Influence of Cross-Sectional Temporomandibular Joint Tomography on Diagnosis and Management Decisions of Patients with Temporomandibular Joint Disorders

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Aim: *To assess whether changes in diagnoses and management of temporomandibular joint disorder (TMJD) patients are influenced by radiographic findings and if there is an association between specific radiologic alterations and management strategy changes.* ***Methods:*** *A total of 204 patients with TMJ symptoms were examined using the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). Diagnoses and management were first decided without the aid of radiographs. Management categories were: pharmacology, physiotherapy, counseling and behavioral treatment, occlusal stabilization, surgery, additional examinations, and referrals, each with subcategories. Sagittal TMJ tomograms were assessed for the presence of flattening, erosion, osteophyte, and sclerosis in the TMJ components. Diagnoses and management were reevaluated after gaining access to the radiographs and radiographic classifications. Logistic regression analyses were performed with changes in management as the dependent variable and age and radiographic findings as the independent variables.* ***Results:*** *Diagnosis was changed for 56 patients, mainly from arthralgia to osteoarthritis. Management was changed for 55 patients. Most changes occurred in pharmacology and physiotherapy followed by counseling and behavioral treatment, occlusal stabilization, referrals, additional examinations, and surgery. Changes were mostly within the categories, and the highest number of changes was seen in pharmacology, physiotherapy, and counseling and behavioral treatment. Radiographic degenerative findings increased the chance of change (any change) (odds ratio [OR] ≥ 2.03) and the chance of change in pharmacology (OR ≥ 2.56) and physiotherapy (OR = 2.48) separately. No other significant associations were found.* ***Conclusion:*** *Radiographic degenerative findings increased the chance of changes in management strategy. However, 73% of the TMJD patients had no changes in management after radiographic examination. In cases with changes, these were mainly adjustments within management categories.* J OROFAC PAIN 2011;25:223–231

Key words: clinical investigation, management, radiography, Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), temporomandibular joint (TMJ), therapy

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)[1] widely used for clinical research have proven reliable for the diagnosis and assessment of temporomandibular disorders (TMD),[2,3] even for inexperienced examiners.[4] They are also applicable for multicenter and crosscultural comparison of clinical findings.[5,6] On the other hand, no similar

internationally recognized guidelines or management algorithms are available for the management of TMD, although several guidelines exist.[7–11] Furthermore, planning a management strategy may not be straightforward as several therapeutic options are available,[12] and the management often seems to include many different approaches.

Radiographs may be included in the examination of patients with symptoms related to the temporomandibular joint (TMJ). Corrected lateral cross-sectional tomography is an accurate radiographic technique[13] with high diagnostic accuracy for the evaluation of the osseous components.[14] In recent years, cone beam computed tomography (CBCT) has been introduced. It allows for the obtaining of high-quality three-dimensional (3D) images with a reduced radiation dose compared to conventional computed tomography (CT),[15] but the two techniques have been reported to be equally accurate for the detection of osseous changes.[16]

Guidelines and position papers for TMJ imaging have been reported.[17–19] Its indication, however, is still not well defined. A radiographic examination may establish the stage of disease by the degree of joint involvement or confirm or rule out expected pathological findings. The radiographic information should, however, serve to establish a more accurate diagnosis and significantly influence the management. While several clinical investigations have related the radiographic findings to TMJ problems[20–26] and therapeutic outcome,[21,27,28] the few studies that addressed the impact of radiographic findings on management strategy came to different conclusions.[29,30]

This article reports on part of a study dealing with corrected cross-sectional tomography of TMJ disorder (TMJD) patients.[20,31] The purpose of this investigation was to assess whether changes in diagnoses and management of TMJD patients are influenced by radiographic findings and if there is an association between specific radiologic alterations and management strategy changes.

Materials and Methods

This multicenter study included 204 consecutive patients (48 men, 156 women) referred during 2004 to 2006 to one of three centers: University of Aarhus (51%) and University of Copenhagen (24%), Denmark, and Malmö University, Sweden (25%). The study was approved by the Danish regional ethical committee and was classified as a quality control study. Inclusion criteria were: age above 18 years, complaints of TMJ pain, sounds (clicking or crepitus) from the TMJ or problems with mandibular motion. Exclusion criteria were: recent trauma to the jaw and, to avoid bias, previous treatment for TMD at the department where the patient was examined.

The mean age ± standard deviation (SD) was 38 ± 16 years for men and 41 ± 16 years for women, ranging from 18 to 90 years. The female-to-male ratio was 4:1. The age and gender distribution has been previously described.[20]

The clinical examination was performed by one of six trained and calibrated orofacial pain specialists using the RDC/TMD protocol. They were calibrated by going through the RDC/TMD procedure and together applying the procedure on TMD patients. However, no formal calibration study was performed, but all orofacial pain specialists had extensive experience with the RDC/TMD protocol. The RDC/TMD procedure includes a clinical examination, assessment of the presence of pain to palpation of the masticatory muscles and TMJ area, the presence of joint sounds, and the measurement of the range of mandibular mobility (Axis I) together with detailed questionnaires providing information on the patient's health status, psychosocial dysfunction and onset, duration, and characteristics of pain (Axis II).

The initial diagnosis and management strategy were set according to the information gained by the history and clinical examination. The clinical diagnoses were made according to the RDC/TMD guidelines and supplemented with guidelines of the American Academy of Orofacial Pain[32] and the American Rheumatism Association[33] to diagnose a TMJ condylar dislocation and rheumatoid arthritis. The choice of initial management strategy was based on the findings from clinical examination and the initial clinical diagnosis. There were seven management categories: pharmacology, physiotherapy, counseling and behavioral therapy, occlusal stabilization therapy, surgery, additional examinations, and referrals; each had a number of subcategories (Table 1).

The initial diagnosis and management strategy was reevaluated by the same orofacial pain specialist after receiving the TMJ tomograms and the radiologist report a few days after the first appointment. According to the RDC/TMD, the presence of radiographic findings of degenerative changes (flattening, erosion, osteophyte, and sclerosis) may modify the initial diagnosis only in patients diagnosed either with arthralgia (IIIa) or without clinical signs of joint pain (no arthralgia). In the first case, the diagnosis changes from arthralgia to osteoarthritis (IIIb) and in the second one to osteoarthrosis (IIIc). Thus, the diagnoses that could not be changed after the radiographic examination were those of myofascial pain, disc displacement, condylar dislocation, and rheumatoid arthritis.

Table 1 Number of Management Categories and Subcategories Before and After Radiographic Examination as well as Number of Additions/Removals of Each Management Option

Management	Before radiographic examination	Added after radiographic examination	Removed after radiographic examination	After radiographic examination
Pharmacology (no. of patients)	99*	9*	2*	106*
Systemic analgesics	34	3	3	34
Topical analgesics	41	4	2	43
Intra-articular steroids	25	11	1	35
Intra-articular hyaluronic acid	7		1	6
Glucosamine	9	6	1	14
Antidepressants	3			3
Anticonvulsants	1			1
Other	15	2	2	15
TOTAL (no. of subcategory managements)	135	26	10	151
Physiotherapy (no. of patients)	155*	3*	3*	155*
Jaw stretching exercises	89	4	1	92
Coordination exercises	36	7	4	39
Heat/cold	36	3	4	35
Strength/muscle training	31	7	2	36
TENS	9	1	1	9
Acupuncture	2		1	1
Manual repositioning				
Other	18	1	1	18
TOTAL (no. of subcategory managements)	221	23	14	230
Counseling and behavioral treatment (no. of patients)	198*	1*	1*	198*
Information/prognosis	195	4	1	198
Relaxation exercises	45	3	8	40
Biofeedback	8			8
Stress management	2			2
Other	4			4
TOTAL (no. of subcategory managements)	254	7	9	252
Occlusal stabilization (no. of patients)	109*	2*	5*	106*
Interocclusal splints	98	1	5	94
Occlusal equilibration	2			2
Occlusal rehabilitation	5		1	4
Other	9	2		11
TOTAL (no. of subcategory managements)	114	3	6	111
Surgery (no. of patients)	8*		1*	7*
Arthrocentesis/arthroscopy	5	1		6
Open surgical intervention				
Osteoplastic procedures				
Other	4		1	3
TOTAL (no. of subcategory managements)	9	1	1	9

Table 1 *(continued)*

Management	Before radiographic examination	Added after radiographic examination	Removed after radiographic examination	After radiographic examination
Additional examinations (no. of patients)	13*	5*	1*	17*
Blood test	1	1		2
Scintigraphy	1	1	1	1
MRI	4	1		5
CT				
Other	7	3		10
TOTAL (no. of subcategory managements)	13	6	1	18
Referrals (no. of patients)	44*	6*		50*
General practitioner	5	3	1	7
Rheumatologist	2			2
Neurologist	7			7
Psychologist	3			3
Physiotherapist	12	1		13
Pain clinic	6			6
Hospital	2	1		3
Other	11	2		13
TOTAL (no. of subcategory managements)	48	7	1	54

Numbers with * = number of patients with one or more subcategories of management in the mentioned category. The numbers under "Added" express number of patients whose management strategy changed from not including any of the subcategories of management in the category to including at least one subcategory of management. The numbers under "Removed" express number of patients whose management strategy changed from including one or more subcategories of management in the category to not including any subcategories of management in the category. All other numbers = number of managements/changes in management. A patient can have one or more subcategories of management or changes in subcategories of management in each category. Total = 204 patients.

Radiological Examination

The right and left TMJs were examined by individually corrected, sagittal TMJ tomography using conventional film in either a Cranex Tome or a Scanora tomographic x-ray unit (Soredex); each of these uses the exact same tomographic technique. For each TMJ, eight tomograms were taken, four in maximum intercuspation and four at maximum opening. The maximum open mouth position was stabilized by mean of mouth prop. The tomograms taken at maximum opening position were not used in the present part of the study. The tomograms, 4 mm thick, were perpendicular to the long axis of the condyle. This was achieved by means of a sagittal four-angle "preexamination" assessing the condyle orientation. All tomograms were taken by experienced radiographers.

The tomograms were evaluated on a light box with an x-ray magnifying viewer by one of five calibrated oral radiologists, who were blind to the clinical diagnosis and management strategy. The calibration of the radiologists included discussions of definitions and numerous examples of morphological osseous changes visible in TMJ tomograms. These examples of morphological osseous changes in TMJ tomograms were used to develop an atlas. The radiologists could confer with this atlas while evaluating the tomograms if they were in doubt how manifest a change should be to be recorded.

Each of the following radiographic findings was scored as yes/no: the presence of flattening, osteophyte, sclerosis, and erosive changes in the condyle, mandibular fossa, and articular tubercle. The following definitions were used: flattening = loss of convexity/concavity of the joint outlines; osteophyte = a local outgrowth of bone arising from the mineralized surface; sclerosis = increased radiopacity of the spongy bone or thickening of the compact bone; erosion = a local area of rarefaction in the layer of compact bone.[16,20,34,35]

Data Analysis

To evaluate whether data from the three centers could be pooled, the patients' demographic data and symptom profiles from the three centers were

compared by analysis of variance (ANOVA), post-hoc *t* test, and chi-square test, and the number of patients with changes in management strategy was counted for each of the three centers.

Separate logistic regression analyses were performed with "any change" in management as the dependent variable and thereafter with change in a specific management category as the dependent variable. "Any change" in management was defined as any change at all, that is removal or addition of one or more subcategories in one or more management categories. It therefore covered both minor changes within the categories and additions/removals of overall management categories from the patients' management strategy. A change in a specific management category was defined as removal or addition of one or more subcategories of management in that category and could be both minor adjustments within the category or addition/removal of that specific overall category. The independent variables were age (an interval-scale covariate entered ascending with the youngest age first), different types of radiographic findings (flattening, osteophyte, sclerosis, and erosion), and a variable expressing the total number of radiographic findings (regardless of type) with thresholds being 1 radiographic finding and > 1 radiographic finding. All independent variables were analyzed separately. The purpose of the logistic regression analyses was to evaluate if and to what extent certain radiographic findings were associated with changes in management strategy. However, this is only of interest in centers that change management because of radiographic findings. Therefore, only centers that fulfilled the prerequisite "change in management strategy" were included in these analyses. The level of significance reported was set at $P \leq .05$. The statistical analysis was performed using the SPSS package, GLM, version 10.0 for Windows (SPSS, IBM).

Results

Symptom profiles and demographic data did not differ significantly between the three centers except for mean age: the Malmö patients were older than those of the other two centers (mean age ± SD was 50 ± 15 years compared to 35 ± 13 years and 37 ± 15 years in the other two centers).

Changes in Diagnoses

The most frequent diagnosis for the entire study population was myofascial pain (Ia and Ib), followed by TMJ arthralgia (IIIa) and disc displacement with reduction (IIa); for details, see Wiese and coworkers.[20]

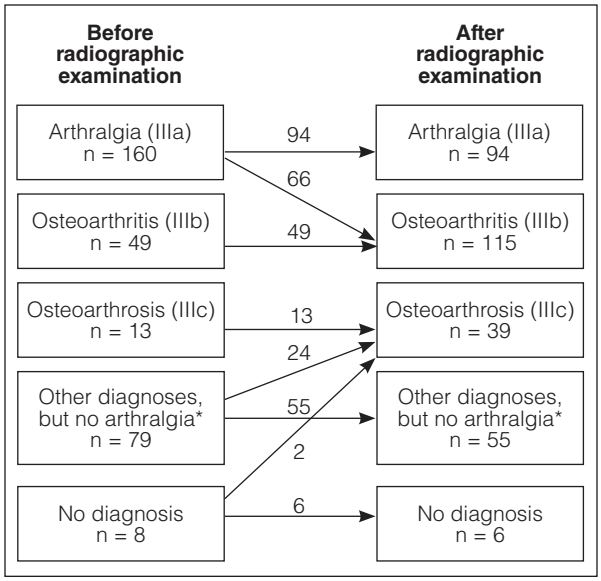

Fig 1 Diagnostic classifications of the TMJs according to RDC/TMD assessed clinically before radiographic examination and adjusted after radiographic examination. Only diagnoses that changed are shown. *This group included TMJs with other diagnoses than IIIa, IIIb and IIIc, but with no signs of arthralgia; n = number of diagnoses. Total = 408 TMJs in 204 patients. More than one diagnosis could occur in a TMJ. The number of patients with a change in diagnosis was 56.

Overall, the diagnosis was changed in 56 patients (Fig 1). The diagnosis of arthralgia changed to osteoarthritis 66 times (41%), which corresponds to a 135% increase in the number of osteoarthritis diagnoses. The diagnosis "no diagnosis" and "other diagnoses" without signs of arthralgia changed to osteoarthrosis in 2 and 24 cases, respectively. Thus, the number of osteoarthrosis diagnoses increased from 13 to 39, which is an increase of 200%. In the other cases in which the diagnosis was not changed, the initial diagnosis was of myofascial pain (diagnosis Ia in 170 patients, diagnosis Ib in 128 patients), disc displacement (diagnosis IIa in 83 TMJs, diagnosis IIb in 10 TMJs, diagnosis IIc in 8 TMJs), condylar dislocation (in 8 TMJs), and rheumatoid arthritis (in 4 patients).

Changes in Management Strategy

The management strategy changed after radiographic examination in the three centers in 33% (16 out of 49 patients), 36% (38 out of 105 patients), and 2% of the patients (1 out of 50 patients), respective-

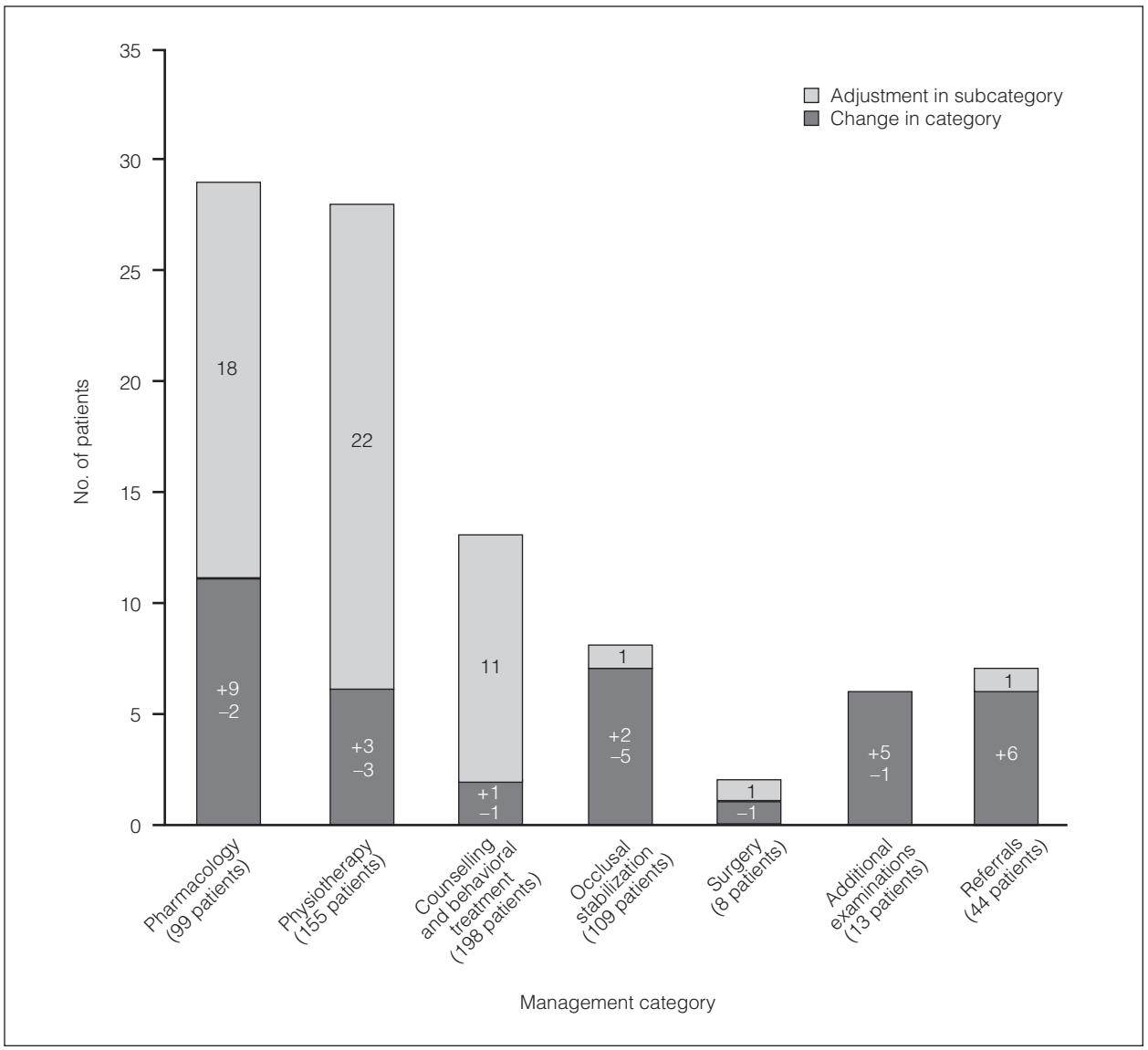

Fig 2 Number of patients with some type of change in management (category or subcategory) after radiographic examination and reevaluation of TMJ diagnosis. Change in category = removal or addition of category. Adjustment in subcategory = removal or addition of one or more subcategories of management. For each patient, changes can occur in one or more of the management categories. Management strategy was changed in 55 of the 204 patients. Example of interpretation: Pharmacology management was proposed for 99 patients before radiographic examination. For 29 patients (18 + 9 + 2), changes in pharmacology were suggested after radiographic examination. Nine had pharmacology added, and for 2 patients, pharmacology was removed from their management strategy. The rest of the changes were subcategorical adjustments (additions or removals of one or more subcategories).

ly. Overall, 27% of the patients (55 patients) had one or more changes in management strategy, ie, the management strategy did not change for 73% of the patients (Fig 2 and Table 1). In general, few changes in management strategy were made. Most changes occurred in the pharmacology (29 patients) and physiotherapy (28 patients) categories, followed by counseling and behavioral treatment (13 patients), as shown in Fig 2. The majority of changes were seen within a category (37 additions/removals in 22 patients in physiotherapy, 36 additions/removals in 18 patients in pharmacology, and 16 additions/removals in 11 patients in counseling and behavioral treatment), as noted in Table 1 and Fig 2. Most often was the addition of another treatment modality of the same category, eg, the addition of TMJ intra-articular steroid injections in 11 patients who already had pharmacological treatment included

Table 2 Associations Between Radiographic Findings and Changes in Management Strategy from Separate Logistic Regression Analyses

	"Any change" in management (n = 54)			Change in pharmacology (n = 28)			Change in physiotherapy (n = 28)		
	OR	CI	*P*	OR	CI	*P*	OR	CI	*P*
Radiographic variables									
Flattening (no) n = 89	2.28	1.13–4.61	.02	2.56	1.02–6.45	.05			
Erosion (no) n = 60	2.03	1.03–4.00	.04	3.60	1.53–8.48	.01			
> 1 radiographic finding, any type (no findings) n = 71	2.28	1.16–4.47	.02				2.48	1.06–5.80	.04

OR with 95% CI estimating the risk of changes in management. The reference groups for the independent variables are those presented in parentheses, ie, no flattening; no erosion; no radiographic findings. Blank entries represent nonsignificant associations. Only patients from two of the three centers are included (total = 154 patients).

in their management strategy. Changes in category occurred less often. The highest number of changes within a category was seen in the pharmacology category (addition of pharmacological treatment in 9 patients and omission of pharmacological treatment in 2 patients), as shown in Fig 2.

Twenty-three of the 56 patients with changes in diagnoses also experienced some kind of change in management, most often within the already decided pharmacological and/or physiotherapeutical plan. In the group of patients with changes both in diagnoses and management, the same overall distribution of management changes were seen as for the total patient sample. The management strategy was changed in 18 of the 42 patients who changed diagnosis from arthralgia to osteoarthritis: the pharmacological plan was changed in 12 of these patients, the physiotherapeutical plan in 7, occlusal therapy type in 4, and 2 patients received additional examinations and/or counseling and behavioral therapy, and 1 patient was referred.

The management strategy was changed for 7 of the 23 patients who had no clinical diagnosis of osteoarthrosis, but obtained an osteoarthrosis diagnosis after radiographic examination: the pharmacological plan was changed in 6 of these patients, the physiotherapeutical plan in 4, 1 received a different occlusal therapy, 2 were referred, 1 received counseling and behavioral therapy, and 1 an additional examination.

Associations between Radiographic Findings and Changes in Management Strategy

Because in one center the management strategy was changed only in 1 patient, data from this center was excluded from the logistic regression analyses. Thus, the patients from the remaining two centers were pooled, giving a total sample of 154 patients. The chance of "any change" in management strategy was more than twice as high with a radiographic finding of flattening (odds ratio [OR] = 2.28, 95% confidence intervals (CI): 1.13–4.61) and erosion (OR = 2.03, 95% CI: 1.03–4.00) than without these degenerative changes. An increased chance of "any change" in management strategy was also found when there was more than one radiographic finding (OR = 2.28, 95% CI: 1.16–4.47) compared to not having any radiographic findings (Table 2).

A logistic regression analysis with changes in the specific management categories as the dependent variables was only performed for pharmacology and physiotherapy, where the highest number of changes was found. An increased chance of change in pharmacology was found with a radiographic finding of flattening (OR = 2.56, 95% CI: 1.02–6.45). Having an erosion increased the chance of change in pharmacology by more than three times (OR = 3.60, 95% CI: 1.53–8.48), while the presence of > 1 radiographic finding increased the chance of change in physiotherapy (OR = 2.48, 95% CI: 1.06–5.80) compared to not having any radiographic findings. There were no associations between only 1 radiographic finding and changes in management.

No statistically significant associations between age or a specific finding of osteophyte and sclerosis and changes in management were found.

Discussion

No internationally established or validated TMD management algorithms exist, and therefore, no common management algorithm was used in the present study. While the orofacial pain specialists were calibrated for examination and diagnosis according to the RDC/TMD, no calibration existed as far as management. Thus, it is possible that the clinicians managed the same condition differently. Likewise, there is a lack of guidelines concerning the influence of radiographic TMJ findings on management. This could have resulted in differences in the interpretation and signifi-

cance of radiographic findings in terms of influence on changes in management strategy in the present study. This may suggest the need for consensus discussions and development of evidence-based and operationalized management algorithms, including the influence of radiographic TMJ abnormalities.

The radiographic finding changed the management strategy in less than one third (n = 55) of the patients, while the diagnosis changed in 56 patients. However, both changes occurred in only 23 patients, suggesting that changes in diagnosis and management are rarely associated. This hypothesis requires further analysis. Not surprisingly, most changes in management strategy occurred within the categories that were most often used in the patient's management. This was, however, not the case for the "occlusal therapy" category, which was proposed for approximately half of the patients but was rarely changed.

In the literature, there are two similar studies. White and Pullinger[29] reported that the information provided by the tomograms changed the management in 40% of the cases and that these changes were "substantial" for 22% of them. They also reported that there was a highly significant association between the amount of radiographic osseous alterations and change in management strategy. Conversely, Callender and Brooks[30] reported that the management was altered in only 17% of the patients after tomographic examination and that most changes were only of minor relevance. They concluded that the radiographic evaluation has little effect on the management of TMD patients. These differences may be the consequence of different study design. Indeed, one study was a retrospective review of records,[30] and the other, a prospective study.[29] Furthermore, the two studies had different examination protocols and management guidelines and therefore possibly different approaches to diagnosis and treatment, which impedes a direct comparison of all these results.

Some of the recorded changes in management strategy found in this study may seem surprising, eg, those recorded in the counseling and behavioral therapy and physiotherapy categories. Unexpected radiographic findings (eg, osteoarthrosis) could have an impact on the decision to include counseling and behavioral management such as information/prognosis of degenerative findings but would not lead to major changes in other psychological approaches because these would be related mainly to Axis II findings. Furthermore, physiotherapy (eg, stretch exercises) could be suggested for TMJ arthralgia but would not be suggested if the diagnosis changed from TMJ arthralgia to acute osteoarthritis or rheumatoid arthritis after the radiographic examination. When associations between radiographic findings and changes in management were found, the radiographic findings increased the chance of changes in management. The chance of "any change" in management was more than twice as high with a radiographic finding of flattening and erosion compared to not having these findings. Why the presence of osteophyte and sclerosis did not influence the management plan is unclear. Either some radiographic findings were considered "worse" than others, or the lack of association could have been due to flattening and erosion being the osseous changes that occurred most often in the present study population. Radiographic findings were associated with an increased chance of changes only in pharmacology and physiotherapy. However, only changes in these two management categories were tested since too few changes occurred in the other management categories. It is, therefore, possible that radiographic findings could also influence the other management categories, but to test this, a larger patient sample, which would probably result in a larger number of changes in all management categories, would be needed.

Signs of structural changes of the TMJ such as flattening or erosion are believed to be of importance in TMJ diagnostics. These signs, however, may simply reflect normal variation or nonpathological remodeling and not necessarily degenerative changes. The diagnostic significance of radiographic TMJ findings may therefore be hard to state. From autopsy material, it is known that older individuals have a higher frequency of TMJ degenerative changes,[36–38] and that the risk of radiographic degenerative TMJ changes increases with age.[20] In this study, age was not found to be associated with an increased risk of changes in management, which suggests that changes in management after radiographic examination are due to the radiographic findings by itself and that any relation between age and radiographic changes is of no or only minor importance when deciding which management to offer to the patient.

Conclusions

Radiographic findings of patients with TMJD may alter the diagnosis and influence the management decision. However, in the majority of cases (73%), no change in management was deemed necessary. Proposed changes were mainly minor adjustments within management categories.

References

1. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders. Review, criteria, examinations and specifications, critique. J Craniomandib Disord 1992;6:301–355.
2. John MT, Dworkin SF, Mancl LA. Reliability of clinical temporomandibular disorder diagnoses. Pain 2005;118:61–69.

3. Dworkin SF, Sherman J, Mancl L, Ohrbach R, LeResche L, Truelove E. Reliability, validity, and clinical utility of the research diagnostic criteria for temporomandibular disorders axis II scales: Depression, non-specific physical symptoms, and graded chronic pain. J Orofac Pain 2002;16:207–220.
4. Leher A, Graf K, PhoDuc JM, Rammelsberg P. Is there a difference in the reliable measurement of temporomandibular disorder signs between experienced and inexperienced examiners? J Orofac Pain 2005;19:58–64.
5. List T, Dworkin SF. Comparing TMD diagnoses and clinical findings at Swedish and US TMD centers using research diagnostic criteria for temporomandibular disorders. J Orofac Pain 1996;10:240–253.
6. Manfredini D, Segu M, Bertacci A, Binotti G, Bosco M. Diagnosis of temporomandibular disorders according to RDC/TMD axis I findings, a multicenter Italian study. Minerva Stomatol 2004;53:429–438.
7. Dawson PE. Position paper regarding diagnosis, management, and treatment of temporomandibular disorders. The American Equilibration Society. J Prosthet Dent 1999;81:174–178.
8. McNeill C. Management of temporomandibular disorders: Concepts and controversies. J Prosthet Dent 1997;77:510–522.
9. Hall HD, Merrill RG, Sanders B; American Society of Temporomandibular Surgeons; American Society of Maxillofacial Surgeons. Guidelines for management of disorders of the temporomandibular joint and related structures. J Tenn Dent Assoc 2002;82:58–64.
10. Uyanik JM. Evaluation and management of TMDs, part 2. Dent Today 2003;22:108–117.
11. Clark CT, Seligman DA, Solberg WK, Pullinger AG. Guidelines for the treatment of temporomandibular disorders. J Craniomandib Disord 1990;4:80–88.
12. Okeson JP. Orofacial Pain. Guidelines for Assessment, Diagnosis, and Management. Chicago: Quintessence, 1996.
13. Ludlow JB, Davies KL, Tyndall DA. Temporomandibular joint imaging: A comparative study of diagnostic accuracy for the detection of bone change with biplanar multidirectional tomography and panoramic images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;80:735–743.
14. Cholitgul W, Petersson A, Rohlin M, Tanimoto K, Akerman S. Diagnostic outcome and observer performance in sagittal tomography of the temporomandibular joint. Dentomaxillofac Radiol 1990;19:1–6.
15. Schulze D, Heiland M, Thurmann H, Adam G. Radiation exposure during midfacial imaging using 4- and 16-slice computed tomography, cone beam computed tomography systems and conventional radiography. Dentomaxillofac Radiol 2004;33:83–86.
16. Hintze H, Wiese M, Wenzel A. Cone beam CT and conventional tomography for the detection of morphological temporomandibular joint changes. Dentomaxillofac Radiol 2007;36:192–197.
17. Brooks SL, Brand JW, Gibbs JS, et al. Imaging of the temporomandibular joint. A position paper of the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83:609–618.
18. Pharoah MJ. The prescription of diagnostic images for temporomandibular joint disorders. J Orofac Pain 1999;13:251–254.
19. White SC, Heslop EW, Hollender LG, Mosier KM, Ruprecht A, Shrout MK. Parameters of radiologic care: An official report of the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91:498–511.
20. Wiese M, Svensson P, Bakke M, et al. Association between TMJ symptoms, signs and clinical diagnosis using RDC/TMD and radiographic findings in TMJ tomograms. J Orofac Pain 2008; 22:239–251.
21. Mejersjo C, Hollender L. TMJ pain and dysfunction: Relation between clinical and radiographic findings in the short and long-term. Scand J Dent Res 1984;92:241–248.
22. Kopp S, Rockler B. Relationship between clinical and radiographic findings in patients with mandibular pain or dysfunction. Acta Radiol Diagn (Stockh) 1979;20:465–477.
23. Hansson LG, Hansson T, Petersson A. A comparison between clinical and radiologic findings in 259 temporomandibular joint patients. J Prosthet Dent 1983;50:89–94.
24. Helenius LM, Hallikainen D, Helenius I, et al. Clinical and radiographic findings of the temporomandibular joint in patients with various rheumatic diseases. A case-control study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;99:455–463.
25. Kurita H, Kojima Y, Nakatsuka A, Koike T, Kobayashi H, Kurashina K. Relationship between temporomandibular joint (TMJ)-related pain and morphological changes of the TMJ condyle in patients with temporomandibular disorders. Dentomaxillofac Radiol 2004;33:329–333.
26. Hansson L-G, Petersson A, Vallon-Christensen D. Clinical and radiologic six-year follow-up study of patients with crepitation of the temporomandibular joint. Swed Dent J 1984;8:277–287.
27. Eliasson S, Isacsson G. Radiographic signs of temporomandibular disorders to predict outcome of treatment. J Craniomandib Disord 1992;6:281–287.
28. Nilner M, Petersson A. Clinical and radiological findings related to treatment outcome in patients with temporomandibular disorders. Dentomaxillofac Radiol 1995;24:128–131.
29. White SC, Pullinger AG. Impact of TMJ radiographs on clinician decision making. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:375–381.
30. Callender KI, Brooks SL. The usefulness of tomography in the evaluation of patients with temporomandibular disorders: A retrospective clinical study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;81:710–719.
31. Wiese M, Wenzel A, Hintze H, et al. Osseous changes and condyle position in TMJ tomograms: Impact of RDC/TMD clinical diagnoses on agreement between expected and actual findings. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:e52–e63.
32. McNeill C (ed). Temporomandibular Disorders. Guidelines for Classification, Assessment and Management. Chicago: Quintessence, 1993.
33. Arnett FC, Edworthy SM, Bloch DA, et al. The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis. Arthritis Rheum 1988;31:315–324.
34. Omnell K-Å, Petersson A. Radiography of the temporomandibular joint utilizing oblique lateral transcranial projections. Comparison of information obtained with standardized technique and individualized technique. Odont Revy 1976;26:77–92.
35. Wiese M, Hintze H, Svensson P, Wenzel A. Comparison of diagnostic accuracy of film and digital tomograms for assessment of morphological changes in the TMJ. Dentomaxillofac Radiol 2007;36:12–17.
36. Widmalm SE, Westesson PL, Kim IK, Pereira FJ Jr, Lundh H, Tasaki MM. Temporomandibular joint pathosis related to sex, age, and dentition in autopsy material. Oral Surg Oral Med Oral Pathol 1994;78:416–425.
37. Pereira FJ Jr, Lundh H, Westesson PL. Morphologic changes in the temporomandibular joint in different age groups. An autopsy investigation. Oral Surg Oral Med Oral Pathol 1994;78:279–287.
38. Ishibashi H, Takenoshita Y, Ishibashi K, Oka M. Age-related changes in the human mandibular condyle: A morphologic, radiologic, and histologic study. J Oral Maxillofac Surg 1995;53:1016–1023.