Original Article

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The mental foramen in panoramic versus cone beam computed tomogram

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Backgrounds: The mental nerve is one of the important inferior alveolar nerve block, were to find the existence the mental foramen, anterior loop of mental foramen and dimensional distortion of radiography. The purpose was to determine the size distortion versus the presence of mental foramen with anterior loop of mental nerve by panoramic radiography and cone beam computed tomography (CBCT).

Materials and methods: Eighty volunteers of the radiographs of the mental and accessory mental foramina as well as their anterior loop were examined. The diameters of mental foramen, distance of upper border of mental foramen to the second premolar root, distance of lower border of mental foramen to inferior border of mandible and distance of anterior border of mental foramen to anterior border of anterior loop, were measured. Paired t test ($P<0.05$) for comparing between the distances obtained from both imaging modalities.

Results: The mental foramen, the accessory mental foramina and the anterior loop of mental foramen were exhibited in 90%, 1.38%, 65.27% in panoramic radiograph, and was shown 100%, 3.75%, 88.75% respectively, in CBCT. All measurements obtained from panoramic technique were significantly lesser than from CBCT except, distance from upper border of mental foramen to the second premolar root in panoramic radiograph was significantly greater than CBCT.

Conclusion: It was worthy for local anesthetic injection to note that three observed anatomical structures were more difficult to identify in panoramic radiograph than CBCT. Additionally, the panoramic technique expressed more dimensional distortion in linear measurement than CBCT.

Keyword: accessory mental foramen, anterior loop of mental foramen, cone beam computed tomography, mental foramen, panoramic radiography.

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Introduction

The dental remedy plan requires delicacy of evaluation and precision of radiograph such as local anesthetics injection in implantology or any oral surgery. According to recent recommendation, tomography is useful and American Academy of Oral and Maxillofacial Radiology suggests the use of conventional cross sectional tomography, computed tomography due to theirs high resolution. [1]

Although many previous research studies concluded that the cone beam computed tomography shows more detail than the panoramic radiography in dental treatment planning but almost of dentist still use the panoramic radiograph for dental planning from observational study. The reasons are cost, easy to interpretation, access to CBCT may be unavailable. [2]

In addition to some previous studies showed that the distortion of panoramic radiograph is more in anterior region of jaw than the posterior due to the narrow focal trough in anterior region. So the chance of "out of focal trough" in anterior region is higher. The anatomical structures in anterior region of jaw are mental foramen and anterior loop of mental nerve that are vital in dental treatment planning. The previous studies about distortion of image in the panoramic radiograph especially in anterior region are important. They compared the distance of mental foramen and anterior loop and the location of them between the panoramic radiograph and CBCT. [3]

This study is reliability of panoramic radiograph in anterior region of mandible. Thus it can be used for dental treatment planning alone instead the use of CBCT for some disadvantage such as unavailable of CBCT, skill of interpretation, high cost, etc.

CBCT is a radiograph technique in maxillofacial region by consisting of X-ray computed tomography where the radiographs are divergent, forming a cone. [4-6] The scanning software collects the data and reconstructs it, producing what is termed a *digital volume* composed of three-dimensional voxels of anatomical data that can then be manipulated and visualized with specialized software. The advantages and disadvantages of CBCT were shown in **Table1**.

A panoramic radiograph is a panoramic scanning outside oral cavity that captures an entire mouth and jaws. Upper and lower jaws are taken in the same frame. Though an image received by this method is distorted and cannot show a cross-sectional relationship, it covers a cervical vertebrae and palate.

Table 1 The advantages and disadvantages of CBCT

ADVANTAGES	DISADVANTAGES
• Deliver fine detail of anatomical structure in all three planes without an overlapping area, which can be combined to produce a 3-dimension model that can be viewed in any perspective • Quick scan time with computer-operated procedure • Provide an actual-size radiographic because of an isotropic acquisition • Patient received less dose compared with X-ray computed tomography • Data recorded in digital format. It can be easily modified for using in other aspects. • Suitable for studying pathology of hard tissue, e.g., bone	• Patient exposed to more dose compared with conventional radiograph, e.g, panoramic radiograph • Could not provide detail in soft tissue and lesion in soft tissue, unlike an X-ray computed tomography method • Artifacts occurred when beam scattered with metallic object and also causing beam hardening on surrounding area • Limit availability to few hospital • High cost of operation

Panoramic radiograph [7] uses a tomography technique which allows us to get a clear image of layers where the maxilla and mandible are in, called focal trough, while other parts are blurred. Table 2 showed the advantages and disadvantages of Panoramic.

Mental foramen is an important anatomical structure in injection for surgery. Its placement and a chance to come across an anterior loop of mental nerve on the medial side of the chin should be concerned in injection before surgery to prevent nerve damage. The mental nerve may have been compromised by the surgery, dental implant, [8] or anesthesia injection. This can cause paresthesia or anesthesia along a nerve branch.

Generally, mental foramina appear as a small round hole. They are located on both sides of mandible, slightly toward the front. Additional holes in that section are called 'accessory mental foramen'. Mental nerve forks through this gap to innervate soft tissue of chin, lower lip, and gum. [1,2]

Mental nerve splits from mandibular canal can be found in two types. Type 1 is described as the nerve branching with the presence of anterior loop, while Type 2 is branching through mental foramen with no loop. [1,2,9] According to the study on Thai people, anterior loop of mental nerve is found in 40.3 percent of specimens. The space from the edge of mental foramen to the front of mandibular canal hoop is between 0.3-4.0 mm with average length of 1.8±0.9 mm. The mental nerve opening location is about half way between the upper and lower edge of the bone, close to the second premolar. [4]

The interpretation of anterior loop of mental nerve radiograph could be inaccurate due to both horizontal and vertical distortion of an image, especially on the front side of the jaw. Therefore, dental implant should be done with 25-30 degrees inclination to the center to fit the anatomy of the anterior loop of mental nerve. [9]

The previous study mentioned the comparison between images acquired from panoramic radiograph and CBCT, showed that the accessory mental foramen is revealed on only 48.6 % of images compared to the latter technique. However, radiation exposure from CBCT is up to ten times higher.[9]

In the local anesthetics injection this location is difficulty in anesthesia for the operation of this area so we have to study the location of mental foramen. So the aim of this study was to determine and compare the size distortion and the presence of mental foramen and anterior loop of mental nerve in images provided by panoramic radiography and CBCT.

Table 2 The advantages and disadvantages of Panoramic

ADVANTAGES	DISADVANTAGES
• Broad coverage of upper and lower jaws in one frame	• Image is not as clear as conventional radiograph
• More convenient for the patient than full mouth intra-oral technique especially for child, patient who vomit easily, and patient with disability	• Dental caries and early lesions of bone could not be seen obviously
• Can be used to observe jaws briefly, i.e., looking for leftover root fracture	• Glossopalatal and glossopharyngeal air space regions could not be shown clearly
• Not hurting patient as no need to put film in the mouth	• Image is distorted and enlarged for 4-25%, depended on patient's posture
• Image taken in short time	• Use a large space for machine installation
• Lower exposure to radiation than full mouth intra-oral technique	• Require expertise for image analysis

Methods & materials

This research got Institutional Review Board (Protocol No. MU-DT/PY-IRB 2011/042.2812) with approved by the Committee in the Ethics of Research in Human Dentistry and Pharmacy of Mahidol University.

This observational study was studied in male and female volunteers, 40 for each gender (total of 80) age range 21 to 73 years, with following attributes (inclusions criteria)

1. Older than 19
2. References for both methods can be made, e.g., no impacted tooth, no embedded tooth, or no root overlapping which conceal mental foramen
3. No abnormal growth of the head
4. No medical record of jaw trauma or injury
5. Not receiving orthodontic treatment
6. Received research document, well informed, and present his or her signed consent

The exclusion criteria were not followed inclusion criteria. The cone beam computed tomograph (CBCT) (3D Accuitomo FPD XYZ Slice View Tomograph, J. Morita, Kyoto, Japan) with flat panel detector uses i-Dixel software to create images in three planes, which are axial plane, coronal plane, and sagittal plane. Each plane image is in 60x60 mm size with voxel size of $(0.125)^3$ mm^3. Each volunteer received a radiograph covered premolar region on both sides of lower jaws. Patient doses for male and female volunteers are 78 kV, 4.5 mA and 76 kV, 4 mA, respectively. When tomogram processing finished in all three planes, the brightness and contrast were adjusted to provide better clarity.

The panoramic radiograph (Planmeca Proline EC, Planmeca OY, HELSINKI, Finland) operates with 15x30 cm film. Then, the film is treated by X-Ray film processor (Kodak X-OMAT 2000 Processor). Each volunteer received a radiograph covered premolar region on both sides of lower jaws. A patient dose is 64-70 kV, 4-6 mA on 18 seconds duration.

From CBCT image and panoramic radiography image on each volunteer were collected data with i-Dixel software. Then count the number of accessory mental foramen in panoramic radiograph, the number of anterior loop of mental nerve, a diameter of mental foramen horizontally and vertically, a length between an upper edge of mental foramen and the second premolar root, a length between a lower edge of mental foramen and the lowest part of an inferior border of mandible, a length from mesial edge of mental foramen to distal edge of anterior loop of mental nerve and a size of anterior loop of mental nerve in Bucco-Lingual direction only in CBCT. The measurement of both CBCT and panoramic radiograph of each volunteer was performed by same person. **(Fig. 1)**

Results

The interpretation of panoramic radiograph acquired from 80 volunteers showed the presence of mental foramen in 72 images (90%), including the existence of accessory foramen 2 images (1.38%). The anterior loop of mental nerve was found in 47 images (65.27%). Its distribution for the right, left, and both sides were 7, 4, and 36 images (14.89%, 8.51%, and 76.60%) respectively. **(Fig. 2 and Table 3)**

Table 3 Numbers of mental foramen, accessory mental foramen, and anterior loop of mental nerve observed in panoramic radiograph and CBCT images

	Panoramic	CBCT
Mental foramen	144 (90%)	160 (100%)
Accessory foramen	2 (1.38%)	6 (3.75%)
Anterior loop	47 (65.27%)	71 (88.75%)

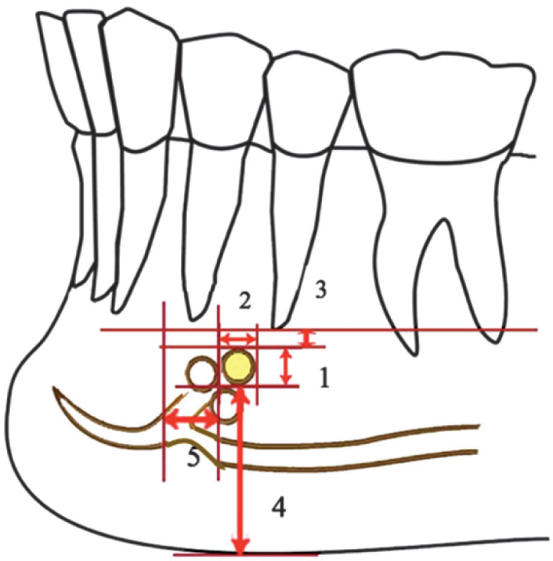

Fig. 1 Measurement in the radiograph
1 = vertical diameter of mental foramen
2 = horizontal diameter of mental foramen
3 = length from second premolar root to an upper edge of mental foramen
4 = length from a lower edge of mental foramen to the inferior border of mandible
5 = length from mesial edge of mental foramen to mesial edge of anterior loop of mental nerve

Remark: The upper most one will be used as a reference if more than one mental foramen presented.

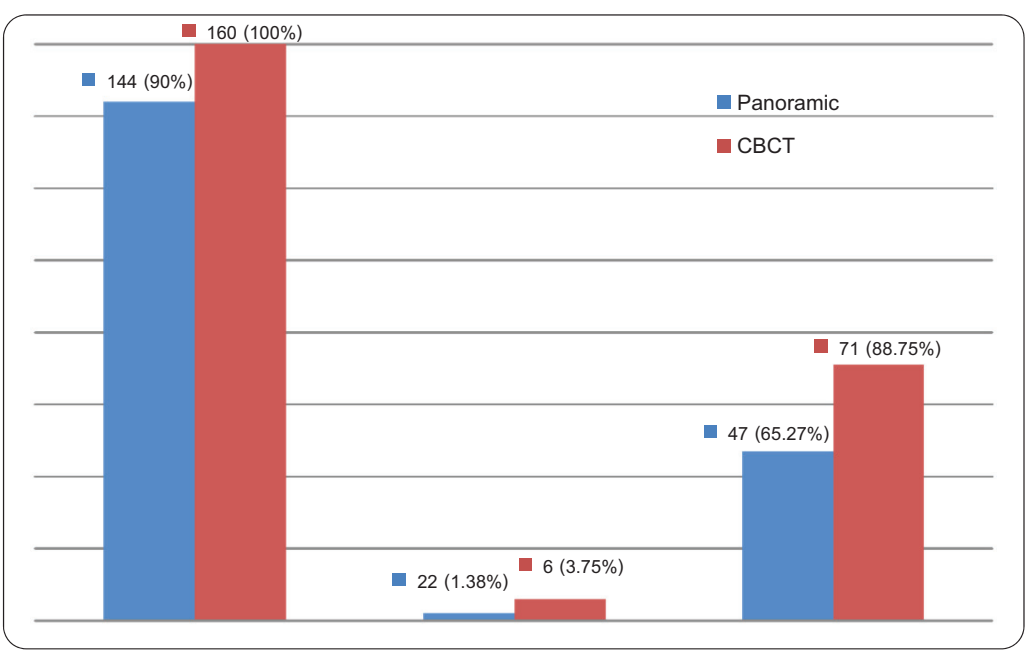

Fig. 2 Numbers of mental foramen, accessory mental foramen, and anterior loop of mental nerve observed in panoramic radiograph and CBCT images

Remark: CBCT: Cone Beam Computed Tomography

The CBCT counterpart reveals the mental foramen in all 80 images (100%) with the accessory foramen observed in 6 images (3.75%), 3 for each side (50%). There were anterior loops of mental nerve in 71 images. Their distribution for the right, left, and both sides were 1, 2, and 68 images (1.41%, 2.82%, and 95.77%) respectively.

The amount and spots of mental foramens found with the CBCT are: 53 (33.1%) located between first and second premolar, 86 (53.8%) located below second premolar, and 68 (95.77%) located between roots of second and first premolar.

The average length of interesting mandible features measured in panoramic radiograph and CBCT images is shown in Table 4 and 5. Notable values are horizontal diameter of mental foramen and length between a lower edge of mental foramen and the inferior border of mandible in panoramic radiograph, and vertical diameter of mental foramen and length between a lower edge of mental foramen and the inferior border of mandible in CBCT image, because they are significantly greater in males than females. Other average lengths measured among each method do not depend neither on the gender nor the measured side as there was no significant difference.

However, average lengths acquired from both imaging are significantly different. Those measured using panoramic radiograph are less than ones from CBCT except the length between second premolar root and an upper edge of mental foramen.

Table 4 Average length of interesting mandible features measured in panoramic radiograph and CBCT images

	Mean distance of each landmark that measured in panoramic radiograph (mm)								
	Male			Female			Overall		
	Right	Left	Mean	Right	Left	Mean	Right	Left	Mean
1	2.60±0.63	2.57±0.67	2.58±0.65	2.39±0.58	2.51±0.55	2.45±0.56	2.50±0.61	2.54±0.61	2.52±0.61
2	3.65±0.92	3.55±1.08	3.60±0.99	3.22±0.75	3.31±0.91	3.26±0.83	3.44±0.86	3.43±1.00	3.44±0.93
3	4.38±2.93	3.72±2.88	4.05±2.91	4.00±3.03	3.43±2.94	3.71±2.98	4.26±2.95	3.58±2.90	3.89±2.93
4	13.73±1.89	14.06±2.27	13.89±2.08	12.13±1.78	11.86±1.53	12.00±1.66	12.97±1.99	13.02±2.24	13.00±2.11
5	2.70±1.64	3.40±1.72	3.02±1.70	3.27±2.17	3.01±1.77	3.14±1.96	2.95±1.90	3.21±1.74	3.08±1.82

Remark: 1 = vertical diameter of mental foramen
2 = horizontal diameter of mental foramen
3 = length from second premolar root to an upper edge of mental foramen
4 = length from a lower edge of mental foramen to the inferior border of mandible
5 = length from mesial edge of mental foramen to mesial edge of anterior loop of mental nerve

Table 5 Average length of interesting mandible features measured in and CBCT images

	Distance of each landmark that measured in CBCT (mm)±(SD)								
	Male (mm)±(SD)			Female (mm)±(SD)			Overall (mm)±(SD)		
	Right	Left	mean	Right	Left	mean	Right	Left	mean
1	2.60±0.63	2.57±0.67	2.58±0.65	2.39±0.58	2.51±0.55	2.45±0.56	2.50±0.61	2.54±0.61	2.52±0.61
2	3.65±0.92	3.55±1.08	3.60±0.99	3.22±0.75	3.31±0.91	3.26±0.83	3.44±0.86	3.43±1.00	3.44±0.93
3	4.38±2.93	3.72±2.88	4.05±2.91	4.00±3.03	3.43±2.94	3.71±2.98	4.20±2.96	3.58±2.90	3.89±2.93
4	13.73±1.89	14.06±2.27	13.89±2.08	12.13±1.78	11.86±1.53	12.00±1.66	12.97±1.99	13.02±2.24	13.00±2.11
5	2.70±1.64	3.40±1.72	3.02±1.70	3.27±2.17	3.01±1.77	3.14±1.96	2.95±1.90	3.21±1.74	3.08±1.82
6	6.05±1.21	6.02±1.64	6.04±1.43	5.68±1.46	5.48±1.41	5.58±1.43	5.88±1.33	5.76±1.55	5.82±1.44

Remark: 1 = vertical diameter of mental foramen
2 = horizontal diameter of mental foramen
3 = length from second premolar root to an upper edge of mental foramen
4 = length from a lower edge of mental foramen to the inferior border of mandible
5 = length from mesial edge of mental foramen to mesial edge of anterior loop of mental nerve
6 = size of anterior loop of mental nerve in Bucco-Lingual direction

Discussions

The review of panoramic radiograph may not good enough when compared to the CBCT image, because there are some cases where some anatomical landmarks could not be identified, such as an unusual bone density, since the inability to differentiate from the surrounding structure. Moreover, false positive findings of accessory foramen and anterior loop of mental nerve observation were occurred because of the quantity of bone trabeculae in lower jaw. The anterior loop of mental nerve found in panoramic radiograph was only 40.2% of those found in the CBCT images from the same group of dentate patients. Several previous studies also support that this method may not suitable for detecting anterior loop of mental nerve because of false positive results. [7, 8, 9, 10]

In this study, CBCT image interpretation reveals rather high rate of anterior loop presence (88.75%). Even though the prevalence was relatively low (26%) in the previous study **[11]**, further reports reveal that the trend is getting increase, including the study of Mardinger et al. (28% in 2000) [7], Kuzmanovic et al.(37% in 2003) [11], and Neiva et al. (88% in 2004) [12]. In addition, the recent outcome regarding the frequency of anterior loop in 20-to-29-year population group found that more than 50% of them have a loop at least on one side. Since the average age of volunteers in this study is 21 years, the result is consistent with those afore mentioned researches.

At present, those anatomical features which cannot be seen with conventional panoramic radiograph, especially an anterior loop of mental nerve in the new generation, should be taken into account when interpreting image. Doing it inaccurately could harm such concealed organ or other structures.

The statistical comparison in this research, comparing volunteers' characteristics acquired from panoramic radiography and CBCT, found significant difference in length of all features. Despite some studies show that a panoramic radiography is good enough for studying human skull, such as a case that measure only ipsilateral side [13] and a case that could securely keep a skull in the focal trough easily [14], others disagreed

because the results were not accurate enough to be used in the evaluation before the treatment. [15] Hence, it can be said that a head alignment is very important to the integrity of an image. Moreover, a chance of getting error is high if researchers are not skilled enough.

Although CBCT could provide better quantitative and qualitative data for the medication, this method could not be used in all cases because of many limitations. [16-19] These including:

1. More radiation dose patient received
2. Only accessible in few hospitals
3. Experts needed to interpret an image
4. High operating cost.

Therefore, in case that panoramic radiograph has to be used, head alignment, image interpretation expertise, and concealed anatomical features, should be concerned about. However, there should be a safe margin about 2 mm above mandibular canal. [4] If there is any doubt close to a critical structure, it is recommended to use CBCT in diagnosis before the treatment.

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