Association Between Temporomandibular Joint Symptoms, Signs, and Clinical Diagnosis Using the RDC/TMD and Radiographic Findings in Temporomandibular Joint Tomograms

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Aim: *To identify associations between clinical symptoms of temporomandibular joint disorders and radiographic findings.* ***Methods:*** *Two hundred four adult patients (156 women, 48 men, mean age 40 years) with temporomandibular joint (TMJ) pain/sounds or changes in mandibular motion were examined according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). Bilateral sagittal corrected TMJ tomograms in closed and open positions were assessed for the presence of flattening, erosion, osteophytes, and sclerosis in the joint components and the range of mandibular motion. Logistic regression analyses were performed with the radiographic findings as the dependent variables and the following clinical variables as independent variables: opening pattern, maximal jaw opening, TMJ sounds, number of painful muscle/TMJ sites, duration of pain, presence of arthritic disease, depression and somatization scores, graded chronic pain, and age and gender.* ***Results:*** *Coarse crepitus on opening/closing (odds ratio [OR] ≥ 3.12), on lateral excursions (odds ratio ≥ 4.06), and on protrusion (OR ≥ 5.30) was associated with increased risk of degenerative findings in tomograms. A clinical diagnosis of osteoarthritis increased the risk of radiographic findings (OR ≥ 2.95) and so did increasing age (OR ≥ 1.03 per year) and the female gender (OR ≥ 2.36). Maximal assisted opening and maximal opening without pain (< 40 mm) was associated with a posterior condyle-to-articular tubercle position (OR ≥ 2.60). No other significant associations were observed.* ***Conclusion:*** *Age, gender, and coarse crepitus, but no pain-related variables, were associated with increased risk of degenerative findings in TMJ tomograms. Maximal opening < 40 mm was associated with a posterior condyle-to-articular tubercle relation on opening.* J OROFAC PAIN 2008;22:239–251

Key words: clinical investigation, radiography, Research Diagnostic Criteria for Temporomandibular Disorders, temporomandibular joint, tomography

Several clinical investigations have related temporomandibular joint (TMJ) disorders with radiographic findings. Previous studies have shown that patients with clinical TMJ crepitus had a higher frequency of radiographic abnormalities than patients without crepitus.[1–3] A relation has furthermore been found between loss of molar support and an increased prevalence of structural bone changes.[2–4] Associations between radiographic evidence of restricted translation of the condyle and subjective symptoms as well as an association between clinically restricted TMJ movement and erosion in panoramic radiographs in patients with various rheumatic diseases have also been reported.[5] Another study suggested a possible relationship between pain on function and radiographic bone changes at the articular surface of the condyle[6] as well as a relationship between pain on lateral palpation of the TMJ and erosion of the condyle.[3,6]

Data from existing studies comparing clinical and radiographic findings do not point unequivocally to an association between clinical signs and symptoms and structural changes in the TMJ. Thus, indications for radiographic examination of the TMJ are not well defined.

Previous studies have used various conventional radiographic methods, such as *(1)* submentovertex (axial) projection, individualized oblique lateral transcranial projection, and/or transmaxillary projection,[2,3] *(2)* panoramic radiography,[5] or *(3)* corrected lateral tomography.[6] Recently cone-beam computerized tomography (CBCT) has become an alternative to conventional tomography, as it is possible to achieve images of high quality with a reduced radiation dose compared to conventional CT. However, in a recent study comparing the diagnostic accuracy of CBCT with conventional cross-sectional tomography for the detection of morphologic changes in the TMJ, no differences in accuracy were found.[7] Magnetic resonance imaging (MRI) may be the most reliable method for the asssessment of TMJ abnormalities, but a recent systematic review concluded that the evidence grade for diagnostic efficacy of MRI in the diagnosis of degenerative and inflammatory TMJ disorders was insufficient.[8] Furthermore, MRI is costly and thus is not available as a diagnostic tool in most cases. Thus, conventional radiographic techniques are still most frequently used for the assessment of the hard tissue of the TMJ. While panoramic radiography may be insufficient for the assessment of hard tissue changes,[9] cross-sectional sagittal tomography is considered the most accurate technique,[10–12] revealing the greatest number of true structural changes compared with the oblique transcranial projection.[13]

The clinical significance of the condyle position in the mandibular fossa is controversial. An association between disc displacement and changes in fossa shape together with a more posterior condyle position has been demonstrated.[14] Other studies have found that the condyles of patients with anterior disc displacement were positioned more posteriorly[15] or posteriorly-superiorly[16] than those in a control group. Another study concluded that joint pathology is the consequence of changes in the position of the condyle.[17] However, although a centered condylar position in the mandibular fossa is most often found in asymptomatic subjects, substantial variability is observed[18–20]; therefore, a diagnosis of TMJ dysfunction may not be based on the radiographic observation of a noncentric condyle position.

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)[21] constitute a well-established diagnostic system that has been shown to be reliable for the diagnosis and assessment of TMD.[22,23] It is the most widely used TMD diagnostic system in clinical research and allows multicenter and cross-cultural comparison of clinical findings.[24,25] Many studies have used the RDC/TMD, but to the authors' knowledge it has not been used to estimate the association between clinical findings and radiographic findings in cross-sectional corrected TMJ tomography.

This paper is part of a study dealing with the impact of corrected cross-sectional TMJ tomography on diagnosis and treatment planning of patients suffering from TMJ disorders as diagnosed with the RDC/TMD. The aim of this part of the study was to identify associations between clinical symptoms of TMJ disorders and radiographic findings.

Materials and Methods

Patients

This multicenter study included 204 consecutive patients (156 women, 48 men) referred from 2004 to 2006 to the University of Aarhus (51%), the University of Copenhagen (24%), and Malmö University (25%). The study was approved by the regional ethics committees and classified as a quality control study. Patients were included in the study if they were more than 18 years and had symptoms of pain, sounds from the TMJ, or problems with mandibular motion. Patients who had recently had a trauma to their jaw or who had previously been treated for TMD at the departments were excluded from the study to avoid bias.

Clinical Examination

The patients were examined by 1 of 6 calibrated orofacial pain specialists according to the RDC/TMD.[21] The orofacial pain specialists were calibrated by undergoing a thorough review of the RDC/TMD procedure, after which they worked together to apply the procedure to TMD patients. The RDC/TMD procedure includes assessment of the presence or absence of pain and joint sounds, intraoral and extraoral palpation of the masticatory muscles, and measurement of mandibular movement (Axis I). It also requires the collection of information on the patient's general health, pain

Table 1 Diagnostic Classification		
Diagnosis	Description	Comments/source
Ia	Myofascial pain	RDC/TMD Ia*
Ib	Myofascial pain with limited opening	RDC/TMD Ib*
IIa	Disc displacement with reduction	RDC/TMD IIa*
IIb	Disc displacement without reduction with limited opening	RDC/TMD IIb*
IIc	Disc displacement without reduction, without limited opening	RDC/TMD IIc*
IIIa	Arthralgia	RDC/TMD IIIa*
IIIb	Osteoarthritis of the TMJ	RDC/TMD IIIb*
IIIc	Osteoarthrosis of the TMJ	RDC/TMD IIIc*
4	Temporomandibular joint dislocation	AAOP modified from ICD9.CM 830.1†
5	Fibrous ankylosis	AAOP modified from ICD9.CM 524.61†
6	Bony ankylosis	AAOP modified from ICD9.CM 524.61†
7	Rheumatoid arthritis (RA)	ARA criteria 1987‡
8	Polyarthritides involving the TMJ	AAOP modified from ICD.9.CM 714.9†
9	Aplasia	AAOP's description modified from ICD.9.CM 754.0†
10	Hypoplasia	AAOP's description modified from ICD.9.CM 526.89†
11	Hyperplasia	AAOP's description modified from ICD.9CM 526.89†
12	Neoplasia	AAOP's description modified from ICD.9.CM 213.1/ 170.1†

*Dworkin et al,[21] †McNeill,[26] ‡Arnett et al.[27]

characteristics, and psychosocial dysfunction (Axis II). The clinical diagnoses were made according to the guidelines of this protocol. As RDC/TMD classifications do not cover every TMD, they were supplemented with guidelines from the American Academy of Orofacial Pain (AAOP)[26] and the American Rheumatism Association (ARA).[27] The diagnostic classification is listed in Table 1. Each patient was given 1 or more diagnoses consistent with these classifications. The orofacial pain specialists were asked to select their initial diagnoses without the aid of radiographs.

From the RDC/TMD Axis I, the opening pattern/deviation (E 3), the maximal opening without pain (E 4ad), the maximal unassisted and assisted jaw opening (E 4bd, E 4cd), and TMJ sounds on opening/closing/lateral excursions/protrusion (E 5a, E 5b, E 7) were used together with number of muscle sites (E 8, E 10) and number of joint sites (E 9) painful on palpation. From Axis II information on gender and age (Q 23, Q 24), duration of pain (Q 4a), self-reports of TMJ sounds (Q 15a, Q 15b), and the presence or absence of arthritic disease (Q 16a) was used. Furthermore a depression score, scores of nonspecific physical symptoms with and without pain items (somatization scores), and graded chronic pain, including disability points and characteristic pain intensity, were calculated according to the RDC/TMD Part 3 scoring protocol. In the RDC/TMD protocol, a classification of limitations related to mandibular functioning has not yet been proposed. The jaw disability checklist score was calculated as the number of activities the jaw problem prevented or limited the patient from doing (Q 19). Finally, the clinical diagnoses of disc displacement (IIa, IIb, IIc), arthralgia (IIIa), osteoarthritis (IIIb), and osteoarthrosis (IIIc) (Table 1) were used in further analysis.

Radiographic Examination

The patients' left and right joints were examined by individually corrected lateral TMJ tomography with conventional film in either a Cranex Tome x-ray unit or a Scanora tomographic unit (Soredex), which utilize the same tomographic technique. The examination consisted of 4 central sections in closed position and 4 sections in maximal open position of each joint. The thickness of each section was 4 mm. When the open-mouth images were made, a mouth prop was used to stabilize the position. All examinations were performed by experienced radiographers. The tomograms of each patient were evaluated by 1 examiner from a panel of 5 calibrated oral radiologists who were blinded to the clinical diagnosis. The calibration included discussions of definitions and changes from numerous examples of morphologic changes evident in TMJ tomograms, resulting in an atlas with examples to consult whenever there was doubt about the observations. The tomograms were examined using the following definitions for the presence of flattening, osteophytes, sclerosis and erosive changes in the condyle, and abnormalities of the mandibular fossa and articular tubercle:

Table 2 Age and Gender Distribution in Patients with TMJ Symptoms Included in the Study at Each Center

	Age			Gender			
				Male		Female	
	Mean	SD	Range	n	%	n	%
Copenhagen	35	13	18 to 65	11	22.4	38	77.6
Aarhus	37	15	18 to 84	25	23.8	80	76.2
Malmö	50	15	24 to 90	12	24.0	38	76.0

- Flattening: Loss of convexity/concavity of the joint outlines
- Erosion: Local area of rarefaction in the layer of compact bone
- Osteophyte: A local outgrowth of bone arising from the mineralized surface
- Sclerosis: Increased radiopacity of the spongy bone or thickening of the compact bone[13,28]

The position of the condyle in relation to the mandibular fossa (in closed position) and articular tubercle (in maximal open position) was evaluated by eye inspection of the anterior joint space versus the posterior joint space for the horizontal relation and the superior joint space for the vertical relation. The condyle was evaluated as being central, or, in the case of differences between the joint spaces, anterior or posterior in the horizontal direction. In addition, for the closed position, the vertical aspect of the condyle was evaluated as being central, superior, or inferior in relation to the mandibular fossa. Morphologic and positional changes were scored as present or not present using a binary registration scale. The films were placed on a light box and evaluated using an x-ray viewer with magnification.

Data Analysis

Demographic data and symptom profiles of patients from the 3 centers were compared by post-hoc *t* test and chi-square test.

Duration of pain was categorized as being ≤ 1 year or > 1 year. The jaw disability checklist score was divided into 2 groups, scores of ≤ 3 and scores > 3. Maximal opening without pain and maximal unassisted and assisted jaw opening were categorized as being ≥ 40 mm or < 40 mm.

Logistic regression analyses were performed with the radiographic findings as the dependent variable and the clinical RDC/TMD variables (outlined in the Clinical Examination section) as the independent variables. The maximal jaw opening and opening pattern/deviation were analyzed with the dependent variable being the presence or absence of a posterior, central, or anterior position of the condyle in relation to the articular tubercle in open position. The disc displacement diagnoses (IIa, IIb, and IIc) were analyzed with presence or absence of posterior position and presence or absence of posterior-inferior position of the condyle in relation to the mandibular fossa in closed position as the dependent variable. All other clinical variables were, together with the maximal jaw opening, analyzed with the dependent variable being radiographic findings of morphologic changes in the TMJ. These analyses were performed in 2 steps. First, the dependent variable was presence of 1 of the individual findings of morphological changes versus no radiographic findings of pathology. Second, the dependent variable was the total number of morphologic changes, with thresholds being ≥ 1, ≥ 2, and ≥ 3 morphologic changes. Clinical variables related specifically to the right or left TMJ (such as diagnosis, TMJ sounds, and number of muscle and joint sites painful on palpation) were tested against radiographic findings at that joint, whereas clinical variables related to the patient (such as maximal opening, depression score, age) were tested against radiographic findings located for 1 or both joints. The analyses were performed using the SPSS package GLM (version 10.0 for Windows, SPSS). The level of significance is reported where *P* was less than or equal to .05.

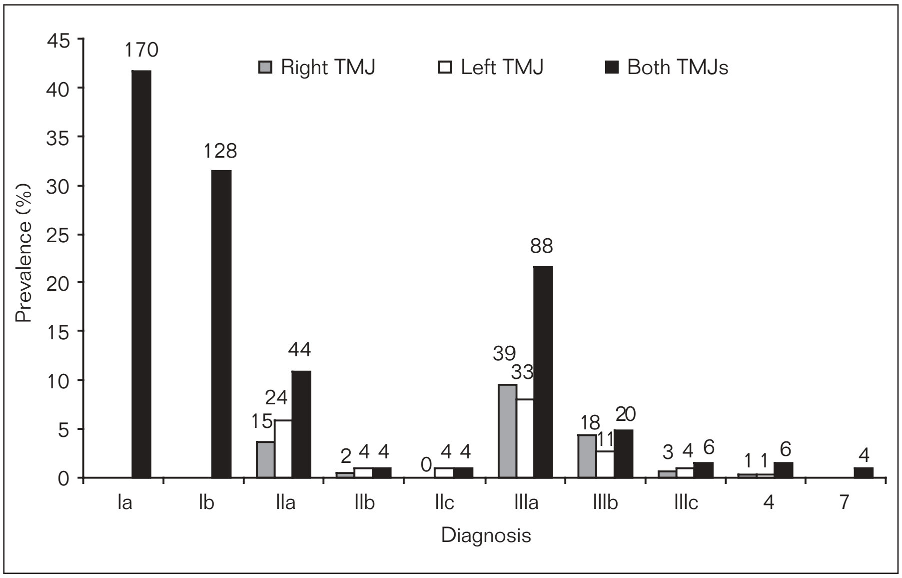

Fig 1 Prevalence of clinical TMJ diagnoses before radiographic examination. More than 1 diagnosis could occur in the same joint or patient. The number above each bar indicates the number of TMJs.

Results

Descriptive Results

Age ranged from 18 to 90 years, with a mean of 38 years (SD 16) for males and 41 years (SD 16) for females. The female-male ratio was 4 to 1. The distribution of age and gender is shown in Table 2. There was a minor but statistically significant difference in mean age between centers; the patients from Malmö were somewhat older compared to the other 2 centers. The rest of the variables tested showed no statistically significant difference between the centers, and therefore the 3 groups of patients were pooled.

The number and prevalence of the individual clinical diagnoses before radiographic examination are shown in Fig 1. In a few cases, however, patients additionally presented with clinical findings that could not be labeled with a diagnosis according to the classification system. These diagnoses were hypermobility (3 cases) and sequelae after a previous fracture (1 case). The myofascial pain diagnoses (Ia and Ib) were most frequently used, followed by arthralgia (IIIa) and disc displacement with reduction (IIa). Table 3 shows the number and percentage of the clinical diagnoses, including combinations of diagnoses in a patient (right and/or left TMJ) that occurred in at least 1% of the study population before radiographic examination. All other diagnoses or combinations of diagnoses occurred in less than 1% of the study population. The most prevalent combination of diagnoses in a patient was arthralgia and myofascial pain (IIIa + Ia/Ib), which was found in 25.0% of the patients. Arthralgia, disc displacement with reduction, and myofascial pain (IIIa + IIa + Ia/Ib) in combination were found in 16.6% and osteoarthritis and myofascial pain (IIIb + Ia/Ib) in

Table 3 Prevalence of the Most Frequently Used Clinical Diagnoses or Combinations of Diagnoses (Right and/or Left TMJs) Before Radiographic Examination

	Patients	
Diagnoses	n	%
IIIa + Ia/Ib	51	25.0
IIIa + IIa + Ia/Ib	34	16.6
IIIb + Ia/Ib	23	11.3
IIIa	14	6.8
IIa	13	6.4
Ia/Ib	11	5.4
No TMJ diagnosis	8	3.9
IIa + Ia/Ib	8	3.9
IIc	4	1.9
IIIb	4	1.9
IIIc + IIIb + Ia/Ib	4	1.9
IIIb + IIIa + Ia/Ib	3	1.5
IIIc	2	1.0
04	2	1.0
IIIa + IIa	2	1.0
IIIa + IIb	2	1.0
IIIc + Ia/Ib	2	1.0
IIIa + IIb + Ia/Ib	2	1.0
All other combinations*	15	7.5
Total	204	100

*All other combinations of diagnoses occurred in less than 1% of the patients.

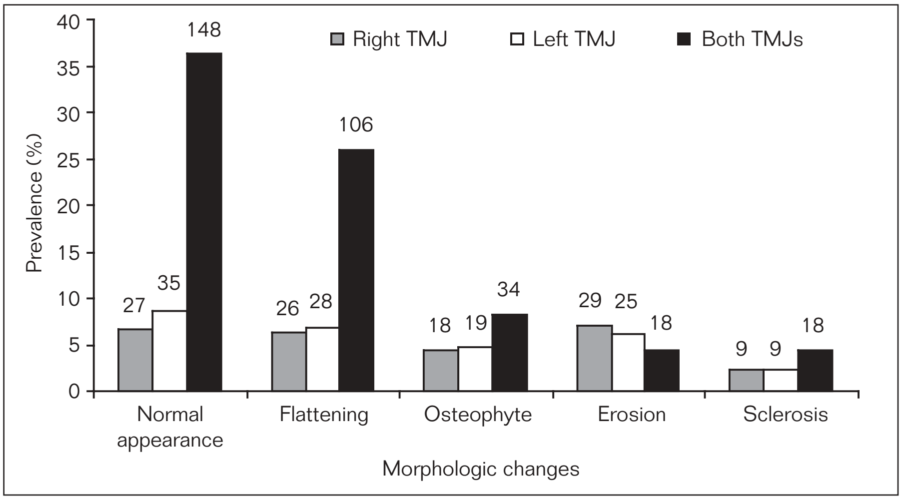

Fig 2 Prevalence of radiographic findings in the TMJ condyle, mandibular fossa, and articular tubercle. The radiographic finding could occur either alone or in combination with other findings. The number above each bar indicates the number of TMJs.

Table 4 Radiographic Morphologic Appearance of the Condyle, Mandibular Fossa, and Articular Tubercle in a Patient (Right and/or Left TMJ)

	Patients	
Morphologic changes	n	%
Normal appearance	74	36.3
Flattening	32	15.7
Flattening + osteophyte + erosion	21	10.3
Flattening + erosion	19	9.3
Flattening+ osteophyte	13	6.4
Erosion	12	5.9
Osteophyte + erosion + sclerosis + flattening	9	4.4
Osteophyte	6	2.9
Flattening + sclerosis	6	2.9
Sclerosis	5	2.5
Flattening + osteophyte + sclerosis	5	2.5
Flattening + erosion + sclerosis	2	1.0
Total	204	100

11.3% of the patients. Each of the other combinations occurred relatively rarely, in less than 7% of the patients.

The number and percentage of radiographic findings of flattening, erosion, osteophyte, and sclerosis can be seen in Fig 2. The most frequent finding was flattening, which occurred in both joints in 26% of the patients. Osteophytes, erosion, and sclerosis were found in both joints in fewer than 9% of patients. The number and percentage of radiographic findings and combinations of findings in a patient (right, left, or both joints) are presented in Table 4. About two thirds of the patients had radiographic findings of morphologic changes in at least 1 TMJ. The most frequent combination in a patient was flattening, osteophyte and erosion, which occurred in 10.3% of the cases.

The radiographic appearance of the condyle-to-fossa relationship in a closed position is presented in Table 5. The condyle was positioned centrally in both the horizontal and vertical direction in approximately 56% of the TMJs, and in about 40% of the TMJs this position occurred bilaterally. The most frequent deviation from this position was a combination of a posteriorly-centrally positioned condyle, followed by a central-inferior position. For the horizontal direction alone the most prevalent position of the condyle, second to a central position, was a posterior position. For the vertical direction alone the most prevalent position, second to a central position, was an inferior position. For a detailed review of the various combinations of positional changes, see Table 5.

The prevalence of the condyle-to-articular tubercle relationship in the open position is shown in Fig 3. The condyle was positioned under the top of the articular tubercle in open position in 49% of the TMJs, followed by a posterior position in 27% and an anterior position in 24%. A given condyle-to-articular tubercle relation most often occurred bilaterally, whether it was central, posterior, or anterior. A central position of the condyle occurred more often in the right TMJ (56%) than in the left TMJ (42%). The opposite was seen with an anterior condyle position, which occurred more often in the left (29%) than in the right TMJ (18%).

Analytic Results

When logistic regression analysis was used to estimate the association between the clinical independent variables 1 by 1 and the radiographic findings, there was a statistically significant association between radiographic findings and several of the

Table 5 Radiographic Appearance of the Condyle-to-Mandibular Fossa Relationship in Closed Position

	Horizontal relation																			
	Centrally						Anteriorly						Posteriorly							
	Right		Left		Both		Right		Left		Both		Right		Left		Both		Total	
Vertical relation	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Centrally	33	8.1	32	7.8	162	39.7	5	1.2	8	2.0	4	1.0	15	3.7	10	2.5	14	3.4	283	69.4
Superiorly	5	1.2	5	1.2	4	1.0	5	1.2	3	0.7	0	0.0	4	1.0	5	1.2	4	1.0	35	8.5
Inferiorly	7	1.7	13	3.2	16	3.9	7	1.7	6	1.5	16	3.9	9	2.2	8	2.0	8	2.0	90	22.1

n = no. of TMJs.

clinical variables. The variables that were statistically significant at or below the 5% level are shown in Tables 6 and 7. Some of these associations were found only for the right or the left TMJ. It was decided to focus only on strong consistent associations ($P \leq .01$) that were significant for both TMJs; only these results are considered likely to be conclusive.

There was an overall association between coarse crepitus sounds in the TMJ, clinical diagnoses of osteoarthritis, age and gender, and the radiographic findings. These variables had an impact on both the type (Table 6) and number (Table 7) of radiographic findings.

Clinical findings of coarse crepitus on opening and closing were significantly associated with an increased risk of having ≥ 2 radiographic findings (odds ratio [OR] ≥ 3.12). Coarse crepitus on protrusion was significantly associated with an increased risk of having ≥ 3 radiographic findings (OR ≥ 5.30). Crepitus/coarse crepitus on lateral excursions was associated with increased risk of ≥ 2 radiographic findings (OR ≥ 5.98). A significant association between coarse crepitus on opening and closing and flattening and erosion was also observed (OR ≥ 3.26). Furthermore, an association between osteophyte and coarse crepitus on closing (OR ≥ 4.06) and on lateral excursions to the right (significant for both the right and the left TMJ, OR ≥ 4.06) was found. No strong associations were found between lateral excursions to the left and any of the individual radiographic findings ($P > .01$). Coarse crepitus on protrusion was associated with increased risk of flattening, erosion, and osteophytes (OR ≥ 6.33).

A clinical diagnosis of osteoarthritis (IIIb) was found to increase the risk of having ≥ 2 radiographic findings (OR ≥ 2.95). This diagnosis was also found to be associated with increased risk of the individual finding of erosion (OR ≥ 4.55).

An association between the range of jaw opening and the condyle-to-articular tubercle position

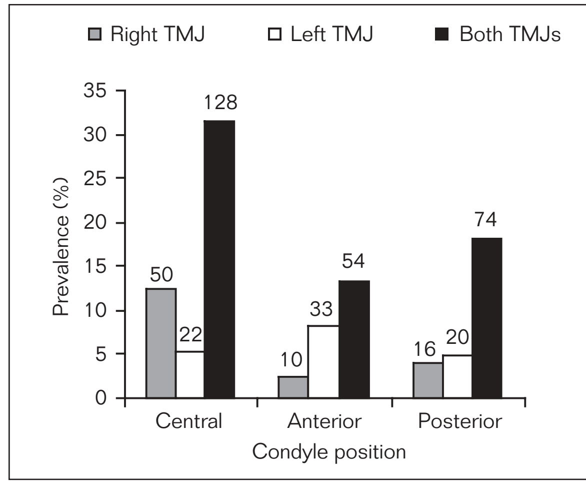

Fig 3 Prevalence of TMJ condyle in relation to the articular tubercle (most inferior part) in the open position. The number above each bar indicates the number of TMJs. (total 407, 1 radiograph missing).

in open-mouth position was observed. Maximal assisted opening and maximal opening without pain < 40 mm was associated with a condyle position posterior to the top of the articular tubercle in at least 1 of the TMJs ($2.60 \leq OR \leq 7.60$; $P < .01$; significant for both the right and the left TMJ), and maximal assisted opening < 40 mm was furthermore associated with a condyle position posterior to the top of the articular tubercle bilaterally (OR = 6.75; $P < .01$).

Increased risk of radiographic changes, whether it was the number of findings or the individual findings of morphologic changes, was observed with increasing age (OR ≥ 1.03 per year) and for females (OR ≥ 2.36). When all statistically significant variables were entered into an adjusted logistic regression model, age was the most determinant factor.

Associations between the position of the condyle and the opening pattern/deviation together with disc displacement diagnoses were inconsistent ($P > .01$). None of the pain-related variables (mus-

Table 6 Association Between Clinical Signs and Individual Radiographic Findings of Flattening, Erosion, Osteophyte, and Sclerosis

	Flattening			Erosion			Osteophyte			Sclerosis		
	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*
Gender (male)												
Female												
Right/left TMJ	**2.36**	**1.19-4.46**	**.01**	**4.33**	**1.73-10.87**	**< .01**	**4.33**	**1.64-11.47**	**< .01**			
Age (18 y)												
> 18 y												
Right/left TMJ	**1.03**	**1.00-1.05**	**.01**				**1.05**	**1.02-1.07**	**< .01**	**1.04**	**1.01-1.07**	**.01**
TMJ sounds (no)												
Opening												
Crepitus												
Right TMJ	4.31	1.24-14.97	.02									
Left TMJ	6.27	1.59-24.63	.01									
Coarse crepitus												
Right TMJ	**9.10**	**2.88-28.78**	**< .01**	**12.94**	**3.69-45.41**	**< .01**	8.63	2.31-32.21	< .01	7.84	1.82-33.79	.01
Left TMJ	**3.65**	**1.40-9.55**	**.01**	**5.07**	**1.63-15.78**	**.01**	4.14	1.30-13.18	.02	4.44	1.21-16.26	.03
Closing												
Crepitus												
Right TMJ	4.48	1.13-17.88	.03				6.39	1.39-29.28	.01			
Left TMJ	5.21	1.34-20.33	.02									
Coarse crepitus												
Right TMJ	**7.15**	**2.25-22.72**	**< .01**	**9.04**	**2.60-31.36**	**< .01**	**6.71**	**1.77-25.45**	**.01**	7.84	1.82-33.79	.01
Left TMJ	**3.26**	**1.28-8.33**	**.01**	**4.06**	**1.34-12.27**	**.01**	**4.06**	**1.34-12.27**	**.01**	4.56	1.25-16.71	.02
Excursions, right												
Crepitus												
Right TMJ	8.40	1.79-39.36	.01	11.31	2.21-57.82	< .01	8.40	1.54-45.96	.01			
Left TMJ	10.69	1.28-89.31	.03	7.46	1.28-43.39	.03	6.47	1.01-41.48	.05			
Coarse crepitus												
Right TMJ	4.26	1.43-12.68	.01				**6.71**	**1.77-25.45**	**.01**			
Left TMJ				5.22	1.51-18.04	.01	**4.06**	**1.34-12.27**	**.01**			
Excursions, left												
Crepitus												
Right TMJ	15.39	3.37-70.35	< .01	16.67	3.26-85.29	< .01	11.84	2.21-63.39	< .01			
Left TMJ												
Coarse crepitus												
Right TMJ	8.33	2.24-31.00	< .01	9.72	2.29-41.32	< .01	7.90	1.81-34.49	.01			
Left TMJ	3.47	1.02-11.76	.05	4.52	1.32-18.05	.03	4.90	1.22-19.64	.03	5.42	1.09-27.01	.04
Protrusion												
Crepitus												
Right TMJ	14.25	1.75-116.06	.01	22.80	2.59-200.40	< .01	18.10	2.00-163.43	.01			
Left TMJ												
Coarse crepitus												
Right TMJ	**17.42**	**2.18-139.24**	**.01**	**15.20**	**1.61-143.64**	**< .01**	**21.71**	**2.48-190.46**	**.01**			
Left TMJ	**6.33**	**1.71-23.44**	**< .01**	**7.57**	**1.76-32.58**	**.01**	**7.57**	**1.76-32.58**	**.01**	7.25	1.31-40.07	.02
Maximal opening (≥ 40 mm)												
Without pain												
< 40 mm												
Right TMJ												
Left TMJ	2.20	1.20-4.03	.01	3.30	1.46-7.49	< .01						
Unassisted												
< 40 mm												
Right TMJ												
Left TMJ	3.10	1.36-7.10	.01	4.50	1.69-11.93	< .01						
Assisted												
< 40 mm												
Right TMJ												
Left TMJ	3.12	1.04-9.39	.04	5.12	1.50-17.45	.01						
Arthralgia (no)												
Yes												
Right TMJ												
Left TMJ				0.36	0.15-0.83	.02	0.36	0.14-0.89	.03			
Osteoarthritis (no)												
Yes												
Right TMJ	6.51	2.32-18.27	< .01	**8.86**	**2.86-27.42**	**< .01**	4.80	1.41-16.30	.01			
Left TMJ				**4.55**	**1.59-12.97**	**.01**						

Consistent results (significant for both the left and right TMJs) with $P \leq .01$ are shown in bold. The reference group for the independent variables is presented in parentheses. Empty spaces represent nonsignificant associations.

Table 7 Associations Between Clinical Signs and No. of Radiographic Findings

	≥ 1 radiographic finding			≥ 2 radiographic findings			≥ 3 radiographic findings		
	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*
Gender (male)									
Female									
Right/left TMJ	**2.66**	**1.37-5.15**	**< .01**	2.43	1.20-4.94	.02	2.23	1.01-4.95	.05
Age (18 y)									
> 18 (per year)									
Right/left TMJ	**1.03**	**1.01-1.05**	**.01**				**1.03**	**1.01-1.05**	**< .01**
TMJ sounds (no)									
Opening									
Crepitus									
Right TMJ							7.09	10.7–47.08	.04
Left TMJ	4.95	1.27-19.31	.02	4.43	1.30-15.10	.02			
Coarse crepitus									
Right TMJ	7.78	2.53-23.89	< .01	**3.53**	**1.47-8.46**	**< .01**	13.65	3.26-57.22	< .01
Left TMJ	3.10	1.21-7.91	.02	**4.06**	**1.58-10.45**	**.01**	5.80	1.85-18.17	< .01
Closing									
Crepitus									
Right TMJ							11.53	2.20-60.59	< .01
Left TMJ	4.29	1.11-16.64	.04	3.77	1.12-12.66	.03			
Coarse crepitus									
Right TMJ	6.25	2.03-19.23	< .01	**3.12**	**1.28-7.58**	**.01**	**9.71**	**2.51-37.62**	**< .01**
Left TMJ	2.86	1.14-7.19	.03	**3.77**	**1.52-9.36**	**< .01**	**4.69**	**1.58-13.99**	**.01**
Excursions, right									
Crepitus									
Right TMJ	6.63	1.44-30.59	.02	**5.98**	**1.89-18.96**	**< .01**	5.18	1.20-22.34	.03
Left TMJ				**10.84**	**2.08-56.38**	**.01**	7.20	1.52-34.19	.01
Coarse crepitus									
Right TMJ	8.84	1.08-72.34	.05						
Left TMJ	3.76	1.29-11.01	.02	3.25	1.22-8.70	.02	5.54	1.76-17.43	< .01
Excursions, left									
Crepitus									
Right TMJ	10.99	2.44-49.49	< .01	5.16	1.89-14.04	< .01	6.05	1.24-29.49	.03
Left TMJ				7.33	1.29-41.65	.03			
Coarse crepitus									
Right TMJ	6.03	1.66-21.99	.01	3.33	1.18--9.43	.02	**13.44**	**3.18-56.81**	**< .01**
Left TMJ							**6.62**	**1.93-22.69**	**< .01**
Protrusion									
Crepitus									
Right TMJ	12.67	1.59-100.73	.02	4.81	1.43-16.19	.01	11.50	2.23-59.39	< .01
Left TMJ									
Coarse crepitus									
Right TMJ	12.67	1.59-100.73	.02	4.81	1.43-16.19	.01	**24.64**	**5.40-112.48**	**< .01**
Left TMJ	5.80	1.59-21.19	.01	3.34	1.17-9.56	.02	**5.30**	**1.58-17.79**	**.01**
Maximal opening (≥ 40 mm)									
Without pain									
< 40 mm									
Right TMJ									
Left TMJ	2.15	1.20-3.84	.01	2.21	1.15-4.25	.02			
Unassisted									
< 40 mm									
Right TMJ									
Left TMJ	2.83	1.26-6.36	.01	3.15	1.43-6.94	< .01			
Right/left TMJ				2.44	1.11-5.33	.03	2.26	1.04-4.90	.04
Assisted									
< 40 mm									
Right TMJ									
Left TMJ				3.68	1.33-10.14	.01			
Right/left TMJ							3.47	1.25-9.63	.02
Osteoarthritis (no)									
Yes									
Right TMJ	5.52	2.01-15.18	< .01	**2.95**	**1.30-6.71**	**.01**	**4.57**	**1.38-15.15**	**.01**
Left TMJ				**3.93**	**1.56-9.92**	**< .01**	**4.48**	**1.52-13.25**	**.01**

Consistent results (significant for both the right and left TMJs) with $P \leq .01$ are shown in bold. The reference group for the independent variables is presented in parentheses. Empty spaces represent nonsignificant associations.

cle and TMJ pain on palpation, duration of pain, somatization scores, and graded chronic pain, including disability points and characteristic pain intensity) nor depression score, jaw disability score, or presence or absence of arthritic disease were associated with degenerative findings in TMJ tomograms.

Discussion

Methodologic Considerations

The prevalence of the RDC/TMD Axis I diagnoses was comparable to that found in a study based on a Swedish and American population of adult TMD patients,[24] except for group III disorders (arthralgia, osteoarthritis, osteoarthrosis), for which prevalence was higher in the present study. This finding was expected, since the inclusion criteria for the present study focused on patients with pain or complaints from the TMJ, whereas the aforementioned study included all consecutive adult patients referred to TMD centers, excluding only patients medically diagnosed with polyarthritis. However, as shown in this study, TMJ pain often coexists with myofascial pain. Compared to an Italian study of adult TMD patients without polyarthritis or other rheumatic diseases,[25] both the prevalence of group I disorders (muscle disorders) and group III disorders were higher in the present investigation, whereas the prevalence of group II disorders (disc displacement) was the same. A lower prevalence of all Axis I diagnoses was observed in a group of Asian TMD patients[29] with the same inclusion criteria as the Swedish and American study. As the RDC/TMD protocol, which is considered useful and reliable for research purposes[22,23] and also suitable for multicenter comparisons,[24,25] was used in the present as well as the aforementioned studies, the differences can most likely be explained by variation in the inclusion criteria and patient sample.

Among the conventional radiographic techniques, corrected lateral tomography is considered the method of choice for examination of the TMJ.[10–12] In the present investigation, corrected lateral tomography was performed using the same radiographic technique in all 3 centers by means of either a Cranex Tome or a Scanora tomography unit. Frontal tomography has been found to give only minor additional information on structural changes[30] and was therefore not performed in the present study.

Intraobserver variability and interobserver reliability were not assessed because of geographic distances between the centers and because the radiographs were used in the clinical departments immediately after evaluation. To minimize the variation, the observers were calibrated, and an atlas with diagnostic examples was available during the evaluation of the radiographs.

When a large number of variables are tested in logistic regression analyses, some will be significant by chance, and the risk of a type I error (false positive result) is increased. Thus, the results should be interpreted with caution, and only consistent results with strong associations (high ORs with low P values) should be considered as possibly significant. In the present study, a large number of variables were tested with several outcome variables. However, it was decided to focus on associations that were strong and consistent.

Implications of Associations

Maximal assisted opening and maximal opening without pain < 40 mm were associated with a condyle position posterior to the top of the articular tubercle in an open-mouth position. However, the maximal open position, which, with the aid of the mouth prop, was held for a long time during the radiographic examination, might be somewhat smaller than the maximal opening observed at the clinical examination. An association between a clinically decreased opening capacity and a decrease in the horizontal condylar movement has been reported previously[2,5] and is not a surprising correlation. It should lead to the conclusion that radiographs in open position will not provide significant additional information regarding the horizontal movement of the condyle compared to information that can be obtained from the clinical evaluation of the range of maximal jaw opening. The position of the condyle in relation to the top of the articular tubercle in open position differed between the left and the right TMJs. It is noticeable that an anterior position was found in 29% of the left TMJs but only in approximately 18% of the right TMJs. The opposite was seen with a central position, which was observed more often in right TMJs (56%) than in left TMJs (42%). These differences were statistically significant ($P < .01$). Subtle methodologic differences in the recording of the tomograms, eg, placement of the mouth prop, could have contributed to the asymmetric position of the right and left TMJs during maximal jaw opening.

Corrected lateral tomography is believed to provide information about the true position of the condyle in the mandibular fossa. A previous study suggested measuring the condyle-to-fossa relation in millimeters to allow assessment of interactions of direct anatomic measurements.[31] In the present study, the position of the condyle was evaluated by visual inspection, and a simple categorical classification was used, since this procedure resembles the way most clinicians use radiographs. The reader is thereby cautioned that the gross positional relationship determinations were subjective, and the results must be considered in this light. No association was found between a clinical diagnosis of disc displacement and a posterior position of the condyle in relation to the mandibular fossa in closed position. In a previous study, approximately half of the joints diagnosed with an anterior disc displacement with reduction and two thirds of the joints with disc displacement without reduction appeared to have a posterior condyle position, but an anterior or central position of the condyle was also observed in many joints with a displaced disc.[18] Furthermore, a substantial range of the radiographic position of the condyle in asymptomatic populations has been observed,[18–20] indicating that a radiographic observation of a noncentric condyle-to-fossa relationship is not necessarily associated with a diagnosis of TMJ dysfunction.

Increased risk of radiographic structural changes was observed for females and with increasing age. Age was entered ascending, which means that the increased risk (odds ratio) reported is per year. Thus, the increased risk of having, eg, an osteophyte in a 40-year-old compared to a 20-year-old is 1.05^{20}, which equals 2.65. An association between age, gender, and prevalence of TMJ radiographic changes has been reported even among preorthodontic patients aged 9 to 15 years, where a higher frequency of osseous abnormalities was found in girls and the highest frequency was found in the older girls.[32] Autopsy studies have also found the frequency of morphologic changes in TMJs to be higher in older individuals,[33–35] but gender was not found to be a major factor for development of TMJ pathosis.[33] Thus, several studies have found the frequency of TMJ changes to increase with age, but the magnitude of the increased risk with ascending age seems not to have been evaluated previously.

The prevalence of the individual structural TMJ changes was low compared to observations made in previous studies.[12,30] This variation may be due to differences in patient material, radiographic examination techniques, or the interpretation of the tomograms.

Structural changes such as flattening, erosion, osteophytes, and sclerosis are believed to be important characteristics in establishing a diagnosis of the TMJ. The diagnostic significance of each of these individual findings, however, is difficult to state. Thus, the associations between clinical signs and symptoms of TMD and the overall number of findings, as well as the presence of individual structural changes in the TMJ, were analyzed in this study. Associations between clinical features and the various individual radiographic findings showed overall the same pattern, except for sclerosis. However, sclerosis was found in few TMJs compared with flattening, osteophytes, and erosion, which could explain why associations between clinical features and sclerosis were not found.

A clinical diagnosis of osteoarthritis was found to increase the risk of having radiographic structural changes. According to the RDC/TMD system, a diagnosis of osteoarthritis is applied only if crepitus or radiographic evidence of degenerative changes is present. Hence, the associations found in the present study indicate agreement between clinical findings leading to a clinical diagnosis of osteoarthritis and the actual radiographic findings, which supports the RDC/TMD. How often a diagnosis based on the clinical examination is changed because of unexpected radiographic findings is uncertain but will be addressed in a successive study.

Strong associations were found between coarse crepitus and radiographic findings (either the individual findings or the overall number of changes). Again, this is in agreement with the RDC/TMD diagnostic system, since clinical signs of coarse crepitus and radiographic findings of structural changes are the 2 features differentiating arthralgia from osteoarthritis. According to the RDC/TMD, only clinical findings of coarse crepitus qualify for a diagnosis of osteoarthritis or osteoarthrosis. In the present study, fine crepitus was also observed to be associated with an increased risk of radiographic findings, but these associations were inconsistent. An association between crepitus and radiographic findings corresponds to results from previous studies.[1–3] Whether the presence of coarse crepitus should be an absolute indication for TMJ tomography depends on the importance of the radiographic findings for correct diagnosis and choice of treatment, which will be evaluated in a subsequent study.

In a recent study, the range of maximal mouth opening was observed to be inversely correlated with the severity of erosion in panoramic radiographs of patients with various rheumatic diseases.[5] The association between maximal jaw opening and osseous changes was not consistent in the present study, since it was found either for the left TMJ only with a P value greater than .01. The lack of association could be explained by the low prevalence for some of the individual TMJ changes.

It is a striking finding that none of the pain-related variables were associated with radiographic structural TMJ changes. However, for osteoarthritis patients, there may be differences between onset of pain and detectable degenerative changes, as radiographs do not represent ongoing processes but rather the result of previous processes. A recent study found no association between facial pain and degenerative changes in the TMJ,[36] but panoramic radiography, which may not be sufficient in assessing the hard tissue of the TMJ,[9] was used. Associations between pain-related variables and radiographic findings have been documented in previous studies.[3,5,6] These studies, however, did not use the RDC/TMD clinical examination criteria and specifications, which can impede a comparison.

Conclusions

Increasing age and female gender as well as coarse crepitus were associated with an increased risk of radiographic degenerative changes in the TMJ. Maximal assisted opening and maximal opening without pain < 40 mm was associated with a condyle position posterior to the top of the articular tubercle on opening, ie, reduced translation, in TMJ tomograms. None of the pain-related variables were associated with radiographic findings.

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