How much are radiological parameters related to clinical symptoms and function in osteoarthritis of the shoulder?

Jörn Kircher · Markus Morhard · Petra Magosch ·
Nina Ebinger · Sven Lichtenberg · Peter Habermeyer

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Abstract Loss of joint space, formation of osteophytes and deformation are common features of osteoarthritis. Little information exists about the radiological features of arthrosis in relation to clinical findings and the radiological appearance in degenerative shoulder joint disease especially with regard to decision making about the timing of joint replacement. We retrospectively examined 120 standardised X-rays of patients with advanced osteoarthritis of the shoulder. Exclusion criteria included rotator cuff tear, severe glenoid erosion or protrusion. Measurements of joint space width at three levels in each plane (anteroposterior and axillary view), humeral head diameter and size of humeral osteophytes were made by two independent examiners. Osteoarthritis was graded according to Samilson and Prieto. Seventy-five of these patients had a complete record from the clinical investigation (pain record on VAS scale, active and passive range of motion) and the constant score (CS). Mean joint space width in the central anteroposterior level was $1.46 \text{ mm} \pm 1.08$ and in the central axillary $0.98 \text{ mm} \pm 1.02$. Increasing age was positively correlated with joint space narrowing at all measured levels. The joint space width was not correlated with the Samilson grade or the size of osteophytes. The

joint space width was neither correlated with pain nor active or passive ROM. Pain was correlated with active and passive flexion and abduction but not for internal or external rotation. The size of the osteophytes was negatively correlated (active and passive) with flexion, abduction and external and internal rotation. The study illustrates that joint space narrowing and development of osteophytes are reliable but independent parameters of primary shoulder arthrosis and should be recorded separately. The size of the caudal humeral osteophyte is a predictive factor for function and should be taken into account for clinical decision making. The primary clinical feature, pain, as the main indication for surgery is not related to radiological parameters.

Introduction

Primary osteoarthritis of the shoulder accounts for 3% of arthritis cases, but exact data about the incidence are not available [4, 9, 21].

The maximum amount of degenerative change in the glenoid at an age of about 60 years is clearly below the typical age of degenerative osteoarthritis of the hip and knee [4, 12]. Increasing age together with enhanced activities and functional demands even for the elderly are challenges to modern shoulder surgery [1].

A standardised clinical investigation together with an X-ray series is still the diagnostic gold standard [4]. Additional diagnostic imaging such as ultrasound or MRI is helpful to determine the amount of additional degenerative changes to the cuff and biceps tendon in special cases [4]. The use of computer tomography for the assessment of glenoid wear and pathological retroversion is strongly recommended for the planning of successful arthroplasty [13].

Level of evidence: Level IV retrospective study.

J. Kircher (✉)
Department of Orthopaedics, University Hospital Düsseldorf,
Moorenstrasse 5,
40255 Düsseldorf, Germany
e-mail: joern.kircher@med.uni-duesseldorf.de

M. Morhard · P. Magosch · N. Ebinger · S. Lichtenberg ·
P. Habermeyer
Shoulder and Elbow Surgery, ATOS Clinic Heidelberg,
Bismarckstrasse 13–15,
69115 Heidelberg, Germany

Neer has described primary gleno-humeral osteoarthritis consisting of limitation of gleno-humeral movement, loss of joint space, humeral head enlargement due to osteophytes and the absence of rotator cuff tears [11]. Little information exists about the radiological features of arthrosis in relation to clinical findings and radiological appearance in degenerative shoulder joint disease especially with regard to decision making about the timing of joint replacement [3, 6, 18, 21].

The objective of this study was to describe the radiological appearance of osteoarthritis of the shoulder and its relationship to clinical findings (pain and function).

Materials and methods

This was a retrospective analysis of 120 standardised X-rays of the shoulder, between 2002 and 2008, in the true anteroposterior and axillary views.

Inclusion criteria were advanced primary omarthrosis, no previous surgery, intact rotator cuff (proven by ultrasound or MRI), and absence of severe glenoid erosion or protrusion. Measurement of the joint space was performed at three levels in each plane (anteroposterior: superior, central, inferior; axillary: anterior, central, posterior) (Fig. 1). The size of the caudal humeral osteophyte and the diameter of the articular surface was measured in the anteroposterior view in neutral rotation of the forearm with the longest distance from caudal to the joint surface line (Fig. 1a). We used a digital X-ray machine. All measurements were performed by two independent examiners (first and second author), and measurements were averaged and rounded to 0.1 mm. The degree of osteoarthritis was graded according to Samilson and Prieto by the size of the caudal osteophyte (grade I: <3 mm; II: 3–7 mm; III: >7 mm) [19].

In addition 75 of these patients had a complete set of clinical investigations on the same day as the radiological examination, which included pain record on VAS scale, active and passive range of motion and the constant score (CS).

Statistical analysis was performed using SPSS 13.0 (SPSS Inc., Chicago, Illinois). Tests included the U-test according to Mann and Whitney, the chi-square test, bivariate correlation analysis (Spearman), partial correlation analysis, and intraclass correlation coefficient. The level of significance was set to $p < 0.05$.

Results

The mean age of all patients (56 female) was 64.9 ± 10.7 years. Male patients were significantly younger than female (63.3 ± 9.2 vs 70.0 ± 9.17 years, $p = 0.001$). We found a good

Fig. 1 True anteroposterior (ap) X-ray (a) and axillary view (b) of a left shoulder with advanced osteoarthritis. The X-rays illustrate the levels of joint space width measurement, i.e. ap superior, ap central and ap inferior in the coronal plane (a), and axillary anterior, axillary central and axillary posterior in the transverse plane (b). Measurements were made perpendicular to a tangent to the articular surface of the humerus at the different levels. The arrow illustrates the measurement of the size of osteophytes in the anteroposterior view (a)

interobserver reliability in the anteroposterior projection at the superior and central level ($r = 0.887$ and 0.881), but less at the anteroposterior inferior level and at all axillary measurements ($r = 0.477$; 0.738 ; 0.750 ; 0.669). Gender and side made no difference for the joint space measurements but greater values were found in male patients for axillary anterior (3.83 ± 2.27 vs. 2.02 ± 1.76 , $p = 0.001$) and axillary central (1.12 ± 1.11 vs. 0.91 ± 1.12 , $p = 0.012$).

Mean joint space width in the central anteroposterior level was $1.46 \text{ mm} \pm 1.08$ and in the central axillary $0.98 \text{ mm} \pm 1.02$ (Table 1). The stage of osteoarthritis was

Table 1 Joint space width at three levels in each plane

Measurement	Anteroposterior view			Axillary view		
	Superior	Central	Inferior	Anterior	Central	Posterior
Joint space width (mm)	2.00	1.47	1.48	3.01	1.08	1.17

graded as Samilson grade 1 in seven patients, Samilson grade 2 in three patients and Samilson grade 3 in 110 patients. The mean size of the humeral osteophytes was 14.14 ± 6.19 mm.

Male patients had significantly larger osteophytes (15.5 vs 12.7 mm, $p=0.013$; $r=0.286$, $p=0.002$) and larger humeral head diameters (54.49 ± 3.10 vs. 48.16 ± 2.66 mm, $p=0.001$; $r=0.198$, $p=0.031$).

This difference between male and female patients was not observed in the Samilson classification. Increasing age was positively correlated with joint space narrowing at all measured levels (Table 2) but not to grades of Samilson classification or size of osteophytes. The joint space width at all measured levels was not correlated with the Samilson grade or the size of osteophytes.

The joint space width was neither correlated with pain nor active or passive ROM. Pain was correlated with active and passive flexion and abduction but not internal or external rotation.

Male patients had significantly more strength with the standardised abduction test for the constant score using the Isobex device (Isobex Device Solutions AG, Oberburg, Switzerland) ($r=0.443$, $p=0.001$), with a higher CS ($r=0.273$, $p=0.018$) and less active ($r=-0.308$, $p=0.007$) and passive external rotation ($r=-0.30$, $p=0.038$) (Table 3).

The degree of osteoarthritis as reflected in the Samilson grade was negatively correlated with active flexion ($r=-0.261$, $p=0.004$) and abduction ($r=-0.208$, $p=0.023$).

The size of the osteophytes was negatively correlated (active and passive) with flexion ($r=-0.203$, $p=0.026$; $r=-0.254$, $p=0.026$, respectively), abduction ($r=-0.197$, $p=0.032$; $r=-0.270$, $p=0.017$), external rotation ($r=-0.243$, $p=0.008$; $r=-0.338$, $p=0.002$) and internal rotation ($r=-0.243$, $p=0.008$; $r=-0.245$, $p=0.030$), even after correction for age.

Discussion

The demographic results illustrate that the patients included in the study were at a typical age for degener-

ative osteoarthritis of the shoulder and most of them were in an advanced stage of the disease with reduced joint space and the presence of large osteophytes. Only ten patients were not graded to be Samilson stage III, but there was a wide range for the clinical findings such as pain and function and for the radiological appearance of these patients. In other words, the Samilson classification is rather nonspecific for the differentiation of advanced shoulder arthrosis [19]. The addition of the size of the osteophyte gives more details to compare patients in clinical practice and scientific studies.

Interestingly there was no correlation between loss of joint space and the size of the osteophytes or clinical function. It is commonly accepted that joint space narrowing and the development of osteophytes are classic radiological signs of osteoarthritis [6]. The fact that these standard radiological parameters are independent at the shoulder has not been documented or published before. The clinical consequences are that both parameters should be measured and recorded separately, both for the accurate description of the disease and for clinical research. The absence of a correlation between joint space width and size of osteophytes with pain was expected, and we can confirm the generally applied rule that the main indications for operation are not degenerative findings on X-rays but pain and clinical function of the patient.

Increasing size of the caudal humeral osteophyte was clearly associated with a decreased functional status in all planes. This is no surprise, as the osteophyte decreases the joint volume and tightens the capsule and therefore mechanically restricts joint motion. This has impact on the decision concerning the timing for implantation of a joint replacement as preoperative and postoperative function are related to each other. In our opinion, patients should be carefully informed about possible disadvantages in postponing such an operation when in advanced stages of osteoarthritis. Because of the discrepancy between clinical symptoms and radiological appearance, particularly for advanced osteoarthritis, patients should be regularly seen to clinically monitor progression of the

Table 2 Correlation of age and joint space width at three levels in two planes according to Spearman with coefficient of correlation

Measurement	Anteroposterior view			Axillary view		
	Superior	Central	Inferior	Anterior	Central	Posterior
Correlation coefficient	-0.194	-0.383	-0.251	-0.466	-0.397	-0.248
P value	0.034	0.000	0.006	0.000	0.000	0.006

Level of significance set to $p < 0.05$

Table 3 Constant score (CS) and functional results with mean values and standard deviations

Measurements		Mean	Standard deviation
Constant score (points)	CS pain	7.50	3.27
	CS ADL	9.05	3.90
	CS ROM	19.04	7.69
	CS strength	5.55	5.34
	Constant score total	39.58	14.48
	Constant score adjusted	52.76	19.30
Function (degrees)	Active flexion	123.96	34.19
	Passive flexion	136.41	33.50
	Active abduction	103.21	40.42
	Passive abduction	117.94	39.44
	Active external rotation	22.21	20.86
	Passive external rotation	30.13	24.15
	Active internal rotation	47.58	27.32
	Passive internal rotation	52.66	30.12

degenerative disease. Advanced glenoidal erosion and protrusion can make total arthroplasty very difficult or technically impossible because of the limited bone stock of the glenoid.

We observed a positive correlation between increasing age and joint space narrowing. This is in contrast with the observations of Petersson and Redlund-Johnell, who described preservation of joint space in age groups between 60 and 90 years [17]. Unlike these authors, we measured patients with advanced osteoarthritis and not normal individuals, and we used digital X-ray with an increased accuracy of one magnitude. Other authors have reported increasing degenerative changes with increasing age [5, 10, 14, 15]. This was also observed by Petersson and Redlund-Johnell in a cadaveric study with patients over 60 years of age, but cartilage thickness was not significantly different for the seventh to tenth decade with mean values of about 2 mm at the humerus. In these age groups, many of the patients had additional pathologies such as cuff degeneration or rupture and degeneration or rupture of the long head of the biceps in contrast to the patients in our study, which limits the comparability of the two studies [16].

We cannot give an explanation for the different findings regarding the correlation of joint space narrowing and increasing age in this study, as the underlying cause of so-called primary osteoarthritis of the shoulder is still unknown. Genetic factors and individual features of connective tissue recently have attracted greater focus of basic research [2, 7, 8, 20]. Mechanical factors such as individual variations of humeral torsion and glenoid version have been investigated before without a clear relation to the development of osteoarthritis [21].

Nove-Josserand et al. investigated both shoulders of 200 patients with a mean age of 84.2 years. Normal shoulders

without signs of remodelling were seen in 72% of the patients. Humeral and/or inferior glenoid osteophytes were found in 23%, and in 4.7% there was a total loss of the glenohumeral space. The joint space itself was not measured by the authors but graded into the three groups described. They did not find differences in gender (which is in part in contrast to our results). The authors observed subacromial impingement in one out of five patients aged 70–90 years and in one out of three aged over 90 years. Only eight patients had a total loss of joint space with an accompanying normal acromio-humeral interval of >6 mm [12]. This illustrates the main difference in the study population compared to our data with all of our patients having a centred joint in the anteroposterior view and preserved acromio-humeral distances. The authors conclude that rotator cuff tears are more related to shoulder aging than glenohumeral osteoarthritis. This seems to be a certain as well as a different mechanism of aging compared to our study population. The natural course of cartilage aging at the shoulder is still unclear and needs further investigation.

Conclusion

Joint space narrowing and development of osteophytes are reliable but independent parameters of primary shoulder arthrosis and should be recorded separately.

The size of the caudal humeral osteophyte is a predictive factor for function and should be taken into account for clinical decision making. The Samilson classification can be meaningful supplemented with measurements of joint space width and the size of osteophytes. The primary clinical feature, pain, as the main indication for surgery is not related to radiological parameters.

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