Effect of age on the natural history of the shoulder: a clinical and radiological study in the elderly

L. Nové-Josserand [1], G. Walch [1], P. Adeleine [1], P. Courpron [1]

[3] Hôpital A. Charrial, rue de la Table-de-Pierre, 69290 Francheville.

ABSTRACT

Purpose of the study
Classically, the shoulder joint is thought to age more by its tendons than by its cartilages, the incidence of rotator cuff tears being considered to increase with age. The purpose of this work was to assess the natural history of the shoulder joint based on a clinical and radiological study of 200 patients aged 70 to 101 years.

Material and methods
The cohort was composed of 48 men (34%) and 152 women (76%), aged 84.25 ± 6.7 years. All patients underwent a physical examination and the Constant score was established. The radiographic examination included an AP view in neutral rotation of both shoulders. The Hamada classification was used to stage full thickness cuff tears. The glenohumeral compartment was analyzed to search for osteophyte formation and joint narrowing.

Results
The subacromial height was greater than 6 mm, mean 9.89 ± 2 mm, in 349 shoulders (87.25%), corresponding to stage I in the Hamada classification; it measured less than 6 mm, mean 3.08 ± 1.7 mm in 51 shoulders (12.75%) in 38 subjects (19% of the total cohort). The Hamada classification for the other shoulders was stage II (n = 21 shoulders, 5.25%), and stage III (n = 16 shoulders, 4%), stage IV (n = 5, 1.25%) and stage V (n = 5, 1.25%). The Hamada stage could not be determined for four shoulders. There was a strong statistical correlation between the Constant score and Hamada stage. The glenohumeral space was normal in 288 shoulders (72%). Ninety-three shoulders (23.25%) in 62 patients (31%) presented humeral and/or inferior glenoid osteophytes without glenohumeral impingement and 19 shoulders (4.75%) in 14 patients (7%) presented complete glenohumeral impingement. There was a significant correlation between the Constant score and severity of the glenohumeral degradation. The proportion of subacromial impingement increased significantly and regularly with
Degradation of the glenohumeral space ($p << 10^4$). For half of the shoulders, glenohumeral impingement was associated with subacromial impingement (eccentric osteoarthritis).

**Discussion**

The results of this study confirm that the frequency of rotator cuff tears increases with age. One out of five patients aged 70-90 years presented subacromial impingement versus one out of three among patients aged over 90 years. Clinical tolerance of subacromial impingement or subacromial osteoarthritis is good. Glenohumeral impingement, associated or not with subacromial impingement, is poorly tolerated, the patients presenting shoulder pain and marked stiffness.

**Conclusion**

Our results demonstrate that the natural history of the shoulder does not exhibit a regular linear relationship with the Hamada radiological classification.

**Key words:** Shoulder, natural history, rotator cuff, osteoarthritis, age effect.

**INTRODUCTION**

Classically, unlike the weight-bearing joints of the lower limb, the shoulder joint is thought to age more by its tendons than by its cartilages [Apoil et al. [1]]. Degenerative disease of the shoulder generally involves the rotator cuff with full thickness tears predominating [Chard et al. [2] [3], Chakravarty et al. [4], Vecchio et al. [5]]. Most, but not all authors consider that the incidence of rotator cuff tears increases with age. Two types of studies, cadaver dissection [Codman et al. [6], Olsson [7], Petersson [8]] and clinical trials, with or without x-ray assessment [Chard et al. [2] [3], Chakravarty et al. [4], Vecchio et al. [5], Olsson [7], Cotton et al. [9], Milgrom et al. [10], Sher et al. [11], Sillar et al. [12], Yamaguchi et al. [13]] can be used to evaluate the shoulder.

The incidence of osteoarthritic degradation of the shoulder joint is probably low but no precise figures are available [Nakagawa et al. [14]]. The incidence of osteoarthritis is on the contrary well known for other joints such as the hip, the knee, the fingers, or the spine.

Data on the clinical and functional impact of shoulder aging in living elderly subjects are scarce [Chard et al. [2] [3], Chakravarty et al. [4], Vecchio et al. [5], Olsson [7], Sillar et al. [12]]. In large population studies, subacromial impingement seen on standard AP views obtained during routine examinations has been found to be a reliable and specific though not highly sensitive marker of rotator cuff tears [Cotton et al. [9], Hamada et al. [15]]. Glenohumeral osteoarthritis has also been observed [Samilson et al. [16]].

The purpose of this prospective cross-sectional study was to assess the natural history of the shoulder joint based on a clinical and radiological analysis of patients aged 70 to 101 years.

**MATERIAL AND METHODS**

Clinical and radiographic data were collected for both shoulders of 200 patients aged 70-101 years recruited in a hospital geriatric ward. These patients were hospitalized between November 1994 and April 1995 in the A. Charrial Hospital for acute or chronic care. Inclusion criteria were: age 70 years or more, ability to provide appropriate oral responses to a standard questionnaire, ability to stand or at least maintain the sitting position without assistance. Exclusion criteria were state of confusion or altered superior functions preventing response to the questionnaire, hemiplegia or other neurological deficit which might alter the physical examination, inflammatory, infectious, or neoplastic disease, or a history of shoulder trauma or surgery.

The study population included 48 men (24%) and 152 women (76%) aged 84.25 ± 6.7 years (mean ± SD). The ten-year age groups were: 53 subjects (26.5%) aged 70-80 years, 114 subjects (57%) aged 81-90 years, and 33 subjects (16.5%) aged 91-101 years. The right shoulder was dominant for 183 subjects (91.5%) and four were ambidextrous. Three groups were defined according to occupational activity level: heavy manual labor, light manual labor, no manual labor. One hundred one subjects (50.5%) had had an occupation involving no manual labor or had not had an occupation; 71 (35.5%) light manual labor; 28 (14%) heavy labor. We searched for a history of periarticular scapulohumeral inflammatory reactions.

A physical examination was performed in order to establish the Constant score [Constant et al. [17]]. This 100-point scale is divided into four parts. Pain (15 points) and daily activity (20 points) are established from history taking. Joint motion (10 points each anterior elevation, abduction, external rotation, internal rotation) is an objective measurement as is joint force (25 points) measured with a dynamometer arms extended.

The standard x-ray for all patients was an anteroposterior double oblique view in neutral rotation of both shoulders. Two investigators (an orthopedic surgeon and a rheumatologist) analyzed the x-rays independently, establishing a common interpretation in the event of disagreement. The acromiohumeral height was measured in millimeters and used to establish the grades of massive cuff tear as described by Hamada et al. [15]. For grade 1 the acromiohumeral interval measures ≥ 6 mm. For grade 2 the acromiohumeral interval measures < 6 mm (fig. 1a). Grade 3 corresponded to remodeling of the proximal humerus and acromion with acetabulization of the acromial arch and femorization of
the humerus (fig. 1b). The glenohumeral joint space is normal in grade 3 whereas glenohumeral impingement is noted in grade 4 (fig. 1c). Grade 5 presents complete glenohumeral impingement, possibly with osteolysis suggestive of cuff-tear arthropathy defined by Neer [Neer et al. [18]] (fig. 1d).

Regarding the glenohumeral compartment, the shoulders were divided into three groups: normal glenohumeral joint space; presence of inferior glenohumeral osteophyts without joint space narrowing (fig. 2); loss of joint space defining osteoarthritis (fig. 3 and 4).

The statistical analysis was performed by Dr Adeleine of the data processing department of the Hospices Civils de Lyon using the chi-square test of variance and the trend test for ordinal variables.

RESULTS

Subacromial space

The acromiohumeral interval, or subacromial space, measured $9 \pm 3.2$ mm ($m \pm SD$), ranging from 0 to 24 mm. The subacromial space measured $>6$ mm (mean $9.89 \pm 2$ mm) in 349 (87.25%) shoulders (grade 1) and $<6$ mm (mean $3.08 \pm 1.7$ mm) in 51 (12.75%) shoulders in 38 subjects (19% of the study population). Subacromial impingement by 10-year age group is presented in table I. Bilateral impingement was more frequent in males (5 out of 8) than in females (8 out of 30). There were 21 (5.25%) grade 2 shoulders and 16 (4%) grade 3 shoulders. Patients with grade 3 shoulders were younger than patients with all other grade shoulders. There were five (1.25%) grade 4 shoulders and five (1.25%) grade 5 shoulders. Four shoulders presenting advanced-stage glenohumeral degradation associated with subacromial impingement without femoralization of the humeral head could not be classified.

The Constant score is presented by Hamada grade in table II. There was a statistical correlation between patient age and Hamada grade although the trend was not linear. For the Constant score, there was a strong statistical correlation between worsening scores with more advanced degeneration. No statistically significant correlation could be identified regarding gender ($p = 0.42$) or occupation.
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There was however a statistically significant correlation between subacromial impingement and dominance (p = 0.006) and history of periarthritic conditions (p = 0.001).

Glenohumeral joint

The glenohumeral joint was normal without any signs of remodeling in 288 (72%) shoulders. Humeral and/or inferior glenoid osteophytes were observed in 93 (23.25%) shoulders in 62 patients (31% of study population) without glenohumeral impingement and 19 shoulders (4.75%) in 14 patients (7% of study population) presented total loss of the glenohumeral space.

The Constant score is presented by glenohumeral joint degradation in table III. Regarding age, the group of patients with joint space narrowing was significantly different from the others (p=0.009). Distribution by age group is presented in table IV. For the Constant scores, there was a strong correlation between worsening scores and more advanced degeneration. There was no statistically significant difference regarding gender (p=0.29).

Occurrence had a significant effect on presence of glenohumeral osteophytes (p=0.045) but not joint space narrowing. Dominance (p=0.019) and history of periarthritic conditions (p=0.013) had a statistically significant effect.

The percentage of subacromial impingement increased significantly and regularly with glenohumeral joint space narrowing (p < 10^{-4}). Two groups, determined by the presence or absence of subacromial impingement, could be defined for patients with total loss of glenohumeral space. The first group included eight patient (4% of the study population) with a normal subacromial space (acromiohumeral interval measuring 6 mm or more). In this group the osteoarthritic glenohumeral joint was centered. The second group included nine shoulders (2.25%) in seven patients (3.5% of the study population) with subacromial impingement. This group had excentered degenerative glenohumeral joints. The two groups were not significantly different regarding age and Constant scores. The space narrowing was harmonious on the centered degenerative joints (fig. 3) where as the impingement was localized and excentered to the superior third of the glenoid cavity in 7/9 of the excentered joints (fig. 4).

DISCUSSION

Despite the selection bias of our hospital patient population, the results of our study agree well with data in the literature on increasing incidence of rotator cuff tears with age [Chard et al. [2] [3], Chakravarty et al. [4], Vecchio et al. [5], Codman et al. [6], Olsson [7], Petersson [8], Cotton et al. [9], Milgrom et al. [10], Sher et al. [11], Sillar et al. [12], Yamaguchi et al. [13]]. We found subacromial impingement in one out of five patients aged 70-90 years and one out of three aged over 90 years. Looking at cadaver studies in subjects aged over 70 years, the rate of full thickness rotator cuff tears is on average 56%. For Glatthaar the incidence was 30% between the 7th and 9th decade [Olsson [13]], 70% at about 80 years for Olsson [7] and 100% after the age of 70 years for De Palma reported by Olsson [7]. These different studies agree that incidence increases with age. In our series, the incidence of full-thickness tears was underestimated because small tendon tears are not seen on plain
x-rays due to the lack of sensitivity of acromiohumeral interval measurements [Cotton et al. [9]]. Conversely, subacromial impingement is always associated with a wide cuff tear. Our results thus correspond to the incidence of wide tears, underestimating overall incidence of cuff tears. Unlike the dominant limb, the subject’s occupation would not be a significant factor favoring tears [Olsson [7]].

The Hamada classification [Hamada et al. [15]] depend on characteristic changes in the subachromial space. When it come in contact with the acromion, the proximal humerus rounds off loosing the characteristic shape of the trochiter. This is a mechanical adaptation of the humerus to the acromial vault. According to Hamada et al. [15], the acromial vault turns into an "acetabulum" and the proximal humerus "femorizes" creating a ball and socket formation. This reciprocal adaptation is similar to osteoarthritic degenerative processes although the subacromial space cannot be considered a joint from a strictly anatomical point of view. The presence of this subacromial osteoarthritic reaction is well tolerated if the glenohumeral joint space is preserved (Hamada grades 2 and 3 [Hamada et al. [15]]). The shoulder appears to have achieved a new mechanical equilibrium allowing preserved joint motion. On the contrary, involvement of the glenohumeral space (Hamada grades 4 and 5) leads to characteristic loss of clinical tolerance with stiff often painful shoulder. Our findings are not in favor of a linear progression through the Hamada grades. They do not provide any explanation of the glenohumeral degradation.

Studies on glenohumeral osteoarthritis are scarce and the few reports available do not provide incidence figures [Chard et al. [2], Petersson [8], Sillar et al. [12]]. We found a low incidence in our population, most cases being observed in the oldest age groups. Glenohumeral impingement has a significant clinical impact both subjectively (pain) and objectively (stiffness). In half of the cases, glenohumeral impingement was associated with subacromial impingement. Presence of joint narrowing, particularly in the upper par of the glenoid cavity would suggest that the glenohumeral involvement is secondary to cuff injury. Inferior glenohumeral osteophytes also have an important subjective and objective clinical impact. In 29% of cases, it was associated with subacromial impingement but even with a normal subacromial space, glenohumeral osteophytes might be a radiographic sign of an asympto-

### Table I. – Hamada grades: percentages by age (10-year groups) and gender.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Acromiohumeral interval ≥ 6 mm</th>
<th>Acromiohumeral interval &lt; 6 mm</th>
<th>Subacromial impingement</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-80 years</td>
<td>90.6% men: 100% women: 86%</td>
<td>9.4% men: 0% women: 14%</td>
<td>19%</td>
</tr>
<tr>
<td>81-90 years</td>
<td>88.5% men: 83% women: 89%</td>
<td>11.5% men: 17% women: 11%</td>
<td>18%</td>
</tr>
<tr>
<td>91-100 years</td>
<td>82.8% men: 78.5% women: 81%</td>
<td>17.2% men: 21.5% women: 19%</td>
<td>33%</td>
</tr>
</tbody>
</table>

### Table II. – Constant score by Hamada grade.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Age</th>
<th>Pain</th>
<th>Activity</th>
<th>Motion</th>
<th>Force</th>
<th>Constant</th>
<th>Cst p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamada 1 349 shoulders</td>
<td>84.2 ± 6.6</td>
<td>13.5 ± 2.5</td>
<td>17.7 ± 3</td>
<td>35 ± 6</td>
<td>8.75 ± 4</td>
<td>84.2 ± 6.6</td>
<td>116 ± 19.5</td>
</tr>
<tr>
<td>Hamada 2 21 shoulders</td>
<td>86.5 ± 7</td>
<td>13.3 ± 2.4</td>
<td>15.5 ± 3</td>
<td>28.5 ± 10</td>
<td>3.4 ± 3</td>
<td>60.7 ± 15</td>
<td>96.4 ± 24</td>
</tr>
<tr>
<td>Hamada 3 16 shoulders</td>
<td>79.6 ± 7</td>
<td>11.8 ± 3.7</td>
<td>14.6 ± 5</td>
<td>30 ± 10</td>
<td>3.4 ± 3</td>
<td>60 ± 18</td>
<td>89.2 ± 26</td>
</tr>
<tr>
<td>Hamada 4 5 shoulders</td>
<td>91.8 ± 2</td>
<td>15</td>
<td>14 ± 4.7</td>
<td>22.4 ± 13</td>
<td>2.8 ± 3</td>
<td>54.8 ± 21</td>
<td>98.8 ± 48</td>
</tr>
<tr>
<td>Hamada 5 55 shoulders</td>
<td>88.8 ± 4</td>
<td>10.4 ± 1</td>
<td>13.2 ± 2</td>
<td>18.4 ± 5</td>
<td>1.6 ± 1</td>
<td>43.5 ± 6.5</td>
<td>74.4 ± 15.7</td>
</tr>
<tr>
<td>p</td>
<td>0.001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

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Table III. – Constant score by glenohumeral joint degeneration.

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Pain</th>
<th>Activity</th>
<th>Joint motion</th>
<th>Force</th>
<th>Constant</th>
<th>Cst p</th>
<th>% Acromiohumeral interval &lt;6mm*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal 288 shoulders</td>
<td>84 ± 6.7</td>
<td>13.6±2.4</td>
<td>17.7 ±3</td>
<td>35.3±5.7</td>
<td>8.97±4</td>
<td>75.7±12</td>
<td>117±19</td>
<td>5.2</td>
</tr>
<tr>
<td>Osteophyte 93 shoulders</td>
<td>84.3±6.7</td>
<td>12.9±2.9</td>
<td>16.5±3.8</td>
<td>31.9±8.2</td>
<td>6.1±4</td>
<td>67.4±15</td>
<td>104±24</td>
<td>29</td>
</tr>
<tr>
<td>Joint space narrowing 19 shoulders</td>
<td>88.9±5.2</td>
<td>11.8±2.9</td>
<td>14.5±3.9</td>
<td>24±9.6</td>
<td>3.4±3</td>
<td>53.7±15</td>
<td>90.2±27</td>
<td>47</td>
</tr>
<tr>
<td>p</td>
<td>0.29</td>
<td>0.02</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Table IV. – Glenohumeral degeneration (percent per shoulder) by 10-year age group and gender.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Normal glenohumeral joint</th>
<th>Inferior humeral osteophyte</th>
<th>Glenohumeral joint space narrowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-80 years</td>
<td>79% men: 88% women: 75%</td>
<td>21% men: 12% women: 25%</td>
<td>0% men: 0% women: 0%</td>
</tr>
<tr>
<td>81-90 years</td>
<td>69% men: 62.5% women: 70.5%</td>
<td>25.8% men: 35.5% women: 23.5%</td>
<td>5.2% men: 2% women: 6%</td>
</tr>
<tr>
<td>91-100 years</td>
<td>71.2% men: 86% women: 67.5%</td>
<td>18.2% men: 14% women: 19%</td>
<td>10.6% men: 0% women: 13.5%</td>
</tr>
</tbody>
</table>

matic cuff tear [Petersson [8], Feeney et al. [19], Konno et al. [20]].

Among the factors favoring the development of subacromial impingement or osteoarthritis, the dominant side appears to be more important than presence of scapulo-humeral periarthritic reaction announced later secondary degradation. The level of manual labor did no have any significant effect on the development of subacromial impingement but on the contrary, presence of inferior glenohumeral osteophytes was associated with subacromial impingement. Gender had no effect on shoulder aging in our population.

CONCLUSION

Our study demonstrated that the rotator cuff tears are involved more in shoulder aging than glenohumeral osteoarthritis. In our population, subacromial impingement was observed in one out of five patients aged 70-90 years and one out of three after the age of 90 years. Our radiographic evidence only demonstrated the presence of large cuff tears and underestimated the real incidence of full-thickness tears of the rotator cuff. The presence of subacromial impingement (Hamada grade 2) or subacromial osteoarthritis (Hamada grade 3) are well tolerated clinically. Presence of glenohumeral impingement, associated or not with subacromial impingement, is poorly tolerated (pain and joint stiffness). Our findings demonstrate that natural history of shoulder aging does not follow the Hamada classification linearly over time.

References