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Facial alveolar bone width at the first and second maxillary premolars in healthy patients: A cone beam computed tomography study

--Manuscript Draft--

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Abstract:	The purpose was to analyze the thickness of the facial alveolar bone at the first and second maxillary premolars and determinate the percentage of premolars that reached 2 mm in width. A retrospective study analyzing cone beam computed tomography scans from the database of the Oral Surgery Unit of the University of Valencia was performed. Patients with periodontal disease, orthodontic treatment, absence among the first maxillary molars, premolars with endodontic treatment and/or prosthetic restorations were excluded. The facial alveolar bone width was measured at 1, 2, 3 and 5 mm apical to the vestibular bone peak. A total of 44 patients were included in the study, of whom 72 first premolars and 72 second premolars were analyzed. A descriptive analysis was performed and the normal means were assessed using the Kolmogorov-Smirnov test. The average width of the facial alveolar bone at first and second maxillary premolars was respectively: 1.41 ± 0.50 and 1.72 ± 0.56 at 1 mm; 1.68 ± 0.72 and 2.23 ± 0.66 at 2 mm; 1.71 ± 0.89 and 2.43 ± 0.82 at 3 mm; 1.44 ± 1.00 and 2.31 ± 1.06 at 5 mm from the vestibular bone peak. The facial alveolar bone width at the second maxillary premolars was greater than at the first maxillary premolars at all points measured. This information should be taken in account when planning immediate implants. Further studies analyzing bone resorption at maxillary premolars are needed to better understand facial alveolar bone width influence in implant treatment.
Response to Reviewers:	Dr. Jim RutkowskiFebruary 15th, 2017 Editor-in-Chief Journal of Oral Implantology Dear Dr. Jim Rutkowski,

Thank you very much for evaluate and review the manuscript “Facial alveolar bone width at the first and second maxillary premolars in healthy patients: A cone beam computed tomography study” aaid-joi-D-16-00195. Following the valuable comments of the reviewer we have had the opportunity to improve our study. We have made, as mentioned in your letter, changes to the manuscript. In our opinion this has enhanced our study.
The changes in the paper are in yellow, so it is easy to see which changes have been made. Here we show highlighted the changes that we have made:

Reviewers' comments:

Facial alveolar bone width at the first and second maxillary premolars in healthy patients: A cone beam computed tomography study (aaid-joi-D-16-00195).

Positive declarative statements were used by the reviewer to rate the submitted manuscript. The reviewer rated each statement using a scale from 1 –4: 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree, NA/NC = Not Applicable or No Comment by the reviewer.

SEE RESULTS

I. Title and Abstract:
[1] A. Title clearly identified target(s) population and variables under study.
Facial alveolar bone width at the first and second maxillary premolars in healthy patients: A cone beam computed tomography study
[1] B. Abstract was well written and clearly described the purpose, methods {subjects, instrument(s), design, procedures}, important findings, implications, theoretical support, limitations, and recommendations for future research.
The purpose was to analyze the thickness of the facial alveolar bone at the first and second maxillary premolars and determinate the percentage of premolars that reached 2 mm in width. A retrospective study analyzing cone beam computed tomography scans from the database of the Oral Surgery Unit of the University of Valencia was performed. Patients with periodontal disease, orthodontic treatment, absence among the first maxillary molars, premolars with endodontic treatment and/or prosthetic restorations were excluded. The facial alveolar bone width was measured at 1, 2, 3 and 5 mm apical to the vestibular bone peak. A total of 44 patients were included in the study, of whom 72 first premolars and 72 second premolars were analyzed. A descriptive analysis was performed and the normal means were assessed using the Kolmogorov-Smirnov test. The average width of the facial alveolar bone at first and second maxillary premolars was respectively: 1.41 ± 0.50 and 1.72 ± 0.56 at 1 mm; 1.68 ± 0.72 and 2.23 ± 0.66 at 2 mm; 1.71 ± 0.89 and 2.43 ± 0.82 at 3 mm; 1.44 ± 1.00 and 2.31 ± 1.06 at 5 mm from the vestibular bone peak. The facial alveolar bone width at the second maxillary premolars was greater than at the first maxillary premolars at all points measured. This information should be taken in account when planning immediate implants. Further studies analyzing bone resorption at maxillary premolars are needed to better understand facial alveolar bone width influence in implant treatment.

II. Introduction:
[NC] A. A clear statement of the problem was provided.
[NC] B. The rationale for the study was very logical and convincing.
[NC] C. A review of literature was current, thorough, accurate, and clearly related to the statement of the problem.
[NC] D. Terms were clearly defined.
[NC] E. The specific purpose of the study, research questions, or hypotheses was a logical extension of the problem, rationale, and literature review.
[NC] F. Theoretical foundation for the study was provided and supported.
[NC] G. A clearly written research question(s) was provided.
[NC] H. The introduction was well organized and well written.

III. Methods:
A. Human or Animal Selection and Protections:

[NC] 1. Protection of humans or animals was clearly described and complied with national and international protection guidelines.
[NC] 2. Human or animal selection and exclusion criteria were clearly described.
[NC] 3. Random selection of humans or animals and random assignment to groups was clearly described.
[NC] 4. Differential selection of humans or animals and threats to internal validity were clearly controlled.
[NC] 5. Humans or animals were not selected on basis of extreme scores.
[NC] 6. Interaction of human or animal selection and threats to external validity were clearly controlled.
[] Instrumentation/Measurement:
[NC] 1. The instrumentation was appropriate.
[NC] 2. The instruments were calibrated for the population sampled.
[NC] 3. The instrumentation measurements were reliable and valid.
[NC] 4. Experimenter bias was controlled.
[NC] 5. Test environment was controlled.
[NC] 6. Instructions to humans were controlled.
[NC] 7. Adequate selection and measurements of independent variable(s) were described.
[NC] 8. Adequate selection and measurements of dependent variable(s) were described.
[NC] 9. The instrumentation text was well organized and well written.
C. Materials:
[NC] 1. Materials were clearly described.
[NC] 2. Materials were referenced to connect readers with vendors.
[NC] 3. Materials were well organized and well written.
D. Procedures:
[NC] 1. The research design was appropriate for the study.
[NC] 2. The procedures controlled threats to internal validity (confidence that independent and dependent variables were experimentally related).
a. Extraneous variables in the study were controlled.
b. Potential confounding variables were controlled.
c. Variable relationships (e.g. convincing antecedence conditions) were controlled.
d. Causality was clearly described.
e. The procedures controlled threats to external validity were well controlled (e.g. history, maturation, etc.).
[NC] 3. The procedures supported external validity.
a. Population validity (research sample like the population being generalized) was controlled.
b. Ecological validity (research procedures generalized across settings) was controlled.
c. Threats to external validity were controlled (e.g. interaction effects of testing, etc.)
[NC] 4. Procedures were well organized and well written.

IV. Results (Quantitative):
[1] A. Data organization and tabulation procedures were clear.
[3] B. A clear and measurable question(s) from the introduction was analyzed.
[3] C. Informal Analysis were effectively used and presented (e.g. boxplots, scatterplots, etc.) to informally answer the research question(s). Tables and figures from this informal analysis were labeled, used within text, self-explanatory, and efficiently used.
[3] D. Summary Descriptive Statistics were effectively used, tabled, and integrated into text. Tables and figures from descriptive statistics were labeled, used within text, self-explanatory, and efficiently used.
[1] E. Formal Statistical Analysis, when used, effectively: controlled for mathematical assumptions and alpha levels, answered the research question(s), and provided a clear summary table(s) and figure(s) of the software output results. Tables and figures from the formal statistical analysis were labeled, used within text, self-explanatory, and efficiently used.
Following his suggestions, we applied the Bonferroni correction to control the propagation of type I error. In that case, the reference level would be 0.05 / 12, where 12 is the total number of contrasts, ie 0.004.

All p-values in Table 2 remain <0.004 and therefore the conclusions and results are mainained
[1] F. The name and version of the statistical software used was provided in text and cited in references.
Statistical Package for the Social Sciences, SPSS 15.0; SPSS Inc, Chicago, Illinois.
[1] G. The name of the statistical tool(s) used is exactly the same as used by the statistical software publisher, and this name is consistently used throughout the manuscript.
Statistical Package for the Social Sciences, SPSS 15.0; SPSS Inc, Chicago, Illinois.
[2] H. The results were clearly related to research question(s) asked without overgeneralizing the results.
[1] I. Tables and figures from a formal statistical analysis were: clearly and accurately labeled, were used with text, were self-explanatory, and efficiently communicated useful information related to the research question(s).
[2] J. Results were well organized and well written.

V. Discussion, Summary, and Conclusions:
[NC] A. The discussion, summary, and conclusions were clearly related to the research problem and the research question (questions) investigated.
[NC] B. Limitations of the study were clearly discussed.
[NC] C. Conclusions were drawn directly and accurately from results.
[NC] D. Reasonable explanations were given for unusual, atypical, or discrepant results.
[NC] E. The results were clearly related to one or more theoretical explanations.
[NC] F. The results were empirically argued as externally valid to the population from which the sample was taken.
[NC] G. Implications for application of findings were empirically discussed and not overgeneralized beyond the scope of the study.
[NC] H. Suggestions for future research were empirically discussed and limited to the results of the study.
[NC] I. The discussion, summary, and conclusions were limited to the empirical findings of the study, well organized, and well written.

VI. References:
[NC] A. References (not a bibliography) were cited in text and all text citations were listed in references.
[NC] B. References followed the Journal of Oral Implantology requirements.
[NC] C. References were well organized and well written.

VII. The Manuscript:
[NC] A. The manuscript was well written and clearly presented.
[NC] B. The manuscript was accurate and efficiently presented as a convincing empirically persuasive
argument.

Comments: The study was interesting. The main concern was for the persuasive use of the statistical analysis. While the study reported that normality was measured and assessed, there were other mathematical assumptions that needed to have been addressed prior to using the “related measures t-test” (see rubric for areas of concern).

There should have been no significant outliers in the difference between the two related groups.
We have found that the atypical cases are exceptional and, therefore, in a sample of the size as the present one they do not have greater repercussion. We have checked that the medians of the difference variables are similar to the means and, therefore, there is no significant distortion of the means because of atypical values.
While dependent t-test is robust to violations in normality, the distribution of the difference in the dependent variable between the two related groups should have been demonstrated as approximately normally distributed.

Since the original variables follow a normal distribution (we check with Kolmogorov), the difference is expected to do so as well. Nevertheless, following its indications, we

have contrasted it obtaining the following results, confirming the adjustment to normal (p> 0.05):

Kolmogorov-Smirnov´s test

VAR	Distance from the bone peak	Z	p-value
Diference between first and second right premolars	10,5	600,912	
	20,6	440,801	
	30,9	790,293	
	50,6	340,817	
Difference between first and second left premolars	10,7	930,556	
	20,9	150,372	
	31,2	110,107	
	50,6	920,724	

The variances between the groups should not have been significantly different.
The groups are dependent so it is not necessary to test for homogeneity of variances.
The deviation used for the paired t-test is directly that of the difference variable.
There were 12 “t-test” contrasts reported in Table 2. Discuss how the familywise alpha level was controlled to insure readers that this statistical construct was addressed and to put the manuscript’s overall Type I error rate into perspective.
Following his suggestions, we applied the Bonferroni correction to control the propagation of type I error. In that case, the reference level would be 0.05 / 12, where 12 is the total number of contrasts, ie 0.004.
All p-values in Table 2 remain <0.004 and therefore the conclusions and results are maintained.

If the above areas (rubric and Comments) were addressed and if any applicable changes need to be made to the Results and Discussion, the manuscript may then, after further review, have merit as a publication.

We hope the new version of the manuscript has reached now the standards of the journal to be published.

Sincerely yours,

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Facial alveolar bone width at the first and second maxillary premolars in healthy patients: A cone beam computed tomography study

Short title: Facial alveolar bone width at maxillary premolars

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Conflicts of interest: The authors declare no conflicts of interest related to the present study.

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ABSTRACT

The purpose was to analyze the thickness of the facial alveolar bone at the first and second maxillary premolars and determinate the percentage of premolars that reached 2 mm in width. A retrospective study analyzing cone beam computed tomography scans from the database of the Oral Surgery Unit of the University of Valencia was performed. Patients with periodontal disease, orthodontic treatment, absence among the first maxillary molars, premolars with endodontic treatment and/or prosthetic restorations were excluded. The facial alveolar bone width was measured at 1, 2, 3 and 5 mm apical to the vestibular bone peak. A total of 44 patients were included in the study, of whom 72 first premolars and 72 second premolars were analyzed. A descriptive analysis was performed and the normal means were assessed using the Kolmogorov-Smirnov test. The average width of the facial alveolar bone at first and second maxillary premolars was respectively: 1.41 ± 0.50 and 1.72 ± 0.56 at 1 mm; 1.68 ± 0.72 and 2.23 ± 0.66 at 2 mm; 1.71 ± 0.89 and 2.43 ± 0.82 at 3 mm; 1.44 ± 1.00 and 2.31 ± 1.06 at 5 mm from the vestibular bone peak. The facial alveolar bone width at the second maxillary premolars was greater than at the first maxillary premolars at all points measured. This information should be taken in account when planning immediate implants. Further studies analyzing bone resorption at maxillary premolars are needed to better understand facial alveolar bone width influence in implant treatment.

Keywords:

Facial bone thickness, alveolar crest, buccal bone, CBCT, premolars.

INTRODUCTION

The alveolar process is a tooth-dependent structure, and its development is strictly connected to dental eruption.[1] It is well known that marked volumetric alterations occur at the edentulous site following tooth extraction; not only the facial alveolar bone (FAB) is reabsorbed but, in consequence, the buccal-lingual/palatal dimension is reduced.[2] Such resorption is related with the width of the FAB. When FAB width is < 1 mm, a mean height loss of 7.5 mm has been observed after tooth extraction, while in the case of a width of ≥ 1 mm the mean height loss was found to be 1.1 mm.[3] Thus, the thickness of the FAB in the anterior maxilla is crucial for the selection of the appropriate implant treatment approach.[4]

Several studies using CBCT images have analyzed FAB of dentate patients at different levels below the alveolar bony crest.[5-8] CBCT provides a highly accurate method to evaluate bone architecture.[9] Most studies focus on measurements referred to the incisors and canines, but relatively few studies[10-12] analyze FAB width at first and second premolar, which also belong to the aesthetic zone. Authors that have measured anterior and posterior areas have reported a significant decrease in thickness from premolars to anterior teeth.[4,11] The Literature does not fully clarify the width of the FAB at the maxillary premolars. These values also vary according to the measurement method and the level below the bone crest at which measurement is carried out, but it seems that FAB at first maxillary premolars is thinner than that at second maxillary premolars.[8,12] To our knowledge, no studies have focused on and analyzed the FAB width in detail at the first and second maxillary premolars.

The aim of the present study was to evaluate and compare the FAB width at the first and second maxillary premolars. A further aim was to analyze the percentage of first and second premolars in which the width of this cortical bone is greater than 2 mm.

MATERIAL AND METHODS

The study protocol was submitted to, and approved by, the Ethics Committee of the University of Valencia (Spain) (procedure no. H145639215058). The CBCT images were retrospectively obtained from the database of the Unit of Oral Surgery in the University of Medicine and Odontology of Valencia. All CBCT scans had been performed for diagnostic and/or treatment purposes between September 2014 and February 2016. None of the scans were made for purely scientific reasons.

Inclusion criteria

The subjects meeting the inclusion criteria were men and women aged between 18 and 60 years, with all teeth present from central incisors to first molars bilaterally, and who had no history of orthodontic treatment. In addition the distance between cementoenamel junction (CEJ) and the vestibular bone peak at premolars was < 3.5 mm.

Exclusion criteria

Patients with periodontal disease, orthodontic treatment, absence among the first maxillary molars, premolars with endodontic treatment, caries and/or prosthetic restorations.

Patient data collection

The following variables were collected for each patient using a predetermined study protocol: sex, age, smoking habits and the reason for having the CBCT scan performed.

Radiographic image analysis

The CBCT images were acquired using Planmeca ProMax 3D (Helsinki, Finland) Software 2.3.1. R TM Planmeca Romexis® with a voxel size of 150 mSv, 90 kV, 10.0 mA and a field of view (FOV) of 4 x 4 cm. The scans were uni or bilateral depending on their diagnostic purpose. All images were analyzed with the same computer and same monitor, (Eizo Nanao Flexscan with a resolution of 1,280 x 1,024 pixels). In order to

detect the slice location to perform the measurements, we proceed as follows: the alveolar crest was located at the axial plane, and a buccolingual slice was traced at the middle of the root. Then, the long axis of the root was determined at the sagittal slice (Fig. 1). The measurements from the CEJ to the vestibular bone peak and of the thickness of the FAB were performed at the coronal plane. In this sense, four measurements were then made parallel to this perpendicular line 1, 2, 3 and 5 mm apical to the vestibular bone peak (Fig. 2).

Statistical analysis

A descriptive analysis was made, based on the most relevant statistics: mean, standard deviation, maximum, minimum and median. Statistical software used was "Statistical Package for the Social Sciences, SPSS 15.0; SPSS Inc, Chicago, Illinois". The normality of the measures was assessed by means of the Kolmogorov-Smirnov test, obtaining a confirmatory result for most of the measures ($p > 0.05$).

The mean bone width and standard deviation per tooth and per patient were recorded based on four measurements at various depths. Measurements were compared between right maxillary first and second premolars, between left maxillary first and second premolars and between all first and second maxillary premolars. The related measures t-test was used for comparing means. The significance level used in the analysis was 5% ($\alpha = 0.05$), but Bonferroni´s correction was applied to control the propagation of type I error. In that case, the reference level would be 0.004 (=0.05/12, where 12 is the total number of contrasts). A t-test had a power of 90% to detect a moderate effect (d=0.5), which is equivalent to detecting a mean difference in bone width between first and second premolars of 0.35 mm with a standard deviation of ± 0.70 mm.

RESULTS

Sample description

The study population consisted of 44 patients, 25 men and 19 women aged between 18 and 60 years. Nine patients were heavy smokers (> 10 cigarettes/day), twelve were light smokers (≤ 10 cigarettes/day) and twenty-three were no smokers.

Sixteen CBCT scans were unilateral and 28 were bilateral. Thus, a total of 72 upper first premolars and 72 upper second premolars were analyzed (Table 1).

Radiographic outcomes

The mean distance between the CEJ and the vestibular bone peak was 2.34 ± 0.82 (0.95 – 3.5) mm at the first premolars and 1.82 ± 0.72 (0.62 – 3.48) mm at the second premolars, with a statistically significant difference ($p < 0.001$).

The FAB width at the four levels below the vestibular bone crest (1, 2, 3 and 5 mm) for first and second maxillary premolars is reported in Table 2 and Figure 3. All comparisons showed statistically significant differences with higher values at the second premolar.

Moreover, most of second premolars reached 2 mm FAB width, while very few of the first premolars analyzed reached it. Data reported in Table 3.

DISCUSSION

The main purpose of this study was to analyze and compare the FAB width at different locations apical to the CEJ of the first and second maxillary premolars, and to determine the percentage of cases in which the width reached 2 mm.

This study describes the mean FAB thickness observed in a sample of 44 patients with a healthy dentition. The FAB width was greater at the second premolars, and a width of at least 2 mm was more frequently observed at second premolars. Another finding of the present study refers to the distance from the CEJ to the bone crest, which was significantly

greater in the case of the first premolars. These results are in line with those reported in the Literature. A recent study[8] analyzed CBCT images of 3618 teeth including incisors, canines, premolars and first molars. The mean FAB width at anterior teeth was 0.9 mm and increased towards distal regions. Only 1.8% of anterior teeth reached 2 mm in width. The results of those studies that have measured FAB width at the first and second maxillary premolars have reported increased thickness at the second premolar compared with the first premolar.[10,12] These results possibly could be explained by the fact that the first premolar usually has two roots, and is located in a more anterior zone where the alveolar ridge is usually thinner, while the second premolar usually has just one root and is located in a more posterior zone where the alveolar ridge tends to widen.

In recent years, thin cortical thickness has been linked to height loss after tooth extraction in the maxillary anterior regions. Many authors agree that the FAB width should be at least 2 mm wide if the alveolar bone level on the facial aspect is to be maintained after tooth extraction.[13,14] Also, some studies have found a positive correlation between gingival thickness and FAB width.[15-17]

It is important to note that the data in our study were based on the dimensions of sockets in a "healthy" situation. The socket dimensions around diseased teeth may be very different from those reported herein.

A finite element study has assessed the impact of the implant design and dimensions and FAB width upon the peri-implant stress. The authors concluded that the most important factor was implant FAB.[18] The study of FAB width before extraction is a key factor to predict the bone loss and to avoid implant treatment complications.

CONCLUSION

Within the limitations of our study, the results obtained suggest that FAB width at the second maxillary premolars is greater than at the first maxillary premolars. At 2 mm below the bone crest, most of the second maxillary premolars showed a FAB width of at least 2 mm, while very few first premolars reached this value.

Abbreviations

FAB: facial alveolar bone

CBCT: cone beam computed tomography

CEJ: cementoenamel junction

FOV: field of view

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TABLES

Table 1. Sample description according first or second premolar, type of CBCT scan and its purpose and smoking habits

Patients included in the study: 44										
First premolars	Second premolars	CBCT scans		CBCT purpose				Smokers		
		Unilateral	Bilateral	Palatally impacted canines	Impacted wisdom molars	Apical surgery	Implant planning	No	Light ((≤ 10 cigarettes/day)	Heavy ((> 10 cigarettes/day)
72	72	16	28	9	16	7	12	23	12	9

Table 2. FAB of all first and second premolars at 1, 2, 3 and 5 mm apical distance from the vestibular bone peak

Mean (SD; range)					
Distance from the bone peak	**Premolar**	**Left (n=35)**	**Right (n=37)**	**Whole sample (n=72)**	**t-test (p-value)**
1 mm	First	1.39 (0.51; 0.62-3.3)	1.43 (0.49; 0.45-3)	1.41 (0.5; 0.45-3.3)	Left: 0.003** Right: 0.002** Whole sample: <0.001***
	Second	1.68 (0.52; 0.9-3.3)	1.76 (0.59; 0.75-4.06)	1.72 (0.56; 0.75-4.06)	
2 mm	First	1.68 (0.7; 0.47-3.9)	1.68 (0.74; 0.6-3.63)	1.68 (0.72; 0.47-3.9)	Left: <0.001*** Right: <0.001*** Whole sample: <0.001***
	Second	2.22 (0.56; 1.20-4.05)	2.25 (0.75; 0.75-4.66)	2.23 (0.66; 0.75-4.66)	
3 mm	First	1.70 (0.85; 0.45-4.05)	1.72 (0.93; 0.45-3.93)	1.71 (0.89; 0.45-4.05)	Left: <0.001*** Right: <0.001*** Whole sample: <0.001***
	Second	2.48 (0.75; 0.45-4.5)	2.37 (0.9; 0.6-4.51)	2.43 (0.82; 0.45-4.51)	
5 mm	First	1.39 (0.84; 0.3-4.05)	1.5 (1.13; 0.3-5.25)	1.44 (1.00; 0.3-5.25)	Left: <0.001*** Right: <0.001*** Whole sample: <0.001***
	Second	2.39 (1.06; 0.3-5.85)	2.23 (1.06; 0.6-4.51)	2.31 (1.06; 0.3-5.85)	

Table 3. Percentage of premolars that reached a FAB width of 2 mm

Premolars that reached 2 mm width		
Distance from the bone peak	First (%)	Second (%)
1 mm	11.36	56.81
2 mm	25	70.83
3 mm	30.55	79.16
5 mm	20.83	76.30

Figure

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Figure

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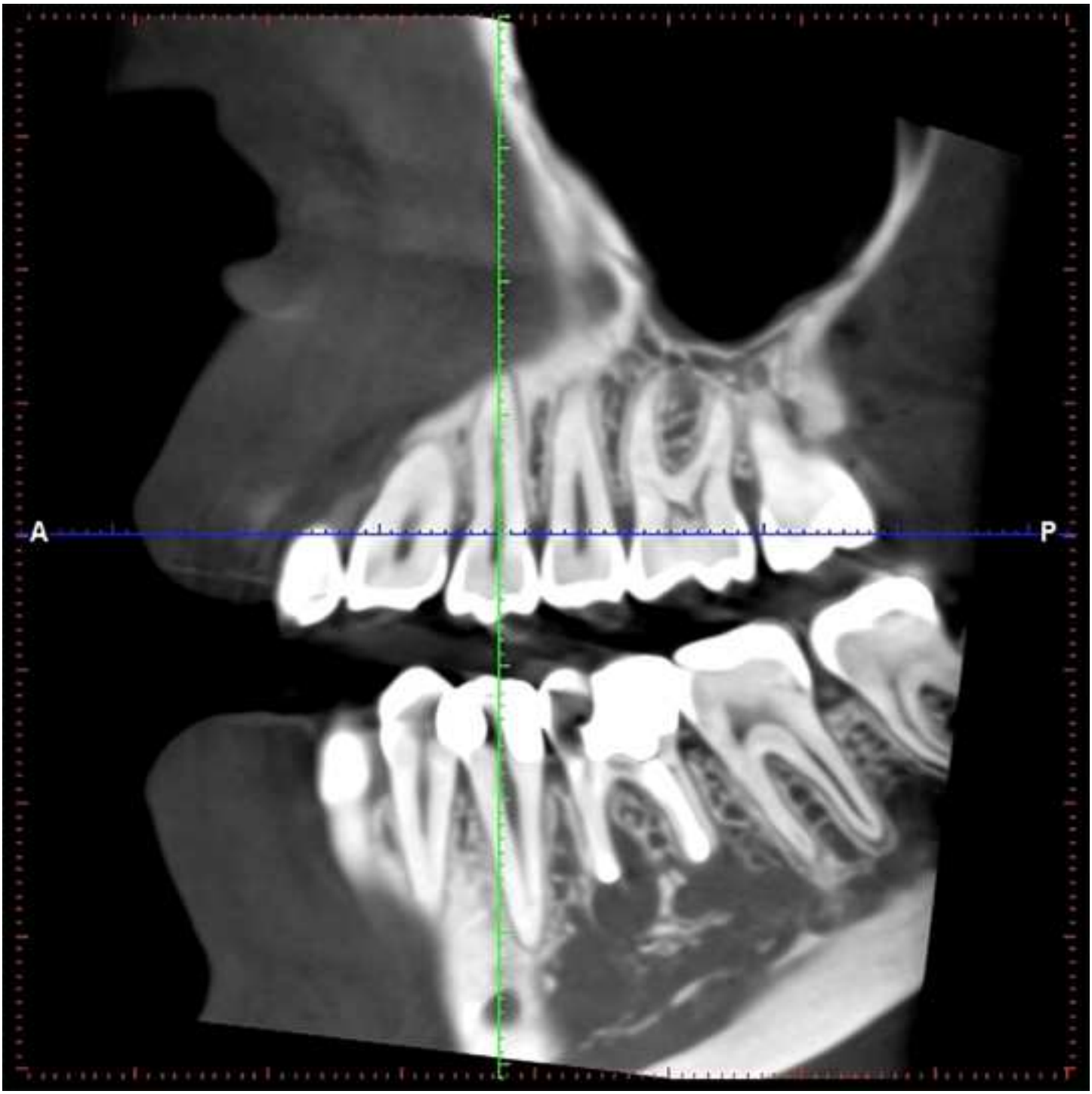

Figure

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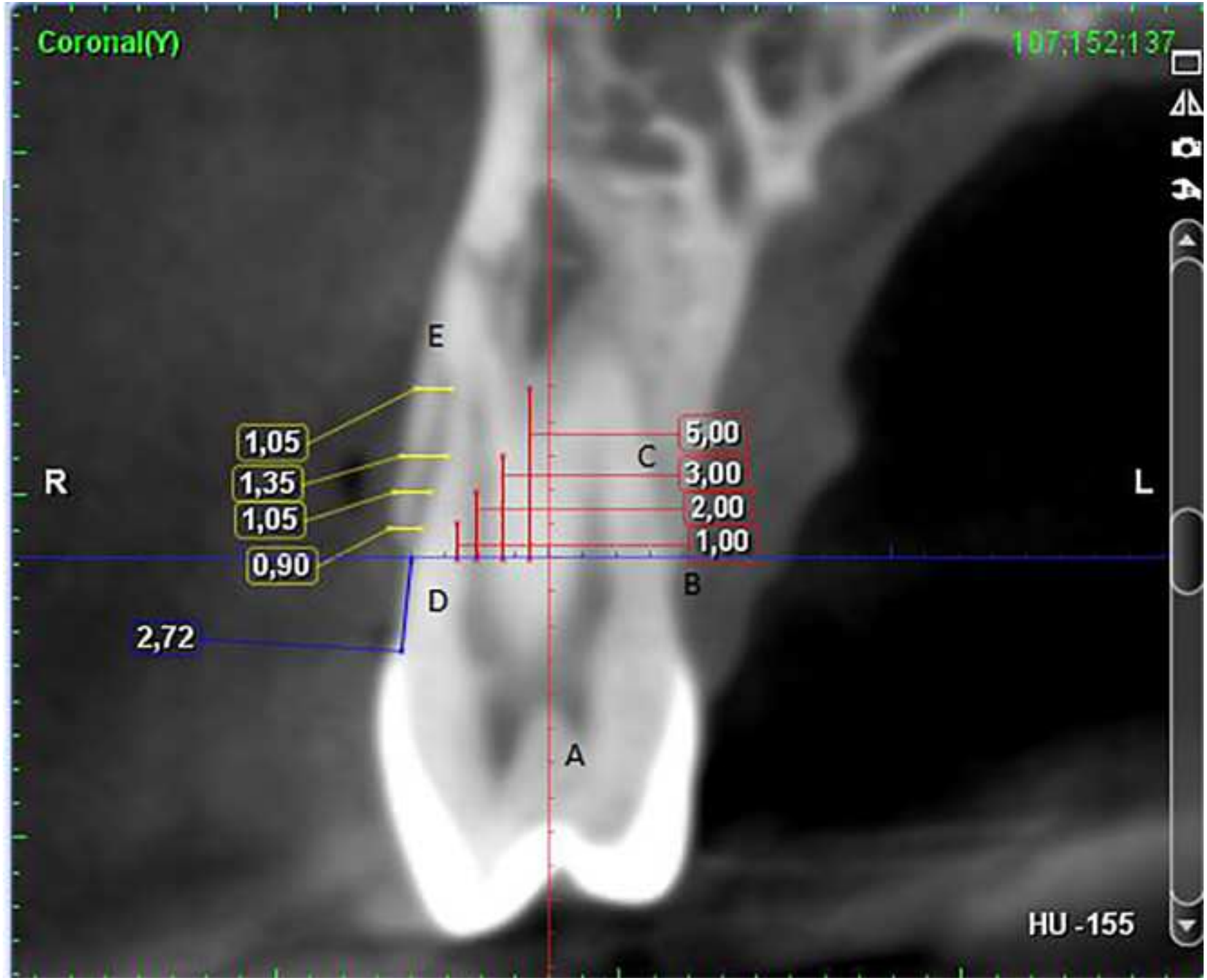

Figure

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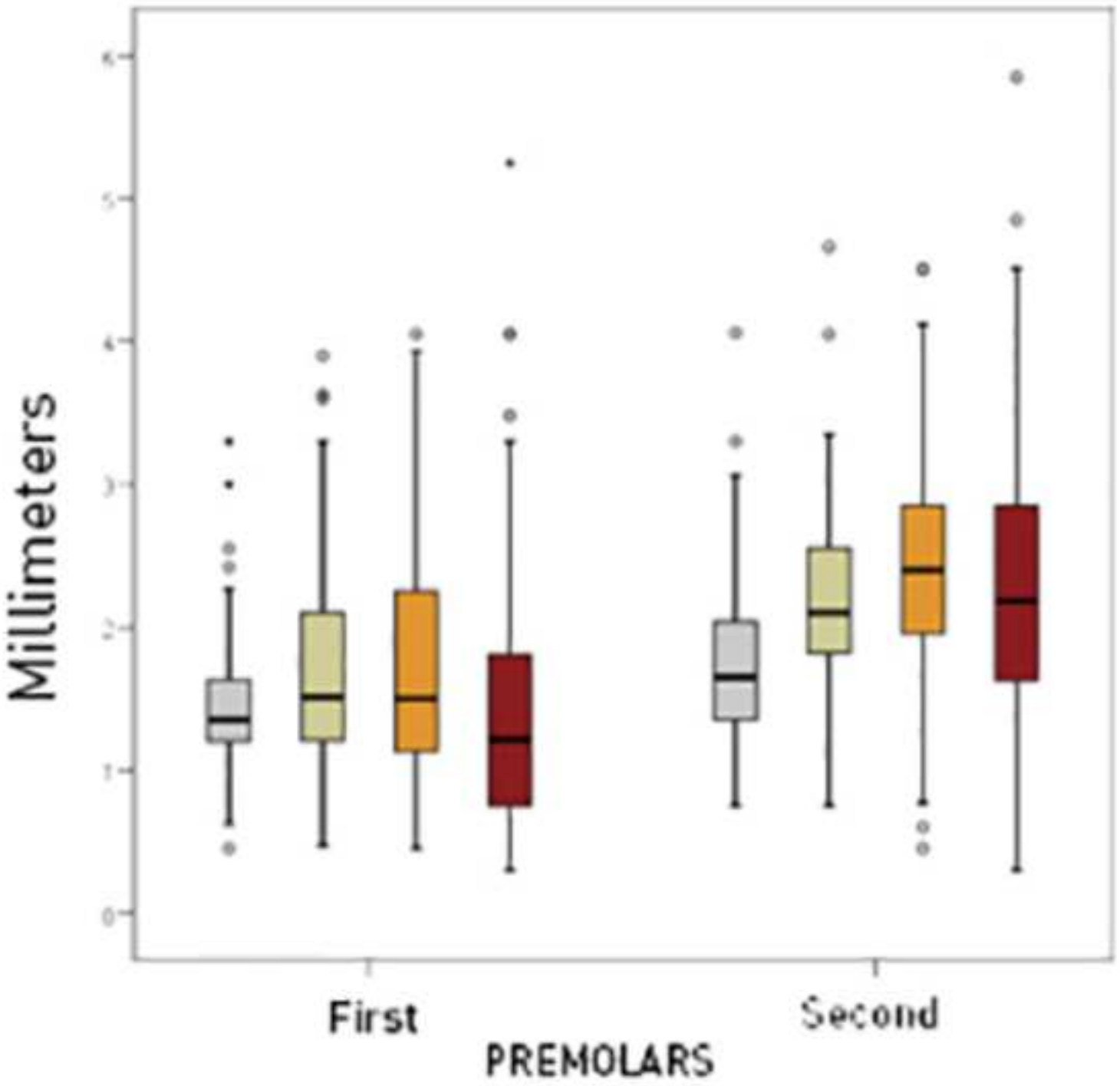

Cover Letter