

Accuracy in the Diagnosis of the Mental Nerve Loop. A Comparative Study Between Panoramic Radiography and Cone Beam Computed Tomography

Precisión en el Diagnóstico del Bucle del Nervio Mental. Estudio Comparativo
entre Radiografía Panorámica y Tomografía Computadorizada de Haz Cónico

Carlos Eduardo Gomes do Couto-Filho* ; Paulo Hemerson de Moraes* ; Maria Beatriz Carrazzone Alonso** ;
Francisco Haiter-Neto** ; Sergio Olate***,**** & José Ricardo de Albergaria-Barbosa*

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SUMMARY: Dental implant and chin osteotomy are executed on the mandible body and the mental nerve is an important anatomical limit. The aim of this research was to know the position of the mental nerve loop comparing result in panoramic radiography and cone beam computed tomography. We analyzed 94 hemimandibles and the patient sample comprised female and male subjects of ages ranging from 18 to 52 years (mean age, 35 years) selected randomly from the database of patients at the Division of Oral Radiology at Piracicaba Dental School State University of Campinas; the anterior loop (AL) of the mental nerve was evaluated regarding the presence or absence, which was classified as rectilinear or curvilinear and measurement of its length was obtained. The observations were made in the digital panoramic radiography (PR) and the cone beam computed tomography (CBCT) according to a routine technique. The frequencies of the AL identified through PR and CBCT were different: in PR the loop was identified in 42.6% of cases, and only 12.8% were bilateral. In contrast, the AL was detected in 29.8% of the samples using CBCT, with 6.4% being bilateral; Statistical comparison between PR and CBCT showed that the PR led to false-positive diagnosis of the AL in this sample. According to the results of this study, the frequency of AL is low. Thus, it can be assumed that it is not a common condition in this population.

KEY WORDS: Panoramic radiography; Cone-beam computed tomography; Mental nerve loop.

INTRODUCTION

The mental nerve (MN) is a general somatic afferent nerve that provides sensation to the lip, chin, and gingival tissue. It is the terminal branch of the mandibular nerve, which is the third division of the trigeminal nerve. MN exits the mandible through the mental foramen, divides into 3 branches deep to the depressor angulioris muscle, and supplies the skin and mucous membrane of the lower lip, the skin of the chin, and the vestibular gingiva of the mandibular incisor (Jacobs *et al.*, 2002). Anatomical literature has described the interforaminal region of the mandible as possessing a mental nerve with a path that creates an anterior loop (AL) before entering the mental foramina and another division in this point (anterior to the anterior loop of the mental nerve) as mandible incisive canal (Beltrán *et al.*, 2011). The AL is described as an extension of the mental nerve that is anterior to the mental foramen (Benninger *et al.*, 2011).

Treatment with dental implant and osteotomies are often complicated by the unknown extent of the anterior loop of the mental neurovascular bundle. Sensory disturbances of the mental nerve region may arise after endosseous implants are installed in the mandibular interforaminal. A relatively common problem is the use of an inappropriate attachment depth or path during the insertion of dental implant fixtures, which may damage the inferior alveolar nerve (IAN) and MN. The incidence of permanent sensory disturbance to the lower lip after dental implant insertion in the mental foramen area is reportedly 7% to 10% (Wismeijer *et al.*, 1997; Mardinger *et al.*, 2000). Complications such as loss of lip and chin sensation may result in lip biting, impaired speech, and diminished salivary retention, deficits that have a significant impact on a patient's activities of daily living (Mucci & Dellon, 1997; Deeb *et al.*, 2000).

* Division of Oral and Maxillofacial Surgery, Piracicaba Dental School, State University of Campinas, Piracicaba, Brazil.

** Department of Oral Diagnosis and Oral Radiology, Piracicaba Dental School, State University of Campinas, Piracicaba, Brazil.

*** CIMA Research Group, Division of Oral and Maxillofacial Surgery, Universidad de La Frontera, Temuco, Chile.

**** Center for Biomedical Research, Universidad Autónoma de Chile, Temuco, Chile.

Preoperative radiographic examination is essential for selecting the sites for the installation of an optimum number of implants of optimal size. The potential location and angulations for each implant must be carefully determined and the operator must be familiar with the dimensions and shape of the jaws and the location of anatomical structures. Panoramic radiographs provide 2-dimensional information, while 3-dimensional determination requires tomography. Panoramic radiographs have severe limitations for the evaluation of anatomical structures and available bone for implants (Garay & Olate, 2013; Garay *et al.*, 2014). Preoperative tomography, is preferable, but is not always performed. Therefore, bone dimensions are usually assessed only by panoramic radiographic examinations.

Therefore, the aim of this research was to determine the correlation between the visual interpretation of the panoramic radiographs (PR) and the cone beam computed tomography (CBCT) for the detection of the AL as well as the clinical relevance for planning the installation of dental implants.

MATERIAL AND METHOD

The patient sample comprised 47 female and male subjects of ages ranging from 18 to 52 years (mean age, 35 years). All of them were informed about the study and signed a document to participate in this research. The patient sample was selected randomly from the database of patients at the Division of Oral Radiology at Piracicaba Dental School State University of Campinas. The patients had to have undergone CBCT also had to have undergone PR within the previous 6 months.

Digital panoramic radiographs were acquired in Orthopantomograph OP100 D, (Instrumentarium Corp., Imaging Division, Tuusula, Finland). The CBCT examinations were performed with an i-CAT CBCT unit (12-bit Imaging Sciences International, Inc., Hatfield, PA, USA) using the exposure parameters recommended by the manufacturer: scan time, 40 seconds; 120 kVp, 3–8 mA; FOV, 13 cm; voxel size 0.25 mm. The resultant slice image

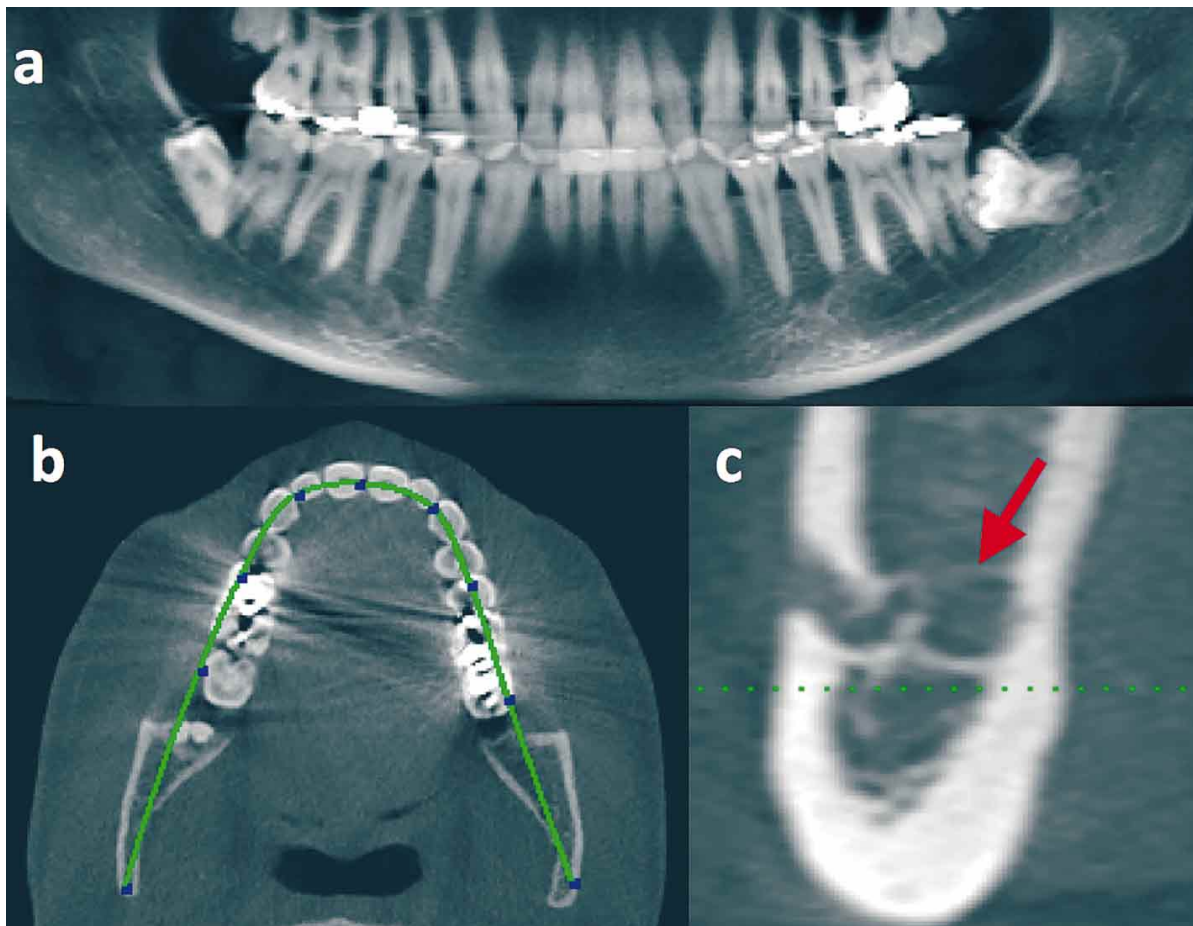


Fig. 1. A) Panoramic reconstruction from the CBCT, B) Axial view showing the final position of the inferior alveolar nerve, and C) cross-sectional image showing the anterior loop (AL) of the mental nerve (red arrow).

data were converted to three-dimensional CT images in DICOM format, reconstructed by XoranCat software (version 3.1.62). The reconstructed image was 2 mm (slice thickness), and cross-sectional CT images were obtained and evaluated in the same XoranCat software.

This study was divided into 2 steps: firstly panoramic radiography was performed for subjective evaluation of the trajectory of curvilinear AL, thus classified as present or absent (rectilinear) only on a total of 94 hemimandibles. In the second step, for each cross-sectional imaging on CBCT, the hemimandibles were evaluated regarding the presence of the AL, which was classified as rectilinear or curvilinear, and the measurement of its length was obtained (de Oliveira-Santos *et al.*, 2011). The length was obtained by the linear distance between the most anterior border of the mental foramen to the most anterior margin of the anterior loop (ALL, anterior loop length). Slice thickness of panoramic reconstructions were 25 mm, so that the entire course of the canal could be visualized, including the mental foramen, without impairing image superimposition. For the cross-sections, the anterior loop was determined by counting the number of sequential 1 mm slices displaying two round hypodense images (corresponding to the upper and lower segments of the mandibular canal, typically ending in an “8-like” shape anteriorly), from the anterior-most image of the mental foramen and start point of the incisive canal. The number of parasagittal cuts containing the ALL was counted and multiplied by 0.25, thus achieving the ALL measurement.

The occlusal plane served as the reference for the cross-sections since the slices were reconstructed following the occlusal plane. Before starting the evaluation of parasagittal cuts, the occlusal plane was aligned, avoiding inclination and rotation of the image due the inclinations of the head during image acquisition. Thus centralized parabolic curve (axial), leading the points up dental crowns (Fig. 1).

One oral and maxillofacial radiologist with experience in manipulation and interpretation of CBCT images performed the measurements. Reliability was assessed using replicate measurements and intraobserver reliability was estimated based on 2 measurements performed at the right and left sides of the mandible with a 20-day

interval to avoid dilution of error. The final mean values of each measurement resulted from the average of the 2 measurements.

RESULTS

This research was realized without complications. No differences in image quality or variations in the analyses were observed; other situation involved in this study as economical cost of the exam, quantity and quality of radiation to the patient, time to take the exam or another situation are evaluated in other research in progress, so this report shows only the anatomical situation of the mental nerve anterior loop.

The frequencies of the AL identified through PR and CBCT were different. In PR the loop was identified in 42.6% of cases, and only 12.8% were bilateral. In contrast, the loop was detected in 29.8% of the samples using CBCT, with 6.4% being bilateral (Table I). Out of the 47 patients studied, 14 (29.8%) presented the AL: three were bilateral, seven unilateral right and four unilateral left. Making calculations based hemimandibles study, 94, out of which 17 (18.1%) out of the loop anterior mental nerve was bilateral and 35.3%, 41.2% and 23.5% unilateral right-sided left.

Statistical comparison between PR and CBCT showed that the PR led to false-positive diagnostics of the loop in the samples (Table II). On the other hand, the length of the AL showed variations between the right and left side showing distances from 3.0 mm to 11.2 mm in the evaluations.

Table I. Distribution of the conditions of AL in 47 patients using panoramic radiography (PR) and cone beam computed tomography images (CBCT), bilaterally.

Side	n (%)	
	PR	TCCB
Absent	27 (57.4%)	33 (70.2%)
Right	9 (19.2%)	7 (14.9%)
Left	5 (10.6%)	4 (8.5%)
Both	6 (12.8%)	3 (6.4%)
Total	47 (100.0%)	

Table II. Correlation between panoramic radiography (PR) and cone beam computed tomography (CBCT) evaluation for the detection of the anterior loop of the mental nerve in the 47 subjects.

Side	PR	CBCT		Kappa	IC95%
		Presence	Absence		
Rigth	Presence	3 (6.4%)	12 (25.5%)	-0.02	-0.29; 0.25
	Absence	7 (14.9%)	25 (53.2%)		
Left	Presence	2 (4.3%)	9 (19.2%)	0.05	-0.24; 0.34
	Absence	5 (10.6%)	31 (66.0%)		

DISCUSSION

Methodology of Measurement. Radiographs have been the dominant source for diagnostic information on the maxillofacial complex (Jacobs *et al.*). However, other study has shown that the reliability of the panoramic radiographs, when planning for implant placement in the interforaminal region of the mandible, may be limited (Kuzmanovic *et al.*, 2003). One of the disadvantages of panoramic images is the geometric distortion of the anatomical structures (Garay & Olate; Garay *et al.*; Garay & Cantín, 2013). Distortions of the panoramic images in the horizontal and vertical planes, especially in the anterior region, depend on the anatomical variations between arch curvatures - focal plane shape - and operator error in patient positioning affects the utility of panoramic images to provide accurate measurements (Laster *et al.*, 2005; Stramotas *et al.*, 2002).

Our results are in agreement with Kuzmanovic *et al.*, regarding the limitation of using panoramic radiographs, when planning for implant placement in the interforaminal region of the mandible. The interpretation of the panoramic radiograph did not show accuracy in diagnosis of the presence of AL, as well as inferred the underestimation or overestimation of the size of the AL when compared with the CBCT. Thus, panoramic radiography is unreliable in identifying the AL (Table I), which is in agreement with other studies that use exclusively in implant planning in the region is questionable interforaminal (Mardinger *et al.*; Kaya *et al.*, 2008).

The picture quality and contrast between adjacent structures are important factors in the task of identifying various anatomical structures and possible injuries. CBCT has been proven as reliable imaging technique for the maxillofacial region (Kobayashi *et al.*, 2004; Lou *et al.*, 2007; Uchida *et al.*, 2007, 2009), extremely useful in evaluating bone, once it provides images with high contrast without overlapping images and displays real action.

The use of CBCT for oral and maxillofacial imaging holds the promise of overcoming these obstacles while providing more accurate craniometrical and diagnostic information than conventional radiographic techniques (Ludlow *et al.*, 2007; Martínez *et al.*, 2013). Furthermore, computed tomography is the best method to obtain minimally invasive and correct preoperative measurement of the AL in living patients (Mischkowski *et al.*, 2006; Chiu *et al.*, 2006).

Despite of the prevalence of AL varies considerably in the literature, our results are in agreement with others modalities of studies such as: anatomic cadavers studies;

use of panoramic radiographs as well as in CBCT (Kuzmanovic *et al.*; Uchida *et al.*, 2007, 2009; Ngeow *et al.*, 2009). Using panoramic radiographs, AL was detected in 42.6% of the cases, while using CBCT it was found in only 29.8% of them (Table III).

The method used to measure the extent of previous AL is relevant. Conventional radiography does not seem to show the true anatomical shape and extent of the AL. Confirming the reliability of CBCT as a tool to determine the extent of previous AL, differences of less than 0.1 mm between anatomical measurements performed on cadavers and CBCT images were found (Kuzmanovic *et al.*; Uchida *et al.*, 2007, 2009). Our results ranged from 2.5 mm to 3.25 mm length, which is consistent with other studies (Table III).

Anatomical Considerations. The length of AL ranging from 0 mm to 9 mm has been reported (Table III) and the longest loop reported in the literature was 11 mm (Neiva *et al.*, 2004).

Although some potential influence of ethnic-geographic variability (Liang *et al.*, 2009), methodological differences and lack of clear definitions for AL are recurrent in the literature and may yield differences in prevalence findings and measures. The term AL refers to the curvature of the nerve chin in a "loop", which surpass the earlier level of mental foramen returns toward the right in the upper, lateral and distal.

A measure of the extent of previous AL is a feature that should be viewed cautiously. Extensions of AL greater than 2 mm are clinically relevant, especially for installation of dental implants (de Oliveira-Santos *et al.*) or for application of mental osteotomy (Fuentes *et al.*, 2014). Where such values corroborate our results, when the AL present, the minimum length of 2.5 mm found, should to be considered when planning surgery.

Clinical Considerations. Clinically, if an implant was placed in contact with the anterior loop of the mental nerve, the implant would likely fail because of increased edema and a lack of supportive hard tissue together with increasing soft tissue in the area. Injury to the mental nerve or inferior alveolar nerve should be carefully considered when placing an implant in this area.

Fixed distances above the mental foramen, supposedly safe, were recommended in the past (Kuzmanovic *et al.*). However, the results of this study in accordance with the results of other studies (Uchida *et al.*, 2007, 2009) show that beyond the limitation of radiographic conventional anatomic variability cannot be neglected.

Table III. Comparison for directed measurement of the anterior loop length in some studies from 1994 to 2009.

Authors	Sample	n	Incidence AL	Mean±SD (Range)
Bavitz <i>et al.</i> (1993)	Cadavers	24	11	---
		Dentate group (n=24)	---	0.2±0.3 (0.0–1.0)
		Edentulous group (n=23)	---	0.0±0.0 (0.0–0.0)
Solar <i>et al.</i> (1994)	Cadavers	37	60	1.0±1.2 (0.0–5.0)
Rosenquist (1996)	Patients	58	26	0.15 (0.0–1.0)
Mardinger <i>et al.</i> (2000)	Cadavers	46 hemimandibles	28	1.05±0.47 (0.4–2.19)
Kuzmmanovic <i>et al.</i> (2003)	Cadavers	22 (44 hemimandibles)	---	1.2±0.9 (0.11–3.31)
		Caucasian descent	---	---
Neiva <i>et al.</i> (2004)	Caucasian skulls	22	88	4.13±2.04 (1.0–11.0)
Hwang <i>et al.</i> (2005)	Cadavers	30 fresh hemimandibles	---	5.0(1.9)
		Korean	50 dry hemimandibles	---
Uchida <i>et al.</i> (2007)	Cadavers	---	---	---
		Japanese	38 (75 hemimandibles)	62.7
Uchida <i>et al.</i> (2009)	Cadavers	71(140 hemimandibles)	71	2.2 (0.8)
		Japanese	---	---

Therefore, sectional tests, such as CBCT should be used for evaluation of AL. Thus, the surgeons must familiarize themselves with anatomic information obtained, by measuring the length of the previous loop on a case-by-case basis once the recommendations of fixed distances to the anatomical landmarks of the AL are unreliable. Implant and Osteotomy (Hwang *et al.*, 2005) could be modified in according with AL of the IAN.

Although it is known that the linear measurements obtained in CBCT images represent real values, an important

aspect to be considered is the transfer of these measures for clinical practice. Ideally, measurements should be easily reproduced during surgery. However, the plan used as a reference for the implementation of measures is often overlooked.

According to the results of this study, the frequency of AL is low. Thus, it can be assumed that it is a not common condition in the population studied; considering that LA has a range of 0 mm to 11 mm, it becomes extremely relevant when present.

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RESUMEN: Implantes dentales y la osteotomía de mentón son realizadas en el cuerpo mandibular y el nervio mental es un importante limite anatómico. El objetivo de esta investigación es conocer la posición del bucle del nervio mental comparando resultados entre radiografía panorámica y tomografía computadorizada de haz cónico (TCHC). Fueron analizadas 94 hemimandíbulas; la muestra de pacientes de sexo femenino y masculino con edades fluctuando entre 18 y 52 años (edad media, 35 años) seleccionados de la base de datos de pacientes de la División de Radiología de la Facultad de Odontología de Piracicaba, Universidad Estadual de Campinas; el bucle anterior (BA) del nervio mental fue evaluado según su presencia o ausencia, el cual fue clasificado como rectilíneo o curvilíneo obteniéndose el largo total del bucle; las observaciones fueron realizadas en radiografías panorámicas digitales (RP) y en TCHC de acuerdo a técnicas de rutina. La frecuencia de identificación del BA en RP y TCHC fue diferente: en la PR, el BA se identificó en un 42,6% de los casos y solo el 12,8% fue bilateral. En contraste, el BA fue detectado en el 29,8% de la muestra utilizando TCHC, con un 6,4% bilateral; la comparación estadística entre RP y TCHC muestra que la RP lleva a diagnósticos falsos positivos de la muestra de BA. De acuerdo con los resultados de este estudio, la frecuencia de BA es baja. Por este motivo se puede asumir que esta es una condición anatómica poco frecuente en la población estudiada.

PALABRAS CLAVE: Radiografía panorámica; Tomografía computadorizada de haz cónico; Bucle del nervio mental.

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Correspondence to:
Prof. Sergio Olate, PhD
CIMA & CEMyQ Research Group
Division of Oral and Maxillofacial Surgery
Universidad de La Frontera
Claro Solar 115, Of. 414-A
Temuco - CHILE

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Email: sergio.olate@ufrontera.cl