Evaluation of TMJ by conventional transcranial radiography and indirect digitized images to determine condylar position in primary dentition

Luciano José Pereira* / Leonardo Rigoldi Bonjardim** / Paula Midori Castelo*** / Francisco Haiter Neto**** / Maria Beatriz Duarte Gavião*****

The aim of this study was to evaluate temporomandibular joint radiographs of children in primary dentition, obtained by conventional transcranial radiography, indirect digitization, digitized images using 3D and brightness/contrast tools. Condyle position was also determined measuring anterior, superior and posterior joint space. The X-Ray machine GE-1000 and the head positioner Accurad 200 were used. Radiographs were digitized using a scanner with transparency and registered in Adobe Photoshop 5.0. Images were evaluated by four examiners as follows: 0 – unacceptably quality; 1 – poorly diagnostic quality; 2 – optimal visualization quality. Articular space was measured using a digital caliper. A significant difference (Sign Test) was found between conventional radiography and the remaining modalities (Conventional/Unenhanced $p<0.001$; Conventional/3D $p<0.001$; Conventional/Brightness and Contrast $p=0.017$). The mean distance of anterior, superior and posterior regions was 2.2(0.5, 3.5(0.9 and 3.9(1.2mm, respectively. Conventional and brightness/contrast digitized radiographs showed higher diagnostic quality. The posterior joint space was larger than the anterior one, demonstrating anterior condylar position.
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INTRODUCTION

Temporomandibular joint (TMJ) is a dynamic organ formed by internal and external structures. It is one of the most specialized and differentiated articulations of the human body, because of its capability to perform complex movements, related to almost all stomatognatic system functions. Temporomandibular joint movement is not only controlled by the joint morphology itself, but also by teeth that function as a lever. The main components of TMJ, temporal bone, condyle and articular disk are being remodeled with age.[1]

Technological progress has advanced diagnostic techniques, permitting a better evaluation of anatomic structures. During the last two decades there has been a dramatic development in the potential of diagnostic imaging that has led to a significant increase in understanding TMJ Disorders.[2]

Mohl and Dixon[3] reported that diagnostic imaging could provide useful information on the structural and functional integrity of the TMJ. Conventional transcranial radiographs are largely used to evaluate osseous conditions of the TMJ. Digital radiography came along with technology progress, enabling clinicians to assess the region with some computer tools.

Digitization of conventional radiographs played an important role in the development of digital images. These images are transferred to a computer, and can be stored and/or manipulated on screen. The digitization process requires either a camera or a scanner. This image is then transferred into a computer monitor by digitally converting emitted signs using specific

* Luciano José Pereira, DDS, Post-Graduate Students of the Oral Physiology Department, Piracicaba Dental School - State University of Campinas (FOP/UNICAMP), Piracicaba, SP, Brazil.
** Leonardo Rigoldi Bonjardim, DDS, MS, Post-Graduate Students of the Oral Physiology Department, Piracicaba Dental School - State University of Campinas (FOP/UNICAMP), Piracicaba, SP, Brazil.
*** Paula Midori Castelo, DDS, Post-Graduate Students of the Oral Physiology Department, Piracicaba Dental School - State University of Campinas (FOP/UNICAMP), Piracicaba, SP, Brazil.
**** Francisco Haiter Neto, DDS, MS, PhD, Professor, Department of Oral Diagnosis, Piracicaba Dental School - State University of Campinas (FOP/UNICAMP), Piracicaba, SP, Brazil.
***** Maria Beatriz Duarte Gavião, DDS, MS, PhD, Professor, Department of Oral Diagnosis, Piracicaba Dental School - State University of Campinas (FOP/UNICAMP), Piracicaba, SP, Brazil.

Send all correspondence to Dr. Maria Beatriz Duarte Gavião, Faculdade de Odontologia de Piracicaba/UNICAMP, Departamento de Odontologia Infantil – Área de Odontopediatria Av. Limeira 901 CEP 13414-903 Piracicaba – SP/Brazil.

Voice: 55 19 3412 5200/3412 5368
Fax: 55 19 3412 5218
E-mail: mbgaviao@fop.unicamp.br

software, manipulated according to the examiner's conveniences.

The objective of this study was to evaluate the quality of various types of TMJ images from children aged 3 to 6 years. The images included conventional transcranial radiographs, digital unenhanced transcranial radiographs, and enhanced digital images using 3D and brightness/contrast tools. The condylar position was also assessed by estimation of the anterior, superior and posterior joint space.

MATERIALS AND METHODS

Sample

The transcranial radiographs were made on 98 male and female children aged 3 to 6. All subjects were asked to come to the Department of Pedodontics, Piracicaba Dental School – State University of Campinas (UNICAMP). Written and verbal consent was obtained from parents/guardians after they were informed about the procedures, possible discomforts or risks, as well as possible benefits. The Human Subjects Review Committee of the Piracicaba Dental School approved this research.

Conventional transcranial radiography

Transcranial radiographs were made utilizing the Accurad-200 head holder (Denar Company, Anaheim, California) 13 x 18 cm extra-oral films (Kodak T-mat G) with Kodak Lanex regular intensifying screens (Eastman Kodak Company, Rochester, New York). The films were processed in the automated processor MX-2 (Macrotec, São Paulo, SP, BR) using Kodak solutions (X-omat). The X-ray machine used was a GE-1000 (General Electric Company, Milwaukee, WI, USA) and the exposure settings were 50 kVp and 10 mA, 0.16 sec. The Frankfurt horizontal plane and the external auditory meatus were used as reference points for positioning. The radiographs were made at maximum intercuspidation.

Radiographic digitization

The radiographs were digitized using a Hewlett Packard 6390 (HP, USA) Scanner with a SCSI, transparency adapter, and a SCSI Kit. A square area containing the TMJ structures was selected on each radiograph to be scanned. The scanner resolution was 75 dpi. The Adobe Photoshop 5.0 (Adobe Systems, San Jose, Calif) software was used to record all images, which were saved in JPEG format at 238 x 238 pixels. The resulting images were approximately 11 x 10 cm on the computer screen (SVGA) and 54KB in size.

Osseous integrity analysis

Conventional and digitized images were submitted to a subjective analysis by four examiners. Previous calibration was accomplished to achieve familiarization with the evaluation process. The different modalities of images and also the images order were randomized. According to Borg and Gröndal,[4] examiners should be careful when observing details that would be of great importance to the TMJ diagnosis. All types of images were evaluated for diagnostic quality by means of appearence of the osseous structures of right and left TMJ (condyle and mandibular fossa). A three-point scale (0-2) was used as shown in Table 1.

Table 1. Classification Score

	OSSEOUS STRUCTURES INTEGRITY
0	Unacceptably quality
1	Poorly diagnostic quality
2	Optimal visualization quality

The following parameters were considered: morphology of the condylar process, general outline of the glenoid fossa and the joint space distance was measured to indicate the condyle position. If the TMJ osseous structures were not well determined on the radiographic images, the examiners should classify them as 0. If the osseous structures could be seen, but not very well delimitated, the examiners should grade the images as 1. However, if the temporal bone and condyle outlines were clearly determined and differentiated, the images should be graded as 2.

Conventional radiography

The conventional radiographs were viwed in a darkened room, using a view box and a mask trimmed to block out peripheral structures and improve the visibility of the temporomandibular joint.

Indirect digital radiography

Examiners evaluated digitized images utilizing Adobe Photoshop 5.0 software, under optimum viewing conditions and they were allowed to adjust brightness and contrast.

- Unenhanced digital images
- Brightness and contrast enhanced images
- 3D images

Articular space measurement

The articular space was measured using a digital caliper in those conventional radiographs graded as 1 and 2 only. A piece of acetate paper was placed over the completed radiograph and a tracing of the condyle and the glenoid fossa was made. All locations and measurements were recorded. Dual linear measurements were made by one examiner at the subjective narrowest posterior, superior and anterior interarticular joint space locations. In cases of relevant difference in the measurement values, it was repeated again and those measurements with the closest values were recorded.

Table 2. Data of the image quality based on the score degrees from all examiners.

Grade	CL	CR	Total	%	DL	DR	Total	%	3DL	3DR	Total	%	BL	BR	Total	%
0	68	73	141	17.9	97	93	190	24.2	125	113	238	30.3	81	76	157	20.0
1	93	104	197	25.1	130	125	255	32.5	120	102	222	28.3	112	124	236	30.1
2	231	215	446	56.8	165	174	339	43.2	147	177	324	41.3	199	192	391	49.8
Total			784				784				784				784	

CL: Conventional Left Side; CR: Conventional Right Side; DL: Unenhanced Digitized Left Side; DR: Unenhanced Digitized Right Side; 3DL: 3D Left Side; 3DR: 3D Right Side; BL: Brightness/Contrast Left Side; BR: Brightness/Contrast Right Side.

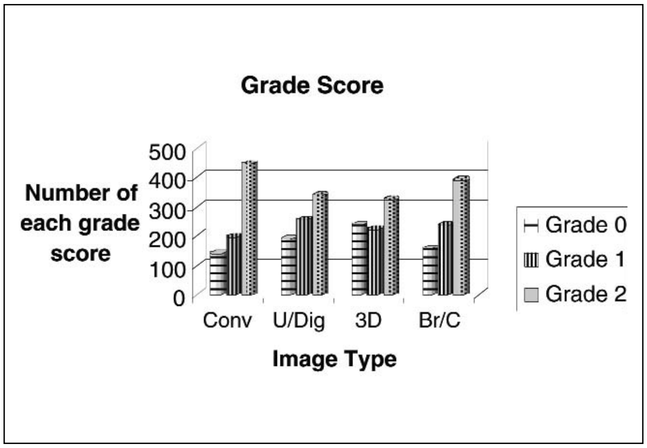

Figure 1. Score for each image type.

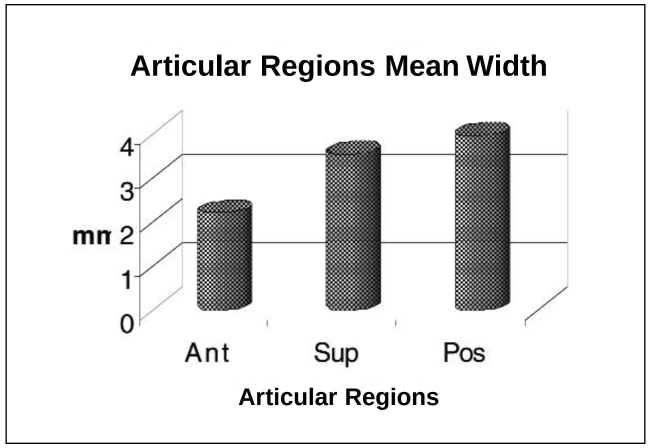

Figure 2. Articular regions mean distance measured with digital caliper in conventional radiograph.

Statistical analysis

The Sign Test was used to evaluate the frequency distribution of the examiners scores in each image type. The hypothesis (H_0) was established as: no diagnonostic quality difference among the imaging types. The descriptive statistical analysis was performed to evaluate the measurements of articular spaces, thus obtaining the means, standard deviation and standard error of the means. Student "t" test was employed to verify if there was difference in the articular spaces between right and left sides.

RESULTS

The diagnostic quality of right and left side of each image type was added because there was no statistical difference between them (p>0.05). The score grades of each image type are expressed in Table 2 and Figure 1. Conventional radiographs demonstrated significantly higher quality when compared to the other techniques (Conventional/Unenhanced p<0.001; Conventional/3D p<0.001; Conventional/Brightness and Contrast p=0.017), thus H_0 was rejected. They were followed by brightness/contrast digitized images, unenhanced digital images and 3D images.

There was no significant statistical difference between the right and left side for the articular space (*t* test p>0.05), thus the results were pooled in relation to this variable. The mean and standard deviation are expressed in Table 3 and Figure 2.

Table 3. Mean value of the articular space width and standard deviation:

	Anterior	Superior	Posterior
Mean Distance	2.21±0.47	3.54±0.88	3.95±1.24

DISCUSSION

Guidelines for TMJ imaging have been developed and proposed by the American Academy of Oral and Maxillofacial Radiology.[5] The goal of imaging the TMJ is the same as imaging any other region of the body, namely to evaluate the integrity of the structures when disease is suspected, to confirm the extent of known disease, to stage the progression of known disease, or to evaluate the effects of treatment.[2,5,6]

It has been demonstrated that clinical examination alone cannot reliably lead to a correct diagnosis in many cases of Temporomandibular Disorders. Therefore, we agree with several others, who considered the TMJ images as an auxiliary diagnostic method to TMJ disorders. For that reason the highest standard of patient care suggests that it be appropriate to use both patient history and clinical examination, supplemented with adjunctive diagnostic procedures as needed, to develop a different diagnosis.[7]

According to the research results, the conventional images demonstrated higher quality than the indirect digitized images (compression level applied 100:1). On the contrary, Trapnell *et al.*[8] found TIFF and wavelet (25:1, 50:1,75:1 and 100:1) images to be better than the conventional ones, with reference to condylar position. Besides, as it was conducted by Held, Ferguson and Gallo[9] using graphic software, such as Adobe Photoshop 5.0, images could be viewed, retouched, enhanced, measured, and/or compressed. Furthermore, the loss of details that occurred when an image was compressed into a JPEG format did not significantly affect the diagnostic quality of the image when standard compression settings were used. The disagreement with the findings of the present study may be justified by the fact the authors above have compared only digital images. Nevertheless, we are in agreement with Versteeg, Sanderink and Van Der Stelt[10] who found a considerably smaller optical density range in the indirect digitized images when compared with conventional films. Hence, some possibly valuable diagnostic information is lost during digitization.

Gynther and Tronje[11] considered that transcranial radiographs have several limitations. However, they agree that the use of this exam, associated with clinical information, could be indicated to advanced degeneration stages. Small, early changes, especially those in the temporal component of the joint, are not well detected, although digital subtraction radiology may prove to be clinically useful in that task in the future.[12] It was clinically demonstrated by Sanchez-Woodworth *et al.*[13] that internal derangements do occur in the pediatric age-group: "the high percentages of both internal derangements and degenerative joint disease suggest a cautious clinical acceptance of imaging for internal derangements in the young patient". Since symptoms are usually more prominent in the early stages of disease and early osseous changes are very hard to detect, correlating imaging observations with patient signs and symptoms is still a problem.[14-17]

Wenzel[18] stated that adjustments in density and contrast of the digital image could result in a smaller number of repetitions, reducing the radiation dose received by the patient. Even though, in this case it was not considered the image quality lost during digitization process. In the present research, it was observed several qualities of indirect digitized images, but they were not enough to overcome the conventional transcranial radiography.

There appears to be little information available concerning the possible effects of condylar displacement in primary dentition. Standard deviation in children can alter condylar growth and eventually lead to a TMJ disturbance.[19] Thus, the diagnostic work-up must or should include a deep clinical examination of the masticator system and radiographic studies of the TMJ. The subjective evaluation and linear measurement of the subjective closest posterior and anterior interarticular space was considered the method of choice to represent condyle position, according to Pullinger and Hollender.[20] In this way, we decided to evaluate the condylar position in studied sample. We used the conventional transcranial radiographs taking into account their best quality in relation to the other techniques and the findings of Ekberg, Peterson and Nilner,[21] who considered that conventional visual evaluation should be recommended for the assessment changes in condylar position from TMJ radiographs.

Relating to, The present study found that the condylar position obtained by articular regions measurements had a mean distance for the anterior, superior and posterior regions of 2.2(0.5, 3.5(0.9 and 3.9(1.2mm, respectively. This agrees with Weinberg,[22] Preti *et al.*[23] and Pullinger *et al.*[24] who found that the posterior region was larger than the anterior.

Zhou *et al.*[25] found the anterior positioned condyles in patients with skeletal and functional Class III malocclusion, concentric positioned condyles with slightly anterior displacement in Class II division 1, and posterior positioned condyles in Class II division 2. In this study, they used the corrected Scholler's position radiographs in patients aged 10 to 27. Although the current study did not consider morphologic occlusion and children were aged 3 to 6, anterior condylar position was observed in most patients, agreeing with those authors. The characteristics of occlusion were assessed during the clinical examination before radiographs were taken. Such details will form the basis for another research.

Lam, Sadowsky and Omerza[26] observed the condylar position in children with unilateral posterior crossbite (aged 6 to 14) comparing to a non-crossbite group (aged 9.5 to 14.1), using corrected tomograms. Examination of condylar position demonstrated a large standard deviation, resulting in an inability to detect any significant differences within or between groups. The present study does not agree with this data because we used a very stringent sample, which minimizes the standard deviation into the primary dentition group.

Myers *et al.*[27] investigated the condylar position in children aged 4 to 9 with functional posterior crossbites before and after correction, using transcranial radiographs. After treatment the superior mean measurement on the crossbite side was of 3.4mm, and the anterior mean measurement was of 1.7 mm. On the non-crossbite side the superior mean measurement was of 3.4mm and the anterior mean measurement was of 1.8mm. Comparing to our results, both the anterior and the superior measurements are slightly different (2.21mm and 3.54 mm).

In small children, due to a long period of condylar growth, the non-symmetry of the condyles could interfere with the normal growth and development.[27] Assessing condyle position in children, it is possible to prevent dysfunction advance and anticipate the disease control with non-surgical treatment modalities.

CONCLUSIONS

It was concluded that conventional transcranial radiographs and brightness/contrast enhanced digitized images showed better image quality of the TMJ structures in the primary dentition. Furthermore, the posterior joint space was larger than the anterior one, demonstrating anterior condylar position in this group of patients.

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