

Resorption of the Peri-Implant Bone in the Lateral Region of the Lower Jaw – The Significance of the Mandibular Canal

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ABSTRACT

Background: This study aimed to determine whether early peri-implant bone resorption on 2D panoramic radiographs differs between patients with implants placed close to the mandibular canal and those with implants placed farther from it.

Methods: The study included 30 radiographs. All images were obtained at the 3Dent radiology center using cone-beam computed tomography (CBCT) with Planmeca Romexis software and digital two-dimensional panoramic imaging with a Planmeca coupled device. On panoramic radiographs, the position of the mandibular canal was measured from the upper border of the alveolar process and from the lower mandibular border in the molar region. The distance from the implant apex to the mandibular canal was then assessed. Group 1 consisted of 15 radiographs with implants placed less than 1 millimeter from the canal, and Group 2 of 15 radiographs with implants placed more than 1 millimeter away. Peri-implant osteolysis was assessed mesially and distally utilizing customized software for two-dimensional image processing and classified as vertical or horizontal.

Main findings: Female predominance was not statistically significant. Horizontal bone resorption was also not significant. The mean canal-implant distance differed considerably between the groups. Vertical mesial resorption diverged significantly, while distal resorption did not. No gender-related differences were found. The average canal distance among all subjects was 1.64 mm.

Principal conclusion: The hypothesis that implants placed closer than 1 mm to the mandibular canal would show greater early peri-implant bone resorption on 2D radiographs was not confirmed.

Key words: resorption, mandibular canal, implant, radiograph

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INTRODUCTION

The opening of the lower jaw, the mandibular foramen, marks the beginning of the mandibular canal. The opening is located approximately in the middle between the anterior and posterior borders of the mandibular ramus, at a distance of 16 to 18 (15 to 20) mm from the borders. It is situated approximately 30 to 35 mm below the lower border of the mandible. The mandibular canal has its own wall made of compact bone tissue and runs through the entire body of the bone up to the mental foramen. The canal contains alveolar blood vessels and a nerve, as well as their branches. In older age, the dental part of the mandible resorbs, so the canal and mental foramen may directly reach the newly formed edge of the mandibular body. Throughout life, the teeth are in close relationship with the canal, with the roots of the third and second molars sometimes located within the canal itself (1). There is also the retromolar canal, a bifid variation of the mandibular canal that branches off above the main canal and travels anterosuperiorly within the bone to exit through one or more foramina in the retromolar fossa. The retromolar foramen allows auxiliary branches of the inferior alveolar neurovascular bundle to supply tissue in the retromolar triangle. It is important to determine the location of the mandibular canal and identify its retromolar accessory branches when performing surgery on the posterior mandible (2).

Inadequate preparation of the alveolar ridge or improper placement of implants in the mandible can lead to perforation of the mandibular canal and injury to the inferior alveolar nerve. Injury can range from mild to severe, manifesting as slight sensory loss or change, or persistent painful sensations, to complete and permanent sensory loss (3). Mild injury caused by compression of the nerve, with axons remaining intact, results in sensory impairment or loss that typically recovers within four weeks after surgery. More significant compression or traction causing

edema, ischemia, or demyelination can lead to axonal damage; however, nerve continuity remains preserved. If conditions permit, positioning the implant 1–2 mm away from the nerve is recommended.

If sensory changes are due to inflammatory response, therapy with corticosteroids or non-steroidal anti-inflammatory drugs (NSAIDs), such as ibuprofen 800 mg for three weeks, may be prescribed (4). The clinician may recommend an additional three weeks of anti-inflammatory therapy. Partial recovery of sensation in such cases can be expected within five to 11 weeks, with further improvement over the following 10 months. The most severe injury involves complete nerve transection, which requires microsurgical repair. The prognosis for complete recovery of such injuries is poor and unpredictable.

Preoperative and intraoperative steps are highly recommended, such as: detailed analysis of cone-beam computed tomography (CBCT) images to determine the spatial relationships of anatomical structures, including the superior border of the mandibular canal and the crest of the alveolar ridge at the planned implant site, maintaining a safety margin of 2 mm between the apical end of the implant and the superior border of the mandibular canal (7), using stoppers on drills whenever possible to prevent over-penetration, employing surgical guides for navigation, and accounting for an additional 0.5–1 mm length of the drill in relation to the implant length.

Loss of posterior teeth causes neuromuscular instability of the mandible, reducing masticatory efficiency, decreasing vertical occlusal dimension, and inducing changes in the alveolar bone. Resorptive changes depend on the number and position of remaining teeth, the age of the individual, and metabolic rates (5). Bone resorption around implants is considered a physiological phenomenon acceptable within defined limits, mostly pronounced during the first year. After one year of implant placement, bone remodeling concludes, and a stable phase begins, with vertical bone loss stabilizing at approximately

0.1 mm annually. If vertical loss exceeds 0.2 mm per year, the finding is considered pathological (6).

The alveolar bone receives nourishment from three sources: the periodontal ligament, bone marrow, and periosteum. With the placement of an implant, the periodontal ligament is lost, removing one source of bone nourishment. The reason for resorption of the buccal lamella lies in its structure. The buccal bone lamella consists solely of the lamina dura with little or no marrow tissue in the apical area. The function of the lamina dura is to anchor teeth via periodontal fibers in the alveoli; with tooth and periodontal tissue loss, it loses its function and gradually resorbs (7).

Elevation of the surgical flap during implant placement, which disrupts vascularization from soft tissues, also contributes to resorption, resulting in additional bone loss of 0.5–0.7 mm (8). Therefore, whenever possible, it is better to perform a limited incision necessary for visualization of the bone without elevating a full-thickness flap.

Planning minimizes complications and is an extremely important step (9). It involves initial examination, taking a medical history, clinical assessment, radiological evaluation, and prosthetic planning for the procedure. Before implant therapy, it is necessary to treat any pathological conditions of the jaw or teeth, evaluate the optimal position for implant placement, and determine the surgical approach to ensure safety.

Proper positioning of dental implants in vertical and horizontal dimensions ensures implant stability, which is crucial for osseointegration. In the mandible, structures that should not be damaged during surgery include the mandibular canal, along with its nerves and blood vessels (5,10,11). Today, CBCT diagnostics are most commonly used for planning implant therapy, as they provide three-dimensional visualization with minimal radiation exposure. For flapless procedures, panoramic 2D radiographs are usually utilized to guide implant placement.

The aim of the research was to determine whether there is a difference in early peri-implant bone resorption on 2D panoramic radiographs in patients whose implants are placed too close to the mandibular canal compared to those whose implants are placed farther away from the canal. The hypothesis is that patients with implants placed in close proximity to the mandibular canal on 2D radiographs will exhibit greater early peri-implant bone resorption than those with implants placed at a greater distance.

PARTICIPANTS AND METHODS

Participants

The study included 30 panoramic 2D radiographs. They were divided into two groups: 15 panoramic 2D images with implants placed in the lateral region of the mandible at a distance less than 1 mm from the mandibular alveolar canal, and 15 panoramic 2D images with implants situated in the lateral region of the mandible at a distance greater than 1 mm from the mandibular alveolar canal. Each patient had a 3D CBCT scan performed prior to the surgical procedure and a 2D panoramic radiograph taken after the surgical procedure. The patient groups were age- and sex-matched. All implants were placed subcrestally, and all implants were inserted using the covering technique. The implants were placed in the lateral, molar region of the mandible and at the time of measurement, they were neither exposed nor equipped with a gingivally positioned abutment or abutment screw. All patients reported good general health in their medical history, denying hypersensitivity to medications or anesthesia.

Inclusion criteria for participants in the study were all 3D CBCT and 2D panoramic radiographs of patients who had undergone implant therapy in the lateral, molar region of the mandible, aged over 16 years for women and over 19 years for men. All images were taken at the same radiological center, 3Dent.

Exclusion criteria included patients who had not undergone implant therapy in the lateral,

molar region of the mandible, 2D panoramic radiographs where the radiological projection of the mandibular alveolar canal was unclear or artifacts were present in the region, patients younger than 16 years or men younger than 19 years, images taken in other radiological offices or with different CBCT or 2D devices, implants placed using different techniques, and all CBCT and 2D images interpreted by other dental medicine professionals.

Methods

The study included 30 radiographic images from the archive of the Dr Šarac specialized dental practice. All images were taken at the same radiological center, 3Dent, using CBCT, Planmeca Romexis with digital software, and 2D orthopantomograms with the Planmeca coupled device, and were viewed on an Asus laptop with an Intel Core i3 processor. All implant planning was performed by the same dental medicine doctor who also carried out the implant treatment.

In the 2D orthopantomogram, within the implant package, the position of the mandibular alveolar canal from the upper marginal edge of the alveolar process and from the lower mandibular edge in the projection of the molar region was first measured. Then, the distance from the apical point of each implant to the edge of the mandibular alveolar canal was assessed.

Measurements were taken using the customized Measure Length option, which allows for measuring thickness, height, and length in the desired area.

Two groups of 15 patients' 2D orthopantomograms were created: one group with implants in the lateral mandibular region placed less than 1 mm from the mandibular alveolar canal, and another with implants placed more than 1 mm away from the canal.

Peri-implant osteolysis on the mesial and distal sides of each implant was measured with the measure tool, from the marginal point of the implant neck to the initial bone shadow shown on the 2D radiological image, for each participant and both groups. The peri-implant

osteolysis was classified as vertical or horizontal.

After measuring the osteolysis, the approximate marginal bone loss was determined, and the average peri-implant osteolysis for each group was calculated.

Statistical analysis

Statistical processing and data analysis included values of peri-implant resorption on the mesial and distal sides, the distance from the apical point of the implant to the edge of the mandibular canal, and the presence of horizontal resorption on 2D orthopantomographic images. For statistical data processing, the Mann-Whitney U test and Chi-square test were utilized. Statistical analysis was conducted using SPSS for Windows (Version 17.0; SPSS Inc., Chicago, IL, United States) and Microsoft Excel (Office 2016, Microsoft Corporation, Redmond, WA, USA).

RESULTS

In the studied sample, there were more female participants, and more subjects with the presence of horizontal resorption; however, the differences were not statistically significant (Table 1).

Table 1. Sample characteristics

	n	%	χ^2	p
Gender			1.200	0.273
M	12	40.0		
F	18	60.0		
Horizontal resorption			3.333	0.068
Yes	20	66.7		
No	10	33.3		

The mean distance from the alveolar canal in 30 subjects was 1.64 mm, with a standard deviation of 1.47 mm, indicating that in most cases, the distances from the alveolar canal are small.

The average distance from the alveolar canal in the two study groups shows a statistically significant difference. In Group 1, where

implants were placed less than 1 mm from the alveolar canal, the mean distance was 0.56 mm, while in Group 2, with implants placed more than 1 mm from the canal, the mean distance was 2.72 mm.

The mean mesial bone resorption was greater in Group 2 (0.84 mm) compared with Group 1 (0.34 mm). This difference was statistically significant, indicating that implants positioned farther from the mandibular canal exhibited slightly higher values of mesial bone loss.

The mean distal bone resorption was higher in Group 2 (0.85 mm) compared with Group 1 (0.45 mm). Although the values were numerically greater in the group with implants placed farther from the mandibular canal, the observed difference did not reach statistical significance. These results indicate that, unlike mesial bone changes, distal peri-implant bone resorption was not substantially influenced by the distance between the implant apex and the mandibular canal.

In most examined cases, mesial bone resorption was minimal or completely absent, indicating a generally stable peri-implant bone level in the mesial region. The mean mesial resorption value for all examined implants was 0.64 mm, with a standard deviation of 0.896 mm. Higher levels of resorption were observed only sporadically and occurred less frequently among the studied sample.

Similarly, distal bone resorption showed predominantly minimal changes, with a mean value of 0.64 mm and a standard deviation of 0.817 mm, based on 30 measurements. Higher degrees of distal resorption were observed less frequently, confirming that most implants exhibited stable peri-implant bone conditions distally as well.

Male subjects showed greater distances from the alveolar canal; however, the difference was not statistically significant (Figure 1).

Male subjects showed higher mesial resorption values compared to female subjects, but the difference was not statistically significant (Figure 2).

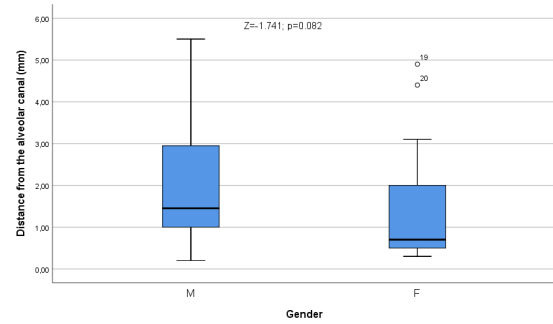


Figure 1. Gender differences in the distance from the alveolar canal.

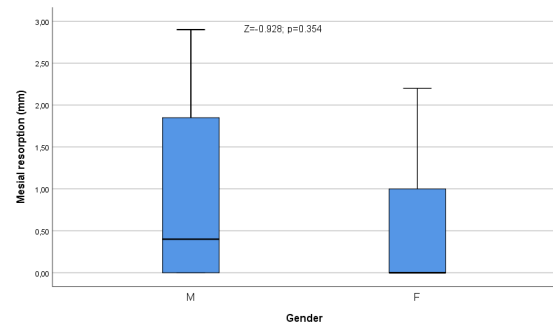


Figure 2. Gender differences in mesial resorption.

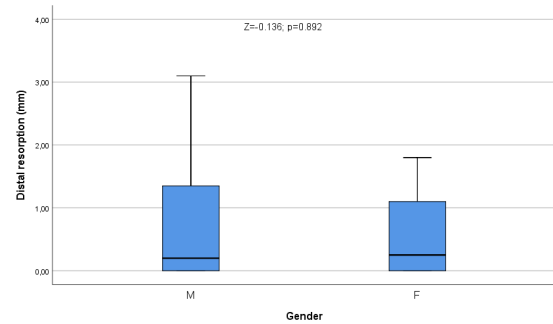


Figure 3. Comparison of distal bone resorption values between male and female subjects.

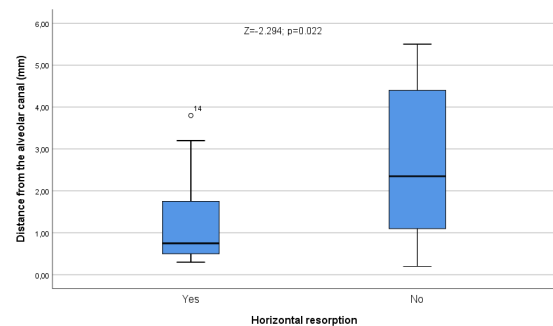


Figure 4. Distance from the alveolar canal in relation to horizontal resorption.

Male subjects showed higher distal resorption values compared to female subjects, but the

difference was not statistically significant (Figure 3).

There was a statistically significant difference in the distance from the alveolar canal between implants with and without horizontal resorption (Figure 4).

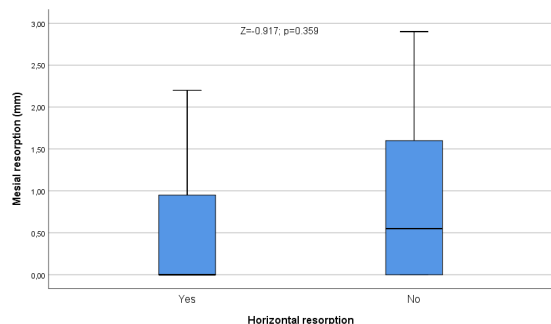


Figure 5. Mesial resorption in relation to horizontal resorption.

There was no statistically significant difference in mesial resorption between implants with and without horizontal resorption, and the presence of horizontal resorption did not have a significant impact on mesial resorption (Figure 5).

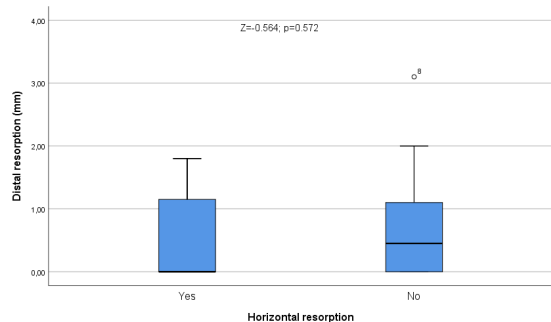


Figure 6. Distal resorption in relation to horizontal resorption.

There was no statistically significant difference in distal resorption between teeth with and without horizontal resorption, and horizontal resorption did not have a significant impact on distal resorption (Figure 6).

DISCUSSION

The study showed that patients with implants positioned farther from the mandibular

alveolar canal according to 2D imaging have greater levels of early peri-implant resorption than patients whose implants are placed closer to the alveolar mandibular canal. There is little cross-sectional research on this topic. In the examined sample, the distribution of the distance from the alveolar canal demonstrates that the majority of measurements indicate a distance of approximately 1 mm. The statistically significant difference between Group 1 and Group 2 is the average distance from the mandibular alveolar canal, with vertical mesial resorption being higher in the examined Group 2. The average distal resorption values are higher in Group 2, but not statistically significant. The evaluation confirmed that mesial and distal resorptions around the implants are minimal, which means that implantology is a prognostically predictable and safe treatment method.

Greater distances from the mandibular alveolar canal and higher values of peri-implant resorptions were recorded in men compared to women, but the differences were not statistically significant. Sabău et al. also noted gender differences in resorption, with higher resorption values found in males (12). A statistically significant difference was identified in the distance from the mandibular alveolar canal between implants with and without horizontal resorption. In this study, the implants were placed using a freehand technique and fully utilized the bone volume. Zhang et al. concluded in their work that dynamic navigation without a flap ensures surgical safety and visualization precision, as well as protecting the inferior alveolar nerve, while implants can be placed deeper and the remaining bone volume fully employed (13).

The types of complications assessed for implants include: implant loss and peri-implantitis, as well as bone loss greater than or equal to 2.5 mm, in addition to sensory disorders, soft tissue complications, implant fractures, and technical complications related to implant components and superstructures. Implant loss before functional loading can be expected in approximately 2.5% of all placed

implants, including therapies with more than one implant. There are limited data on the occurrence of peri-implantitis and implants showing bone loss greater than or equal to 2.5 mm (14). In this study, both horizontal and vertical bone resorption were observed and recorded. Vertical resorptions are minimal or absent in most cases, while horizontal resorption is more frequent, but statistically, no significant differences in resorption were found. Other authors have also differentiated between vertical and horizontal bone resorption in their works (15).

Tufekcioglu et al. conducted a study involving 474 implants in 314 patients placed posterior to the mental foramen and compared pain, paresthesia, and neurosensory complications associated with implants placed closer than 2 mm to the mandibular alveolar canal with those placed farther than 2 mm. Of these, 153 implants (32.2%) were placed closer than 2 mm, while 321 implants (67.8%) were situated farther than 2 mm from the mandibular alveolar canal. The distance of the implants from the mandibular alveolar canal did not show a significant difference in terms of pain and paresthesia (16). This evaluation included non-loaded implants. Group 1 had a lower average distance (0.56 mm) from the mandibular canal compared to Group 2, which had an average distance of 2.72 mm from the mandibular canal. This work used the same pattern of distance from the mandibular canal, adding to its credibility.

Aljarbou et al. assessed the relationship between the roots of the first and second mandibular molars and the mandibular alveolar canal and cortical plates using CBCT. The average distance between the apices of the lower molars and the mandibular alveolar canal ranged from 1.68 to 4.79 mm, while the mean distance from the outer surface of the buccal cortical plate to the surface of the buccal root ranged from 2.33 to 6.72 mm. The results may be useful to clinicians, as they may be aware of the distance between the first and second mandibular molars and the mandibular alveolar canal, allowing for accurate planning

of endodontic surgeries, extractions, and implant placements (14). The distance from the mandibular alveolar canal (1.68 mm) closely matches the mean distance from the apex of the implant to the mandibular canal in this study (1.64 mm).

In the lower jaw, the proximity to the mandibular canal is the most important factor determining the length of the implant. The height of the alveolar ridge in the lower jaw must be at least 12 mm, or 10 mm for the length of the implant, plus an additional 2 mm to provide a safety distance between the implant apex and the lower alveolar nerve (17). Short implants, even with immediate loading, can be a reliable solution, with platform switching and the use of interpositional devices reducing marginal bone loss (18).

A limitation of this study is the inclusion of images from only one specialist dental office and one radiology center. Panoramic 2D radiographic images, while useful, have limitations in accurately measuring bone resorption compared to 3D radiographs. Including a larger number of CBCT and 2D orthopantomographic images from other specialist dental offices and radiology centers would provide a more comprehensive picture of this topic. Future research could also focus on peri-implant resorption on CBCT images along with recorded injuries to the mandibular canal and resorption in loaded implants.

The results of this study complement the relationship between anatomical structures and peri-implant early bone resorption. Similar works are rare, and the results could enhance prognostic safety in practical dental implantology.

CONCLUSION

The difference in the distance of the placed implants from the alveolar canal according to gender was not statistically significant. Peri-implant horizontal bone resorption according to the distance of the implant from the mandibular canal was not statistically significant. Peri-implant vertical resorption on

2D radiographic findings, measured mesially and distally according to gender, was also not statistically significant.

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CONFLICT OF INTEREST

None to declare.

AUTHORS' CONTRIBUTIONS

AM conceived and designed the study; IŠ collected the data; AM analyzed the data, interpreted the results, and prepared the figures; IŠ edited and revised the manuscript; AM and IŠ approved the final version of the manuscript.

ETHICAL BACKGROUND

Institutional review board statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee.

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: We deny any restrictions on the availability of data, materials and associated protocols. Derived data supporting the findings of this study are available from the corresponding author on request.

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