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Evaluation of the Mandibular Incisive Canal by Panoramic Radiography and Cone-Beam Computed Tomography

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Abstract

Objectives: This study was conducted to investigate the complete anatomy of the interforaminal area of the mandible. For the correct acknowledgement of the anatomical structures in this region is necessary, since it is especially important for planning implants.

Methods: The CBCT and PAN images of 200 patients, taken for general dental diagnoses, were examined with regard to the mandibular incisive canal. The panoramic images were obtained using radiographic equipment Toshiba Corporation, J. Morita Mfg. Corp., Kyoto, Japan, while the cone-beam computed tomography dental imaging system GALILEOS, Sirona Dental Systems, Bensheim, Germany was operated.

Results: In the panoramic images, the mandibular incisive canal was identified in 77 (19.25%) images of 400 examinations (200 each on the left and right sides), while in the cone-beam computed tomography, the mandibular incisive canal was identified in 193 (48.25%) of the images.

Conclusion: Identifying the mandibular incisive canal in cone-beam computed tomography images is necessary so that there is always safety when placing an implant in the anterior site of the mandible, and a decrease in the number of postoperative complications. The CBCT should be considered essential for the preoperative planning of anterior mandibular implants.

Keywords: Cone Beam Computed Tomography; Panoramic; Mic

Introduction

The mandibular incisive canal (MIC) is located in the anterior site of the mandible and lies forward from the mandibular canal to the mental foramen. This canal includes the incisive nerve that provides innervation to the first premolar, canine, lateral incisor, and central incisor [1]. The interforaminal region, which is bounded by the two mental foramina, and the anatomical region of the mandibular incisive canals, is a significant area for surgical dentistry [2].

Panoramic radiography (PAN) is an extraoral radiographic technique often used by dentists, implantodontists, and oral and maxillofacial surgeons in dental practice. However, a PAN is a two-dimensional image, lacking information about the buccolingual aspect, while magnifying in both the vertical and horizontal directions, particularly in the anterior region [3,4]. On the other hand, three-dimensional techniques like cone-beam computed tomography (CBCT) permit finely elaborate scanning of the osseous architecture, with high contrast and without burnout [5]. Those images created using CBCT are high-resolution cross-sectional segments of differing thicknesses, which present high-resolution images of the structures of the jaws [5].

The complete anatomy of the interforaminal area of the mandible is still poorly understood; although the correct acknowledgement of the anatomical structures in this region is necessary and important for the success of surgical procedures, like planning implants [6]. The last part of the inferior alveolar nerve occasionally passes below the inferior border and the anterior wall of the mental foramen and, after giving off a small incisive branch, it curves back to enter the foramen and move out to the soft tissues, becoming the mental nerve. This anatomical feature is also known as the “anterior loop” of the inferior alveolar nerve [7].

The mandibular interforaminal area is considered a safe area for implant surgery and is involved in many other surgical procedures [8]. However, complications can be found due to anatomical variation in the inferior alveolar nerve, because this nerve can extend, forming an incisive nerve canal, with an extension anteriorly to the mental foramen towards the middle line [9]. One of the most difficult complications (mistakes) that may occur during implant placement in the mandible is neurogenesis change of the jaw and lower lip [10]. In addition, damage to the relevant blood vessels (e.g. inferior alveolar or lingual arteries) may cause excessive bleeding [6]. Damage to these structures occurs frequently from a clinician's mistakes, because of their failure to define these structures [11].

Understanding the anatomy of the interforaminal area of the mandible helps one reduce and prevent injuries to the neurovascular bundles. Therefore, the purpose of this study was to examine the differences between those images obtained by PAN and CBCT, in the visual evaluation of the MIC in a Turkish sub-population.

Materials and Methods

The CBCT and PAN images of 200 patients, taken for general dental diagnoses, were examined regarding the MIC. The PAN images were obtained using radiographic equipment (Toshiba Corporation, J. Morita Mfg. Corp., Kyoto, Japan) operating at 80 kV and 10 mA, while the CBCT dental imaging system (GALILEOS, Sirona Dental Systems, Bensheim, Germany) was operated at 98 kV and 15-30 mA. Situations that could cause us to miss the correct appearance of the MIC, like pathologies, fractures in the mandible, the presence of implants, and patients with missing teeth in the mandibular anterior area were excluded from this study.

This research was carried out by two oral radiologists with a minimum of 2 years of experience. First, they examined the CBCT images confirming (or not) the presence of a MIC on the right and left sides. The images were edited (contrast and saturation) by using a CBCT image processing program (SIDEXIS XG 2.56, Sirona Dental Inc., Bensheim, Germany) for the optimal display; then, the examination of the PAN images proceeded in the same manner, using the HBYS (TurcaSoft Software LLC, Samsun, Turkey) visualization program. The examiners considered the MIC as a radiolucent canal in the trabecular bone, surrounded by a radiopaque cortical bone representing the canal walls, extending to the anterior part beyond the mental foramen (Figure 1) [4]. In addition, the examiners noted the patients' ages and genders. In the CBCT scans, the parasagittal and cross-sectional sections (which provided the best images) of the region beyond the mental foramina were assessed (Figure 2). All of the tomographic images were examined in a slightly darkened room using the same computer [Intel Xeon processor, 3.50 GHz, 4 MB, L3 Cache; Intel HD Graphics; RadiForce MX270W, 8 GB memory, Windows 8 operating system; 27", 3.7 MP color medical LCD monitor [EIZO Nanao Corporation, Ishikawa, Japan]), while the examiners used "zoom" to magnify the images of interest. The PAN images were examined using a different monitor (20.1" Dome GX2MP Plus medical monitor). The examiners designated "yes" or "no" with regard to the presence of a MIC on both sides of the mandible, in those images obtained using CBCT and PAN.

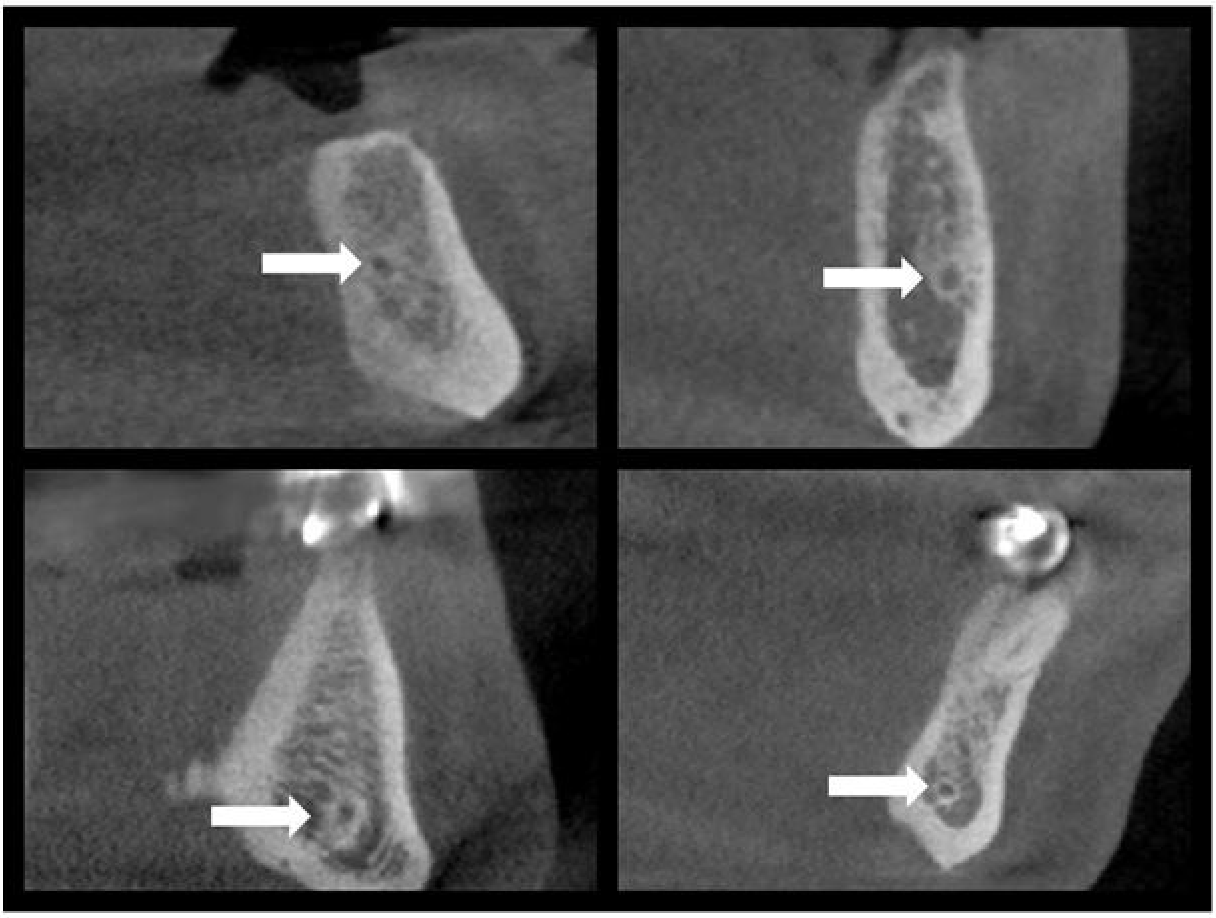

Figure 1: Location of the MIC (white arrow) in four different patients' cross-sectional CBCT images

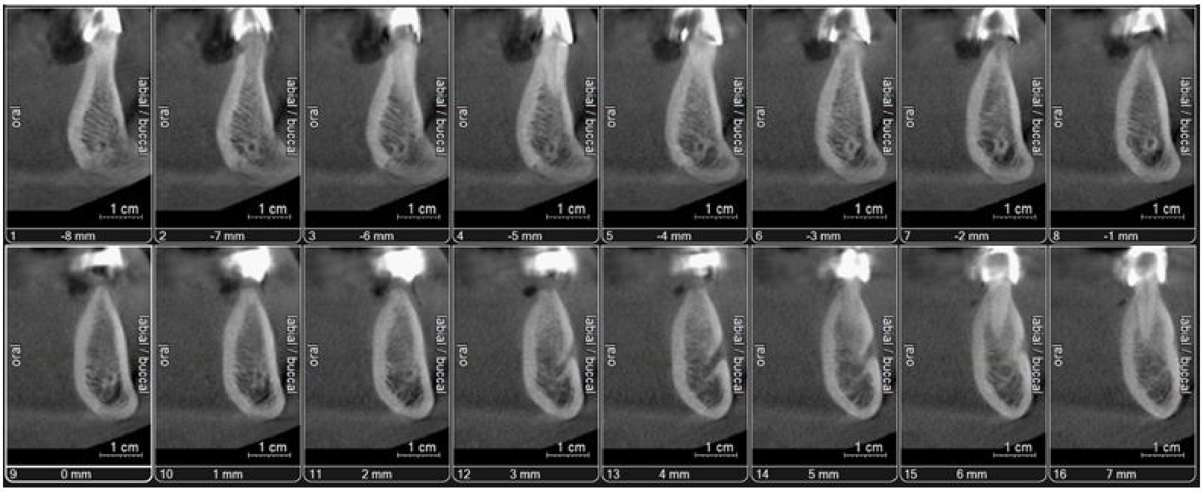

Figure 2: Model of cross-sectional images of the interforaminal area, as analyzed by the examiners

Agreement between the PAN and CBCT images was analyzed using the kappa and McNemar coefficients of the agreement. The percentage rates for detecting the MICs of the intra methods and between methods were compared using the McNemar test because these reflected comparisons within the same group. For the age distribution, the Kolmogorov-Smirnov test was used first for the comparison, to assess the suitability of a normal distribution; then we used the Mann-Whitney U test to make the comparisons. We used the chi-square test in the evaluation according to gender. In this study, each patient had 4 different sets of data (2 methods and 2 sides), and all of the terms of the interaction between the variables were investigated. The Statistical Package for the Social Sciences (SPSS) [v. 15.0] program was used for the calculations.

Results

The study included 117 women and 83 men with a mean age of 41,61 years. In the PAN images, the MIC was identified in 77 (19.25%) images of 400 examinations (200 each on the left and right sides), while in the CBCT, the MIC was identified in 193 (48.25%) of the images. Table 1 shows data for the comparisons between the PAN and CBCT. When comparing the two methods, the difference we found was statistically significant ($P < 0.001$, kappa: 0.182); that is, the frequency of the identification of a MIC in the CBCT images was higher than in the PAN images. In addition, the probability of identifying the MIC was higher on the left side in the CBCT images, when compared to those of the PAN.

Type of method and side		**Identified by both examiners**		**Percentage rate of identification (%)**
PAN		**Male**	**Female**	
	Right	20	25	11.25
	Left	18	14	8
Total	**Right+Left**	77		19.25
CBCT		**Male**	**Female**	
	Right	42	48	22.5
	Left	47	56	25.75
Total	**Right+Left**	193		48.25

Table 1: Comparisons between PAN and CBCT methods

With Fisher's exact tests, the statistic tables did not show any age or gender influence on the MIC's visibility into the mental interforaminal region.

Discussion

In this study, patients were selected randomly and retrospectively. The selected patients were arranged according to the exclusion criteria and after the 200 patients, the study was started. In order to avoid neurological trauma during implant surgery in the interforaminal site, a radiographic examination is obligatory [7]. Our study shows both the significance of identifying the MIC in the site between the mental foramina and difficulty in detecting this structure in PAN images. Table 1 shows that, in any gender, the side and frequency of the identification of the MIC using CBCT is higher than those with PAN. However, many dental surgeons' still plan surgeries in their patients using only PAN imaging in their examinations, probably because of the high costs of CBCT, radiation doses, or time constraints [1,12-14].

Among the 400 analyses of images performed in this study, the examiners detected MICs in about 20% of the PAN images and 49% of the CBCT images. These data confirm the difficulty faced by the examiners in identifying this anatomical structure in the

PAN images and, therefore, the significance of the CBCT in surgical planning for this region. Our results were lower than those of Jacobs *et al.*, who identified MICs in 93% of the images from spiral CT scans; however, our results were similar those of Raitz *et al.* (investigator 1: 60.7%; investigator 2: 64.7%) and Leite *et al.* (51.6%) who studied CBCT images. The reason for the different results in the prevalence of the MICs in the literature is due to the different ways of preparing the materials and methods of the studies [2,4,15]. With CT examinations, the frequency of detection of this structure increased to 83%-100% [15-17]. The frequency of determination of the MIC on panoramic radiographs is lower, ranging from 2.7% to 14% [4,18].

Because of reduced bone-implant contact, large incisive canals may play a negative role in the osseointegration of implants. Also, a large MIC might be involved in postoperative sensory discomforts. A dental implant passing through the MIC could result in the probable stretching of the mental nerve [19]. However, in many cases, the canal narrows by stages until the neurovascular bundle enters medullary spaces, without definitely forming a canal [12]. Perhaps this is also a cause for the low importance given to the MIC by implantodontists.

There is no doubt that PAN underestimates the real entity of the MIC [4]. Therefore, identifying the MIC in CBCT images is necessary, so that there is always safety when placing an implant in the anterior site of the mandible, and a decrease in the number of postoperative complications [20]. This study shows the rates of identification of MICs, revealing that CBCT images are higher than PAN images but lower than CT images. The CBCT should be considered essential for the preoperative planning of anterior mandibular implants.

Conclusion

Identifying the mandibular incisive canal in cone-beam computed tomography images is necessary so that there is always safety when placing an implant in the anterior site of the mandible, and a decrease in the number of postoperative complications. The CBCT should be considered essential for the preoperative planning of anterior mandibular implants.

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