A comparative study of the skeletal morphology of the temporo-mandibular joint of children and adults

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ABSTRACT

Background: The skeletal morphology of the temporo-mandibular joint (TMJ) is constantly remodeled. **Aims and Objectives:** A comparative study was undertaken to determine and characterize the differences in the skeletal morphology of TMJ of children and adults. **Materials and Methods:** The study was conducted on 30 children cadavers and 30 adult volunteers. Parameters that could reflect TMJ skeletal morphology were measured with a new technology combining helical computed tomography (CT) scan with multi-planar reformation (MPR) imaging. **Results:** Significant differences between children cadavers and adults were found in the following parameters ($P < 0.05$): Condylar axis inclination, smallest area of condylar neck/largest area of condylar process, inclination of anterior slope in inner, middle, and outer one-third of condyle, anteroposterior/mediolateral dimension of condyle, length of anterior slope/posterior slope in inner and middle one-third of condyle, anteroposterior dimension of condyle/glenoid fossa, mediolateral dimension of condyle/glenoid fossa, inclination of anterior slope of glenoid fossa, depth of glenoid fossa, and anteroposterior/mediolateral dimension of glenoid fossa. **Conclusion:** There are significant differences of TMJ skeletal morphology between children and adults.

KEY WORDS: Comparison, skeletal morphology, temporo-mandibular joint

The anatomical morphology of skeletal structures of the temporo-mandibular joint (TMJ), which include the glenoid fossa and condyle undergoes remodeling throughout life. Several studies dealing with the TMJ skeletal morphology in adults[1-7] have been reported. However, this aspect has only rarely been studied in children.[8,9] As the TMJ skeletal structures are irregular, it is difficult to describe their morphology comprehensively and accurately with traditional methods. In addition, as the methods and parameters of TMJ skeletal morphology employed differ amongst various studies, it is difficult to compare the results obtained from different studies. With the development of helical computed tomography (CT), it is now possible to measure various parameters of TMJ skeletal morphology accurately and comprehensively. By elucidating the development of TMJ from children to adults, we are able to establish the morphology foundation for further physiological and pathological studies of TMJ. The aim of this study was to study the differences of TMJ skeletal morphology between children and adults with helical CT and multi-planar reformation (MPR) technique.

Materials and Methods

Human subjects

The study was approved by the Ethics Committee of the Fourth Military Medical University (FMMU), P.R. China. Written informed consent was obtained from the volunteers prior to their enrollment. The sample size was determined by preliminary experiments and methods established by Zheng.[10] Thirty adult volunteers were randomly chosen by casting lots from 62 female and 110 male juniors and seniors of FMMU. These adult volunteers were all of Chinese Han ethnicity with normal facial development, good permanent dentition except the third molar, individual normal occlusion and no TMJ problems. Similarly, 30 child cadavers who were preserved in intercuspal position in 10% formalin for more than one year were randomly chosen by casting lots from 22 female and 20 male cadavers in the department of anatomy of FMMU. These child cadavers were also of Chinese Han ethnicity with normal facial development and normal dentition.

Helical CT scanning and data analysis

Scans were obtained with a Philips MX8000 helical CT scanner (Philips Medical Systems, USA) with the study subjects in the supine position, their heads in a neutral position, their Frankfort planes perpendicular to the horizontal plane and their mandible in the intercuspal position. An initial lateral scout view was obtained to select the superior-to-inferior extent of the scan, which ranged from the superior plane of the glenoid fossa of the temporal bone to the mandibular notch plane. Helical scans were then obtained parallel to the Frankfort plane, at 120 kV and 150 mA, with a collimation of 0.6 mm, a pitch of 0.875:1 and reconstructions every 0.2 mm. These data were then transferred to a workstation computer (Silicon Graphics Workstation, ESPII software), where MPR images were obtained and parameters that could reflect TMJ skeletal morphology were measured in corresponding MPR images [Figure 1]. The reformation plane (PR), measurement parameters and their definitions are described in Table 1.

Statistical analysis

To minimize human error, all measurements were repeated three times. Data were statistically analyzed by paired t-test (for readings taken in the same individual) and two-sample t-test. *P* values less than 0.05 were considered statistically significant.

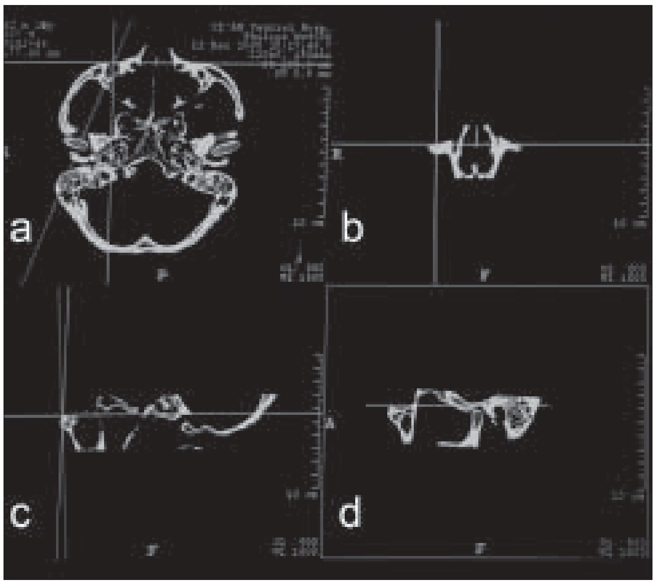

Figure 1: The process of multiplanar reformation (MPR): (a) axial plane; (b) coronal plane; (c) sagittal plane; (d) reformation plane (Frankfort plan parallel to horizontal line)

Results

Adult volunteers: 15 males, 15 females, with an average age of 22.87 ± 1.07years, ranging from 20 to 24 years. Child cadavers: 15 males, 15 females; with an average age of 4.93 ± 0.87 years, ranging from 3 to 6 years. There was no significant difference in any of the parameters between the left and right joints (paired t-test) or between the male and female subjects (two-sample t-test) of the both the groups (data not shown). Hence, further analysis was done by pooling the data in each group. Using two-sample t-test, the comparative results of the parameters of TMJ skeletal morphology between children and adults were obtained and are presented in Table 2.

As shown in Table 2, some skeletal morphological parameters of TMJ were significantly different between children and adults, and others without significant differences. In addition, some representative comparative results are shown in Figures 2-4.

Discussion

Temporo-mandibular joint is one of the most complex and subtle joints of the human body. Its skeletal morphology is influenced by age. Over the years, plain radiographs of TMJ such as trans-cranial lateral oblique radiographs,[6] panoramic radiographs[11] and tomograms[12] have been used to study the skeletal morphology of TMJ. However, the overlap of bony structures and limited slices of plain radiographs make it impossible to study the skeletal morphology of TMJ precisely and comprehensively. Such limitations can now be avoided by combining helical CT imaging with MPR techniques. This new technology is able to generate data with high resolutions,

Table 1: The reformation plane, measurement parameters and definition

Reformation plane	Parameters and definition
Sagittal RP perpendicular to the condylar ML axis and through the midpoint of condyle	AP dimension of condyle: Distance between the most anterior and posterior point of condyle
	Condylar axis inclination: Angle between condylar sagittal axis and horizontal line
Sagittal RPs perpendicular to the condylar ML axis and through the midpoint of inner, middle and outer 1/3 of condyle	AS length of inner, middle and outer 1/3: Distance between highest and most anterior point of condyle
	AS inclination of inner, middle and outer 1/3: Angle between tangent of AS and horizontal line
	PS length of inner, middle and outer 1/3: Distance between highest and most posterior point of condyle
	PS inclination of inner, middle and outer 1/3: Angle between tangent of PS and horizontal line
Sagittal RP through vertex of posterior articular eminence and midpoint of ML dimension of glenoid fossa	AP dimension of glenoid fossa: Distance between vertex of posterior articular eminence and vertex of crest of articular eminence
	AS inclination of glenoid fossa: Angle between tangent of AS and horizontal line
	PS inclination of glenoid fossa: Angle between tangent of PS and horizontal line
Sagittal RP through lowest point of articular eminence and vertex of glenoid fossa	depth of glenoid fossa: Distance between vertex of glenoid fossa and horizontal line through vertex of articular eminence
Coronal RP through lowest point of articular eminence and vertex of petrosquamosal fissure	ML dimension of glenoid fossa: Distance between the lowest point of articular eminence and vertex of petrosquamosal fissure
Transverse RP through most inner and most lateral point of condyle	ML dimension of condyle: Distance between the most inner and most lateral point of condyle
Transverse RPs perpendicular to the condylar sagittal axis	LACP: The largest area in series of larger area of condylar process
	SACN: The smallest area in series of smaller area of condylar neck

SACN: Smallest area of condylar neck; LACP: Largest area of condylar process; AS: Anterior slope; PS: Posterior slope; AP: Anteroposterior; ML: Mediolateral; RP: Reformation plane

Table 2: Comparison of morphological parameters of condyle and glenoid fossa between children and adults (Mean ± SD)

Parameters	Children (n = 30)	Adults (n = 30)	P-values (95%CI)
Condylar axis inclination (degree)	70.44 ± 4.24	80.06 ± 4.02	0.000 (−12.34, −7.31)*
SACN/LACP	0.68 ± 0.08	0.60 ± 0.09	0.012 (0.01, 0.11)*
AS inclination in inner1/3 of condyle (degree)	30.02 ± 7.04	44.24 ± 8.66	0.000 (−15.95, −6.68)*
AS inclination in middle 1/3 of condyle (degree)	28.85 ± 6.68	42.06 ± 9.04	0.000 (−17.49, −7.89)*
AS inclination in outer 1/3 of condyle (degree)	30.88 ± 8.02	45.02 ± 6.88	0.000 (−14.47, −6.06)*
AP/ML dimension of condyle	0.56 ± 0.08	0.50 ± 0.08	0.024 (0.01, 0.09)*
AS/PS length in inner 1/3 of condyle	0.93 ± 0.17	0.63 ± 0.14	0.000 (0.20, 0.38)*
AS/PS length in middle 1/3 of condyle	0.87 ± 0.12	0.63 ± 0.16	0.000 (0.14, 0.31)*
AS/PS length in outer 1/3 of condyle	1.12 ± 0.20	1.06 ± 0.24	0.114 (−0.02, 0.21)†
PS inclination in inner 1/3 of condyle (degree)	47.44 ± 7.50	49.78 ± 8.02	0.273 (−6.51, 1.87)†
PS inclination in middle 1/3 of condyle (degree)	49.02 ± 6.60	51.64 ± 6.34	0.212 (−5.52, 1.25)†
PS inclination in outer 1/3 of condyle (degree)	46.26 ± 9.82	49.45 ± 8.66	0.172 (−8.13, 1.48)†
AP dimension of condyle/glenoid fossa	0.40 ± 0.05	0.62 ± 0.09	0.000 (−0.22, 0.15)*
ML dimension of condyle/glenoid fossa	0.74 ± 0.08	0.88 ± 0.10	0.003 (−0.13, −0.03)*
AS inclination of glenoid fossa (degree)	30.02 ± 10.00	53.46 ± 12.66	0.000 (−20.54, −8.01)*
PS inclination of glenoid fossa (degree)	48.64 ± 9.60	43.88 ± 10.06	0.114 (−1.11, 10.02)†
Depth of glenoid fossa (mm)	4.24 ± 1.24	7.17 ± 1.56	0.000 (−3.23, −1.63)*
AP/ML dimension of glenoid fossa	0.80 ± 0.04	0.70 ± 0.09	0.000 (0.05, 0.13)*

SACN: Smallest area of condylar neck; LACP: Largest area of condylar process; AS: Anterior slope; PS: Posterior slope;
AP: Anteroposterior; ML: Mediolateral; *Significant difference between children and adults; †No significant difference between children and adults

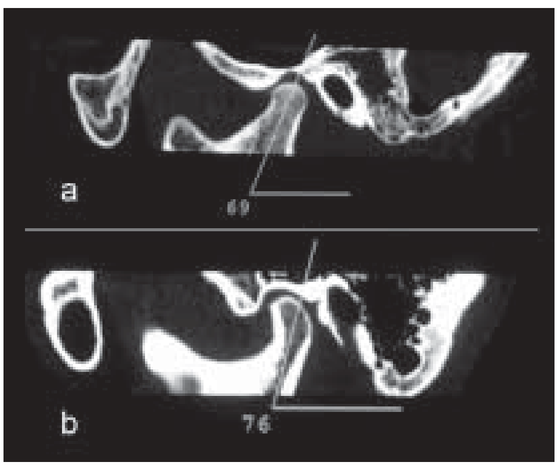

Figure 2: Condylar axis inclination on the saggital reformation plane of child (a) and adult (b)

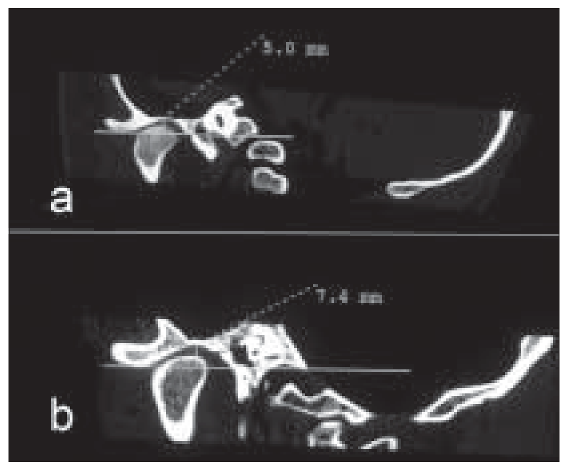

Figure 4: Depth of glenoid fossa on the coronal reformation plane of child (a) and adult (b)

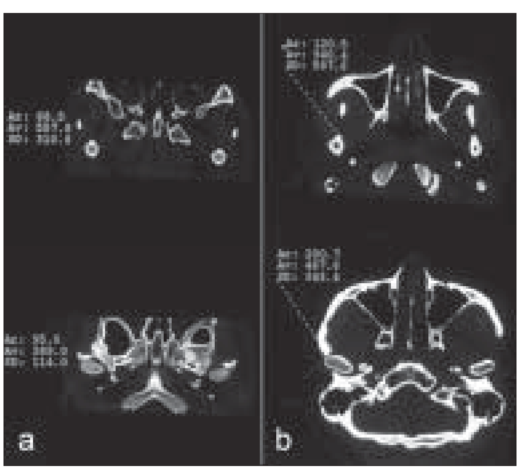

Figure 3: Smallest area of condylar neck and largest area of condylar process on the transverse reformation plane of child (a) and adult (b)

allowing precise measurement of several morphological parameters, such as the smallest area of condylar neck (SACN), the largest area of condylar process (LACP), parameters of inner, middle and outer one-third of condylar process, which cannot be obtained with plain radiographs.[13]

In our study,[14] we found that the technology combining helical CT with MPR was a simple, fast, effective and noninvasive method for the morphological evaluation of TMJ. Indeed, the value of AP/ML dimension of condyle in adults was similar to that of Xiang (0.53)[7] and Solberg (0.46),[1] although it was larger than Matsumoto (0.44),[2] probably due to the selection of different landmark points. The value of the ML dimension of condyle/glenoid fossa in adults was also similar to that of Solberg (0.93)[1] and Xiang (0.90).[7] Furthermore, the values of AS inclination of glenoid fossa in children and adults were similar to that of Katsavrias[9] but larger than that of Nickel *et al.*,[8] who measured the parameters with traditional photographs. Finally, the depth of the glenoid fossa in adults was similar to that of Xiang (7.1 ± 1.0 mm)[7] and Sato (6.9 ± 0,94 mm).[3]

Our data revealed that there were significant differences of TMJ skeletal morphology between children and adults and that TMJs in adults were not simply magnifications of those in children. These morphological descriptions established the foundation for further physiological and pathological studies of TMJ. In addition, these data also suggested different strategies to manage TMJ diseases in children and adults. For example, we found that the shape of condyle of children was almost round (AP/ML dimension of condyle of children was bigger than that of the adults) and smaller compared to glenoid fossa (AP dimension of condyle/that of glenoid fossa and ML dimension of condyle/that of glenoid fossa of children were smaller than that of adults) and that glenoid fossa in children was flat compared to that in adults (depth of glenoid fossa of children was shallower than that of adults and AS inclination of glenoid fossa of children was smaller than that of adults, but PS inclination of glenoid fossa of children was similar to that of adults). Such differences explain why children's TMJs are more flexible and prone to dislocate than those of adults. Moreover, we also found that the condylar neck of children was less shrunken compared to the condylar process (SACN/LACP of children was bigger than that of adults) and that the condylar axis inclination in children was smaller than that in the adults. Such characteristics predispose children to intracapsular fracture of the condyle when a devastating trauma transfers to condyle from mandible. This is consistent with the previous report[15] that more than half condylar fractures are intracapsular in patients less than five years old.

The study of TMJ skeletal morphology in both children and adults uncovered the characteristics of TMJ skeletal morphology. Such a study could be extrapolated to examine TMJ skeletal morphology in patients with various TMJ diseases for accurate diagnosis and effective treatments.

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