Computed tomography of the normal temporomandibular joint

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Abstract – A study was made in two parts, retrospective (I) and prospective (II), on two samples of 36 and 17 individuals, respectively, who had temporal bone CT studies for reasons unrelated to TMJ pain and dysfunction. Groups I and II had no radiographic signs of TMJ disease and Group II had neither radiographic nor clinical signs of TMJ disease. Both groups were considered to have normal joints. Joint morphometrics for the two groups (I/II) were as follows; transverse condylar dimensions were 18.5/18.1 mm. Condylar angulation averaged 24°/25° and intercondylar distance averaged 83/83 mm while extra condylar distance averaged 118/118 mm. The condyle in the sagittal plane showed a smooth and rounded form with anterior-superior joint space averaging 1.9/1.7 mm while central-superior joint space averaged 2.3/2.2 mm. The medial-horizontal joint space averaged 3.9/3.7 mm. The slope of the central portion of the articular eminence averaged 60°/60° in the sagittal plane.

Key words: anatomy; computed tomography; mandible; temporomandibular joint.

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Pain and dysfunction of the temporomandibular joints (TMJ) are not uncommon complaints in patients presenting at dental and medical clinics. Thin section computed tomography (CT) has provided new diagnostic possibilities for this large group of patients. The purpose of this retrospective study was to describe the normal TMJ as it is depicted with computed tomography.

To evaluate the CT appearance of the abnormal TMJ it is necessary to define the CT appearance of the normal TMJ. Our review of the literature has shown that while references have been made to the normal CT appearance of the TMJ, no substantiating morphometrics are presented (1, 2). Since the first paper by Soares et al. (3), interest in TMJ CT has concentrated on scan protocols and imaging of the meniscus (4-10). Several papers presented case reports, CT for facial fractures and specific research topics (11-15). Obvious variations of TMJ anat-
Table 1
Age distribution in number of individuals for Groups I and II by sex separated in three classes of approximately 20 years width. The mean (M) and standard deviation (SD) of age in years are included.

<table>
<thead>
<tr>
<th></th>
<th>21-40</th>
<th>41-60</th>
<th>61-83</th>
<th>M</th>
<th>SD</th>
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<tr>
<td>Groups</td>
<td>I/II</td>
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<td>I/II</td>
<td>I/II</td>
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<td>Women</td>
<td>4/1</td>
<td>9/4</td>
<td>9/4</td>
<td>54/55</td>
<td>18/16</td>
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<tr>
<td>Men</td>
<td>6/2</td>
<td>5/4</td>
<td>3/2</td>
<td>47/50</td>
<td>15/15</td>
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<td>Total</td>
<td>10/3</td>
<td>14/8</td>
<td>12/6</td>
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</table>

Omy and the absence of a morphometric CT description of the normal joint has led us to undertake this study.

Material and methods
Axial plane close sequence CT studies of two groups (I, II) of individuals that included the temporomandibular joints form the basis for this study. Group I (n = 36) represents a retrospective

Fig. 1. Direct sagittal view of right TMJ showing level at which measurements were made in axial plane.
study and Group II \( (n = 17) \) represents a prospective study of temporal bone scans which, for both groups, were not made specifically for the TMJ. Additionally, while there was no history taken nor any clinical examination made of Group I, Group II was examined as to any past or present TMJ symptomatology such as pain, clicking or locking. For Group II, the position of the mandible (centric occlusion with light intercuspation) was controlled whereas it was not controlled for Group I. The scans were loaded on a video display terminal (VDT) where they were evaluated for technical adequacy with respect to display of the joint elements, joint space and freedom from movement artifacts.

Criteria for selection of the two groups were as follows: 1) the scans must be in the axial plane parallel to Reid's baseline, 2) the subjects must be 21 yr or older, 3) no reports in the medical record of pain or dysfunction of the TMJ, 4) no reports of head trauma, 5) no radiographic signs of TMJ disease and 6) no craniofacial neoplastic disease. The CT scan reports and the hospital records were reviewed for indications of trauma or neoplastic disease. The distribution of age and sex of the individuals for each group is shown in Table 1.

All patients were imaged with the General Electric 8800 CT/N scanner (General Electric Co., Medical Systems Operations, Milwaukee, WI, USA) with supine positioning and axial imaging planes. The scan parameters most frequently used included the adult head calibration file, 1.2 prospective soft tissue targeting, 1.6 retrospective bone targeting, 9.6 second scan times and 1.5 mm sections. When the scan data was not retrospectively ReViewed (General Electric Co.), the extended scale video display function was selected for optimum visualization of bone.

Morphometric analysis of the right and left joints of each group was identical. All measurements and assessments in the axial plane were made at the level of the summit of the articular eminence (Fig. 1) because this level most frequently corresponds to maximum condylar dimensions. Furthermore, at this location, visualization of the soft tissue and osseous joint elements is maximized because there is no interference from adjacent bony structures, particularly the articular eminence. Assessments in the vertically reformatted coronal plane were made along the transverse axis of the condyle. Measurements in the vertically reformatted sagittal plane were perpendicular to the transverse axis of the condyle at its visually estimated center.

The antero-superior (AS) sagittal joint space was measured at the center of the condyle, as the shortest distance between the bony surfaces of the condyle and the articular eminence (Fig. 2A). This joint space represents the thin central articular portion of the meniscus as it is normally positioned between the bony joint elements in the sagittally viewed closed mouth position (Fig. 2B). Coronal centro-superior (CS) joint space was measured from the central superior portion of the condyle to the nearest point in the glenoid fossa (Fig. 2C). The medial-horizontal (MH) joint space was measured from the height of contour of the bony surface of the medial condylar pole, horizontally to the adjacent wall of the glenoid fossa.

Condylar angulation was visually estimated, then measured by deposing the cursor at the medial and lateral poles of the magnified (4.0 times) axial image and reading to the nearest \( 1/10 \)th degree directly from the VDT (Fig. 3A). Intercondylar and extracondylar distances were measured from the heights of contour of the respective condylar poles (Fig. 5B). Condylar form, in the axial plane, was assessed as either ellipsoid, concavoconvex or ovoid (Fig. 4A–C). Condylar form in the coronal plane was tabulated as one of four types according to a previous study of dry skull material (16) (Fig. 5A–D). Angulation of the articular eminence in the sagittal plane was measured directly from the film with a protractor along a visually estimated line that provide a visual best-fit of the slope (Fig. 6).

In most individuals the slope of the eminence was readily determined. In a few individuals the eminence was smoothly sigmoid over its entirety and estimating the slope was more difficult. In these cases, the slope was estimated by a tangent to the curve of the eminence. The length and angulation of the inferior bundle of the lateral pterygoid muscle in the axial plane were measured from the condylar center to the medial recess or antero-posterior midpoint of the lateral pterygoid plate and read directly from the VDT (Figs. 7A, B). Differences between sides and sexes in this study were tested for statistical significance by Student's \( t \)-test for comparing the means of two small samples and correlation to age was tested by Pearson's product-moment correlation coefficient \( (r) \).
Fig. 2. a, vertically reformatted sagittal image along antero-posterior condylar axis for determination of antero-superior (AS) joint space, form and slope of articular eminence. b, drawing made from same CT section as A illustrating relation of normal meniscus to osseous joint elements. c, vertically reformatted coronal image along transverse condylar axis illustrating central-superior (CS) and medio-horizontal (MH) joint space.

Results

The results of this study are shown in Table 2 and Figs. 4 and 5. The average transverse dimensions of the condyles in men (19.6 mm) and women (17.7 mm) in Group I were significantly different ($P<0.02$). The extra-condylar distance in men and women in Group I and II was 121 mm and 115.6, respectively, and the difference between these values was also significant ($P<0.05$). No significant differences between right and left sides and no significant correlation to age was found for any of the variables investigated.
Discussion

There is the possibility of a radiographically undetected and asymptomatic meniscal problem in Group I since no clinical examination of the TMJ was made of the individuals in this group. However, this possibility is greatly reduced in Group II, where the clinical examination should have disclosed such a problem of any clinical significance. We therefore consider the joints of the individuals in Group II to be normal from all aspects. The radiographically normal joints in the asymptomatic individuals of Group I do not differ in morphometric pattern from Group II and there is no reason therefore to suspect an asymptomatic meniscal problem of any relevance for this study.
Fig. 4. Axial plane condylar form. Relative frequency is (A) 40% elliptical, (B) 40% concavo-convex and (C) 20% ovoid.

Fig. 5. Coronal plane condylar form (according to YALE et al. (15) and relative frequency (%). I (A) 34%, II (B) 43%, III (C) 19% and IV (D) 9%.

Fig. 6. Slope and form of articular eminence was determined from vertically reformatted images. Line AB illustrates slope of eminence.

The average age of the individuals in this investigation is higher by 15 yr in women and 7 yr in men than what is seen on average in the TMJ clinic at this university. Rather than being a liability to the study, the age distribution of this population is presumed...
Fig. 7. a, length and angulation of inferior belly of lateral pterygoid muscle measured from condylar visual center (arrow) to lateral surface (arrow) of lateral pterygoid plate. b, axial image, soft tissue detail of same subject as A demonstrating deployment (dotted line) of inferior belly of lateral pterygoid muscle.
Table 2

Distribution for Groups I (n=36) and II (n=17) of mean (M), range (R) and standard deviation (SD) of condylar angulation (degrees), transverse (TR) condylar dimension (mm), antero-posterior (AP) condylar dimension (mm), antero-superior (AS) sagittal plane joint space (mm), centro-superior (CS) coronal plane joint space (mm), extracondylar distance (mm), slope of articular eminence (degrees), angle (degrees) and length (mm) of inferior belly of lateral pterygoid muscle

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>R</th>
<th>SD</th>
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<tbody>
<tr>
<td>TR condylar angulation</td>
<td>23.9/25.4</td>
<td>30.9/22.6</td>
<td>6.6/6.2</td>
</tr>
<tr>
<td>AP condylar dimension</td>
<td>18.5/18.0</td>
<td>9.2/8.0</td>
<td>2.4/2.5</td>
</tr>
<tr>
<td>AS joint space</td>
<td>1.9/1.7</td>
<td>2.5/2.1</td>
<td>0.5/0.5</td>
</tr>
<tr>
<td>CS joint space</td>
<td>2.3/2.2</td>
<td>5.3/5.2</td>
<td>0.9/1.1</td>
</tr>
<tr>
<td>MH joint space</td>
<td>3.9/5.6</td>
<td>6.0/4.0</td>
<td>1.1/1.1</td>
</tr>
<tr>
<td>Intercondylar distance</td>
<td>83.0/83.0</td>
<td>22.6/22.6</td>
<td>4.6/6.2</td>
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<tr>
<td>Extracondylar distance</td>
<td>118.5/117.5</td>
<td>28.8/28.8</td>
<td>6.8/8.2</td>
</tr>
<tr>
<td>Eminence angulation</td>
<td>59.6/60.0</td>
<td>55.0/47.0</td>
<td>12.4/11.9</td>
</tr>
<tr>
<td>Muscle angulation</td>
<td>37.8/37.9</td>
<td>14.9/14.2</td>
<td>3.1/3.7</td>
</tr>
</tbody>
</table>

The mean value for condylar angulation is comparable to studies using conventional radiographic techniques (17), however, the standard deviation is less by about 3° (a relative decrease of 33%), indicative of a more homogeneous group. Condylar angulation was not significantly correlated to age in these studies of normal individuals but has been found to be correlated to age in individuals with diseased TM-joints (18). We anticipated that we would find greater differences when we analyzed for differences between left and right sides and by sex. Surprisingly, there were significant differences in only two variables by sex, transverse condylar dimension and extra condylar distance.

The results of this study are consistent with previous reports of TMJ morphometrics for older (19) and younger (20) adults, where the mean condylar transverse dimensions were 19.8 mm and 20.5 mm, respectively. Their description of coronal and axial condylar morphology is essentially the same as that reported in this study.

It is understood that patients do not normally have CT head scans unless a disease process is suspected. However, the patients in these two samples are considered normal insofar as the temporomandibular joints are concerned and the parameters presented should therefore be valid as normal morphometric values.

References


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