

RADIOGRAPHIC ANALYSIS OF THE MENTAL FORAMEN AND MANDIBULAR CANAL LOCALIZATION

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Abstract

Evaluation of the position of mandibular canal and *foramen mentale* have great significance and it is very important aid in different dental procedures, such as: surgical, dental implant, periodontal, endodontic as well in diagnostic procedures. The main aim of this study was to evaluate the detection of mandibular canal and the mental foramen on classic and digital panoramic radiographs among the population in Macedonia.

A total number of 300 panoramic radiographs were evaluated. This investigation was including, the both types of panoramic x-rays, digital or classical. Assessment of the presence of *foramen mentale* and its relation with the adjacent structures and the mandibular canal was made by five independent examiners.

According to the data from this research, in near 60% from the analyzed x-ray images, *foramen mentale* is positioned between the roots of the first and second lower premolars. Most commonly found position of *foramen mentale* is between the vertical axis of the second premolar and the line passing between the first and second premolars in the lower jaw in 46.97%. According to the data presented in our research, the mandible canal in about half of cases (more precisely 47.61%) has a descending path through the mandible's body passing from the second lower molar to the *foramen mentale*.

Most commonly *foramen mentale* is localized between the first and second lower premolars, while the *canalis mandibularis* most often possesses a descending path through the mandible's body passing from the first lower molar to the *foramen mentale*.

Key words: *Canalis mandibularis, Foramen mentale, Panoramic x-ray imaging, Mandibular canal, Mental foramen.*

1. Introduction

Evaluation of the position of mandibular canal and *foramen mentale* have great significance and it is very important aid in different dental procedures, such as: surgical, dental implant, periodontal, endodontic as well in diagnostic procedures. Thus, the present study was conducted among the population in Macedonia, to determine the most common location of the mandibular canal and mental foramen and to estimate differences in position of *foramen mentale* in correlation with the second lower premolar. Knowledge of anatomical locations of the mandibular canal and mental foramen is an important factor in the surgical management of any patient.

Canalis mandibularis begins from the middle of the facies inferior of the *ramus mandibulae* via *foramen mandibulae* and goes through the bone under the roots of the mandibular tooth in the lower part of the *ramus mandibulae* and in *corpus mandibulae*. The final end is *foramen mentale* where this channel is divided into two channels - *canalis mentalis* and *canalis incisivum* [1].

The proportion of this channel with the roots of the posterior teeth is of great importance. The channel of the surrounding spongy tissue is separated by its own thin wall of compact bone tissue and comes into close relation with the roots of the two last molars, passing usually 6 - 7 mm below the roots. There are cases when the roots of these teeth penetrate into this canal, which should lead us to careful tooth extraction. The mandibular canal contains the inferior alveolar neurovascular bundle.

In panoramic X-ray images, a mandibular canal appears as a dark band of radiolucence zone limited by two radio-opaque lines. Knowledge about the anatomy, morphology and topography of the mandibular canal is important when some interventions in the

mandible are done, in order to preserve anatomical structures which pass through it. This is also important for success in some procedures such as successful local anesthesia of the inferior alveolar nerve terminal branches, it is determining factor in reducing paresis and hemorrhage occurrence, as well as lowering the risk of complications during surgical procedures such as osteotomy and mandibular implant positioning [2, 3].

Other important anatomical structure located in the corpus mandibulae is *foramen mentale*. It has to be noted that *foramen mentale* has many anatomical variations not only in its size, location, shape and direction of the opening. The size, shape, location and direction of the opening of *foramen mentale* have many variations and these variations are related to many factors as race, age and gender.

The mental foramen is an opening located on the external surface of the mandible in the region of the mandibular premolars. The inferior alveolar blood vessels and nerve after being conveyed through the mandibular canal exit the *foramen mentale* as the mental blood vessels and nerve. Radiographically the *foramen mentale* is appreciated as an oval or round radiolucent zone in the inferior part of corpus mandible on lateral sides, left and right [4].

Panoramic radiography is most common used in everyday dental practice and it provides an overview, giving a broad coverage of the facial bones and teeth in both jaws, which is useful in the initial evaluation. Most important advantages of panoramic radiography are low cost, low dose of radiation, and greater availability. Nevertheless, panoramic x-ray does not provide precise and detailed information about each individual tooth or soft tissues, such as the muscles. Panoramic radiography generates a two-dimensional (2D) image that lacks information in the bucco-lingual direction and magnification in both the vertical and horizontal directions. The image quality of panoramic radiography can be increased using digital panoramic radiography. In particular, visualization of the mental foramina can be further enhanced by evaluating digital panoramic radiographs with software programs.

Panoramic x-ray images are generally used as an initial evaluation of the bones and teeth. On the other hand, the disadvantages of this diagnostic tool are the magnification, lower sharpness, and lack of information in the third dimension. Because the mouth is curved, panoramic x-ray can sometimes create a slightly blurry image where accurate measurements of teeth and jaw are not possible. If the clinician needs more information, a computed tomography (CT) scan or magnetic resonance imaging (MRI) may be needed. This may include Dental Cone Beam CT, an imaging exam developed specifically for this part of the body [5].

According to Cartes *et al.*, [6], *foramen mentale* is usually located between the apices of the first and second premolars in younger individuals and immediately below the apex of the inferior second premolar in older individuals. Srinivas *et al.*, [7], in their research published that the most common position of the *foramen mentale* was along the long axis of the second premolar in the north Indian population and between the first and second premolar in south Indian populations.

Fishel *et al.*, [8], investigated vertical *foramen mentale* position and reported that in the first premolar area of 936 patients, the foramen mental was situated coronal to the apex in 38.6% of cases, at the apex in 15.4% of cases, and apical to the apex in 46.0% of cases. The *foramen mentale* location, in relation to the second premolar, was coronal to the apex in 24.5% of cases, at the apex in 13.9% of cases, and apical to the apex in 61.6% of cases. It must be noted that is very unusual to find foramen located anteriorly by the canine or posteriorly beyond the first molar

In the part referring to the relation of the mental foramen and the mandibular canal, it is necessary to mention several facts:

- Mandibular canal is not possible to monitor in all his way through the mandible.
- Mandibular canal has numerous curvatures in any direction.
- Mandibular canal can be covered with teeth.
- Orthopantomorphographs x-ray records give only two-dimensional image of the canal.

As it is mentioned, when administering regional anesthesia, performing periapical and dental implant surgical intervention, or implementing endodontic treatments in the mandible, it is important to localize the mental foramen to prevent injuries. However, accurately localizing the mental foramen is typically difficult. Its position is generally described as being below the second premolar, but individual variation is common.

To avoid nerve injury, a better understanding of the anatomo-morphological location and course of the mandibular canal and *foramen mentale* before any surgical procedure is strongly recommended and very useful.

The main aim of this study was to evaluate the detection of mandibular canal and the mental foramen on classic and digital panoramic radiographs among the population in Republic of Macedonia.

2. Materials and Methods

This research was done on 300 panoramic radiographs. The number of female and male examinees was equal, to exclude the gender impact of the results. Evaluation

of the positioning of *canalis mandibularis* and *foramen mentale* was not performed in completely toothless individuals. This investigation was including, the both types of panoramic x-rays, digital or classical.

All radiographic images where *canalis mandibularis* or *foramen mentale* that cannot be localized and confirmed were excluded from the study.

The examination and evaluation was performed on a negatoscope if it is classical orthopantomograph x-ray records, or by adequate software used for imaging of the x-rays. If necessary, adequate magnification was used.

For complete and correct evaluation, the following conditions were fulfilled by the panoramic x-ray to be included in this investigation:

- High quality and contrast.
- Absence of artefacts in the area of *foramen mentale*.
- Appropriate angulation of the x-rays.
- The presence of teeth from the left first to the right first molar (to avoid the possibility of dental migration).
- Absence of periapical changes of teeth in the premolar region (which can be wrongly interpreted as *foramen mentale*).
- Presence of premolars in the upper jaw to avoid elongation of the premolars from the lower jaw.
- Patients should not be under orthodontic treatment.

Assessment of the presence of *foramen mentale* and its relation with the adjacent structures and the mandibular canal was performed by five independent examiners, including the main examiner. All of the examiners were evaluating equal number of panoramic x-rays. This study includes different profiles of researchers, doctors of general medicine and doctors of dental medicine. The main principle that one person could become part of the examiners is a great knowledge of the anatomy of the lower jaw. The following table shows the educational profile and specialization of the researchers (Table 1).

Table 1. Classification of examiners

Education profile of the examiner	Specialization
Full time professor	Anatomy
Assistant teacher	Dentistry
Master of dental science	Dentistry
Assistant teacher	Anatomy
Associate professor	Dental implantology

Relationship of *foramen mentale* with the lower premolars were given according to the following classification:

- The position of *foramen mentale* is distally from the line that passes between the second premolar and the first molar in the lower jaw-first class.
- The position of *foramen mentale* is between the vertical central axis of the second premolar and the passing line between the second premolar and the first molar in the lower jaw- second class.
- Position of the *foramen mentale* is between the vertical axis of the second premolar and the line passing between the first and second premolars in the lower jaw- third class.
- The position of *foramen mentale* is between the line that passes between the first and second premolars in the lower jaw and the vertical central axis of the first premolar-fourth class.
- Positional position of *foramen mentale* is mesially from the vertical center axis of the first premolar-fifth class.

In these cases *foramen mentale* can be localized above or in line with the apex of the premolars from the lower jaw or between the apexes of both premolars.

In the part, where assessing the relationship of *canalis mandibularis* and *foramen mentale* was done, we estimated the relationship of the mental foramen and *canalis mandibularis* in terms of whether the canal stretches only descending, parallel (horizontally) or ascending from the area of the second lower molar towards the mental foramen. Also it was followed whether the canal had a wavy motion through the mandible.

For statistical processing, special software for statistical data processing - Statistic 7.1 was used for this research.

3. Results and Discussion

3.1 Results

In the following section the results of the research concerning the location of *foramen mentale* and its relationship with *canalis mandibularis* are presented.

The average age of participants in the survey was 23.79 ± 6.92 years (range 9 - 54 years with confidence interval from 18.23 to 35.41 years). Regarding the gender distribution, they were used the same number of x-rays from both sexes (150 of each gender).

In the part of the survey where the position of the *foramen mentale* was determined, after an adequate analysis of the panoramic x-rays, 264 (88% of the total number of shots) were used as a subject of the analysis. The reason for this exclusion of some of the x-rays was that they did not meet the criteria for inclusion in the examined group.

Table 2 presents the data referring to the positioning of *foramen mentale* in relation to the two lower

premolars, if it is under the first or under the second premolar or the openings is located between these two teeth.

Table 2. Position of *foramen mentale* in correlation with the mandibular premolars

Under first premolar	Between two premolars	Under second premolar
16.6 %	62.5 %	20.9 %

The table below (Table 3) presents the data referring to the position of the mandibular canal according to the previously presented mandibular channel positioning classes (described in the section 2. Materials and Methods).

Table 3. Position of *foramen mentale* in correlation with the mandibular premolars according to the different classes of positioning

Class	Total (%)
First class	2.27
Second class	14.02
Third class	46.97
Fourth class	25.76
Fifth class	10.98

Based on the presented results, it can be noted that the most common localization of *foramen mentale* is between the two lower premolars, while the remaining positions are rare.

Also, after statistic processing, no significant difference was observed of the different positions of *foramen mentale* in the male and female subjects (for $p < 0.005$).

Regarding the analysis of the positioning and the path taken by the mandibular channel after the application of the exclusion criteria, only 271 (90.33%) of the total number of panoramic images were used. Table 4 shows the most common positioning of the mandibular canal in the region from the second lower molar to the *foramen mentale*.

Table 4. Position of *canalis mandibularis*

Position	Total
Ascending	3.32 %
Descending	47.61 %
Horizontal	19.93 %
Wavy	29.14 %

On the basis of the processed data, it can be noticed that the mandibular canal has the most often descending direction through the corpus mandibulae, in about 50% (more precisely in 47.61%).

3.2 Discussion

This study is an in vitro anatomic-morphological study to help in identifying the position of *canalis mandibularis* and *foramen mentale* in the lower jaw. For proper and accurate determination of positioning panoramic x-ray images were used.

Bearing in mind the fact that knowledge about the various and possible positioning of *canalis mandibularis* and *foramen mentale* is important and helpful to avoid damage of neural and vascular structures in different oral surgical procedures, aids in interpreting anatomical landmarks in oral radiology and it is important for dental implant planning and placing. Understanding the position of these anatomic structures will also assist the clinician in performing local anesthetic blocks while some oral, implant or periodontal surgical techniques are performing. All canals and foramina in the mandible are commonly exposed to local anesthetic procedures, mandibular cystectomy and mandibular tumor resection.

This is a reason why, adequate determination of the radiographic position and features of *canalis mandibularis* and *foramen mentale* is very important in order to discover different anatomic descriptions that were made in past and also to reduce or eliminate the possibility of complications during the interventions.

According to the data from this research, in near 60% from the analyzed x-ray images, *foramen mentale* is positioned between the roots of the first and second lower premolars. A similar common positioning of *foramen mentale* (located at mesial half of the lower second premolar) is presented in one research from 2016 published by Thakare *et al.*, [9]. In one study performed by Fuentes *et al.*, [10], it was found that *foramen mentale* is mostly located on the longitudinal axis of the second premolar on the right side and between longitudinal axes of the first and second premolars on the left side, which shows similarities to our results. Similar results to our study were published by Bokhari *et al.*, [11], after analyzing of 900 panoramic radiographs in Saudi Arabia. In one research from Nigeria, Olosoji *et al.*, [12], reported that the mental foramen was located between the first and second premolars in 34% of the cases and below the apex of the second molar in 24.5% of the cases.

According to the data presented in our research, the mandible canal in about half of cases (more precisely 47.61%) has a descending path through the mandible's body passing from the second lower molar to the *foramen mentale*. Similar data are also presented in most of the professional and scientific literature related to the assessment of the pathway that passes the mandibular canal [13, 14, and 15].

According to the results published by Sirbu *et al.*, [16], shown that the main pattern of the mandibular canal's

vertical trajectory, characterized by the canal's location in the superior half of the mandibular body, descending from the second molar region to the premolar region. This main vertical topographic pattern of the mandibular canal according to these authors was found in 28 (87.5%) of the analyzed cases. In four (12.5%) cases, the mandibular canal had a descending course in the posterior two thirds and a slightly ascending course in the anterior one third of the mandibular body.

Also, it must be noted that Ulm *et al.*, [17], showed that the distance between the mandibular canal and the top of the alveolar ridge is mostly affected by the atrophying process after lower teeth extractions.

At the end, it must be noted that this study has some limitations, primarily because no patient information are available to assess participant ethnicity and previous dental treatment. Also the sample size was small and magnification of the panoramic x-rays was not always used. If the studies related to variations in the position of *foramen mentale* are carried out in larger number of subjects, this data will be reliable for dental medicine clinicians, and with this type of information the possibility of complications will be minimized.

4. Conclusions

- The present results showed variations in position of *foramen mentale* and *canalis mandibularis*. This variability should alert the dental practitioners while performing oral surgical and periodontal interventions.
- According to our results most commonly *foramen mentale* is localized between the first and second lower premolars, while the *canalis mandibularis* most often possesses a descending path through the mandible's body passing from the first lower molar to the *foramen mentale*.

5. References

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