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<Original Article>

Bone Changes in the Condylar Head and Mandibular Fossa in Patients with Temporomandibular Disorders —Helical CT Observation—

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Key words: type IV temporomandibular disordes (TM disotders), condylar head, mandibular fossa, Helical CT, bone change

ABSTRACT

Objectives: In the present study, we investigated whether bone changes are present in sites impossible to observe by panoramic X-ray and Schüller's X-ray examination, namely the medial of the condylar head and mandibular fossa, in patients with type IV temporomandibular joint disorders. We observed the articular fossa using computed tomography, which is able to obtain detailed 3-dimensional information, in patients with type IV temporomandibular disorders.

Methods: We examined 120 joints of 60 patiens who visited the Department of Oral Surgery, Osaka Medical College Hospital,. Each condylar head was clearly visualized in panoramic X-ray and Schüller's X-ray examination findings, and shown to have possible changes unilaterally. Each joint was diagnosed as type IV, according to the diagnostic guidelines set by Japanese Society for Temporomandibular Joint, and further examined using helical CT.

Results: *Changes in condylar head*; We concluded that bone changes were present with considerable probability in the medial of condylar head in a manner similar to those found in the lateral and center of joints with type IV temporomandibular disorders. *Changes in mandibular fossa*; The bone changes occurred in various locations of the mandibular fossa, while they appeared significantly more frequently in the condylar head.

Conclusion: We think that our finding will contribute to development of treatment strategies for temporomandibular disorders, as they clarify bone changes in sites previously unreported.

INTRODUCTION

Recently, recognition of temporomandibular disorders (TM disorders) has been increasing in Japan along with increasing occurrence. In 1996, the Japanese Society for Temporomandibular Joint announced

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Table 1 Classification and procedure of diagnosis for temporomandibular disorder (The Japanese Society for Temporomandibular Joint)

Type of Arthrosis	Type of Disorder	Procedure of diagnosis
Type Ⅰ	masticatory muscle disorders	3
Type Ⅱ	capsule-ligament disorders	4
Type Ⅲ	disc disorders	2
Type Ⅳ	degenerative joint disorders, osteoarthritis	1
Type Ⅴ	not included in Type Ⅰ～Type Ⅳ	5

a disease concept of TM disorders and defined it as, "comprehensive diagnosis of a chronic disease with major symptoms of pain in the temporomandibular joint and masseter muscle, articular noise, and lock-jaw or jaw movement abnormality, which includes a pathology of masseter muscle disorder, disorder of the articular capsule and ligament, articular disc disorder, and osteoarthritis." Prior to that statement, in 1986 the society suggested classification of TM disorders, in which the disease was divided into 5 types. That classification was revised to the current provision in 2001 (Table 1) [1].

According to the guidelines of the society, type IV TM disorders is first diagnosed using a procedure for diagnosing the TM disorders, namely by classifying the type. Clinical diagnosis of type IV TM disorders depends on image analysis. Accordingly, it is important to understand bone changes in the condylar head shown by various imaging modalities and there have been many reports of findings in the condylar head that forms the temporomandibular joint. However, in panoramic X-ray examinations used in daily clinical practice, only bone changes in the lareral slope and center of the condylar head, but not the medial, can be normally obtained, as the X-ray bundle is projected at a slant to the long axis of the mandible. Furthermore, it is extremely difficult to reveal medial findings even when using Schüller's X-ray examination method. Accordingly, studies of bone changes inside the condylar head are scarce. Moreover, for changes in the mandibular fossa, which is located on the opposite side via the articular disk, bone changes are impossible to observe closely by panoramic X-ray and Schüller's examination results, as the zygomatic arch and skull base overlap, which is inferred by the absence of reports on bone changes in the medial of the condylar head and mandibular fossa [2]. However, since type IV TM disorders is presently diagnosed by panoramic X-ray and Schüller's examination findings, additional detailed reports are considered necessary.

In the present study, we investigated whether bone changes are present in sites impossible to observe by panoramic X-ray and Schüller's X-ray examination, namely the medial of the condylar head and mandibular fossa, in patients with type IV TM disorders. We observed the mandibular fossa using multiplanar reconstruction (MPR) images obtained by computed tomography (CT) in patients with type IV TM disorders.

SUBJECTS and METHODS

Subjects

We examined 120 joints of 60 patients (6 males, 54 females; mean age 47±17.3 years, range 16-84 years) who visited the Department of Oral Surgery, Osaka Medical College Hospital, suspected of having TM disorder in the 5-year period from January 2004 to December 2008. Each condylar head was clearly visualized in panoramic X-ray and Schüller's X-ray examination findings, and shown to have possible changes unilaterally (n=13) or bilaterally (n=47). Each joint was diagnosed as type IV TM disorders, according to the diagnostic guidelines set by Japanese Society for Temporomandibular Joint, and further examined using helical CT.

Patients with foundamental underlying diseases such as osteoporosis and bone system disease were excluded. Moreover, for the purpose of eliminating the effects of tooth eruption and loss, subjects with permanent dentition and without molar loss were investigated. When the molar teeth were missing, appropriately fitted artificial dentition was the prerequisite.

Diagnosis of type IV temporomandibular disorders

Diagnoses were made on the basis of clinical findings and image analysis. For the clinical findings, at least one or more symptoms of articular pain (pain at the time of mouth opening or on pressure), lock-jaw (protrusive movement disorder of the condylar

head), or articular noise (crepitation) were demonstrated. For the panoramic X-ray findings and Schüller's X-ray examination findings, localized proliferation of radio-opacity in the marginal region, absorbable changes accompanied by bone cortex rupture, and shrinkage of the condylar head accompanied by absorbable changes were demonstrated. Based on those findings, the joints were diagnosed as having type IV TM disorders (Figure1). Three oral surgeons engaged in the treatment of TM disorders for over 6 years each made the clinical diagnoses, with the final diagnosis was determined by agreement of two or more.

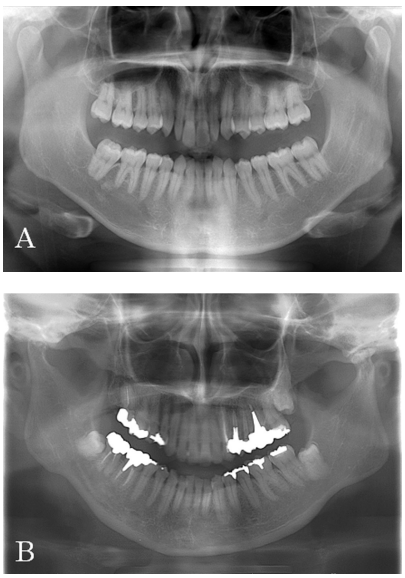

Figure 1 Panoramic radiograph of normal condylar head (A)
Panoramic radiograph of Type Ⅳ(bilateral degenerative joint diseases)
Severe deformities were observed in bilateral condylar head (B)

Analysis of panoramic X-ray and Schüller's X-ray examination finding

The device used for the panoramic X-ray examinations was a Morita PANEX (MORITA Corporation, Kyoto, Japan). To obtain images, the Frankfurt plane was set parallel to the floor surface and the main axis of the X-ray bundle was set parallel to the occlusal plane. Since image acquisition at the intercuspal position superimposes the mandibular fossa with the condylar head, possibly preventing sufficient observation, the image was taken at the edge-to-edge bite or with a bite block. For Schüller's X-ray examination, the images were taken at the positions of mouth closing (intercuspal position) and maximum mouth opening.

CT imaging and analysis

A Toshiba helical device (Toshiba Corporation, Tokyo, Japan) was used for CT imaging. For acquisition of images, the reference line was set parallel to the occlusal plane. The X-ray tube current was set at 150 mA, tube voltage at 130 kV, beam width at 1 mm, and table movement speed at 1 mm/second. Helical scanning was performed at a speed of 1 rotation/second. The computer was a Sun Spark 20 (Sun Microsystems, Palo Alto, CA) workstation, equipped with a Toshiba image analysis device software, and the Xtension and Tooth Pix automated clinical system for dentistry. The MPR image vertical to the long axis of the condylar head and the oblique image cuts vertical to it were continuously observed at 1-mm intervals.

Observations of condylar head and mandibular fossa

Observations of the sagittal section were made using oblique cuts and axial images of the condyar head (Figure2,3). For the mandibular fossa, the area from the articular tubercle anterior to the posterior

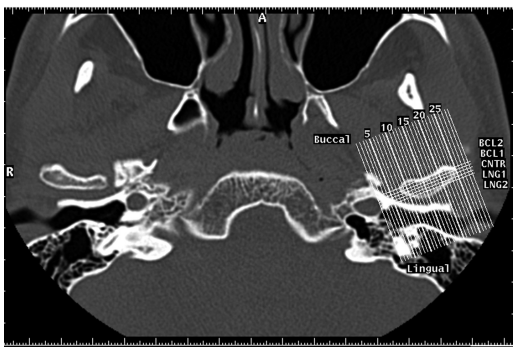

Figure 2 Axial image of the level of condylar head

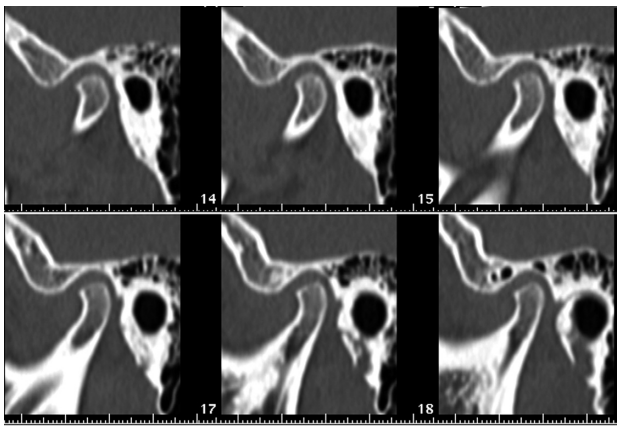

Figure 3 Oblique cut image (sagittal)

Table 2 Radiographic classification of temporomandibular disorders by Uemura

Uemura's Classification of Condylar Head	
1. Eburnation	6. Flattening
2. Sclerosisi	7. Marginal proliferation
3. Erosion	8. Loss of bone density
4. Concavity	9. Calcified body
5. Deformity	

tubercle was observed. For the condylar head, the continuous area from the lateral pole to the medial pole was examined. Bone changes in the condylar head were classified in accordance with the report of Uemura and also those in the mandibular fossa were classified according to the report of Uemura [3](Table 2). The condylar head and the mandibular fossa were divided into three equal points, namely lateral,center and medial, then were observed. Three oral surgeons engaged in the treatment of TM disorders for over 6 years each analyzed the images, with diagnosis determined by agreement of two or more.

For statistical analysis, a χ^2 test was done using a statistical arithmetic program (ystat2006) with Microsoft Excel. Results showing $p<0.05$ were considered to be statistically significant.

RESULTS

Changes in condylar head

Bone changes related to the condylar head were observed in 107 (89.2%) of the 120 joints examined in the 60 patients, while no changes were observed in 13 patients. A single change was observed in 81 joints and multiple changes were seen in 26 joints. When the location of the changes was classified into 3 groups, namely, the lateral, center and medial areas, according to the oblique cuts images, joints with changes in the center were predominant, (n=101, 84.2 % of 120 joints), followed by those with changes in the lateral areas (n=81, 67.5%) and those with changes in the medial areas (n=75, 62.5%)(Table 3).

The most frequent change observed was erosion, followed in order by deformity and flattening. Erosion was observed in 81 joints (67.5%), of which 55 had erosion alone, 10 had erosion with marginal proliferation or deformity, 2 had erosion with eburnation and marginal proliferation or erosion and con-

Table 3 Changes in condylar head
Bone changes were present with considerable probability in the interior of condylar head. The most frequent change observed was erosion followed by flattening.

	Number of joints	Lateral	Center	Medial
Eburnation	0	0	0	0
Erosion	55	42	54	34
Concavity	4	2	2	1
Deformity	8	7	7	7
Flattening	10	9	10	10
Marginal proliferation	3	0	3	0
Calcified body	1	0	1	0
Erosion+Eburnation	1	1	1	1
Erosion+Marginal proliferation	10	9	10	9
Erosion+Deformity	10	7	8	9
Erosion+Calcified body	1	1	1	0
Erosion+Eburnation+Marginal proliferation	2	2	2	2
Erosion+Concavity	2	1	2	2
Normal	13	0	0	0
Total	120	81	101	75

n=120

cavity, 1 had erosion and eburnation, and 1 had erosion and a calcified body. Deformity was observed in 18 joints (15%), while marginal proliferation and flattening were seen in 15 (12.5%) and 10 (8.3%), respectively (figure 4,5).

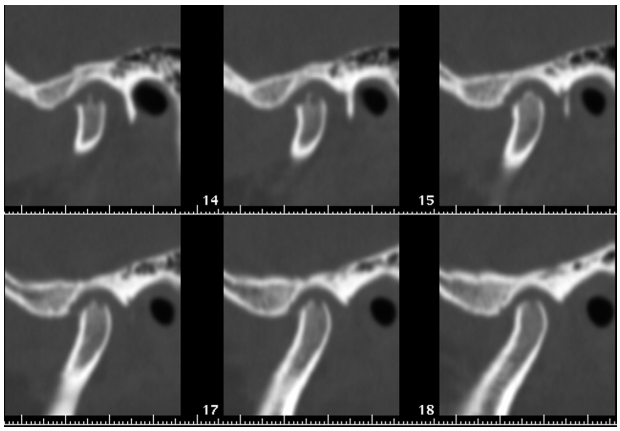

Figure 4 Oblique cut image (sagittal)
The most frequent change in condylar head was erosion.

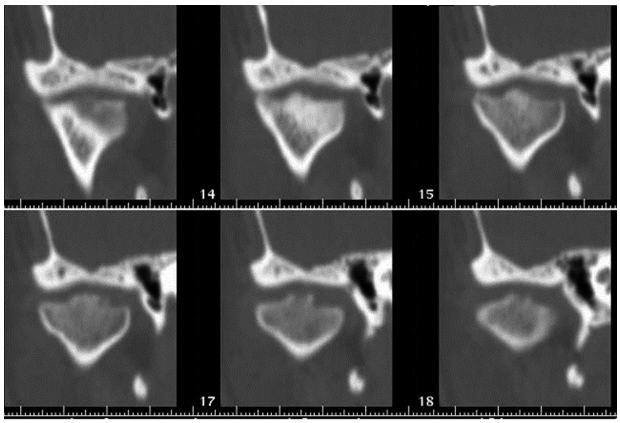

Figure 5 Obique cut image (coronal)
57 condylar heads showed bony changes (erosion) were in center and medial portion

We also classified the location of those changes. For erosion, 63 joints had changes in the lateral areas, while 54 showed changes in the center areasand 57 in the medial areas. As for flattening, in the lateral, center and medial areas, 9, 10, and 10 joints, respectively, showed such changes, while 14, 15, and 16 joints, respectively, showed changes related to deformity in those locations.

Based on these findings, we concluded that bone changes were present with considerable probability in the medial areas of the condylar head in a manner similar to those found in the lateral and center areas of joints with type IV TM disorders.

Changes in mandibular fossa

Bone changes related to the mandibular fossa were observed in 73 (60.8%) of 120 joints examined in the 60 patients, while no changes were observed in 47 joints. A single bone change was observed in 66 joints and multiple changes were seen in 7 joints. Multiple changes were observed significantly more frequently in the condylar head. In the oblique cuts images, bone changes were seen in the lateral areas of 38 (31.7%) joints, and in the center and medial areas of 65 (54.2 %) and 21 (17.5%), respectively. Thus bone changes were observed significantly more frequently in the center as compared to the other locations.

For all locations, bone changes were significantly less frequent in the mandibular fossa than in the condylar head. The most frequent change was erosion, followed by eburnation and flattening (Figure 6). Erosion was observed in 67 joints (55.8%), while 60 joints had erosion alone, and 7 joints had erosion and eburnation. Moreover, eburnation was observed in 9 joints, with flattening alone seen in 4 and eburnation in 2 (Table 4).

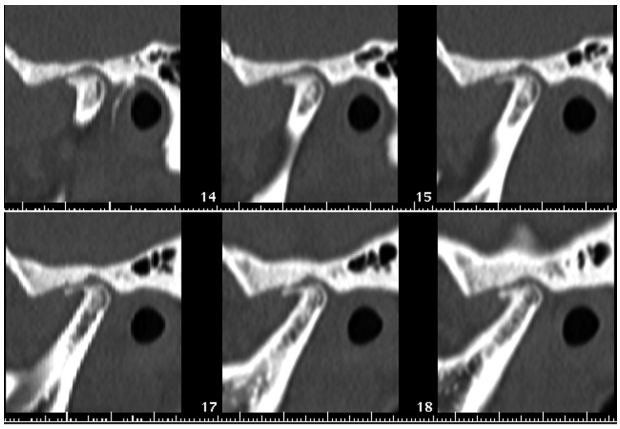

Figure 6 Oblique cut image (sagittal)
Eburation was observed in mandibular fossa
(Marginal proliferation was observed also in condylar head)

These results indicated that bone changes occurred in various locations of the mandibular fossa, while they appeared significantly more frequently in the condylar head (Figure 7,8).

Table 4 Changes in mandibular fossa.
Three changes were seen in mandibular fossa. The most frequent change was erosion, followed by eburnation and flattening.

	Number of joints	Lateral	Center	Medial
Eburnation	2	3	4	2
Erosion	60	31	55	15
Flattening	4	1	2	2
Erosion+Eburnation	7	3	4	2
Normal	47	0	0	0
Total	120	38	65	21

n=120

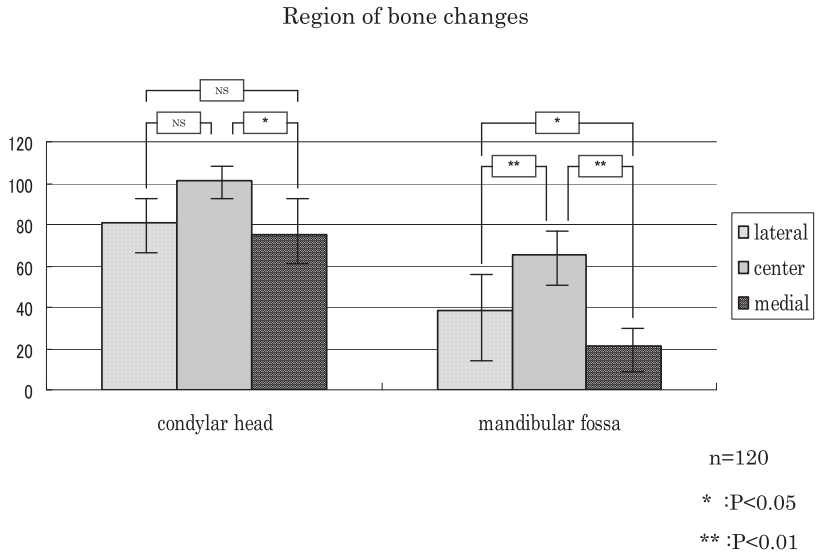

Figure 7 Bone changes were most frequently observed in the middle third of the condylar head and madibular fossa.

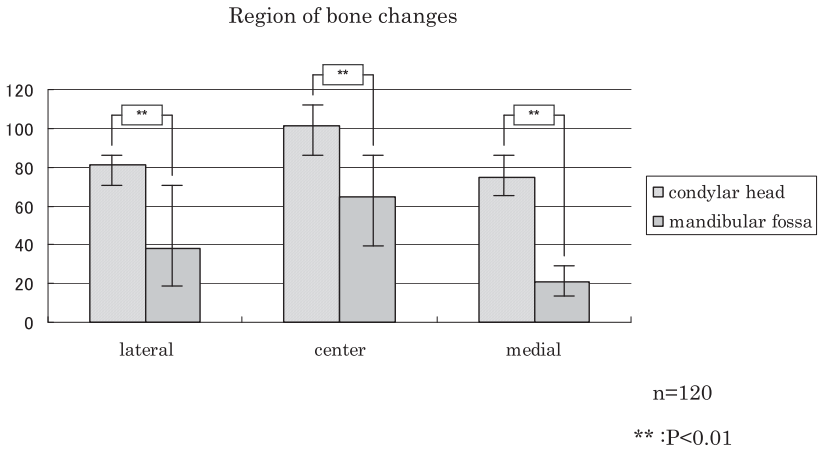

Figure 8 The bone changes appeared significantly more frequently in the condylar head than in mandibular fossa.

DISCUSSION

Temporomandibular disorders (TM disorders) is comprehensive diagnosis of a group of chronic diseases, with major symptoms including pain in the temporomandibular joint and masseter muscle, articular noise, lockjaw, and mandibular movement abnormality. The Japanese Society for Temporomandibular Joint classified the pathology into 5 types, as follow: disorder of the masseter muscle (type I), disorder of the articular capsule and ligament (type II), articular disc disorder (type III), osteoarthritis (type IV), and other disorders not classifiable as category I-IV (type V). For determining type, it has been proposed to classify type IV first, as shown in Table 1. For diagnosis of type IV TM disorders, diagnostic imaging is especially important [4]. However, the rate of correct diagnosis for panoramic X-ray imaging is reported to be 78% and that for Schüller's X-ray examination ranges from 50-60%. Both are frequently used for screening in daily clinical practice, though it is not uncommon to encounter cases that are difficult to diagnose. Furthermore, it is extremely difficult to reveal the conditions inside the condylar head and mandibular fossa by those imaging modalities. Although CT [5-10] and MRimaging [11-14] examinations have been recently applied, including a number of reports of the morphology of the condylar head, there is no known report of findings from the medial areas of the condylar head or mandibular fossa [15]. Moreover, superimposition of the zygomatic bone and skull base make the image extremely unclear when observing the mandibular fossa. Accordingly, in the present study we performed observations of the interior of the condylar head and mandibular fossa using helical CT findings.

It has been reported that bone changes in the condylar head are frequently located in the lateral or center areas, while those of the mandibular fossa tend to be located in the lateral areas. In the present study, we observed bone changes in the condylar head more frequently in the center areas, followed by the lateral and medial areas, though the differences in frequencies were not significant. In the medial areas, bone changes were observed in 62.5% of the cases. Accordingly, we consider that bone changes occur often in cases other than those categorized as type IV TM disorders. Although diagnostic imaging is not indispensable for types II, III, and V TM disorders, we consider other examinations to be necessary, as type IV cases might be included in those diagnosed as another type.

Uemura et al. [3] and Koyama et al. [16] reported that bone changes were frequently seen in the condylar head, whereas they did not report that finding in the mandibular fossa. In the mandibular fossa, bone changes were observed in the lateral areas, center areas, and medial areas. However, changes were significantly less frequent than in the condylar head for all locations. Regarding the cause of bone changes in the mandibular fossa in patients with TM disorders, Shimahara [17] reported that active bony outgrowths were observed in the mandibular fossa in an articular process cut-down study for observing changes in the condylar head. It has also been reported that a variety of regressive changes were observed in the condylar head of patients with type IV TM disorders [18-21].

In the present study, bone changes were observed even in the mandibular fossa in patients with type IV TM disorders. However, the cause of such changes in the mandibular fossa has not been clarified. In type IV patients, a variety of clinical symptoms are the result of regressive changes that develop in the articular disk, bone, and cartilage of the condylar head, which constitute the temporomandibular joint. Furthermore, a squeaky gritting sound in the joint, termed articular noise (crepitation), and mobility restriction of the joint accompanied by anterior dislocation of the articular disc have been reported. In the present type IV patients, in addition to changes of the condylar head, dislocation of the articular disc, perforation, and rupture developed. We speculated that resultant direct contact of the cartilage or bone surface of the condylar head and fossa, as well as the effects of a degenerated articular disc or loss of buffering action of the articular disc might be related to those changes. Additional studies are needed to elucidate the remaining unknown issues, though the present findings may help to elucidate some of the factors. In addition, diagnostic criteria set by the Japanese Society for Temporomandibular Joint would be helpful.

At present, type IV TM disorders is treated generally the same as typeⅢ disorders, as the abnormalities are mainly located in the temporomandibular disk. Thus, it is mostly treated with splint therapy. However, in type IV patients, long-term follow-up observations are usually needed, as symptoms such as arthralgia, lockjaw, and articular nurmurs can often persist for relatively long periods. This is because present treatment strategies emphasize bone changes in the condylar head in type IV disorders. It is hoped that the findings in the present study, which demonstrated a considerably high incidence of changes in the mandibular fossa, lead to the development of a suitable treatment protocol for patients with type IV TM disorders.

CONCLUSION

In the present study, we observed the condylar head and mandibular fossa in type IV TM disorders patients using helical CT and a Tooth Pix automated clinical system for dentistry. Our findings revealed changes in the medial areas of the condylar head, including erosion, deformity, and marginal proliferation. In the mandibular fossa, bone changes were observed in the lateral, center and medial areas, which included erosion and eburnation. We think that our findings will contribute to development of treatment strategies for TM disorders, as they clarify bone changes in sites previously unreported.

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