original article

Mandibular incisive canal in edentulous patients: Analysis by means of digital panoramic radiography

Abstract / Introduction: *The aim of this study was to radiographically assess the region between the mental foramina for the presence and characteristics of mandibular incisive canal, a major repair associated with postoperative complications of osseointegrated implant placement surgeries.* Material and Methods: *Fifty-two edentulous patients treated during twelve months in the Dental Clinics of the Federal University of Bahia underwent digital panoramic examination. The images were evaluated by a single radiologist and the presence of the mandibular incisive canal, its length, the shape of its trajectory and the distances from the alveolar crest and mandibular base were recorded.* Results: *The final sample consisted of 49 exams. Mandibular incisive canal was observed in eight radiographs, and accounted for 16.3% of the population investigated, with length varying from 10.7 to 19.7 mm. Bilateral lesions were more frequent (50%), and so was the horizontal path (5 cases).* Final consideration: *The presence and intraosseous anatomy of mandibular incisive canal should not be ignored in surgical planning involving the anterior mandible region. This becomes critical to prevent perioperative complications and also to prevent the occurrence of sensory and bleeding disorders in the postoperative period.* Keywords: *Jaw. Anatomy. Mandibular incisor canal. Panoramic radiography.*

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INTRODUCTION

In Brazil, population projection data and percentage of edentulism were used to calculate the absolute number of dental arches in need of complete denture until the year of 2050. Within the most elderly age group comprising patients aged between 50 and 74 years old, the number of subjects in need of complete denture will increase in 2% until 2020. This percentage accounts for an increase of 300,000 subjects in need of complete denture. This number might be significantly higher if subjects older than 75 years were considered; however, there is no up-to-date data for this age group.[1,2]

Prosthetic rehabilitation treatment for complete edentulous patients used to be limited to tissue-supported complete denture. However, some patients did not get used to this treatment modality. Bone resorption hinders complete denture retention and stability, thereby leading to patient's dissatisfaction, insecurity and low self-esteem. Prosthetic rehabilitation treatment with osseointegrated implants arose in this context with the aim of rehabilitating complete edentulous patients, especially in the mandible.[3,4]

Several factors guide the clinician to choose the most suitable prosthesis. Should the patient agree, fixed complete denture placed over implant is the best treatment option due to being a predictable technique of excellent functionality (mastication, esthetics and phonetics). Moreover, it provides the patient with safety of use and consequent quality of life, thereby restoring self-esteem and social reintegration.[4]

The area between mental foramina in the anterior mandible region is commonly chosen to install the implants that retain the fixed complete denture in the mandibular arch.[5] One of the reasons for such choice is the fact that human mandible presents a complex biomechanical behavior when subjected to functional load. Additionally, implants need to be connected so as to form a rigid bar not extended to the posterior region[6] full of vital structures and potentially subject to several surgical procedures such as osseointegrated implant placement, grafting and orthognathic surgery. The mandibular incisive canal is a major repair characterized by an extension that goes from the anterior mandibular canal to the mental foramen.[7,8,9] Mraiwa et al[9] indicated a well-defined incisive canal (mean inner diameter of 1.8 mm) macroscopically identified in 96% of examined mandibles. The incisive canal was located at an average of 9.7 mm from the mandibular cortex and continued towards the incisors region in a slightly downward direction, with a mean distance to the mandibular cortex of 7.2 mm.

Careful preoperative evaluation of remaining bone and anatomical structures to be preserved is essential to yield satisfactory results. Radiographically investigating the region subjected to surgery is one of the major presurgical aspects influencing treatment success.[8,10] Ellies[11] found that 37% of patients answering a research questionnaire reported an unpleasant sensation after implant surgery in the anterior mandible. The author also found that long-term changes occurred in 13% of patients. Abarca et al[12] found that 33% (n = 19) of patients reported some degree of neurosensory changes after implant placement (within 8 to 24 months). They also found that the most commonly affected sites of 19 patients were the gingiva, the lower lip and the chin.[11,12] Speaking and drinking were the daily activities most affected by altered sensitivity of which most common change was numbness. Only one patient reported the benefits not to overcome the disadvantages of fixed prosthesis given the

unpleasant sensation caused in the mandible. Romanos et al[13] reported a case in which a large incisive canal hampered implant placement in the region between mental foramina. To avoid similar complications, the clinician must recognize the existence of the mandibular incisive canal as a normal anatomic structure, identifying by means of proper imaging examination its exact localization for each case in particular before carrying out any surgical procedure in the anterior mandible.[14,15]

Panoramic radiograph is a simple, accessible, low-cost initial examination widely used in Dentistry. For this reason, its effectiveness in surgical planning for interventions in the jaw must be considered.[16] Most authors highlight the use of transverse section so as to better visualize implant placement site, which can only be attained by computed tomography. Cone beam computed tomography (CBCT) has currently been the technique of choice to obtain this kind of information.[5,8,12,17-21] Clinicians commonly use two or more examination techniques for preoperative assessment of implant placement site. Importantly, each examination technique has its specific indications, advantages and disadvantages.[10,16] In this context, the aim of this study is to assess the mandibular incisive canal by means of digital panoramic radiograph, discussing its presence, localization, course and clinical relevance in edentulous patients.

MATERIAL AND METHODS

This research was approved by the School of Dentistry — Federal University of Bahia Institutional Review Board (FOUFBA).

The initial sample comprised 52 digital panoramic radiograph examinations of edentulous patients subjected to a 12-month treatment in the Denture Clinics of the School of Dentistry, Federal University of Bahia. The images were part of patients' initial examination and functioned as a subsidiary method for diagnosing and planning. In selecting the sample, the following exclusion criteria were applied: presence of bone lesions, anomalies, plaque and maxillofacial screws in the anterior mandible, as well as partial view of the area of interest. Final sample comprised 49 images. Before obtaining the images, all patients signed an informed consent form. Imaging was performed with cone-beam computed tomography (CBCT) Kodak 9000 Extraoral Imaging System (Kodak Dental Systems, Carestream Health, Rochester, NY, USA) at the CBCT Laboratory of FOUFBA. Patients were properly positioned at the examining equipment (with the head on a cephalostat so as to determine the median sagittal plane perpendicular to the horizontal plane, and the Frankfurt plane parallel to the horizontal plane). Patient's tongue touched the palate during radiographic exposure at proper maxillomandibular positioning.

A single specialist in Radiology and Dental Imaging assessed the images on the "Report/Implant" mode of Radiocef Studio 2 software (Radiomemory, Belo Horizonte, Brazil) using the digital ruler tool calibrated in millimeters (Fig 1).

Analysis was carried out in two steps. The first comprised three sessions (the first with 17 images, the second and third with 16 images each, totaling 49 images) performed for three days in a row. The second step was performed one week later with 20% of the sample randomly selected (on the site: http://sorteiospt.com/list/) (n = 10) and reassessed by intra-rater reliability test within one single session. All sessions were conducted using the same computer screen (VAIO 14", Sony Corporation of America, California, USA) positioned 60 cm from the examiner in proper lightning conditions. Should it be necessary, the evaluator could make use of contrast and brightness calibration tools.

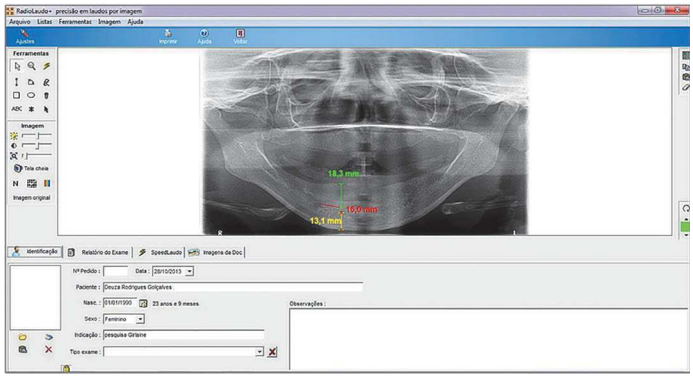

Figure 1. Panoramic image analysis on the "Report/Implant" mode of Radiocef Studio 2 software (Radiomemory, Belo Horizonte, Brazil).

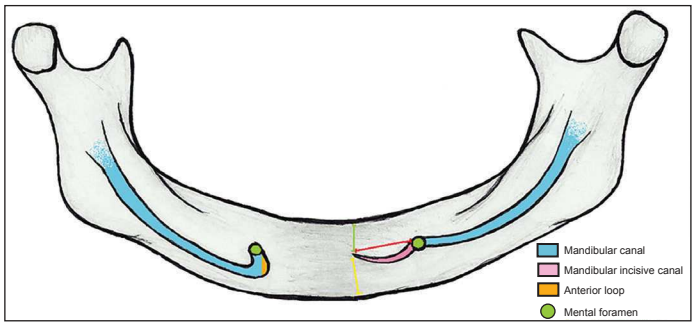

Figure 2. Edentulous mandible: Red line - mandibular incisive canal (MIC) length; green line – distance from the most mesial portion of MIC to the bone ridge; yellow line – distance from the most mesial portion of MIC to the mandibular base.

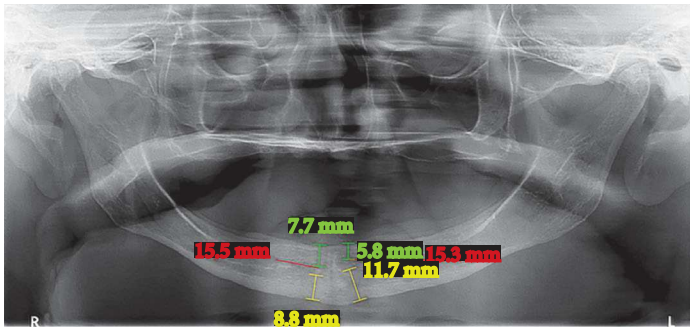

Figure 3. Characteristics of the mandibular incisive canal in the digital panoramic radiograph using digital ruler (millimeters). Red line — mandibular incisive canal (MIC) length; green line — distance from the most mesial portion of MIC to the bone ridge; yellow line — distance from the most mesial portion of MIC to the mandibular base.

The presence of the mandibular incisive canal (MIC) was determined by a radiolucent line/strip showing (or not) a radiopaque image that represented the cortex mesial to the mental foramen. MIC length was determined as being the distance from the mesial border of the radiolucent area of the mental foramen going towards the midline until it reached its final radiolucent point. The distance from MIC to the lower mandibular border in the most mesial area of the incisive canal as well as the distance from MIC to the bone ridge in the most mesial area of the incisive canal were also measured (Figs 2 and 3). The course of the mandibular incisive canal was characterized as type I when straight and horizontally continuous from the mental foramen; type II when going in upward direction with its most mesial portion ending above the mental foramen; type III when going in downward direction

with its most mesial portion ending below the mental foramen; and type IV when curved and with a depression in its course, but with its most mesial portion radiographically visible at same level as the mental foramen.

RESULTS

Patients' mean age was 68 years old (48 – 82 years old). They had been edentulous for an average of 22 years (0.30 – 50 years) and using complete denture for an average of 16.5 years (0 – 40 years) (Tabs 1 and 2).

The mandibular incisive canal was found in eight cases, which accounted for 16.32% of the study population of which six patients were females (75%) and two were males (25%) (Table 1).

Bilateral canals were found in four patients (50%), whereas a unilateral canal was found in one patient on the right side (12.5%) and in three patients on the left side (37.5%) (Table 3).

The course of the mandibular incisive canal was characterized as type I in five cases, whereas type II was not found, type III was found in three cases and type IV was found in four cases (Table 4).

Table 5 shows the cases with mental foramen and mandibular incisive canal on the right and left sides found in the study sample. There was a high prevalence of mental foramen on the left side (69.36% of patients).

Table 6 shows measurements of mandibular incisive canal length, the distance from the most mesial portion of the canal to the alveolar ridge and the distance from the most mesial portion to the mandibular base.

DISCUSSION

Clinicians treating edentulous patients must bear in mind two requirements essential to make treatment feasible: Great empathy with someone else's problem and in-depth knowledge about the impact and limitations

Table 1. Mandibular incisive canal (MIC) identified by digital panoramic radiographs.

Total of image examinations	Mean age (years)	Cases with MIC	Percentage (%) of cases with MIC	Sex
49	68	8	16.32	6 females (75%) 2 males (25%)

MIC = Mandibular incisive canal .

Table 2. Descriptive statistics: Age; time of edentulism; time of prosthesis use.

Mandibular incisive canal		Present Mean ± SD	Absent Mean ± SD
Left	Age	65.57 ± 6.08	68.22 ± 9.65
	Time of prosthesis use	25.50 ± 13.91	14.40 ± 11.58
	Time of edentulism	23.40 ± 13.78	21.52 ± 17.28
Right	Age	67.80 ± 9.44	67.79 ± 9.26
	Time of prosthesis use	21.25 ± 15.48	15.86 ± 12.34
	Time of edentulism	17.00 ± 14.73	22.56 ± 16.81

Table 3. Disposition of mandibular incisive canal (MIC) identified by digital panoramic radiographs.

Bilateral cases	Unilateral right MIC	Unilateral left MIC
4 (50%)	1 (12.5%)	3 (37.5%)

Table 4. Morphological radiographic analysis of mandibular incisive canal.

Course	Type 1 (straight)	Type 2 (upward)	Type 3 (downward)	Type 4 (curved)
Number of cases	62.5% (n = 5)	0% (n = 0)	37.5% (n = 3)	50% (n = 4)

Table 5. Complete edentulous patients' mental foramen and mandibular incisive canal identified by digital panoramic radiographs.

	Cases	Percentage
RMF	31	63.27
LMF	34	69.36
RMIC	5	10.20
LMIC	7	14.29

RMF = right mental foramen; LMF = left mental foramen; RMIC =right mandibular incisive canal; LMIC = left mandibular incisive canal.

Table 6. Distance from the mandibular incisive canal towards the alveolar crest and the mandibular base and mandibular incisive canal length shown by panoramic images.

	Distance from MIC to the alveolar crest	Distance from MIC to the mandibular base	MIC length
Minimum	2.4	7.8	10.7
Maximum	16.8	17.3	19.7

Expressed in millimeters (mm).

of the techniques used to rehabilitate these patients and provide them with quality of life.[1]

Complete denture instability as a result of mandibular resorption leads to masticatory impairment, pain resulting from mental nerve compression, as well as esthetic, phonetic and psychological alterations.[22] Thus, patients who have been edentulous for a longer period of time are expected to have more severe residual ridge resorption, thereby joining the group of patients with major problems with tissue-supported complete denture and in need of dental implant treatment.[1,2] After dental implant treatment, patients tend to expect and experience significant improvements not only in masticatory function, but also in esthetics, facial and body appearance. It is perfectly understandable that patients do not passively accept side effects, as they might hinder one's well-being.[12]

Many studies report patients with altered sensitivity after undergoing implant placement in the anterior mandible.[5,13,14,15,23,24] This complication results from injury caused to the mandibular incisive nerve which clinicians oftentimes disregard[3,4,25-29] or ignore.[1,2] That was the motivation of the present research.

Authors conducting anatomic studies of the human mandible found a well-defined incisive canal (mean inner diameter of 1.8 mm) macroscopically identified in 96% of examined mandibles. The incisive canal was located at an average of 9.7 mm from the mandibular cortex and continued towards the incisors region in a slightly downward direction with a mean distance to the mandibular cortex of 7.2 ± 2.1 mm.[9] In the present research, the incisive canal most commonly continued in a horizontal direction from the mental foramen (five cases) and in a downward direction in three cases, only.

The incisive nerve was anatomically found in all hemimandibles investigated by Mardinger et al,[8] with either a complete canal (n = 10), partial canal (n = 27) or without cortical bone (n = 9). Canal diameter varied from 0.48 mm to 2.9 mm. Conversely, imaging analysis revealed well-defined (n = 11.24%), partially defined (n = 15.32%) or undetectable (n = 20.44%) canal. Liang et al[30] aimed at establishing an association between mandibular neurovascular anatomy and geographical as well as historical variation; however, the authors reached no conclusion.

Other researches have been conducted using imaging exams, especially panoramic radiographs. They found the incisive canal in 15% of the examined images, with good visibility in only 1% of them.[19] Marzola et al[21] found the incisive nerve canal in 175 panoramic radiographs taken from patients older than 18 years old (5.83%). Of the cases in which the incisive nerve canal was radiographically identified, 159 (90.8%) were dentate patients and 16 (9.2%) were edentulous patients. All cases had bilateral incisive nerve canal between mental foramina. The same study highlights that identifying anatomical structures by means of imaging exams is hindered in edentulous patients. Patients' advanced age and time of edentulism might cause significant bone changes that hinder diagnosis. Wadu et al[31] confirm that the neurovascular bundle decreases substantially after tooth extraction. Additionally, the vascular component cannot be easily identified. The study population of the present research comprises elderly edentulous subjects who made use of tissue-supported denture for a long time. These data should be considered during analysis and planning.

The mandibular incisive canal was clearly visible in 83% of CBCT scans and the mean endpoint was approximately 15 mm anterior to the mental foramen.[20] MIC was visible in 20.5% of digital panoramic radiographs and in 45% of CBCT panoramic reformatting.[17] In the present research, the percentage of incisive canal visibility in digital panoramic radiographs (16.32%) was lower than that indicated by Imada[17] (20.5%). Polland et al[18] did not identify incisive canal in their research.

Diagnosis and proper choice of radiographic examination are key to achieve long-term dental implant success.[32] Implant placement in the alveolar bone without previously designing a prosthetic rehabilitation plan is no longer acceptable.[16]

In our research, mandibular incisive canal length varied between 10.7 and 19.7 mm. Uchida et al[33] found that due to great variability in measurements of the anterior loop of the nerve and the mandibular incisive canal, determining a safe area anterior to the mental foramen is not possible.

Some authors report computed tomography as the best method to identify the mandibular incisive canal without highlighting the indications, advantages and disadvantage of this technique. As a result, they end up persuading beginners into mistakenly asking for CT scans as the first diagnosis tool.[34]

With a view to clarifying and providing clinical guidance on dental implant treatment planning, the American Academy of Oral and Maxillofacial Radiology recommends: 1) Panoramic radiograph should be used for initial assessment of patients potentially subject to tooth implant placement. 2) Intraoral periapical radiograph should be used to supplement data provided by panoramic radiograph. 3) Transverse section, including CBCT, should not be used for initial imaging diagnosis.[16]

Panoramic radiograph should be used for initial assessment of bone anatomy and dimensions, particularly in the vertical direction, as well as to diagnose potential pathological changes.[3,4,34]

FINAL CONSIDERATION

Mandibular incisive canal should not be disregarded in surgical treatment planning involving the anterior mandible so as to avoid intraoperative complications and prevent postoperative sensory and bleeding disorders. Although digital panoramic radiograph produces images of higher quality in comparison to conventional panoramic radiograph, it is considered limited for mandibular incisive canal analysis. Cone-beam computed tomography yields more detailed results. Nevertheless, each case requires different subsidiary methods. For this reason, knowing the indications, advantages and disadvantages of each technique is essential to yield safe and predictable treatment planning.

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