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SCIENTIFIC ARTICLE

Radiological glenohumeral osteoarthritis in long-term type 1 diabetes. Prevalence and reliability of three classification systems. The Dialong shoulder study

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Abstract

Objective In the present study, we evaluate the intra- and interrater agreement of radiological glenohumeral OA using three different classification systems and estimate the prevalence of radiological and clinical glenohumeral OA in patients with type 1 diabetes mellitus (DM1), for over 45 years and controls (The Dialong study).

Materials and methods We included 102 patients with DM1 (49% women, mean age, 61.9 years) and 73 controls (57% women, mean age, 62.6 years). Anterior-posterior shoulder radiographs were interpreted by two observers applying the Kellgren–Lawrence (K–L), Samilson–Prieto (S–P) and Samilson–Prieto Allain (S–PA) classifications.

Results The interrater agreement was moderate (weighted kappa, 0.46 to 0.48) for all classifications and the intrarater agreement mainly substantial (0.48–0.86) for both observers. The agreed prevalence of radiological OA was 26 and 18% (OR 1.6 (0.8 to 3.3), $p = 0.22$, 44 and 26% (OR 2.2 (1.2 to 4.2), $p = 0.02$) and 30 and 17% (OR 2.1 (1.0 to 4.5), $p = 0.05$) for the K–L, S–P and S–PA classifications respectively in the diabetes and control groups. The prevalence of moderate or severe radiological OA was 1 to 6% and clinical OA 1 to 2% with no difference between the groups.

Conclusion The prevalence of radiological glenohumeral OA was higher in the diabetes group with the Samilson–Prieto classification systems, but not associated with clinical OA. The interrater agreement was moderate. We recommend the Samilson–Prieto Allain classification for glenohumeral OA to avoid interpretation of osteophytes < 1 mm as OA in patient groups with a low pre-test likelihood of glenohumeral OA.

Keywords Shoulder · Type 1 diabetes · Glenohumeral osteoarthrosis · Kellgren–Lawrence classification · Samilson–Prieto classification · Frozen shoulder · HbA_{1c}

Introduction

There are few studies on osteoarthritis (OA) in type 1 diabetes mellitus (DM1). A systematic review reported an association between DM and OA, but did not report on glenohumeral OA [1]. Three large studies report the prevalence of OA in the general population. A 5% prevalence is reported [2] with the Kellgren–Lawrence classification [3]. A 17% prevalence is reported in two studies [4, 5] using the Samilson–Prieto (S–P) classification [6]. The prevalence seems to vary considerably with the radiological scoring system used. Several classification systems are described in the literature [7–10]. The Samilson–Prieto, Hamada, and Weinstein classifications are developed or adapted for evaluating the shoulder. For severe shoulder OA, the Hamada classification [9] is used regularly, but not for mild OA. The Weinstein classification [10] is rarely used. Most other classification systems are developed for the knees or hips and focus on reduction of the joint space [3, 6, 8]. Despite this, the Kellgren–Lawrence classification is widely used also in evaluation of non-weightbearing joints like the hands, fingers, and

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shoulders [2, 11–13]. The Samilson–Prieto classifications are based on the size of osteophytes and are widely used in both general populations and those with more severe OA [4–6, 11, 14]. We wanted to evaluate and compare the most widely used classification system (Kellgren–Lawrence, joint space based) with classification systems adapted for the shoulder (Samilson–Prieto and Samilson–Prieto Allain [15], osteophyte based).

The inter- and intrarater agreement of these three classifications have been investigated in several studies and are reported to be moderate to almost perfect [5, 7, 11]. Studies in asymptomatic populations have found some degeneration to be common in the knee and the spine [16, 17], but this has not been evaluated in the shoulder. The criteria for clinical OA is debated both in general as well as for clinical shoulder OA [18, 19].

The aims of the present study in patients with long-term DM 1 and control were to:

1. Evaluate the inter- and intrarater agreement of the Kellgren–Lawrence and Samilson–Prieto classifications and the modified Samilson–Prieto classification by Allain et al. for radiological glenohumeral OA.
2. Estimate the prevalence of radiological glenohumeral OA
3. Estimate the prevalence of clinical OA defined as pain and radiological OA.

Materials and methods

We conducted a cross-sectional, controlled study on patients with type 1 diabetes for more than 45 years and a control group without diabetes, the Dialong study.

Ethics: Informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

The study obtained approval from the Regional Ethics Committee for Medical and Health Research Ethics South–East Norway, project no. 2014/851.

Inclusion criteria: All persons attending the Norwegian Diabetics Center in Oslo, Norway, in 2015 having type 1 diabetes diagnosed in 1970 or earlier.

Exclusion criteria: Persons not able to cooperate in the clinical examination due to recent trauma or severe cerebrovascular disease with upper extremity paresis.

Controls: Enrolled patients were asked to bring their spouses or close friends as controls in the study. They had to be free of diabetes confirmed by a current $HbA_{1c} < 6.5\%$. First-degree relatives were excluded.

Descriptive data were collected through questionnaires, interviews and medical records.

Radiological outcomes

Plain radiographs were taken in the same laboratory for all participants according to the hospital standards [20]. We used two standard anterior-posterior projections with maximal external and internal rotation in the glenohumeral joint. The scapula was positioned parallel with the film and we used a 15-degree craniocaudal tilt. The following quality criteria had to be fulfilled to accept the films:

- In internal rotation, the smaller tubercle should be visible on the medial contour of the humeral head and the glenoid fossa had to be projected free of the humeral head.
- In external rotation, the greater tubercle should be visible as the lateral contour of the humeral head and the glenoid fossa had to be projected free of the humeral head.

The images were stored in the hospitals picture archiving and communication system (PACS) and interpreted on screen. Measurements were done with the PACS ruler system.

Two experienced musculoskeletal radiologists (EM and JCH), both with over 20 years of experience in the musculoskeletal field, evaluated the radiographs separately. They were blinded for group affiliation and did also re-evaluate 60 randomly selected radiographs after 2 weeks. Prior to the study, they rated 20 sets of films to achieve scoring agreement for all classifications.

The degree of radiological OA in the glenohumeral joint was rated in both shoulders with three different classification systems, see details in Table 1.

1. The Kellgren–Lawrence classification [3]. The score addresses narrowing of the joint space in particular. Grade 0 and 1 is regarded as normal, grades 2–4 as OA and grades 3–4 as moderate to severe OA.
2. The Samilson–Prieto classification [6] was originally developed for evaluating dislocation arthropathy and is based on the size of the inferior humeral or glenoid osteophytes. Grade 1 to 3 is regarded as OA and grade 2 and 3 as moderate to severe OA.
3. The modified Samilson–Prieto classification by Allain et al. [15] focuses mainly on osteophytes on the humeral head. Grade 1 to 4 is regarded as OA and grade 2 to 4 as moderate to severe OA.

The prevalence of OA is presented as the percentage of persons having OA regardless of having one or two shoulders with OA because the two shoulders are regarded as dependent variables. To estimate the prevalence, agreement was reached in a consensus meeting when the observers had divergent interpretations. The odds ratio for having OA is reported for

the diabetes group compared to the control group for all classifications.

We found no recommendations for the diagnosis of clinical glenohumeral OA. The presence of symptoms as pain and stiffness along with radiographic OA seems to be the most commonly used general definition [18, 19, 21, 22]. The symptom stiffness was not included in our criteria for clinical OA. We required a combination of pain > 2 on a numeric rating scale scored from 0 to 10 (worst possible pain) experienced last week or experienced during active abduction on clinical examination together with radiographic OA to be diagnostic of clinical OA. Persons with reduced passive shoulder motion in external rotation and one more direction of at least 30 degrees together with shoulder pain was diagnosed with frozen shoulder independent of having mild radiological OA (Kellgren–Lawrence grade 0–2, Samilson–Prieto and Samilson–Prieto Allain grade 0–1) [23].

Statistical methods

Based on the power analysis (type I error 5%, type II error 90%, expected prevalence in the diabetes group of 35% and the control group 10% [24]), we needed 38 participants in each group to detect a significant difference in the prevalence of glenohumeral OA. Clinical characteristics are presented as means with standard deviation (SD), medians with range or numbers (%). The prevalence of OA is presented in percent. The risk for having OA was calculated with Pearson's Chi-square test and presented as odds ratio (OR) with 95% confidence intervals (95% CI) and p value.

The inter- and intratester agreements were assessed by calculation of weighted Cohen's kappa (K_w) values with 95% CI in all shoulders independent of group. The kappa values were interpreted as: none to slight (0–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect (0.81–1.00) [25]. We used the statistical package IBM SPSS version 23 (IBM SPSS Inc., Armonk, NY: IBM Corp.).

Results

A total of 136 persons with type 1 diabetes for 45 years or more were registered at the Norwegian Diabetics Center in 2015. All patients were asked to participate in the study and 105 accepted. Three did not attend the examination because of illness. One hundred and two patients from the register (77%), median (range) age 61 (49–77) years, were examined together with 73 persons without diabetes, age 62 (50–81) years. The median duration of diabetes was 49 (45–67) years. There were no significant demographical differences between the groups (Table 2).

Table 1 Definitions of the grading in the three used classification systems

Classification	Grade	1	2	3	4
Kellgren-Lawrence	Joint space		Slight narrowing	Distinct narrowing	
	Osteophyte				
	Other			Bone cysts, sclerosis	Severe structural disorder of joint
Samilson-Prieto	Joint space		Slight irregularity	Narrowing	
	Osteophyte, inferior humeral or glenoid	Humeral > 3 mm	Humeral or glenoid 3 to 7 mm	Humeral or glenoid > 7 mm	
	Other			Sclerosis	
Samilson-Prieto Allain	Joint space				Narrowing
	Osteophyte, inferior glenohumeral	1 to 3 mm	4 to 7 mm	> 7 mm	
	Other				Subchondral sclerosis

Moderate to severe OA

Criteria for moderate and severe OA in gray (Kellgren–Lawrence grade 3 and 4, Samilson–Prieto grade 2 and 3, Samilson–Prieto Allain grade 2, 3, and 4 classifications, respectively)

Table 2 Demographic data and comorbidity

	Diabetes group $n = 102$	Control group $n = 73$	p value
Age, median, range, years	61, 49–77	62, 50–81	0.4
Females, n (%)	50 (49.0)	41 (56.9)	0.4
Duration of diabetes, median, range, years	49, 45–67		
HbA_{1c}, mean (SD), %	7.44 (0.79)	5.48 (0.28)	< 0.001
BMI, mean (SD) kg/m^2	26.2 (4.0)	25.8 (4.3)	0.5
Waist circumference, mean (SD), cm	91.7 (13.0)	89.8 (13.1)	0.3
Smoking, n (%)			
Current smoker	5 (4.9)	8 (11.0)	0.3
Past smoker	39 (38.2)	26 (35.6)	
Never smoked	57(56.0)	39 (54.0)	
Education level			
College or higher, n (%)	54 (74.0)	63 (61.8)	0.1
Comorbidity, n (%)*			
Rheumatoid arthritis	1 (1.0)	0	0.4
Polyosteoarthritis	3 (2.9)	5 (6.8)	0.2
Psoriasis arthritis	0	4 (5.5)	0.04

*The history of rheumatic disease was checked for in the Norwegian Diabetics Center files and interview

The interrater agreements were moderate for all three classifications (Table 3). Within-group analysis showed substantial interrater agreements in the control group for both Samilson–Prieto classifications versus fair in the diabetes group.

The intrarater agreements (K_w) was moderate to almost perfect for the Kellgren–Lawrence (0.56 to 0.86) and the Samilson–Prieto Allain (0.63 to 0.85), but moderate for the Samilson–Prieto classification (0.48 to 0.69).

The prevalence of radiological OA for the three classification systems after consensus is shown in Table 4. The prevalence of moderate to severe OA was two to 5 % in the diabetes group and one to 6 % in the control group.

The odds ratio for having OA was higher in the diabetes group with the Samilson–Prieto and Samilson–Prieto Allain classifications but not the Kellgren–Lawrence classification. For moderate to severe OA, there were no significant differences between the groups (Table 4).

Table 3 Inter-rater agreement

Classification	Weighted kappa (95% CI)
Kellgren–Lawrence	0.46 (0.37 to 0.55)
Samilson–Prieto	0.48 (0.39 to 0.57)
Samilson–Prieto Allain	0.46 (0.33 to 0.58)

Inter-rater agreement for the complete cohort for 350 separate shoulders images

Nine persons were diagnosed with frozen shoulder and radiological OA. Their radiographs were interpreted as grade 2 or lower for the Kellgren–Lawrence classification and grade 1 or 0 for the Samilson–Prieto for the Samilson–Prieto Allain classifications.

Fifty-eight out of 175 (33%) subjects experienced shoulder pain and 14 of these had radiological OA. In the pain-free group, 25 out of 117 (21%) subjects had radiological OA, OR 1.1 (0.5 to 2.4), $p = 0.9$. The odds ratio for having clinical OA was not significantly different for any of the classification systems between the diabetes and control groups (Table 5). Two or three patients were classified as having moderate or severe clinical OA, respectively.

Discussion

Agreement

The interrater agreement in the present study was moderate and almost equal for all classifications. The moderate agreement was somewhat surprising with two very experienced observers who also went through an agreement session for interpretation of the classifications prior to the study. The Kellgren–Lawrence classification was developed for knee and hip OA and has been criticized as being inappropriate for the non-weight-bearing glenohumeral joint due to the difficulty in classifying the minor joint space narrowing required for grade 2 OA [7, 11]. No exact measure for the assessment of the narrowing is given and the evaluation is thus subjective. In

Table 4 Prevalence of radiological glenohumeral osteoarthrosis

Classification	Diabetes	Control	OR (95% CI)	*p* value
Kellgren–Lawrence	26 (27)	18 (13)	1.6 (0.8 to 3.3)	0.22
K–L grade 3–4	2 (2)	1 (1)		ns
Samilson–Prieto	44 (46)	26 (19)	2.2 (1.2 to 4.2)	0.02
S–P grade 2–3	5 (5)	6 (4)		ns
Samilson–Prieto Allain	30 (31)	17 (12)	2.1 (1.0 to 4.5)	0.05
S–PA grade 2–4	4 (4)	4 (3)		ns

The prevalence of persons with OA in one or both shoulders after agreement between two observers in % (*n* persons). Shown for all persons and for persons with moderate or severe radiological OA in all classifications

line with our findings an age-related joint space narrowing is also reported [26], which hampers the evaluation of the joint space further in older populations.

Small osteophytes may be difficult to recognize and differentiate due to the possible variations in the angle of the radiographic tube even with strict image standardization as in the present study [27]. Zero to 20 degrees external rotation of the glenohumeral joint during imaging is shown to reduce intertester agreement, which also increases the likelihood for misinterpretation of small osteophytes [14]. Our findings of lower intertester agreement in the diabetes group, which had significantly less external shoulder rotation than the control group, is in keeping with this [23].

The intrarater agreements were substantial for both observers and all classifications. This is in line with an earlier report from a general population [5].

Both the inter- and intrarater agreement in the present study were lower than in a surgical population [7], which may reflect better interrater agreement in populations with more severe radiological OA.

Prevalence of radiological OA

In the present study, we found a significant higher prevalence of radiological OA in the diabetes group than in the control group using the osteophyte based Samilson–Prieto and Samilson–Prieto Allain classifications. The difference was not significant with the Kellgren–Lawrence classification, which is based on changes in the joint space. The prevalence was 50% higher with the original Samilson–Prieto classification compared to the Samilson–Prieto Allain classification. The difference is most likely due to the delimitation of 1 mm osteophyte size regarded as normal in the Samilson–Prieto Allain classification. Small osteophytes are difficult to distinguish from the normal humeral and glenoid edges and should not be considered pathological.

We have recently reported the prevalence of radiological OA in this cohort to be 35% in the diabetes group and 14% in controls using the Kellgren–Lawrence classification [24] corresponding to 26% and 18% in the present study. The difference in prevalence is most likely due to the agreed prevalence obtained with two observers in the present study while only one observer was available in the previous study. The interrater agreement obtained for the Kellgren–Lawrence classification in the present study was moderate and underlines the pitfalls of using one observer only. For the Kellgren–Lawrence classification, a 5% prevalence was found in a community-dwelling Korean population [2]. They did not report the imaging procedure. The lower prevalence compared to our study may be related to a systematically lowered scoring due to one or more of the following factors: only one observer, ethnicity, physical workload and a higher mean age in the Korean study, as well as selection bias due to the relatively small sample size in the present study [28].

For the Samilson–Prieto classification, the observed 26% prevalence in the control group in the present study is higher than the 16% and 17% prevalence reported in previous studies in the general population [4, 5]. Both previous studies used observations from one observer only and the difference may be affected by several factors such as: ethnicity, workload, and age and detecting and grading small osteophytes [14, 27] as well as selection bias linked to our control group.

The prevalence of moderate and severe radiological OA was low in both the diabetes and control group for all

Table 5 Prevalence of clinical glenohumeral osteoarthrosis

Clinical OA	Diabetes	Control	OR (95% CI)	*p* value
Kellgren–Lawrence	6 (6)	3 (2)	2.2 (0.4 to 11.0)	0.34
Samilson–Prieto	9 (9)	4 (3)	2.2 (0.6 to 8.4)	0.24
Samilson–Prieto Allain	7 (7)	3 (2)	2.6 (0.5 to 12.7)	0.52

Clinical OA defined as radiological OA and pain. The prevalence in % (*n*) of persons with OA in one or both shoulders after agreement between two observers

classifications in the present study, still the prevalence varied from 2 to 5% in DM1 and from 1 to 6% in controls depending on the classification system applied. The 4 to 6% prevalence observed with the Samilson–Prieto and Samilson–Prieto Allain classifications are comparable to the prevalence in a Japanese population using the Samilson–Prieto classification [5, 7].

Clinical glenohumeral OA

Clinical glenohumeral OA was diagnosed is shoulders with both pain and radiological glenohumeral OA without frozen shoulder, in 5 to 7% of the persons in the complete cohort. There was no significant difference in odds ratio between the diabetes and control group. To our knowledge, no comparable studies reporting clinical OA in the glenohumeral joint are available.

Limitations

The relatively small number of participants and the moderate inter-rater agreement limits the confidence in the reported diagnostic prevalence for moderate and severe OA.

Conclusions

Interrater agreement was moderate for all three classification systems. The prevalence of mild radiological OA was higher in the diabetes group with the osteophyte-based Samilson–Prieto classification systems but not associated with clinical glenohumeral OA. Moderate and severe radiological and clinical glenohumeral OA was rare. We recommend the use of the Samilson–Prieto Allain classification to avoid the interpretation of osteophytes < 1 mm as OA in patient groups with a low pre-test likelihood of glenohumeral OA.

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Compliance with ethical standards

Competing interest The authors declare that they have no conflicts of interest.

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