# Mandibular condyle dimensional changes in subjects from 3 to 20 years of age using Cone-Beam Computed Tomography: A preliminary study

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## Abstract

**Introduction:** Cone-Beam Computed Tomography (CBCT) imaging provides an excellent representation of the temporomandibular joint bone tissues. **Objective:** The aim of this study was to investigate morphological changes of the mandibular condyle from childhood to adulthood using CBCT. **Methods:** A cross-sectional study was conducted in 36 condyles of 18 subjects from 3 to 20 years of age. Condyles were scanned with the i-CAT Cone-Beam 3D imaging system and linear dimensions were measured with a specific i-CAT software function for temporomandibular joint, which permitted slices perpendicular to the condylar head, with individual correction in function of angular differences for each condyle. The greatest distances in lateral and frontal sections were considered on both left and right mandibular condyles. **Results:** The linear dimension of the mandibular condyle on the lateral section varied little with growth and seemed to be established early, while the dimension of the frontal section increased. Small asymmetries between left and right condyles were common but without statistical significance for both lateral (P=0.815) and frontal (P=0.374) dimensions. **Conclusions:** The condyles were symmetric in size and only the frontal dimension enlarged during growth. These preliminary data suggest that CBCT is a useful tool to measure and evaluate the condylar dimensions.

**Keywords:** Mandibular condyle. Cone-Beam Computed Tomography. Morphology. Temporomandibular joint.

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## INTRODUCTION

The mandibular condyle (or head), besides joint function, acts as a site of regional adaptive growth even under functional load supported by its cartilage.[8] Mandibular condyle morphology is characterized by a rounded bone projection with an upper biconvex and oval surface in axial plane.[24] Typically, the antero-posterior dimension (or lateral) is shorter than the medial-lateral (or frontal), whose ends are called medial and lateral poles.

A normal variation of the condylar morphology occurs with age,[13,24] gender,[24] facial type,[5] functional load,[7] occlusal force,[16] malocclusion type[14] and between right and left sides.[5,7,16,24] The most prevalent morphologic changes are detected in the temporomandibular joints (TMJ) of elderly persons[20] due to the onset of joint degeneration, and that is probably the reason of greater focused study.[2,13,20]

TMJ morphology has been studied on dry and autopsy human skulls,[13] histology,[13] radiographic exams,[12,13] magnetic resonance[1], traditional computed tomography[12] and Cone-Beam Computed Tomography (CBCT)[12,18] methods. Although the panoramic radiograph has been widely employed in clinical environment, it has limitation to evaluate the accuracy of condylar morphology and to reveal minor osseous change[4]. For this reason panoramic radiographs should be used with caution when performing linear measurements.[12,17] CBCT images provide an excellent representation of TMJ bone tissues, despite the variation in bone density and composition. Studies have shown that CT images can be remarkably accurate for linear,[3,18,19] geometric,[19] and volumetric[22] measurements within the maxillofacial complex. The high potential for clinical application and the accuracy of CBCT compared to other radiologic techniques have contributed in treatment planning, diagnosis, therapeutic and prognosis of different diseases.[2,9-12]

The aims of the present study were to investigate dimensional changes in the mandibular condyle presenting normal growth from infancy to adulthood in different subjects, and to evaluate possible asymmetries in size between right and left sides using CBCT images.

## MATERIAL AND METHODS

### Imaging Selection

This study was developed with the data of private radiology clinics (CIRO, Goiânia, GO, Brazil, RIO, Brasília, DF, Brazil, CROIF, Cuiabá, MT, Brazil) based on dentomaxillofacial records selected from 18 subjects, one of each age (13 males and 5 females, with ages between 3 and 20 years old, 18 right and left mandibular condyles) between May 2007 and May 2010. The subjects were referred to the dental radiology service for different diagnosis purpose. The involved sample had essentially normal condylar morphology with preserved cortical bone. The exclusion criteria included images where the patients had: condylar fracture, TMJ ankylosis, tumors, hyperplasia, condylar resorption and absence of posterior teeth.

The study design was approved by the Local Ethics Research Committee of Federal University of Goiás (Proc.#169/2008).

### Imaging Methods

All subjects were seated during the exam and were oriented to have their heads positioned with the Frankfurt horizontal plane parallel to the floor.

The CBCT scans were taken with an i-CAT Cone-Beam 3D Imaging System (Imaging Sciences International, Hatfield, PA, USA) Volumes were reconstructed with a 0.2 mm isometric voxel size, tube voltage was 120 kVp and the tube current 3.8 mA. The exposure time was 40 seconds. Images were examined with the scanner´s proprietary software (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) in a PC workstation running Microsoft Windows XP professional SP-2 (Microsoft Corp, Redmond, WA, USA) with an Intel (R) Core 2 Duo 1.86Ghz-6300 processor (Intel Corporation, USA), a NVIDIA GeForce

6200 turbo cache video board (NVIDIA Corporation, USA) and an EIZO – Flexscan S2000 monitor with a 1600x1200 pixels resolution (EIZO NANAO Corporation Hakusan, Japan).

### Imaging Measurements

Images of the temporomandibular region were adjusted considering the inclination and position of the central region of the mandibular condyle in lateral and frontal sections. Measurements with a specific TMJ tool were made, which permitted slices perpendicular to the condylar head, with individual correction in function of condyle angulation.

The method used to assess condylar morphology was based on the delimitation and measurement of the distance between anatomical landmarks, considering the greatest distances in the lateral and frontal views of condylar images. The anatomic landmark definitions and linear measurements were similar as proposed by Schlueter et al,[22] criteria and were defined as follows (Fig 1):

» **M** (medial condylar surface): most medial point of the mandibular condyle on the frontal view.

» **L** (lateral condylar surface): most lateral point of the mandibular condyle on the frontal view.

» **A** (anterior condylar surface): most anterior point of the mandibular condyle on lateral view.

» **P** (posterior condylar surface): most posterior point of the mandibular condyle on lateral view.

» **M-L** (condylar width): the distance between M and L landmarks, corresponding to the largest dimension of the mandibular condyle on frontal view.

» **A-P** (condylar length): the distance between A and P landmarks, corresponding to the largest dimension of the mandibular condyle on lateral view.

A specific function of the i-CAT software (Xoran version 3.1.62; Xoran Technologies, Ann Arbor, MI, USA) was used to measure these distances in millimeters. The measurements were made by the same radiologist.

### Method Error

In order to determine the intra-operator measurement reliability for condylar dimensions, these were measured twice with a two-week interval by the same radiologist. Significance testing for linear measurement differences was accomplished using paired Student t-test.

### Statistical Analysis

All data were entered into Excel 2003 (Microsoft, Redmond, WA, USA). The statistical analyses were carried out with SPSS (version 15.0, SPSS, Chicago, IL, USA) for Windows. Average values and standard deviations were computed

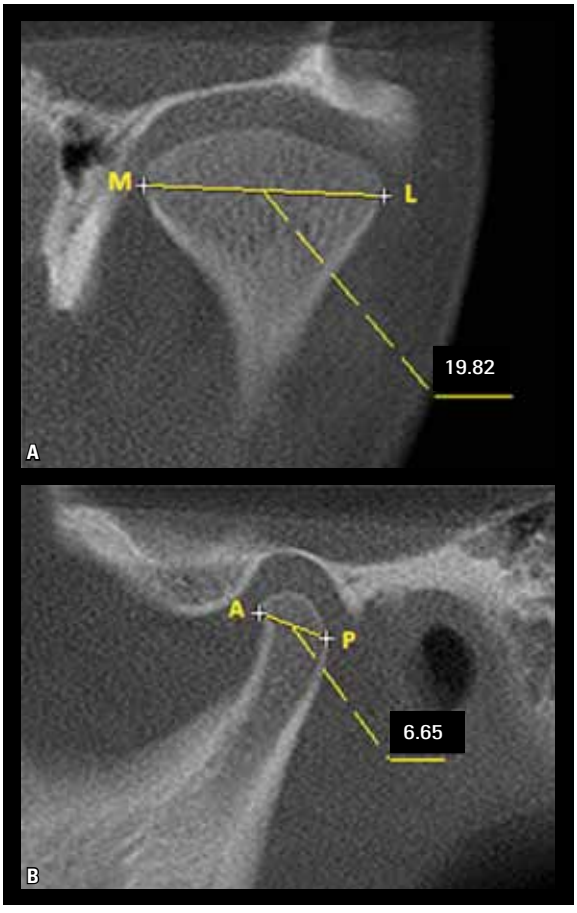


FIGURE 1 - Anatomic landmarks and linear measurements on frontal (**A**) and lateral (**B**) views of the left mandibular condyle (M: medial; L: lateral; A: anterior; P: posterior).

separately for right and left condyles in lateral and frontal sections. Differences for right and left condyles in lateral dimensions were tested using Mann-Whitney test and for frontal dimension a non-paired Student t-test.

## RESULTS

Linear measurements of the mandibular condyles on lateral and frontal sections are presented in Table 1. The values for intra-operator reliability were similar with no statistical difference, indicating agreement for the lateral (right, P= 0.322; left, P= 0.294) and the frontal (right, P= 0.909; left, P= 0.856) duplicated measurements.

There were no significant differences between right and left mandibular condyles for lateral (P=0.815) and frontal (P=0.374) sections. Figures 2 and 3 show mandibular condyle sequences on CBCT imaging between 3 to 20 years of age and the behavior of morphological changes with time is presented on Figure 4.

TABLE 1 - Condylar linear measurements (mm) in relation to age.

| Age | Right Condyle (RC) | | Left Condyle (LC) | |
|---|---|---|---|---|
| | A-P | M-L | A-P | M-L |
| 3 years | 7.52 | 12.60 | 7.50 | 12.61 |
| 4 years | 7.06 | 13.77 | 7.25 | 13.68 |
| 5 years | 7.03 | 15.58 | 6.79 | 14.49 |
| 6 years | 8.73 | 13.65 | 9.22 | 13.82 |
| 7 years | 8.54 | 17.69 | 8.99 | 16.45 |
| 8 years | 8.36 | 19.43 | 8.77 | 19.85 |
| 9 years | 7.47 | 18.64 | 7.47 | 18.45 |
| 10 years | 8.83 | 16.88 | 8.94 | 15.48 |
| 11 years | 9.22 | 17.84 | 8.94 | 16.48 |
| 12 years | 7.72 | 20.25 | 6.84 | 19.80 |
| 13 years | 7.82 | 17.89 | 7.20 | 15.01 |
| 14 years | 9.06 | 17.42 | 9.04 | 16.42 |
| 15 years | 6.62 | 19.27 | 6.46 | 18.49 |
| 16 years | 8.68 | 20.54 | 8.81 | 21.16 |
| 17 years | 7.42 | 20.08 | 6.85 | 17.60 |
| 18 years | 6.83 | 21.42 | 6.61 | 19.55 |
| 19 years | 8.29 | 21.00 | 8.22 | 20.28 |
| 20 years | 9.18 | 20.81 | 8.94 | 20.67 |

Lateral: (RC) P=0.322; (LC) P=0.294 / Frontal: (RC) P=0.909; (LC) P=0.856.

## DISCUSSION

The mandibular condyle is one of the main sites of facial growth, which is expressed in an upward and backward direction.[8] The present study did not aim to quantify the participation of condylar growth on total mandibular growth but, instead, assess in a cross-sectional study the local morphological changes of the mandibular condyle during growth using CBCT images. The results showed that the lateral dimension (A-P) seemed to be established early and to vary a little with age, while the frontal dimension (M-L) increases (Fig 4). Therefore, the mandibular condyle develops by a remodeling process and replaces itself by preserving its lateral dimension and enlarging laterally.

Rodrigues et al[21] investigated the diameter of the right and left condyles in subjects aged 13 to 30 years old. All subjects presented Class I malocclusion and were evaluated by computed tomography. Mean sagittal (lateral) dimensions for right and left condyles were, respectively, 9.39 mm and 9.30 mm, and for mediolateral (frontal) 20.62 mm and 20.57 mm with no statistically significant differences between right and left condyles. The lateral dimensions were slightly larger for the same age group when compared to the present study, but the measurements were done on the axial plane.

The basic morphology of mandibular condyle is thought to be established early, and modified throughout life according to functional load.[6] Small asymmetries are expected to develop during normal condylar growth, but the manner in which this asymmetry occurs has to be differentiated. Asymmetries in size differs from shape, volume or position asymmetries. Conventional linear and angular measurements provide quantitative information about size and position, and fail to define features such as shape and volume of the condyles. The present study found symmetric condyle sizes on lateral and frontal sections using CBCT and did not consider the occlusion. Several other studies have used

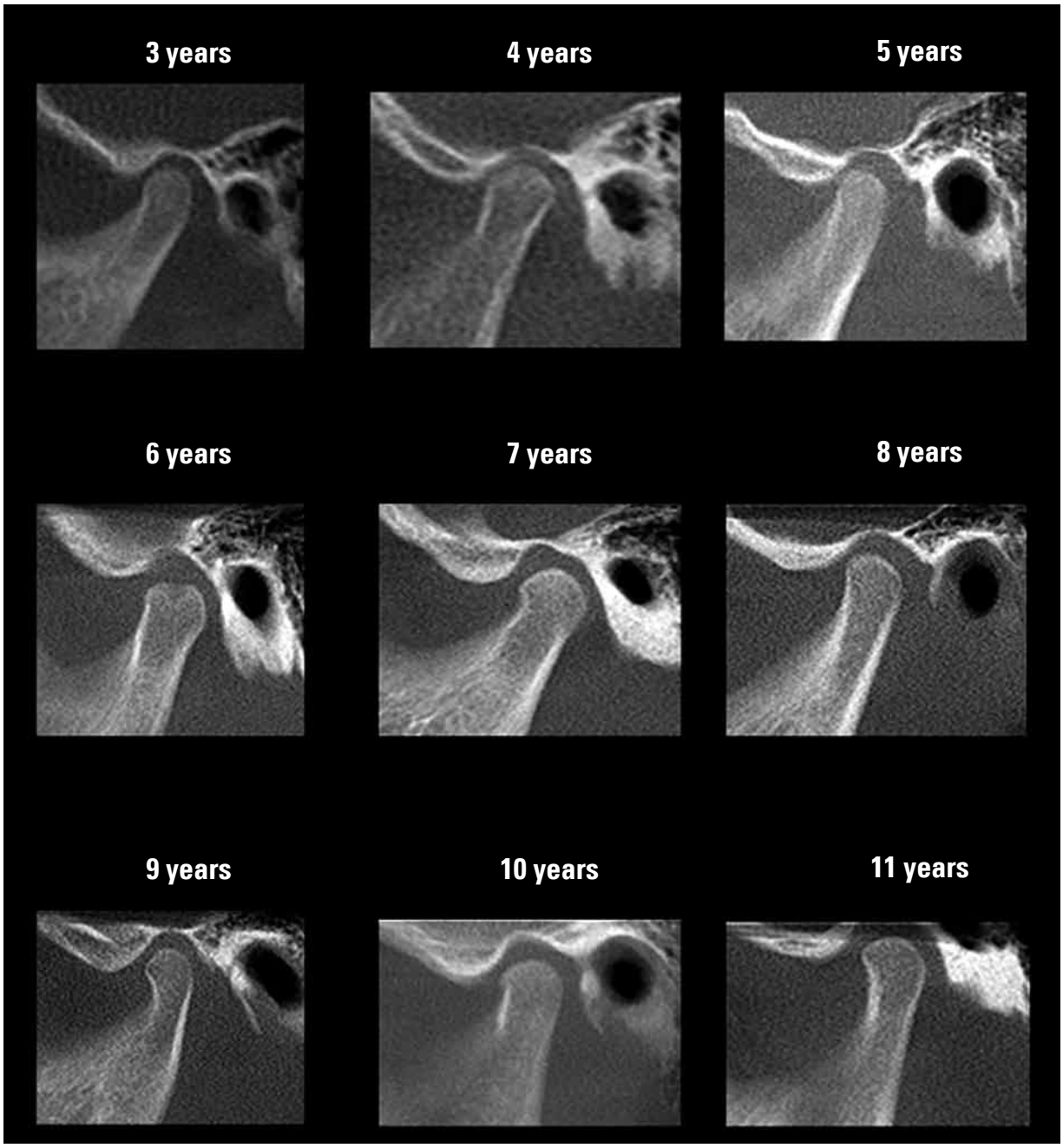


FIGURE 2 - Sequence of morphological variation of the mandibular condyle in lateral view according to age (3 to 20 years old) (continue).

panoramic radiography to evaluate the purpose of symmetry with contrasting results.[15,23] It is known that panoramic radiography is not the most appropriate method since it produces magnification and distortion in the vertical and horizontal directions.[17]

Similar studies should be performed with a larger sample to confirm the present data and to correlate them to gender, facial patterns and condyle types. The vertical dimensions, shape of mandibular fossae, articular eminence, and degree of

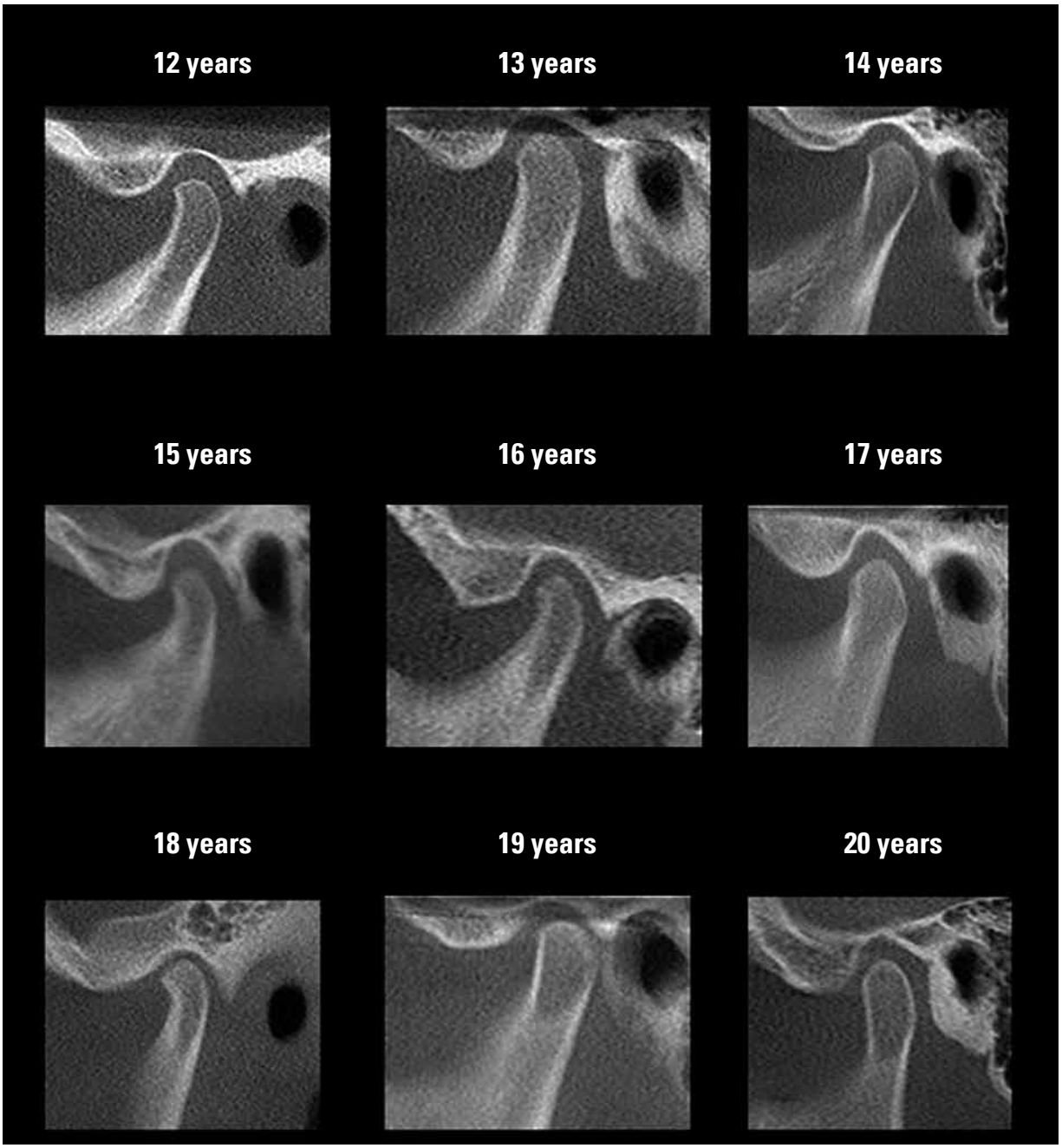


FIGURE 2 - Sequence of morphological variation of the mandibular condyle in lateral view according to age (3 to 20 years old).

inclination of the condyle should be also included with a specific methodology.

CBCT is becoming an important tool in modern dental practice and provides excellent imaging of the osseous components of the TMJ with less radiation exposure compared to other techniques.[1,12] The developed technique showed promising results for condyle measurement and to detect morphological changes during the growth phase in a non-invasive manner using CBCT images in living individuals.

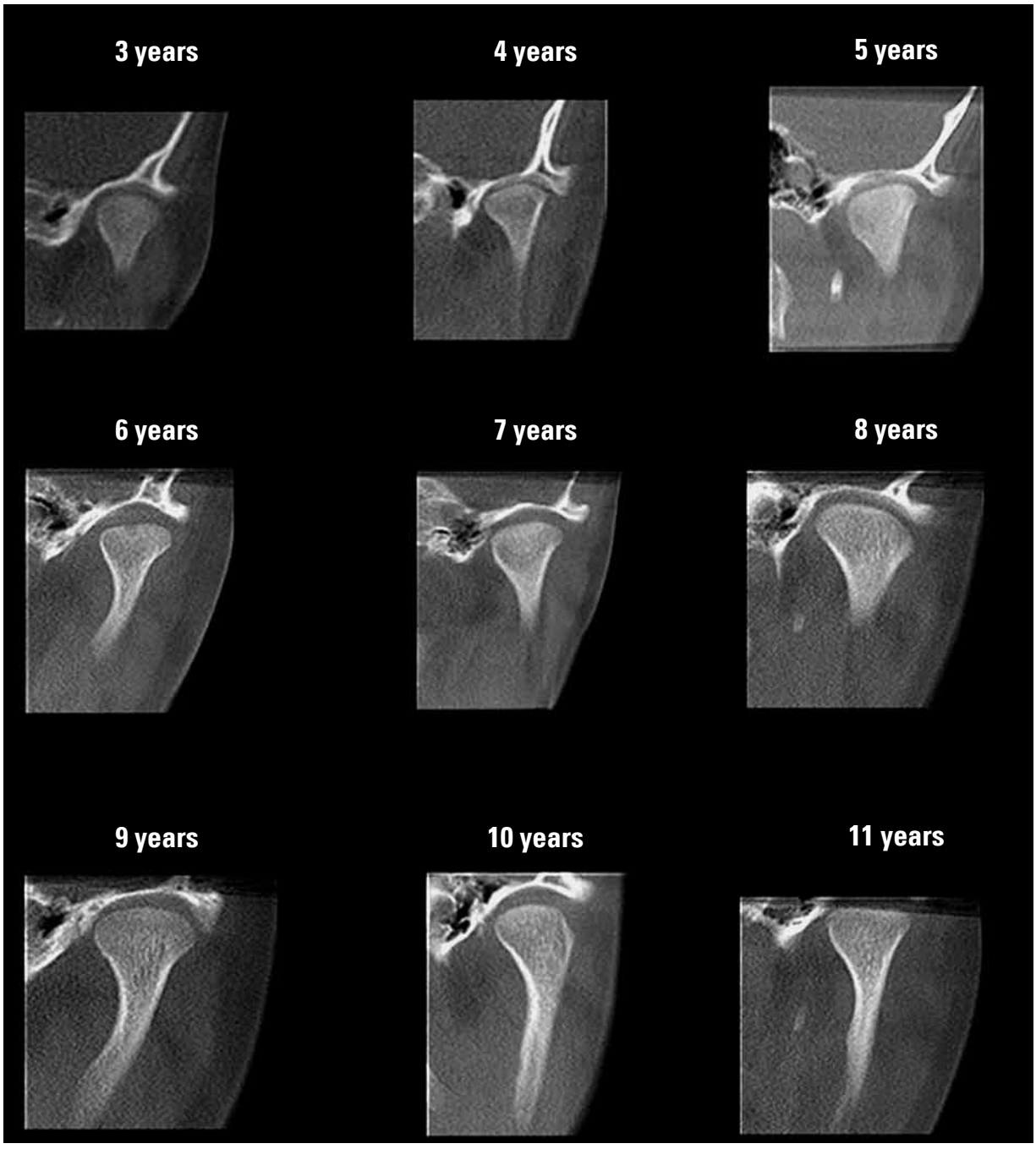


FIGURE 3 - Sequence of morphological variation of the mandibular condyle in frontal view according to age (3 to 20 years old) (continue).

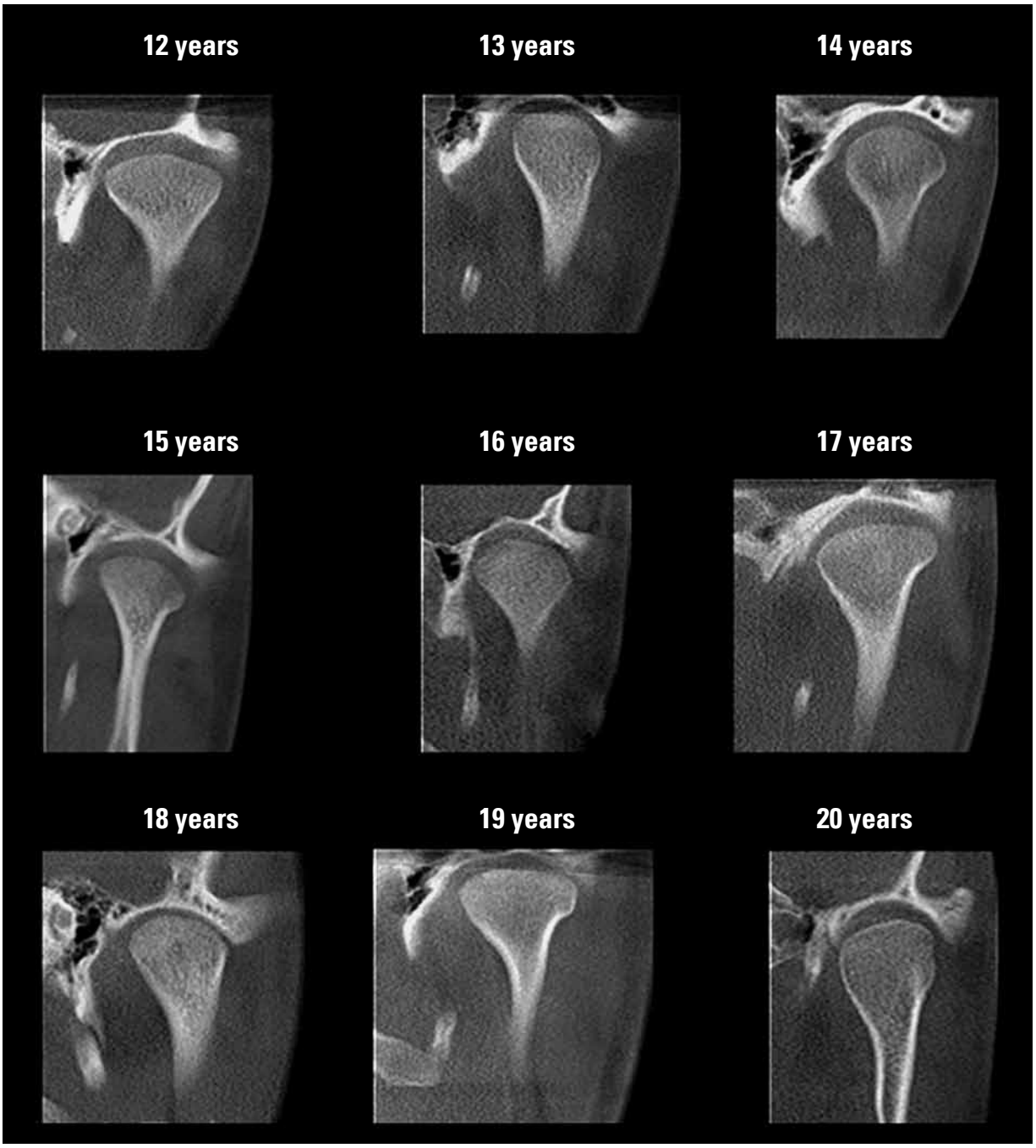


FIGURE 3 - Sequence of morphological variation of the mandibular condyle in frontal view according to age (3 to 20 years old).

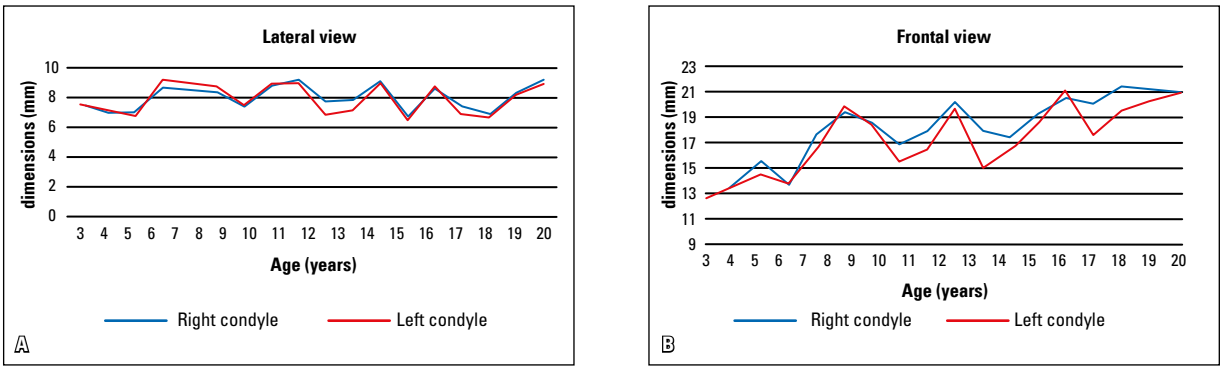


FIGURE 4 - Behavior of mandibular condyle dimensions (in mm) between 3 to 20 years old: Lateral (**A**) and frontal (**B**) view.

## CONCLUSION

The lateral dimension of the mandibular condyle seems to establish itself early because it varied very little with age, while the frontal dimension increased. Small asymmetries between left and right condyles seem to be common, but with no statistical significance. These preliminary data suggested that CBCT is an useful tool to measure and to evaluate condylar morphology during growth.

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