The Clinical and Radiographic Features of Patients with Temporomandibular Joint Osteoarthritis: Comparison of Adolescents and Middle-Old Aged Koreans

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Purpose: The purpose of this study was to compare the clinical and radiographic features of temporomandibular joint (TMJ) osteoarthritis (OA) between adolescents and middle-old aged patients.

Methods: The subjects were chosen among the patients who presented to the Department of Oral Medicine of Pusan National University Hospital and were diagnosed with TMJ OA by clinical exam, X-ray and cone-beam computed tomography (CBCT) from 2010 to 2011. We investigated 93 adolescent patients (12-19 years) and 53 middle-old aged (>45 years) patients who observed the erosive bony changes in TMJ. CBCT scans were retaken at intervals at an average of 8 months.

Results: The adolescent patients showed unilateral degenerative changes more often, and the middle-old aged patients showed degenerative changes more frequently on both sides. The transition of bone changes to the improved group occurred most commonly in both the adolescent and middle-old aged patients. The adolescent patients were more likely to improve than middle-old aged patients. In the adolescent patients, loss of erosion and subjective symptoms occurred in shorter periods than in the middle-old aged patients. In the adolescent patients, the transition of erosion was distributed into proliferative, normal, and shortening in order. In the middle-old aged patients, the transition of erosion was distributed into shortening, proliferative, and normal in order.

Conclusions: The clinical and radiographic features of TMJ OA are significantly different between the adolescent and middle-old aged patients. Moreover, the difference by age of the adaptive and regenerative capacity of TMJ affects the prognosis of TMJ OA and adolescent patients have a better prognosis after treatment.

Key Words: Adolescent; Cone-beam computed tomography; Osteoarthritis; Temporomandibular joint

INTRODUCTION

Osteoarthritis (OA) is one of the most common diseases that affects the temporomandibular joint (TMJ). TMJ OA is a local inflammatory condition that occurs when the dynamic equilibrium between the breakdown and the repair of joint tissue is compromised. The most common etiologic factor that either causes or contributes to OA is overloading of the articular structures of the joint. As loading forces increase, the articular surface becomes softened and the subarticular bone begins to resorb. TMJ OA is characterized by a gradual progressive destruction of the articular tissues, which leads to joint pain, discomfort, and immobility. With advanced degeneration, the subchondral cortical layer is lost and erosion and other radiographic signs of OA appear. The radiographic signs of TMJ OA are as follows: subchondral bone sclerosis, erosion, flattening, osteophytes, and the reduction of joint space. Among other degenerative findings, erosion
seems to be associated with subjective symptoms.4,5)

The diagnosis of OA most commonly depends on findings from clinical and radiographic examinations. A variety of imaging modalities have been used to evaluate OA in the TMJ. Guidelines from the research diagnostic criteria for temporomandibular disorders (RDC/TMD) validation project6) recommend computed tomography (CT) for use in both clinical and research settings. Cone-beam CT (CBCT) is rapidly growing as the imaging modality of choice to evaluate the changes of the TMJ in OA. Honey et al.7) reported that CBCT images provided superior reliability and great accuracy in evaluating the TMJ.

OA has been considered to be an age-related degenerative disease. Epidemiologic studies of OA have revealed that aging is one of the main risk factors for the incidence of OA, and the prevalence of OA increased noticeably after 45 years of age.8) However, recent research has identified OA in the majority of young patients with TMJ pain and dysfunction.9) Some studies also have shown that degenerative changes of the TMJ can begin at a young age.10,11) Furthermore, Ok et al.12) reported that OA was significantly increased in adolescents over the last several years (2000-2008). This suggests that the epidemiological characteristics of TMJ OA may differ from those of other joints, which show an obvious increase in prevalence after middle age.

The aim of the present study was to compare the clinical and radiographic features of TMJ OA between adolescents and middle-old aged patients. This study also reports the results of CBCT follow-up observation of TMJ OA in adolescents and middle-old aged patients.

MATERIALS AND METHODS

1. Subjects

All clinical and radiographic data of the patients visited in the Department of Oral Medicine at Pusan National University Hospital from 2010 to 2011 were reviewed retrospectively. Patients were selected for this study on the basis of their age and clinical and radiographic examinations. The subjects were divided into adolescent patients (12–19 years) and middle-old aged (>45 years) patients. The inclusion criteria were that patients were clinically diagnosed with TMJ OA and exhibited erosive bony changes in the TMJ on CBCT images. The diagnosis of TMJ OA was based on history and clinical examinations performed by an experienced orofacial pain specialist and CBCT readings by experienced oral radiologists. We excluded patients who had any skeletal deformity, condyle fracture, TMJ tumor or systemic disease possibly related to TMJ, such as rheumatoid arthritis. Among the patients whose follow-up CBCT imagery was taken approximately 6 months after the initial examination was available, the records of 104 joints in 93 adolescent patients and 65 joints in 53 middle-old aged patients were finally chosen (Table 1).

All subjects received conservative treatments such as medications, behavioral therapy, physical therapy and splint therapy. During the follow-up period, a recall exam was performed every 2 or 4 weeks, recording subjective pain, joint sound (noise), the limitation of motion (LOM) and maximum comfortable opening (MCO). This study was approved by the Institutional Review Board of Pusan National University Dental Hospital (IRB No. PNUDH-2013-031).

2. Methods

1) Clinical examination

Subjective symptoms and clinical findings were investigated at the first, the second and the last CBCT examinations to evaluate and compare the data before and after conservative treatment. Pain intensity, joint sound and LOM were assessed with a numeric rating scale (NRS) from 0–10 where 0 was ‘no pain, noise and limitation’ and 10 was ‘the worst pain, noise and limitation imaginable’. The mandibular movement was evaluated with measurements of MCO in mm. A maximum opening under 40 mm was considered to be limited mouth opening.

2) Radiographic examination

Once a patient was suspected of having TMJ OA by panoramic and transcranial projections at the first visit, CBCT imagery was taken to evaluate the bony condition of the TMJ. After CBCT confirmation of TMJ OA by experienced radiologists, patients with erosive bony changes on CBCT images were selected. Follow-up CBCT images were taken

<table>
<thead>
<tr>
<th>Table 1, Selected characteristics of patients participating in the study</th>
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<tbody>
<tr>
<td>Total (female/male)</td>
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<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Adolescent</td>
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<tr>
<td>Middle and old</td>
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</table>

Values are presented as number or mean±standard deviation.
approximately 8 months after the first CBCT examination. The CBCT images were taken by a Pax-Zenith 3D (Vatech, Hwaseong, Korea).

3) Assessment of condyle bone change by temporomandibular joint osteoarthritis

Of those patients who were diagnosed with TMJ OA, a retrospective study showed that all of them had reassessment radiographs. The radiographic findings of the reassessment examinations were graded based on the classification proposed by Jeon et al. as follows: (1) improved, erosive bone change was arrested and the cortical bone changed from eroded to an intact or flattened surface; (2) same, erosive bone change remained stable; and (3) worsened, the radiographic changes of erosion became worse.

The transitions of erosive bony changes were evaluated based on the study of Ko et al. and Park et al. in comparisons of the first and the last CBCT image sets. Condyle bone changes were classified as follows: (1) normal condyle, no radiographic signs of OA; (2) proliferative change, flattening with sclerosis, osteophyte or deformity; and (3) shortening, the size of condyle was decreased (Fig. 1).

4) Statistical analysis

The results obtained were presented in mean±standard deviation or in percentages after descriptive statistical analysis. For group comparisons, independent t-tests and non-parametric Mann-Whitney U tests were used for continuous variables, and $\chi^2$ tests were used for categorical variables. Correlations between the period of alleviation of subjective symptoms and erosion were calculated with Pearson’s correlation. The level of significance was 5% ($p<0.05$). All statistical analyses were performed using IBM SPSS Statistics 20.0 (IBM Co., Armonk, NY, USA).

RESULTS

The mean treatment duration of TMJ OA in all subjects was approximately 18 months (18.42±8.52 months). The average interval between the first and second CBCT was 8 months (8.02±2.50 months) and the mean number of total CBCT scans was approximately three times (3.35±1.21 times).

1. Comparison of the Signs/Symptoms at the First Visit

TMJ pain was observed in 71 (76.3%) of the 93 adolescent patients and in 44 (83.0%) of the 53 middle-old aged patients with erosive bony changes of TMJ. Additionally,

<table>
<thead>
<tr>
<th>Number</th>
<th>TMJ pain, n (%)</th>
<th>TMJ crepitus, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent</td>
<td>93</td>
<td>71 (76.3)</td>
</tr>
<tr>
<td>Middle and old</td>
<td>53</td>
<td>44 (83.0)</td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>115 (78.8)</td>
</tr>
</tbody>
</table>

TMJ, temporomandibular joint.

Fig. 1, Sagittal reconstruction of cone-beam computed tomography images showing the transitions of erosive bony changes. (A) Normal. (B) Proliferative changes. (C) Shortening.
43 (46.2%) of the adolescent patients and 25 (47.2%) of the middle-old aged patients reported crepitation as the chief complaint. There was no significant difference between the two age groups (Table 2).

Pain, noise, LOM, and MCO were compared among both groups at the first visit. Limited mouth opening (<40 mm) was observed in the two age groups at the first visit. The MCO measurement of adolescent patients was significantly greater than middle-old aged patients at the first visit (p=0.026, Table 3).

### 2. Comparison of the Clinical Symptoms after Treatment
Clinical symptoms were investigated at the first CBCT examination (CBCT1) and the second CBCT examination (CBCT2) to compare the data before and after conservative treatment. Pain, noise, LOM, and MCO were significantly improved in both groups (p<0.001), and there were no intergroup differences at the follow-up visit (Table 4).

### 3. Degenerative Changes of the Temporomandibular Joint
The distribution of degenerative changes of the mandibular condyle (TMJ) was analyzed. One side (60.2%) was most frequently affected in adolescents, and bilateral changes (62.3%) were most frequent in middle-old aged patients (p=0.009, Table 5).

The CBCT2 was performed after 8 months of conservative treatment. The longitudinal bony changes of erosion were reassessed and graded as ‘improved’, ‘same’, or ‘worsened’. As shown in Fig. 2, the transition of bone changes to the improved group occurred most commonly in both the adolescent and middle-old aged patients (73.1%, 50.8%). The rate of the improved group was significantly higher in the adolescent patients than in middle-old aged patients (p=0.013, Fig. 2).

### Table 3. Difference of clinical signs and symptoms between groups at first visit

<table>
<thead>
<tr>
<th></th>
<th>Pain (NRS)</th>
<th>Noise (NRS)</th>
<th>LOM (NRS)</th>
<th>MCO (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent</td>
<td>4.20±2.14</td>
<td>2.80±2.46</td>
<td>4.13±2.83</td>
<td>37.67±9.95</td>
</tr>
<tr>
<td>Middle and old</td>
<td>4.75±2.14</td>
<td>2.79±2.68</td>
<td>4.57±4.77</td>
<td>33.83±9.77</td>
</tr>
<tr>
<td>p-value</td>
<td>0.128</td>
<td>0.969</td>
<td>0.974</td>
<td>0.026*</td>
</tr>
</tbody>
</table>

NRS, numeric rating scale; LOM, limitation of motion; MCO, maximum comfortable opening. Values are presented as mean±standard deviation. p-value was determined by independent t-test and Mann-Whitney U test. *p<0.05.

### Table 4. Differences of clinical signs and symptoms between the CBCT1 and the CBCT2

<table>
<thead>
<tr>
<th></th>
<th>Adolescent (n=93)</th>
<th>Middle and old (n=53)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain1-Pain2 (NRS)</td>
<td>2.89±2.21***</td>
<td>3.15±2.68***</td>
<td>0.628</td>
</tr>
<tr>
<td>Noise1-Noise2 (NRS)</td>
<td>1.53±2.34***</td>
<td>1.71±3.06***</td>
<td>0.891</td>
</tr>
<tr>
<td>LOM1-LOM2 (NRS)</td>
<td>2.79±2.51***</td>
<td>3.35±4.67***</td>
<td>0.980</td>
</tr>
<tr>
<td>MCO1-MCO2 (mm)</td>
<td>−7.03±9.84***</td>
<td>−6.17±8.97***</td>
<td>0.471</td>
</tr>
</tbody>
</table>

CBCT, cone-beam computed tomography; CBCT1, first CBCT examination; CBCT2, second CBCT examination; NRS, numeric rating scale; LOM, limitation of motion; MCO, maximum comfortable opening. Pain1, Noise1, LOM1, MCO1, clinical symptoms at the CBCT1; Pain2, Noise2, LOM2, MCO2, clinical symptoms at the CBCT2. Values are presented as mean±standard deviation. p-value was determined by independent t-test and Mann-Whitney U test. ***p<0.001.

### Table 5. Comparison between unilateral and bilateral degenerative change in temporomandibular joint

<table>
<thead>
<tr>
<th></th>
<th>Adolescent, n (%)</th>
<th>Middle and old, n (%)</th>
<th>χ²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
<td>Unilateral: 56 (60.2)</td>
<td>Bilateral: 37 (39.8)</td>
<td>Unilateral: 20 (37.7)</td>
<td>Bilateral: 33 (62.3)</td>
</tr>
</tbody>
</table>

Statistics were analyzed by chi-square test. **p<0.01.
previously reported that the prevalence of degenerative changes of the TMJ showed a gentle increase along with age, which was relatively high in young adults. Zhao et al. showed that radiographic TMJ osteoarthritic changes were common in adolescent and young adult patients (<30 years of age) and the occurrence of OA was increased sharply in the age range of 11 to 19 years. This suggests that aging is not the crucial factor in the pathogenesis of OA. Overall, the trend of the high incidence in young adults is noteworthy and we need to compare the clinical and radiographic features of TMJ OA between adolescents and middle-old aged patients. For this purpose, we retrospectively reviewed clinical data and radiographs taken of two age groups (12–19 years, >45 years) with erosive bony changes of the TMJ.

The present study showed that the prevalence of OA is higher in adolescents than in middle-old aged patients. Additionally, the adolescent patients showed unilateral degenerative changes more often, and the middle-old aged patients showed degenerative changes more frequently on both sides. Gray states that OA is generally unilateral, and when bilateral involvement does occur, one side usually exhibits greater severity. Among the reasons for this phenomenon, some studies have reported a relationship between the length of the mandibular ramus, unilateral chewing and parafunctional habits such as holding, bruxing, and clenching. Ok et al. also reported that parafunctional habits are associated with an increased risk of developing OA in adolescents. Therefore, it seems likely that the occurrence of TMJ OA did not indicate age-related changes, but rather changes related to the overloading of the TMJ.

There has been controversy regarding whether clinical changes of the TMJ showed a gentle increase along with age, which was relatively high in young adults. Zhao et al. showed that radiographic TMJ osteoarthritic changes were common in adolescent and young adult patients (<30 years of age) and the occurrence of OA was increased sharply in the age range of 11 to 19 years. This suggests that aging is not the crucial factor in the pathogenesis of OA. Overall, the trend of the high incidence in young adults is noteworthy and we need to compare the clinical and radiographic features of TMJ OA between adolescents and middle-old aged patients. For this purpose, we retrospectively reviewed clinical data and radiographs taken of two age groups (12–19 years, >45 years) with erosive bony changes of the TMJ.

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### Table 6. Comparison of the time required for the alleviation of erosive bony change and subjective symptom

<table>
<thead>
<tr>
<th></th>
<th>Alleviation of erosion (mo)</th>
<th>Alleviation of subjective symptoms (mo)</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescent</td>
<td>11.77±7.19</td>
<td>8.79±6.29</td>
<td>0.607**</td>
</tr>
<tr>
<td>Middle and old</td>
<td>13.58±7.32</td>
<td>11.04±9.55</td>
<td>0.643**</td>
</tr>
<tr>
<td>p-value</td>
<td>0.038*</td>
<td>0.013*</td>
<td></td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation. p-value was determined by independent t-test, Mann-Whitney U test and means of Pearson’s correlation coefficient. *p<0.05. **p<0.01.

DISCUSSION

OA is thought to occur when the ability of the joint to adapt to excessive forces is exceeded. It has been reported that OA of the TMJ is an age-related change and occurs more frequently in older persons than in younger persons. A study by Oliveria et al. indicated that the degenerative changes of the TMJ were found in 75% of an older group (>65 years of age), and the occurrence increased sharply in those older than 40 years of age. In contrast, Jo et al. also reported that the prevalence of degenerative changes of the TMJ showed a gentle increase along with age, which was relatively high in young adults. Zhao et al. showed that radiographic TMJ osteoarthritic changes were common in adolescent and young adult patients (<30 years of age) and the occurrence of OA was increased sharply in the age range of 11 to 19 years. This suggests that aging is not the crucial factor in the pathogenesis of OA. Overall, the trend of the high incidence in young adults is noteworthy and we need to compare the clinical and radiographic features of TMJ OA between adolescents and middle-old aged patients. For this purpose, we retrospectively reviewed clinical data and radiographs taken of two age groups (12–19 years, >45 years) with erosive bony changes of the TMJ.

After 3-year follow-up, all erosion of TMJ disappeared and was converted to ‘normal’, ‘proliferative’, or ‘shortening’. In adolescent patients, erosion lesions turned into proliferative (47.1%), normal (36.8%), and shortening (16.1%) in order. In middle-old aged patients, erosion lesions turned into shortening (40.8%), proliferative (38.8%), and normal (20.4%) in order, as shown in Fig. 3. The percentage of conversion to normal was greater in the adolescents and the percentage of conversion to shortening was greater in the middle-old aged patients (p=0.004) (Fig. 3).

### Fig. 3. Comparison of longitudinal changes of erosive bony change.

Statistics were analyzed by chi-square test ($\chi^2=10.881$, p=0.004).
signs and symptoms have effects on radiographic findings. There were several previous studies that indicated a poor correlation between TMJ OA and the signs and symptoms of TMD. Wiese et al.\textsuperscript{21} reported that pain was not associated with an increased risk of degenerative findings in TMJ tomograms. However, Muir and Goss\textsuperscript{20} showed that there is an increased frequency of radiologic morphologic changes in the TMJ of patients with pain in that area when compared with patients without symptoms, and erosion was the most common finding in the pain (symptomatic) group at all ages. Roh et al.\textsuperscript{21} reported that 78% of subjects with erosion reported pain as their chief complaint, and TMJ pain was associated with the erosion of the TMJ. Yamada et al.\textsuperscript{24} found that erosive bone change was usually accompanied by pain and difficulty in mouth opening. In accordance with these studies, our study founded that 76.3% of adolescents and 83.0% of the middle-aged group with erosion reported pain as the chief complaint, and limited mouth opening was observed in the subjects with erosion. MCO was significantly less in the middle-aged patients. This reduction of jaw movement seems to have been caused by the atrophy of masticatory muscles and the reduced elasticity of connective tissues in the TMJ due to aging.

A number of studies have found that bony changes in TMJ OA are correlated with pain and other clinical signs and symptoms.\textsuperscript{25,26} de Leeuw et al.\textsuperscript{27} showed that a significant decrease in signs of OA can be obtained with conservative treatments based on 30-year follow-up data. Recently, Lee et al.\textsuperscript{28} showed that the improvement of clinical signs and symptoms was not related to the longitudinal bony changes in TMJ OA. This present study evaluated TMJ OA patients presenting with erosive bony changes, significantly associated with subjective symptoms. As a result, clinical symptoms and condylar bony changes were significantly improved after conservative treatment.

The results of this study indicated that the mean periods of the alleviation of subjective clinical symptoms and erosion were 10 months (10.36±6.70 months) and 12 months (12.33±6.87 months), respectively, and the state remained relatively stable. Additionally, there was a positive correlation between the time required for the alleviation of subjective pain and erosion. In the adolescent patient, the loss of erosion and subjective symptoms were in significantly shorter periods than the middle-aged aged patients, and the erosive bony changes were more likely to improve than in middle-aged aged patients after conservative treatment. This implies that adaptation and compensation, are the primary mechanisms to overcome the many adverse influences imposed on the joint, which occur differently with age.

The TMJ has a capacity to proliferate and adapt morphologically to various mechanical stresses. Persistent overloading can exceed the tissue’s adaptive capacity and exhaust the compensatory mechanisms. A return to normal functional loading restores these changes. With aging, it appears that the adaptive and regenerative capacity of the articular tissues of the TMJ declines and the reductions in cell proliferation and matrix synthesis are permanent. Degenerative changes that occur at an increasing frequency with age most likely reflect the reduced synthetic capacity of these aged tissues.\textsuperscript{8,26} In contrast, the TMJ in adolescents is capable of growth adaptation. However, if there is sustained or repetitive adverse loading of the condyles from oral parafunctional habits or postural imbalances before the cortical bone has matured, dysfunctional remodeling of the condyles may occur, leading to OA.\textsuperscript{20} Finally, in younger people, adaptation is based on a combination of growth, modeling, and remodeling. In adults, because growth is no longer occurring, adaptation depends primarily on modeling and remodeling processes.\textsuperscript{30}

Different signs of TMJ OA may represent different stages of the disease. Erosion lesions may indicate acute or early changes, whereas sclerosis, flattening, and osteophytes may indicate late changes in the TMJ.\textsuperscript{17} There are only a few reports on the longitudinal bony changes of TMJ OA. Of these, Ko et al.\textsuperscript{14} studied condylar bone changes of OA patients using CBCT for 10 months and reported that the transition of erosion was distributed as erosion (54.7%), flattening (17%), and normal (13.2%), in that order. In our study, the transition of the erosive bony changes was observed long-term, and all erosion of the TMJ disappeared after conservative treatments. In most adolescent patients, a proliferative change (47.1%) or normal condylar appearance (36.8%) was seen at the last CBCT examination. However, in the middle-aged aged patients, the condyle was markedly diminished in size (40.8%) and altered in shape (38.8%) because of the erosion of the condylar head. This result is also considered that it is a result of adaptation and compensation by growth.
In conclusion, our retrospective study indicated that the clinical and radiographic features of TMJ OA are a significantly different between the adolescent and middle-aged patients. In the adolescent patients, the period of alleviation of subjective clinical symptoms and erosion was shorter than that of the middle-aged aged patients. Additionally, the improvement rate of erosion bony changes was significantly higher in adolescent patients, and the transition of the erosive bony changes was significantly different between the adolescents and the middle-aged aged group. These results imply that the adaptation and compensation of TMJ occur differently with age, and these differences relate to TMJ growth adaptations. Therefore, it seems likely that the occurrence of TMJ OA did not indicate age-related changes, but rather the results of an adaptive process to overloading. However, the difference by age of the adaptive and regenerative capacity of TMJ affects the prognosis of TMJ OA and adolescent patients have a better prognosis after treatment. In the present study, the qualitative analysis of bony changes of TMJ OA has been performed. Further studies should consider the quantification of bony changes in TMJ OA based on a larger sample and will provide a better understanding of TMJ OA.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES


