Investigation of the clinical and radiographic features of osteoarthrosis of the temporomandibular joints in adolescents and young adults

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Objective. The objective of this study was to investigate the clinical and radiographic features of osteoarthrosis (OA) of the temporomandibular joints (TMJOA) in human adolescents and young adults.
Study design. Patients (n = 4883) with temporomandibular disorders (age, 11 to 30 years) underwent clinical and radiographic examinations. The radiographic findings were classified as erosive bony changes, proliferative changes mainly, including flattening with uneven sclerosis, and osteophytes of the condyle, and bilaterally short condylar processes. In addition, we interpreted the reassessment radiographs of 156 of the patients.
Results. Seven hundred eleven patients had radiographic signs of OA. The frequency of OA was higher in women (563/3360, 16.8%) than in men (148/1523, 9.7%). Most patients (541/711, 76.1%) with signs of OA showed proliferative changes of OA. Moreover, 56.4% of patients with TMJOA (88/156) remained stable.
Conclusions. These results suggest that although OA is an age-related disease, aging is not the crucial factor in the pathogenesis of OA. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:e27-e34)**

Osteoarthrosis (OA) is one of the most common age-related debilitation diseases involving all joints, including the temporomandibular joints (TMJs), and is characterized by degeneration of the articular cartilage and bone, which leads to joint pain, discomfort, and immobility.[1-3] Diagnosis of OA most commonly depends on findings from clinical and radiographic examinations. The radiographic manifestations of OA of the temporomandibular joint (TMJOA) include erosion, generalized sclerosis, subcortical cyst, and osteophytes.[4]

The specific causes of OA are unknown, but an overload on normal articular cartilage or normal stresses on aberrant cartilage are considered to be risk factors. Specifically, overload on articular cartilage can be caused by obesity, anatomic abnormalities, and trauma; aberrant cartilage physiology can be caused by aging, genetic and metabolic factors, and inflammation.[5] Epidemiologic studies of OA have revealed that it is more predominant in women and that aging is one of the main risk factors for incidence of OA at all sites, whereas obesity is a main factor for knee and hip OA. Most researchers have used a scale developed by Kellgren and Lawrence, which grades OA based on the degree of joint space narrowing and the presence of osteophytes.[6] Longitudinal study has shown that among women in particular, there was a mean incidence of approximately 2% per year for radiographic knee OA and 1% for symptomatic knee OA.[7]

Toller[2] previously reported that TMJOA most frequently presented in older patients, usually those older than 40 years. Degenerative changes of TMJs have been shown to occur in as many as 80% of people between the ages of 60 and 89 years.[8] Furthermore, an autopsy study indicated that signs of degenerative changes in the TMJ articular surfaces were found in 28% of a younger group of individuals included in the study (age 16 to 39 years) and in 50% of the older group (age 55 to 78 years). In addition, this study also determined that the degenerative lesions observed in the older group were more severe than those in the younger group.[9] There are only a few reports of TMJOA involving young people. Therefore, the purpose of this investigation was to assess the clinical and radiographic features of TMJOA in adolescents and young adults with temporomandibular disorders and to reas-

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sess the radiographic findings of TMJOA in this patient group.

MATERIAL AND METHODS

All clinical and radiographic data of the patients diagnosed in our temporomandibular disorder (TMD) clinic from 1990 to 2007 were reviewed retrospectively. Patients were selected for this study on the basis of their age and clinical and radiographic examinations; the inclusion criteria were that patients were clinically diagnosed with TMD and were 11 to 30 years of age. Exclusion criteria included patients with condyle fracture, infectious arthritis, rheumatoid arthritis, TMJ tumors, or other systemic diseases that could be associated with TMJ.

Based on inclusion and exclusion criteria, 4883 patients were enrolled as the final patient group. Radiographs were interpreted for all enrolled patients.

Clinical examination

Clinical examinations of the patients included assessment of the following: TMJ sounds (clicking or crepitation), range and deviation of mouth opening, tenderness to palpation of the joint and the masticatory muscles, and joint or muscle pain during mouth opening and protrusive or lateral mandibular movements. A Joint Dysfunction index (JDi) was derived from the results of the clinical examinations, as previously devised by Helkimo[10] and Wiberg and Wänman.[11] Briefly, the criteria of the JDi were as follows:

JDi 0: Clinically normal joint function.

JDi I: Clicking or crepitation, no pain during mandibular movement, no locking or dislocation, no pain localized to the preauricular area.

JDi II: Tenderness to joint palpation and/or pain during mandibular movement and/or joint locking or impairment of TMJ movement.

Radiographic examination

Radiographic examination for each patient was performed with transcranial projection coupled with either transpharyngeal or panoramic projection. Two trained radiologists independently (to avoid bias) evaluated each image from these methods. Any disagreements between radiologists were discussed until a consensus was reached. A radiographic diagnosis of OA was made if there was radiographic evidence of the following: erosion, flattening with sclerosis, subcortical cyst, osteophytes, and deformity. Based on the classification of TMJOA proposed by Ma,[12] we used a modified classification as follows: pattern I included erosive bone changes (Fig. 1, *A*), defined as obvious destruction or ill-defined cortical bone of the condyle, and small concave defect of condyle; pattern II included proliferative changes of the condyle, defined as flattening with sclerosis, osteophytes, or deformity (Fig. 2); pattern III included cases with bilaterally short condylar processes (Fig. 3), defined as a bilaterally short condylar process with decreased head height and uneven subcortical sclerosis. If only flattening was present, we considered it to represent remodeling.

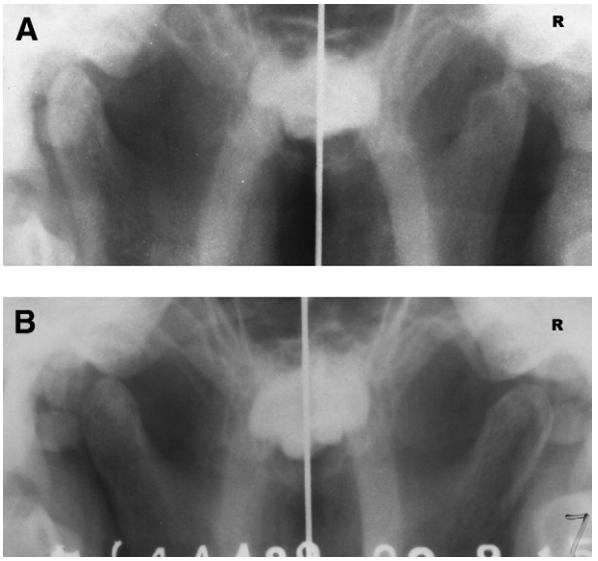

Fig. 1. Samples of a representative 16-year-old man are shown. **A,** Transpharyngeal radiogram showed an erosion change of the right condyle. **B,** A transpharyngeal radiogram for the same patient 12 months later showed erosive bone change was arrested and the cortical bone became well defined.

Of those patients who were diagnosed with TMJOA, retrospective study showed that some of them had reassessment radiographs. The radiographic findings of the reassessment examinations were graded as follows:

Unchanged: the radiographic findings of condyle remained stable (Fig. 4, *A-C*).

Findings less severe: Erosive bone change was arrested and the cortical bone changed from eroded to an intact or flattened surface (Fig. 1, *A* and *B*).

Findings more severe: the radiographic changes of erosion, flattening, and sclerosis became worse, and the size of condyle was decreased (Fig. 5, *A* and *B*).

Statistical analysis

The results of clinical and radiological assessments were compared between genders and among different age groups by using χ^2 tests.

Reproducibility analysis was performed using Cohen's kappa coefficient. In the intraexaminer variations, the agreement percentage for intraexaminers was 88%, and the kappa index was 0.77.

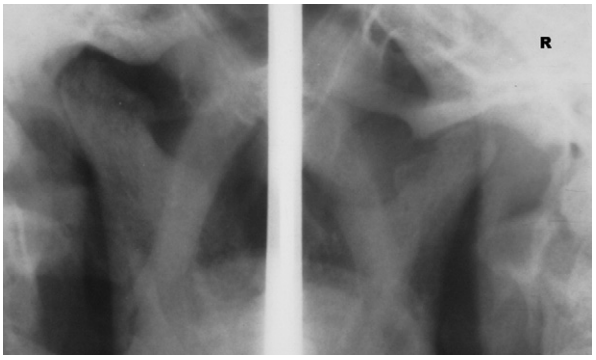

Fig. 2. A sample of a representative 22-year-old woman is shown. Transpharyngeal radiogram showed flattening, sclerosis, and surface irregularity of the condyle.

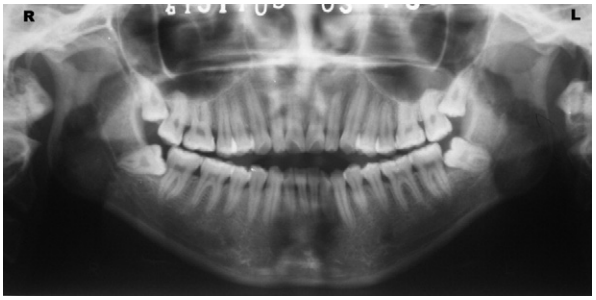

Fig. 3. A sample of a representative 21-year-old woman is shown. Panoramic radiogram showed shortening of the bilateral condyles with anterior open bite.

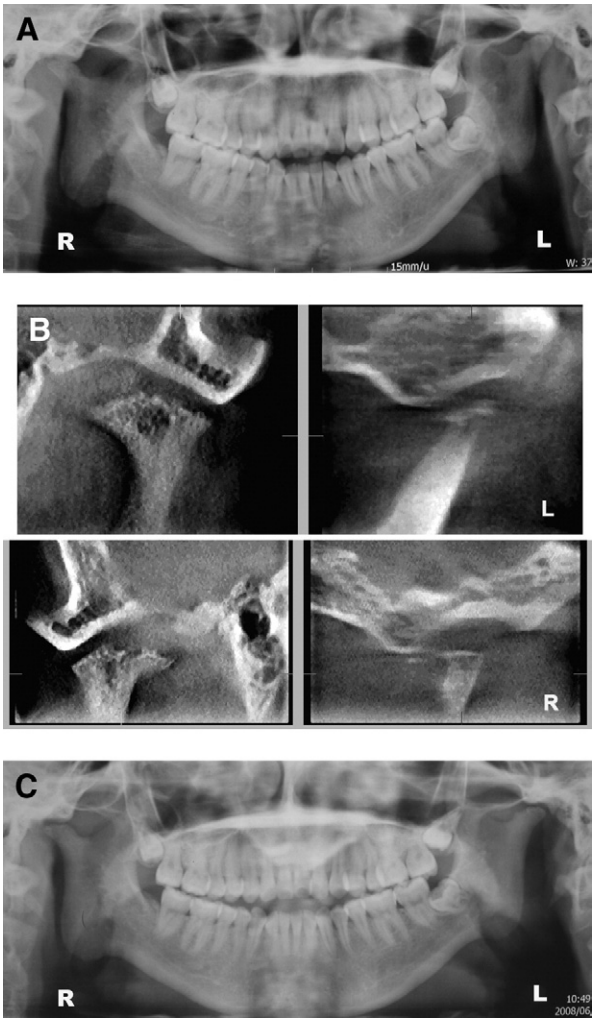

Fig. 4. Samples of a representative 18-year-old woman is shown. **A,** Preorthodontic radiographic examination (panoramic radiogram) showed shortening of the bilateral condyles with anterior open bite. **B,** Cone-beam CT showed a bilateral shortened condylar process with decreased head bulge and cortical erosion. **C,** OA changes of condyle remained stable in the same patient 12 months later.

RESULTS

Description of the gender and age of patients

The present study included a total of 4883 patients with an age range from 11 to 30 years and a mean age of 21 years. We found that radiographic changes representative of TMJOA were registered in 711 patients (14.56%), and the frequency of TMJOA was significantly higher in women (16.8%) than in men (9.7%). Furthermore, statistically significant differences were found between women and men with respect to the frequency of OA in the 15 to 19, 20 to 25, and 26 to 30 age groups (Table I). Of note, the occurrence of OA was increased sharply for patients in the age range of 11 to 19 years, especially for women.

Clinical and radiographic findings

Table II shows the radiographic grading of degenerative changes found in the different gender and age groups. Pattern II (76.1%) was the most common radiographic classification of degeneration in adolescent and young adult patients with TMJOA. Among patients with Pattern II radiographic changes, osteophyte formation was found in 47 cases (6.6%). Table III shows the relationship between the radiographic and clinical findings. Patients with erosive change more commonly had pain and other signs of dysfunction with JDi II. Most patients with bilaterally short condylar processes had mild signs and symptoms of dysfunction with JDi I (Table IV).

Radiographic findings in the reassessment radiographic examination

Retrospective data showed that 156 of the 711 patients who were diagnosed with TMJOA had reassessment radiographic data available, with an average in-

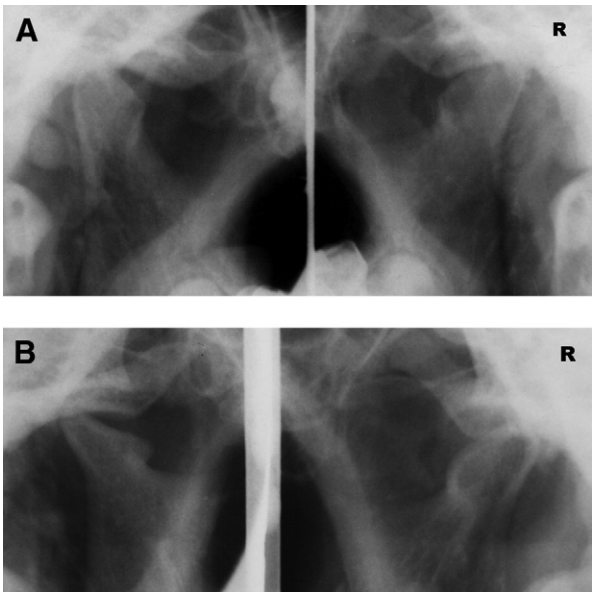

Fig. 5. Samples of a representative 14-year-old woman. **A,** Transpharyngeal radiogram showed flattening and sclerosis of the condyle. **B,** The radiographic changes of condyles became more severe, especially on the left side, in the same patient 5 years later.

terval of 25 months (range: 6 to 72 months). The occurrence and severity of the radiographic OA findings in the reassessment radiographic examination are given in Tables V and VI.

DISCUSSION

The results of this retrospective study showed that radiographic TMJOA changes were common in adolescent and young adult patients (≤30 years) with TMD, especially in women. Interestingly, the occurrence of TMJOA increased sharply during the ages of 11 to 19 years.

Several methods are available, including conventional extraoral X-ray equipment for radiographic examination of the TMJs, such as panoramic, transcranial, and transpharyngeal radiography. Panoramic projection provides an overall view of a patient's teeth and jaw and is widely used in dental clinics. This method has frequently been recommended as a tool for discharging odontogenic disease and other disorders that can cause similar symptoms to TMD. Transcranial projection demonstrates degenerative changes that occur on the lateral portion of the condyle. Furthermore, transpharyngeal projection provides an oblique sagittal view of the condyle without overlapping other bony structures and is effective for visualizing erosive changes of the condyle. Although the diagnostic accuracy of plain and panoramic radiography is less than that of cone beam computed tomography (CBCT), these methods are the most commonly used screening TMJ imaging modalities. Previous findings showed that radiographic methods (panoramic, transcranial, or transpharyngeal projection) demonstrated approximately 80% of abnormal TMJs, as revealed by independent tomography. Furthermore, these methods have a high sensitivity (0.81) and specificity (1.00).[13,14] A different study with a sample of skulls showed that the accuracy of panoramic projection was 0.64 (0.11).[15] Another study indicated that, compared with CBCT, the diagnostic accuracy of panoramic radiography, transpharyngeal, and transcranial projection was 90.64%, 94.10%, and 86.97%, respectively.[16] In our study, we combined either panoramic radiography or transpharyngeal projection with transcranial projection to improve diagnostic accuracy. Using this method, we found that the occurrences of OA were 9.7% (in men) and 16.8% (in women) in the patient group we studied. Of note, CBCT has become widely available in recent years; this method was not used as an initial examination tool for TMD patients earlier because of economic reasons and relatively higher exposure dose. Our investigation is a retrospective study, and the data were collected from 1990 to 2007; this is another reason why transcranial projection coupled with either panoramic or transpharyngeal projection were the main radiographic modalities for diagnosis of OA in the present investigation. The results of our study likely represent the frequency of OA in adolescents and young adults to some extent.

Radiographic and clinical features of TMJOA

TMJOA had different clinical and radiographic features than other large weight-bearing joints. Previous clinical and histopathological studies showed that the mean age of occurrence of TMJOA was 34 years,[17] which is approximately 10 years earlier than for other joints.[18] Epidemiologic studies revealed that most TMD symptoms were reported in patients 20 to 40 years of age.[19] Of the patients treated for TMD, 18% to 66% were diagnosed with OA, and the prevalence increased with age. Packota[20] previously reported that 8 patients younger than 18 years had radiographic signs of degenerative joint disease.

Our findings indicated the occurrence of OA in adolescents and young adults treated for TMD were 9.7% in men and 16.8% in women. Furthermore, we found that the prevalence increased with age, especially during the range of 11 to 19 years. The frequency of OA reached a maximum in the 15- to 19-years age group and remained relatively stable in patients older than 20 years. This finding was in agreement with a previous clinical study.[21] The prevalence of OA in our patient group was higher than that in patients receiving orth-

Table I. Occurrence of temporomandibular joint osteoarthrosis in different genders and age groups

	Women (n = 3360)			*Men (n = 1523)*				
Age range, y	*n-OA*	*OA*	*%*	*n-OA*	*OA*	*%*	χ^2	*P value*
11-14	352	54	13.3	126	11	8.0	2.22	.136
15-19	832	176	17.5	435	52	10.7	11.17	.0008*
20-24	839	172	17.0	449	47	9.5	14.62	.0001*
25-30	774	161	17.2	365	38	9.4	12.89	.0003*
Total	2797	563	16.8	1375	148	9.7	41.16	<.0001*

n-OA, without radiographic signs of osteoarthrosis; OA, osteoarthrosis.
*$P \leq .001$.

Table II. Frequencies of radiographic osteoarthrosis in different age and gender groups

	Pattern I		*Pattern II*		*Pattern III*	
	Number	*%*	*Number*	*%*	*Number*	*%*
Female (n = 563)	103	18.3	417	74.1	43	7.6
11-19 (n = 230)	54*	17.2	155	67.4	21	9.1
20-30 (n = 333)	49*	14.7	262	78.7	22	6.6
Male (n = 148)	23	16.3	124	83.8	1	1.4
11-19 (n = 63)	17*	27.0	46	73.0	0	0
20-30 (n = 85)	6*	7.1	78	91.7	1	1.2
Total	126	17.7	541	76.1	44	6.2

*$P = .05$, significant difference between 11 and 19 and 20 to 30 years old.

Table III. Relationship between the radiographic and clinical findings

	Pattern I	*Pattern II*	*Pattern III*	*Sum*
No signs	0	5	0	5
c	15	177	10	202
p	49	95	0	144
c + p	31	111	2	144
l	1	27	0	28
p + l	30	101	3	134
Open	0	2	2	4
c+open	0	16	23	39
p+open	0	7	4	11
Sum	126	541	44	711

c, click; p, pain; l, limitation of mouth opening; open, anterior open bite.

Table IV. Relationship between JDi and the radiographic grading of osteoarthrosis

	Pattern I	*Pattern II*	*Grade III*	*Total*
JDi 0	0	7	2	9
JDi I	15	193	33	241
JDi II	111	341	9	461
Total	126	541	44	711

JDi, joint dysfunction index.

Table V. Longitudinal changes in 156 patients with osteoarthrosis at first visit and at reassessment examination

	Pattern I	*Pattern II*	*Pattern III*
Female (n = 124)			
First visit	31	75	18
Follow-up	7	96	21
Male (n = 32)			
First visit	9	23	0
Follow-up	1	31	0

Table VI. Radiographic changes in 156 patients with osteoarthrosis at reassessment examination

	Unchanged	*Less severe*	*More severe*
Female (n = 124)	71	24	29
Pattern I (n = 31)	0	22	9
Pattern II (n = 75)	57	1	17
Pattern III (n = 18)	14	1	3
Male (n = 32)	17	8	7
Pattern I (n = 9)	0	8	1
Pattern II (n = 23)	17	0	6
Pattern III (n = 0)	0	0	0
Total (n = 156)	88 (56.4%)	32 (20.5%)	36 (23.1%)

odontic treatment; a previous study has shown that the detection rate of TMJOA in patients receiving orthodontic treatment (age, 13 to 25 years) varied from 1.8% to 4.6%.[22] Furthermore, Yang and Kiyak[23] demonstrated that the greatest proportion of patients who received orthodontic treatment were adolescents or teens between 12 and 18 years old, followed by children between 8 and 11 years old, and finally adults. Our results showed that the occurrence of TMJOA increased sharply in patients in the 11 to 19 years of age range, which corresponds with the ages when the great-

est proportion of adolescents received orthodontic treatment. Some patients in this series were found using regular preorthodontic screening radiographic examination. Therefore, it is particularly important for orthodontists to notice the shape and osseous status of condyle when they conduct standard preorthodontic radiographic examinations. Furthermore, TMJ imaging is recommended for those individuals with TMD-related symptoms and signs, as well as to identify TMJ screening examination findings. Early diagnosis of preorthodontic patients with bilaterally short condylar processes should also be emphasized. Finally, additional attention should be paid to the trend that the frequency of OA increases sharply during the ages of 11 to 19 years.

The results of this study indicated that the predominant findings in the radiographs were flattening and sclerosis, surface irregularity, subcortical cysts, osteophyte formation, or deformity (76.1%). However, osteophyte formation was found in 47 cases (6.6%). Our findings are in line with the results of other studies that showed that TMJOA differs from OA of other weight-bearing joints. Radiologically, erosion is a prominent feature, but osteophyte formation is uncommon for TMJOA. For OA of the knee and hand, space narrowing and osteophyte formation are most closely associated with pain; at the hip, joint space narrowing is the most reproducible sign and is most closely associated with reported pain. In agreement with other studies,[4,12] we found that different stages of TMJOA had different radiographic features: erosive lesions may indicate acute or active changes, whereas sclerosis, flattening, and osteophytes may indicate the late and relatively stable stages. Most of the degenerative changes of OA are stable, especially in the late stage.[24] To date, the relationship between the presence of TMJ pain and OA was controversial. However, the results of clinical features in the present study support the finding that the presence of TMJ pain was associated with erosive changes.

Our results from 156 patients with reassessment radiographic examination showed that the degenerative changes of the condyle were unchanged in 56.4% of the joints. This finding corresponds with reports from other authors, which described that the condylar morphology was unchanged in 63.6% of joints.[25] Peltola et al.[26] reported that individuals who exhibited condylar degeneration in adolescence were more likely to also have them later in life. Our results and previous studies suggest that most of the joint structures for those patients with TMJOA remained stable. Furthermore, most of the joint structures for patients with OA experienced irreversible pathologic changes. Finally, OA existed in all age groups examined, although it varied in different age groups. Furthermore, the prevalence of radiographic OA is higher among older people, although it may become less symptomatic. Moreover, the prevalence of symptomatic signs of OA was determined to be relatively low in elderly people.[27] Our previous studies also showed that the frequencies of OA in TMD patients from 30 to 80 years of age were 28.4% to 32.2%.[28] The TMJ is less likely to show aging-related deterioration than other major body joints; although, further studies are necessary to clarify the mechanism behind this difference.

Condylar hypoplasia and osteoarthrosis in adolescents and young adults

Epidemiologic patterns in the occurrence of OA provide potential clues about its disease pathogenesis. Systemic factors that increase overall susceptibility to joint degeneration and local biomechanical factors that impair the optimal function of a joint both play an important role in determining the risk of developing OA.[29] Systemic factors interact with mechanical factors operating within the local joint environment to determine which joint develops OA and how rapidly the disease progresses in an affected joint.[30] Clinical studies of patients with hip OA have shown that anatomic abnormalities of the hip that are present at birth or that develop during childhood may result in accelerated or premature joint degeneration. Radiographic OA of the hip tends to be enhanced in women and with enhanced mechanical workload. Mechanical workload of the hip includes performing highly physically demanding work and being overweight. Mechanical factors of TMJ include trauma, parafunction, unstable occlusion, functional overloading, and increased joint friction.

De Bont and Stegenga previously described primary OA of the TMJ as a degenerative process of the TMJ that is idiopathic, and secondary OA as being the result of other joint disorders.[31] Factors that potentially influence the host remodeling capacity of the TMJ include advancing age, hormonal factors, facial trauma, and systemic arthritis. Furthermore, permanent disk displacement can increase the risk of developing degenerative bony changes, but OA may also develop without disk displacement.[32] Age-dependent alterations in the joint tissue and systemic arthritis are likely not the main causes of OA in our adolescent and young adult patient groups. Some researchers reported cases of severe TMJ destruction with anterior open bite and suggested that these cases had progressive and rapid destructive disease processes, rather than typical secondary OA.[33]

Our study demonstrated that 6.2% (44/711) of patients with TMJOA exhibited bilaterally short condylar processes (Table II). Distinct clinical and radiographic

features were observed in these patients, including: (1) Almost all patients with this diagnosis were women. (2) Short condylar process was seen symmetrically and bilaterally. (3) For most of these patients, we did not find the progressive resorption from normal-sized condyle to the smaller-sized condyle. These patients had generally good TMJ function, without pain or significant limitation of mouth opening. The complaints of these patients mainly included anterior open bite; some of them were found in regular preorthodontic radiographic examination. (4) History of chronic arthralgia in other joints was not found. (5) Reassessment radiographic examination showed that short condylar process (pattern III) was stable for most patients (14/18). Most typical secondary OA occurred in the unilateral area with joint noise, pain, and limited mouth opening. For bilateral cases, morphologic changes of condyles (in asymmetry of both condyles) exhibited different radiographic findings (Fig. 5, *B*). Therefore, we deem that most of these cases of patients with bilaterally short condylar processes were not caused by internal derangement but may be related with other causes, especially heredity. The TMJ has similar anatomic features to the hip joint. In agreement with hip dysplasia and magnetic resonance images (MRIs) of patients with acquired open bite,[33] 43 of the 44 patients who exhibited bilaterally short condylar processes in our study were women. Our findings suggest that condylar hypoplasia may be a risk factor in the development of severe TMJOA, which can result in acquired anterior open bite. Preadolescent internal derangement may be one of the reasons that restrict the growth of condyle. Unfortunately, there are still many unknown factors related to the cause and progress of TMJOA. Additional research is necessary to elucidate the potential roles of polyarthritis and hormonal factors on the bilaterally short condylar processes. Orthodontic therapy should be careful administered for patients with bilaterally short condylar processes, particularly because stress on the joints may result in secondary degeneration of the condyle (secondary OA) and failure of orthodontic treatment.

There were admittedly limitations to our study. The reliability of the radiographic examinations used in this study, including transcranial projections, transpharyngeal projection and/or panoramic radiogram, may have been affected owing to superimposition by other bony structures, and the incidence of OA may therefore be understated.

In conclusion, our retrospective study indicated a high prevalence of TMJOA among the adolescents and young adults examined. The prevalence of TMJOA reached a maximum in the group that consisted of patients in the age range of 15 to 19 years and remained relatively stable for individuals older than 20 years. Reassessment of radiographic examination showed that most of the patients with radiographic OA remained stable. Condylar hypoplasia may be a potential risk factor for developing TMJOA. The occurrence of TMJOA in our study was not age-related changes, but instead related to changes in TMJ pathosis. Our results support the hypothesis that OA is an age-related disease, but we determined that aging is not the crucial factor in the pathogenesis of OA. Last, it is important for orthodontists to recognize the trend that the frequency of OA increases sharply during the ages of 11 to 19 years.

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