	63			4	20
Skinner[10]	1937	100				6	12
Lindblom[11]	1939	28				Excl	9
Wilson & Duff[12]	1943	216				24	22
Grant & Smith[13]	1948	190		170	20	36/19	
Cotton & Rideout[5]	1964	212				7	60
Neer[6]	1983	500				25	Excl
De Palma[14]	1983	96		72	26	9/96	
Refior & Melzer[15]	1984	195		124	71	22	Excl
Petersson[16]	1984	99	74	55	44	14	18
Bigliani *et al.*[17]	1986	142	74.4	74	68	34	Excl
Uhthoff *et al.*[18]	1987	306	59.4	170	156	61	Excl
Salter *et al.*[19]	1987	53		26	28	6/53	
Yamanaka[20]	1988	268		171	97	18	37
Ozaki *et al.*[21]	1988	200	72	130	70	27	69
Ogata & Uhthoff[22]	1990	76	69.3	32	44	19	36
Jerosch *et al.*[23]	1991	122	79	42	80	37	35
Kolts[24]	1992	37		17	20	6/37	
Hijioka *et al.*[25]	1993	160	69.3	112	48	18	13
Lehman *et al.*[26]	1995	456	64.7	170	286	78	Excl
Itoi *et al.*[27]	1995	41	84			18	12
Panni *et al.*[28]	1996	80	58.4			4	10
Yamanaka *et al.*[2]	1997	227	57	144	83	18	33
Sakurai *et al.*[29]	1998	52	76.3	34	18	16	10
Pieper & Radas[30]	1998	124	75.4	60	64	19	30
Sano *et al.*[31]	1999	82	64	46	36	6	17
Jiang *et al.*[4]	2002	22		11	11	5	7
Totals		4629	69.3	1804	1326	587	481

Excl, author of study excluded either FTTs or PTTs from data.
Numbers expressed as fractions indicate FTTs and PTTs not differentiated.

included from 1988 to 2000 and 14 MRI studies from 1987 to 1999. The findings are summarised in Tables 1–4.

Cadaveric studies

The total number of cadaveric shoulders was 4629. The prevalence of FTTs was 12.68% and PTTs was 10.39%. The overall prevalence of any tear in the rotator cuff was 23.07%.

Only nine studies reported all of the data relating to total number of shoulders, mean age, gender, full thickness and partial thickness tears. Therefore, it was decided to look at studies with a data set for total number of shoulders, number of FTTs and number of PTTs. This reduced the total number of shoulders to 2553 with 11.75% FTTs and 18.49% PTTs. The mean age was 70.1 years (age not recorded for every study). The total prevalence of any tear was 30.24% (Table 1).

Ultrasonography

There were two papers on asymptomatic subjects and nine on symptomatic subjects in this group. In the asymptomatic group, there were a total of 591 subjects. Tempelhof *et al.*[32] studied 411 volunteer shoulders, all of whom were asymptomatic. Milgrom *et al.*[33] recruited volunteers with asymptomatic shoulders and no history of shoulder problems. The prevalence of FTTs was 21.7% and PTTs 17.2% (only differentiated in one study). The total prevalence of tears was 38.9%.

In the symptomatic group, there were 1038 subjects. These were patients with clinical suspicion of a cuff tear,[34–38] heterogeneous rotator cuff symptoms,[39] and non-specific shoulder pain.[40] The mean age, where recorded, was 50.4 years. The prevalence of FTTs was 34.7% and PTTs 6.7% (differentiated in four studies). The total prevalence of tears was 41.4% (Table 2).

Magnetic resonance imaging

There were four asymptomatic papers and twelve symptomatic papers. In the asymptomatic papers, there were 271 subjects, who had never had any shoulder symptoms.[44,45] The prevalence was FTTs 10.33% and PTTs 15.87%. The total prevalence was 26.2%. The mean age was 44.3 years.

In the symptomatic papers, there were 490 subjects, presenting in a variety of ways, for example; pain,[43] multiple provisional diagnosis which were not all rotator cuff disease,[46] and clinical suspicion of a rotator cuff tear.[47] The prevalence of FTTs was 40.81% and PTTs 8.57%. The total prevalence was 49.38%. The mean age was 43.6 years (Table 3).

Discussion

The prevalence of rotator cuff tears has been widely assessed.[32,33,57,58] Estimates vary, but can be as high as 80% of 80-year-olds.[33] This study reviewed the prevalence of rotator cuff tears in the cadaveric, symptomatic and asymptomatic populations. The total prevalence of rotator cuff tears in the full cadaveric data group was 30.3%, partial thickness tears 18.5% and full-thickness tears 11.8%.

It would be expected that the cadaveric population would include subjects that had been symptomatic and asymptomatic. Therefore, a prevalence of tears between the

Table 2 Ultrasound prevalence of rotator cuff tears

Author(s)	Symptoms	Year	Shoulders	Age (mean)	Male	Female	FTT	PTT
Milgrom *et al.*[33]	A	1995	180		86	94	32	31
Tempelhof *et al.*[32]	A	1999	411		191	220	96	Excl
Mack *et al.*[36]	S	1985	72				38/72	
Middleton *et al.*[41]	S	1986	106	47	75	31	37/106	
Crass *et al.*[39]	S	1988	500				112	47
Hodler *et al.*[42]	S	1988	51		38	12	35	4
Miller *et al.*[38]	S	1989	57	55	30	26	17/57	
Soble *et al.*[37]	S	1989	75				31/75	
Brandt *et al.*[35]	S	1989	58	52	45	13	22/58	
Nelson *et al.*[43]	S	1991	19				3	4
Teefey *et al.*[40]	S	2000	100				65	15

Excl, author of study excluded either FTTs or PTTs from data.
A, asymptomatic subjects; S, symptomatic subjects.
Numbers expressed as fractions indicate FTTs and PTTs not differentiated.

Table 3 **MRI prevalence of rotator cuff tears**

Author(s)	Symptoms	Year	Shoulders	Age	Male	Female	FTT	PTT
Chandnani *et al.*[44]	A	1992	20				0	1
Sher *et al.*[45]	A	1995	96	53	47	49	14	19
Needell *et al.*[49]	A	1996	100	54	49	51	14	22
Kneeland *et al.*[50]	S	1987	26		15	10	20	2
Seeger *et al.*[51]	S	1987	107				18/107	
Evancho *et al.*[52]	S	1988	31				8	2
Kieft *et al.*[53]	S	1988	10				0	0
Burk *et al.*[47]	S	1989	38				22/38	
Zlatkin *et al.*[54]	S	1989	32				20	0
Rafii *et al.*[55]	S	1990	80	47.8	58	22	30	20
Iannotti *et al.*[56]	S	1991	88				36	14
Nelson *et al.*[43]	S	1991	21	42	16	5	6	8
Torstensen & Hollinshead[46]	S	1999	57	41	33	24	40/57	

A, asymptomatic subjects; S, symptomatic subjects.
Numbers expressed as fractions indicate FTTs and PTTs not differentiated.

symptomatic and asymptomatic radiological groups would be expected. In the literature, the cadaveric population tends to be older than those in the radiological studies. This should increase the prevalence of tears. However, apart from the MRI asymptomatic group the radiological prevalence of rotator cuff tears exceeds the cadaveric.

The prevalence of partial thickness tears in the symptomatic MRI and ultrasound groups is lower than the asymptomatic and cadaveric groups. This may be due to a number of factors: the limitations of the investigation or partial thickness tears may be less commonly symptomatic than full thickness. Certainly, partial thickness tears are a heterogeneous group in terms of symptoms, territory, depth and involvement of other tissues. The size of tear has been shown to increase with time in cadaveric[59] and *in vivo* studies.[60] The level of symptoms attributed to tears has been shown to alter with time.[61] Yamaguchi[61] used ultrasound to study the asymptomatic shoulders of patients presenting with unilateral cuff tears; 51% of the asymptomatic shoulders with a rotator cuff tear on ultrasound became symptomatic over 2.8 years. There is a possibility that the asymptomatic tears in the radiological studies may represent a presymptomatic stage.

The prevalence of ultrasound-proven full-thickness tears is higher in the symptomatic than the asymptomatic. However, the total prevalence of rotator cuff tears differs by only 2.5%, which may also imply propagation of tears and changing symptoms.

Table 4 **Composite table of results**

Group	Total number	Mean age (years)	FTTs prevalence (%)	PTTs prevalence (%)	Total prevalence (%)
Total cadaveric	4629	69.3	12.7	10.4	23.1
Full data cadaveric	2553	70.1	11.8	18.5	30.3
Ultrasound asymptomatic	591		21.7	17.2	38.9
Ultrasound symptomatic	1038	50.4	34.7	6.7	41.4
MRI asymptomatic	271	44.3	10.3	15.9	26.2
MRI symptomatic	490	43.6	40.8	8.6	49.4

It is possible that partial and full thickness tear configuration is an important factor in the production of symptoms. Tears which have a preserved rotator cable[62] or an intact anterior supraspinatus with less disruption of the tendon footprint may produce less symptoms. Other factors, which may influence symptoms, for example the long head of biceps or subacromial inflammation, are not commonly discussed in the radiological studies.

Another variable to consider was the difference in the mean age of the three groups. However, it is clear from the tables that the age was frequently not recorded and it is not appropriate to reach any conclusions relating to age. It is likely that, as with tendon disease in general, the total prevalence of cuff tears would increase with age.[1]

The ideal study to compare the various investigations would comprise a large number of cadavers, which would have ultrasound and MRI before definitive dissection and determination of pathology. In many papers, partial thickness tears were excluded from analysis due to the difficulty in defining their appearance consistently. There remain problems in defining ultrasound and MRI criteria for PTTs.

Conclusions

Rotator cuff tears are common pathology and are frequently asymptomatic. Rotator cuff tears demonstrated radiologically during investigation of the shoulder may well not be responsible for the presenting symptoms. It is important to correlate radiological and clinical findings in the shoulder.

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