J Shoulder Elbow Surg (2017) ■■, ■■–■■

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Are degenerative rotator cuff disorders a cause of shoulder pain? Comparison of prevalence of degenerative rotator cuff disease to prevalence of nontraumatic shoulder pain through three systematic and critical reviews

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Hypothesis and Background: The role of degeneration is not well understood for rotator cuff pain. If age-related degenerative changes would be the cause of symptoms, degeneration would precede or concur with self-reported pain. We performed 3 systematic literature reviews. Our objectives were to determine the prevalence estimates for rotator cuff partial or complete tears (1) in cadavers and (2) in the general population and (3) to estimate the incidence/prevalence of self-reported nontraumatic shoulder pain in the general population in order to compare their respective age-related profiles.
Methods: We searched PubMed and ScienceDirect, including 2015, for cadaveric studies and transverse and longitudinal studies of the general population reporting the incidence/prevalence of rotator cuff disorders or nontraumatic shoulder pain, or both, according to age. The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. Results were interpreted visually.
Results: We found 6 cadaveric studies, 2 studies from the general population reporting complete tears, and 10 articles on nontraumatic shoulder pain in the general population that met our criteria. The profiles of degeneration vs. pain were very similar in early years. Although degenerative rotators cuff lesions increased gradually after 50 years, the incidence/prevalence of nontraumatic shoulder pain decreased after 65 years.
Conclusion: The profile of age-related degenerative rotator cuff disorders fails to correlate systematically with self-reported nontraumatic shoulder pain, particularly in older age; thus, it appears that degeneration should not be considered the primary source of the pain. Physical activity may play an important role in the production of the pain, a theory that warrants further study.

Institutional Review Board approval was not required for this review study of published articles.

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1058-2746/$ - see front matter © 2017
http://dx.doi.org/10.1016/j.jse.2016.09.060

Level of evidence: Level III; Systematic Review of Cross Sectional Design Epidemiology Studies

Keywords: Rotator cuff; degeneration; shoulder pain; prevalence; age; cadaver; systematic review

The prevalence of shoulder pain in the general adult population is relatively common, with lifetime prevalence estimates reported to be as high as 67%.[14] Shoulder pain can cause considerable discomfort and may therefore have some consequences such as a need for treatment, reduced work capacity, and sickness absence.[16,26,32]

The most frequent cause is known to be problems with the rotator cuff.[16] However, the origin of pain has not been clearly elucidated. The management of painful shoulders includes conservative and surgical treatments, but their effects and comparative outcomes remain unclear.[3-5,27] A better understanding of the definite role of the degenerated rotator cuff in the painful shoulder would represent a step forward toward a logical treatment approach to this large diagnostic subgroup of the painful shoulder.

Teunis et al[28] studied this very issue in a review, in which they concluded that "the prevalence of rotator cuff abnormalities in asymptomatic people is high enough for degeneration of the rotator cuff to be considered a common aspect of normal aging and to make it difficult to determine when an abnormality is new (eg, after a dislocation) or is the cause of symptoms."

Their review, however, failed to clearly demonstrate how they reached this conclusion. For this reason, we decided to perform a new systematic review, to do so in a critical context, and to visualize clearly the results in order to clarify the findings of the previous review, while updating it with any new information that was available.

Our objectives were:

1. to determine the prevalence of rotator cuff partial or complete tears in the cadaveric and the general populations, when demonstrated with validated diagnostic tools, according to age;
2. to determine the prevalence/incidence of self-reported nontraumatic shoulder pain (NTSP) in the general population, according to age;
3. to compare the age-related profiles of degeneration and pain, to see if they concur; and
4. to compare the prevalence estimates of pain for men and women.

We hypothesized that if age-related degenerative changes were the cause of most shoulder pain, then objective signs of degeneration would be as common as or somewhat more common than self-reported pain in each age group but that the 2 age-related curves would not concur if degenerative changes were not the cause.

Materials and methods

Design and registration

We performed 3 systematic and critical reviews of the literature to satisfy each of the 3 objectives: (1) the first on the prevalence of rotator cuff degenerative disorder (RCDD) in cadavers, (2) the second on the prevalence of RCDD in the general population, and (3) the third on the prevalence of self-reported NTSP in the general population. The review was registered in the International prospective register of systematic reviews PROSPERO (PROSPERO CRD42014015240).

Information sources and search

Searches were made in the PubMed and ScienceDirect databases to identify articles until December 2015. The search terms used were Medical Subject Headings and free text. Details of the searches are given in Appendix S1 for each of the 3 reviews.

Eligibility criteria

Inclusion criteria:

1. The design of the studies concerned cadaveric studies for objective 1 and population- based, cross-sectional, or longitudinal studies for objectives 2 and 3.
2. Only articles published in English or French were considered, with no limitation for year of publication.
3. Estimates had to be provided in relation to age group, because our goal was to assess findings in relation to age.
4. The type of RCDD had to be demonstrated at autopsy or by complementary examinations. Arthroscopy was retained because it is a reference standard test in assessing the articular and bursal side of the rotator cuff. We also accepted magnetic resonance imaging and ultrasound imaging because a systematic review showed their diagnostic performance has had good accuracy in the diagnosis of rotator cuff tears.[12]

Exclusion criteria in the population-based studies were:

1. case-control studies;
2. studies that used physical examination as the diagnostic method for RCDD because of its lack of objectivity;
3. studies that did not clearly distinguish between neck and shoulder pain;
4. studies concerning the upper limb if shoulder pain was not clearly distinguished from other painful upper limb areas or pathologies; and
5. sample size <100 (no limit was set for the cadaveric studies).

To retrieve the relevant full texts, the first author (K.V.) selected articles on the basis of their title, abstract, or the whole text, when doubt persisted. The inclusion and exclusion criteria were then controlled independently by the 2 other authors (O.G. and C.L.-Y.) on the basis of the full texts. The opinion of the third author (C.L.-Y.) could be requested in case of disagreement on the inclusion of an article; however, there were no disagreements.

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 2009 flow diagram was followed. Supplementary Fig. S1 shows the entire selection process for each study design and the reasons for exclusions.[18]

Data extraction

Three specific checklists were established to assess the studies according to the methodological requirements of the respective topics and tested for user friendliness and improved before being applied to all included articles. These checklists were based on existing recommendations in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement but modified to suit our specific needs.[30] Each checklist consisted of three sections:

(1) Section 1: Description of the study, which was common to the 3 reviews: first author, country where the research was conducted, year of publication, and study design.
(2) Section 2: Information pertinent to each objective concerning participants and the shoulder.
(3) Section 3: Descriptive checklists to present the results of the data extraction (Tables S1-3). Relevant information regarding study descriptions and method was sought in the Methods section in the main text and information on results was obtained from the Result section in the main text.

Two readers collected this information independently of each other, and in case of disagreement, discussions could be held with the third author. The first author (K.V.) collected information for all checklists for all 3 objectives. The second author (O.G.) was coresponsible for the checklist for cadaveric studies, and the third author (C.L.-Y.) was coresponsible for the other 2 checklists.

Each quality item concerning section 2 was given a score (1 for fulfilled, 0 for not fulfilled), and these scores were added. We also made two final judgments on whether the data were credible or not based on this score but without a cutoff. The final judgment was explained in the text for each relevant section. The rationale for the choice of quality items and final judgments is given in Appendix S2.

Data analysis and interpretation of findings

We aimed to use the above information to distinguish the studies for which the overall quality was acceptable from those of lesser quality in order to trust the acceptable studies and to believe the nonacceptable studies only if their results were coherent with those of the acceptable studies. To do so, we classified the studies according to their two final judgments, based on an overall subjective evaluation of the information on the study sample and the shoulder information.

In addition, we ranked the studies on NTSP by taking into account the definitions of shoulder pain. This was done in order of recall period, going from short-term prevalence to medium-term and long-term prevalence.

The results were placed into a table for each group with the acceptable studies at the top, followed by the nonacceptable studies with results that resembled the acceptable ones, and at the very bottom, the nonacceptable studies with deviant results.

We thereafter illustrated the results through the use of graphs showing estimates in relation to age for the prevalence of RCDD in cadavers and the general population, and thereafter, the prevalence of NTSP in the general population. Interpretation of data was therefore purely visual.

Most of the authors of cadaveric studies presented their results in 10-year age brackets. For practical reasons of presentation but without altering the results and their interpretation, we made 2 main modifications. The first related to the age groups younger than 50 (30-39, 40-49) and older than 80 (80-89, 90-99) that we merged because the number of cadavers was low in these age groups. The second modification concerns the study of Panni et al,[21] whose estimated age group periods were 26 to 45, 46 to 65, and 66 to 82 years, which we forced into groups of younger than 50 years, 51 to 60 years, and older than 60 years.

Two studies of NTSP used different age group periods, respectively, of 10 and 5 years. To compare them in the same figure, we divided the 10-year period in 2 subgroups of 5 years by keeping the same result without altering the overall curve.[15,22]

Results

Prevalence of rotator cuff disorders in the cadaveric population according to age

Study selection

We identified 543 studies (PubMed, 342; ScienceDirect, 201), of which 533 were excluded on the basis of their title or abstract. Of the 10 remaining articles, 7 were excluded on the basis of their text. We indentified 3 additional articles in a manual search from reference lists of the selected articles. Reasons for exclusion are described in Fig. S1. Finally, 6 articles met our inclusion and exclusion criteria.[7,9,10,20,21,23]

Study characteristics

As summarized in Table S1, 3 articles were from Japan, and the others were from Italy, Germany, and Sweden, published between 1988 and 1996, with sample sizes ranging between 40 and 100. The cadavers (57% men) were a mean and median age of between 58 and 77 years. Identification of tears or partial tears of the rotator cuff was always made through visual inspection. Histologic studies completed the visual inspection in 3 studies. An additional radiographic examination was used in 2 studies to visualize the acromion, the presence of osteophytes, or the shape of the glenoid rim.

Quality

All of the samples were clearly defined, and there were no losses or exclusions in 4 of the cadaveric studies (Table S1). In the 2 studies where there were exclusions, this was ac-

counted for. Tithe dissection method was clearly described in all studies.

Concerning the evaluation of lesions, 3 teams made a complete examination of the rotator cuff, and these studies were therefore considered as acceptable.[10,20,21]

One study limited the definition of pathology to complete tears,[23] and 2 other studies included bursal-sided tears and complete tears.[7,9] These 3 studies were considered as nonacceptable because there was a risk of underestimation of the lesion.

Prevalence of RCDD in cadavers

Acceptable studies. As can be seen in Fig. S2, rotator cuff tears in cadavers generally increased with age in the 3 acceptable studies. These lesions were rare before 50 years. Thereafter, the increase was linear throughout life, with the exception of the group aged 60 to 69 years in the first study.[21] In another study, the increase of tears was shown to stabilize after 80 years,[20] whereas this was not the case in the third study.[10]

Nonacceptable studies. The overall profile was the same in the nonacceptable studies. The stabilization of the prevalence after 80 years in the 3 studies[7,9,23] was consistent with the results in 1 of the acceptable studies.[20] The high prevalence of degenerative disorders, particularly before 50 years observed in 1 study, was explained by the fact that the authors included degenerative changes of the cuff obtained with scanning electron microscopy.[7]

Prevalence of RCDDs in the general population according to age

Study selection

In all, 554 studies were identified (PubMed, 337; ScienceDirect, 217), of which 542 were excluded on the basis of their title or abstract. Of the remaining 12 articles, 10 were excluded on the basis of their texts. No additional articles were identified through the manual search of selected articles. Reasons for exclusion are described in Fig. S1. Finally, 2 articles met our inclusion and exclusion criteria.[17,33]

Study characteristics

These 2 articles were cross-sectional studies from 2 different villages in Japan published in 2010 and 2012. There was a majority of women (67% and 64%, respectively). The mean and median age was 58 and 69, respectively. The pathoanatomic lesion searched was full-thickness rotator cuff tears, and the diagnostic procedure used was ultrasound in both studies.

Quality

As reported in Table S2, we considered the first study[33] to be acceptable but the second study[17] was nonacceptable because the study sample appeared not to be representative and shoulder data were unclear.

Prevalence of the RCCDs in the general population

Acceptable study. As can be seen in Fig. S3, the acceptable study[33] clearly showed a steady increase of rotator cuff tears in the general population, beginning between 30 and 39 years with the highest level at 80 years. Then, it appeared that this increase tended to stabilize after 80 years.

Nonacceptable study. The results of the nonacceptable study[17] were coherent with those of the acceptable study.[33]

Prevalence or incidence of self-reported NTSP in the general population according to age

Study selection

We identified 613 studies (PubMed, 270; ScienceDirect, 343), of which 586 were excluded on the basis of their title or abstract. Of the 27 remaining articles, 18 were excluded on the basis of their texts. One article was detected through the manual search from reference lists of the selected articles. Reasons for exclusion are described in Fig. S1. Finally, 10 articles met our inclusion and exclusion criteria.[1,2,6,8,15,19,22,24,29,31]

Study characteristics

As summarized in Table S3, the reviewed articles were from the United Kingdom (n = 4), Sweden (n = 2), Denmark (n = 1), Australia (n = 1), Finland (n = 1), and the Netherlands (n = 1) and were published between 1992 and 2013. One longitudinal study reported incidence rates (Ostergren et al[19]), and the others were cross-sectional studies and studied prevalence rates. Three studies had the shoulder as the major purpose of their research, and the others studied multiple sites. The data in 7 of 10 concerning shoulder pain were collected through questionnaires. In the others, data were collected by interview, accompanied by physical examination in 1 study. Selected adult populations were from the entire country, urban populations, or general practice. The sex distribution was slightly in favor of women, except in 2 studies of workers or old people. The total age range was between 16 and 102 years.

Quality

As summarized in Table S3, the generalizability and shoulder pain data were considered acceptable or likely to be acceptable in 4 studies.[6,15,22,31] In a fifth study, information regarding the representativeness of this subsample of workers was not clearly provided.[19] However, because the original study sample was likely to be representative and data on shoulder pain were considered acceptable, we considered the study, on the whole, as acceptable.

Another 5 studies were considered nonacceptable.[1,2,8,24,29] Three of the studies failed to convince us that their shoulder pain data could be trusted,[12,29] and in the other 2 studies, the

generalizability of the study sample and the shoulder pain data were unclear.[8,24]

Prevalence of NTSP in the general population

Acceptable studies. As summarized in Table S4, of the studies using short duration of the shoulder pain recall period, 2 acceptable studies were limited to the period before retirement.[6,31] In one of them, the prevalence of shoulder pain increased gradually until the age of 64 (Fig. S4).[31] The other study divided the participants into 2 age groups and showed that the prevalence increased from the group aged 16 to 44 to the group aged ≥45 years (Fig. S4).[6]

Two acceptable studies with a medium duration of the recall period showed that the prevalence of shoulder pain increased steeply with age, with a peak in the group aged 55 to 64 years, similar to the results for the short-term period, but the prevalence decreased after age 65 (Fig. S5).[15,22]

Concerning the long-duration period recall, there were no such studies considered to be acceptable.

Nonacceptable studies. For the short-duration recall period of shoulder pain, the results in the nonacceptable studies did not concur with the acceptable studies and were therefore ignored.

For the medium-duration recall period, 1 nonacceptable study showed similar results as the acceptable studies, with a peak of shoulder pain in the group aged 45 to 65 years (Fig. S5).[24]

In relation to the long-duration recall period, the results in 1 nonacceptable study were coherent with acceptable studies of different recall periods, with a peak of shoulder pain in the group aged 55 to 64 years.[8] In the other nonacceptable study, which concerned old people, no characteristic profile could be observed (Fig. S6).[2]

Incidence of self-reported NTSP the general population. One acceptable study reported the incidence of NTSP.[19] The definition used was the presence of shoulder pain often or all the time with a long-term recall period of 12 months. The incidence estimates ranged from 5% to 7% for men and 6% to 10% for women. It showed the same profile as the acceptable prevalence studies with a peak in the group aged 55 to 59 for men (Fig. S7). For women, a peak was observed in the younger age group of 45 to 49 but stabilized at the age of 59, after which the incidence decreased.

Differences in pain reporting between men and women

Three acceptable studies provided data independently for men and women, always with slightly higher estimates for women (Figs. S4, S5, and S7).[15,19,31] Three nonacceptable studies reported the same differences between sexes.[2,24,29]

Comparison of profiles

A comparison of degenerative changes by age between the cadaveric and general populations was only possible for the older age groups because of lack of data for younger people in the cadaveric studies. In the cadaveric population, there was a gradual and steady increase of partial or complete tears throughout life until the age of 80 years. After this age, the prevalence seemed to even out.

The prevalence estimates of tears in the general population all showed a similar profile but were always inferior to those of the cadaveric population. The observed differences between cadavers and the general populations can probably be explained by the fact that the degenerated cuff was evaluated in 2 different ways: full-thickness rotator cuff tears in the general population vs. all types of tears in the cadaveric studies.

The self-reported pain data varied between studies, depending on the definition of the pain and the importance of its recall period: the more "stringent" the definition, the lower the prevalence estimates. For example, in a study in which the pain had to have lasted for 3 months or longer and had to be currently present with a recall period of 1 month, the prevalence estimates ranged between 1% and 8%.[19] When the definition of shoulder pain was less "severe," such as in a study that defined pain merely as any tenderness or pain during passive or active movement with the same recall period, the prevalence estimates were higher, between 12% and 43%.[15]

In sum, whatever the definition and their recall period, pain was already present at the age of 18 years and followed a gradual and steady increase to reach a peak in the group aged 55 to 64. Then, the estimates decreased more or less steadily throughout the rest of life. These findings were similar also when data were viewed separately for men and women.

Finally, although the curves for degeneration and pain were similar in the younger and middle-aged populations, they showed a clear divergence after the age of 65. The prevalence of tears continued to increase, whereas the prevalence of shoulder pain decreased.

Discussion

Summary of findings

Our 3 systematic reviews showed that cadaveric and general population curves had similar profiles for degeneration and that degeneration and pain curves were first similar but then not. There was a discrepancy between the incidence/prevalence rates of degeneration that grew significantly with age, particularly after 50 years, and the prevalence rates of NTSP in the general population that decreased significantly after 65 years.

Methodological considerations

In relation to the completeness of our literature search, this cannot be fully guaranteed, and it is possible that some relevant articles were left out. Nevertheless, we tried to minimize this bias by using Medical Subject Heading terms and free text. We identified articles with the association of PubMed and ScienceDirect databases, which has shown to give excellent results.[25]

In relation to the definition of shoulder pain, the best method for studying shoulder pain related to degeneration would have been to find surveys in which both factors were studied simultaneously. Unfortunately, such surveys do not exist. In most cases, the actual cause of the pain is not known and can only conjecturally be linked to abnormalities in the rotator cuff. Thus, population-based studies evaluating shoulder pain represented the best approximation because the rotator cuff lesions are the most frequently encountered abnormalities.[16] However, traumatic causes could represent a source of bias because they are significantly associated with rotator cuff tears.[9] Probably though, there would only be a small minority of traumatic cases, because one good-quality study showed that a history of trauma was less than 7%.[15] We therefore considered it unlikely that the profiles of shoulder pain would be considerably affected by many traumatic causes. It is also possible that pain reported in these surveys was secondary to other pathologies, such as inflammatory conditions. However, this is also unlikely, considering that such pathologies are present in only a few percent of people with shoulder pain.[15]

In relation to the retrieval of information, we used specific checklists that had been adapted for our specific needs. However, it is possible that other checklist items could have resulted in a different view on how to classify acceptable and nonacceptable articles.

In relation to the analysis of data, a meta-analysis could perhaps have brought more exact estimates, but this was not done for two reasons: First, we were not interested in calculating exact estimates but wanted to observe the general curves as they progressed with age and as they compared with each other. Second, there were considerable differences of definitions of lesions or pain and sometimes also age categorization, which many probably would consider too heterogeneous for an appropriate meta-analysis calculation.

Discussion of findings

The conclusions of our study are in agreement with the sentiment expressed in the previous review by Teunis et al,[28] as it was clearly shown that the prevalence of NTSP does not follow a pattern similar to that of DDRC.

The review also shows that it is somewhat more common for women than for men to report shoulder pain, which confirms what can be observed in other musculoskeletal disorders.[13]

People in general and many clinicians tend to blame musculoskeletal symptoms on "old age" (ie, degeneration). According to the observed curves, degeneration and pain reporting do run a similar course for several decades, indicating that one may well cause or contribute to the other.

However, the curves separate around the age of 60 to 65, when the prevalence of degeneration continues to increase, whereas pain is not as commonly reported anymore. This pain pattern has been shown very clearly also for lumbar, thoracic, and cervical pain reports in the general population, whereas it is well known that spinal degeneration continues throughout life.[6,11]

The question then arises: What does this mean? Is degeneration irrelevant in the production of symptoms or is degeneration important only up to a certain level or for certain types of degeneration? A third possibility is perhaps that degeneration plays a role in the production of musculoskeletal pain in combination with certain levels of physical activities; that is, becomes less important around retirement age, when many people experience less physical demands at work and at leisure. Also, the severity and type of pain are not well understood in relation to the various age groups and were not taken into account in most of the studies. Even if the pain is less prevalent at older age, it is possible that it changes character to become more or less bothersome as age progresses. Obviously, further work is needed to explore the reasons for this finding.

Considerations for future research

To better understand the painful "nonspecific" shoulder pain, its long-term trajectory needs to be mapped out. It would be important to study its natural course in order to be able to contrast it to the clinical course after various treatment approaches.

Also, future studies should take into account the severity of pain in relation to age, and it would be relevant to investigate whether certain specific degenerative changes are more important than others. In view of the clear divergence of the degeneration and pain-reporting curves at the age of retirement, it would be highly relevant to take into account, as a potential modifying factor, the type and amount of physical activity.

Conclusion

Our results show the profiles of the degenerated rotator cuff and the painful shoulder are similar up to a certain age but that there is a discrepancy between them with an increase of degeneration throughout life, accelerating at 50 years while the shoulder pain curve decreases after the age of 65 years. The trajectories of degeneration and pain need to be further studied by taking into account types of degeneration and pain and also the potential modifying effect of physical activity both at leisure and work.

Acknowledgments

Laura Davies, PhD, is acknowledged for the English editing of the text.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Appendix
Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jse.2016.09.060.

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