

## Crown dimensions and proximal enamel thickness of mandibular second bicuspid

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**Abstract:** To achieve proper recontouring of anterior and posterior teeth, to obtain optimal morphology during enamel stripping, it is important to be aware of dental anatomy. This study aimed at evaluating crown dimensions and proximal enamel thickness in a sample of 40 extracted sound, human, mandibular, second bicuspid (20 right and 20 left). Mesiodistal, cervico-occlusal and buccolingual crown dimensions were measured using a digital caliper, accurate to 0.01 mm. Teeth were embedded in acrylic resin and cut along their long axes through the proximal surfaces to obtain 0.7 mm-thick central sections. Enamel thickness on the cut sections was measured using a perflometer. Comparative analyses were carried out using the Student's-*t* test ( $\alpha = 5\%$ ). The mean mesiodistal crown widths for right and left teeth were 7.79 mm ( $\pm 0.47$ ) and 7.70 mm ( $\pm 0.51$ ), respectively. Mean cervico-occlusal heights ranged from 8.31 mm ( $\pm 0.75$ ) on the right to 8.38 mm ( $\pm 0.85$ ) on the left teeth. The mean values for the buccolingual dimension were 8.67 mm ( $\pm 0.70$ ) on the right and 8.65 mm ( $\pm 0.54$ ) on the left teeth. The mean enamel thickness on the mesial surfaces ranged from 1.35 mm ( $\pm 0.22$ ) to 1.40 mm ( $\pm 0.17$ ), on the left and right sides, respectively. On the distal surfaces, the corresponding values were 1.44 mm ( $\pm 0.21$ ) and 1.46 mm ( $\pm 0.12$ ). No significant differences were found between measurements for right and left teeth. However, enamel thickness was significantly greater on the distal surfaces, compared with the mesial surfaces.

**Descriptors:** Bicuspid; Tooth Crown; Dental Enamel; Orthodontics.

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### Introduction

Interproximal enamel stripping may represent a suitable alternative to tooth extraction; and, it has also been associated with short treatment time and favorable final results.<sup>1-5</sup> According to a recent study,<sup>1</sup> clinical follow-up examinations 3.5 to 7 years after orthodontic treatment generally showed healthy dentitions with good occlusion, no signs of iatrogenic effects, and normal periodontal conditions with intact gingival papillae between all teeth in the maxillary and mandibular arches.

Enamel stripping has been used routinely worldwide, including the United States of America,<sup>4,6</sup> Europe,<sup>1,7</sup> Turkey<sup>5</sup> and Brazil<sup>8</sup> because, while providing correction of tooth-arch discrepancies, it increases treatment stability<sup>6-8</sup> and holds the transversal dental arch dimensions and anterior inclinations constant.<sup>1,5,9</sup> Nevertheless, it is important to estimate proxi-

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mal enamel thickness before performing the stripping procedure to avoid damaging the adjacent dental tissues.

Considering that previous studies<sup>10,11</sup> have reported that about fifty percent of proximal enamel thickness can be safely removed, accurate measurements of tooth crown dimensions and enamel thickness are useful to guide the orthodontist during stripping. Thus, the aim of this experimental investigation was to assess the values relative to mesiodistal, cervico-occlusal and buccolingual crown dimensions, as well as the proximal enamel thickness at the contact area of mandibular second bicuspid.

## Methodology

This experimental study was approved by the Institution Committee for Research Ethics and complies with the Brazilian resolution regulating research involving humans (196/96).

## Sample

An *in vitro* model consisting of 20 standardized repetitions would be statistically adequate for a tri-dimensional analysis of the dental crown and to estimate the enamel thickness of teeth from patients who were born in the same geographical area.<sup>8</sup> Based on this methodological premise, 40 sound, human, mandibular, second bicuspid were collected from a human teeth bank associated with a public university located in Goiânia, Goiás, Brazil. The teeth were divided into two groups, 20 right mandibular second bicuspid and 20 left mandibular second bicuspid, and randomly numbered from one to twenty.

## Dental crown measurements

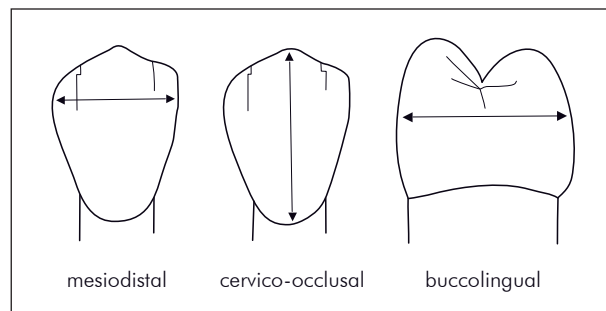
A well-trained examiner performed the dental crown measurements using a digital caliper accurate to 0.01 mm (Mitutoyo® Sul Americana Ltda., Suzano, Brazil), measuring the teeth (right and left) in a sequence from one to 20. During the measurements, each tooth was placed on a flat surface and kept in a fixed position. The mesiodistal width was measured from the most central point in the contact area of the mesial surface to the respective point on the distal surface. Afterwards, the cervico-occlusal dimen-

sion was measured from the most extreme point of the occlusal edge to the dentinoenamel junction on the buccal surface. The buccolingual dimension represented the distance measured between the middle points of the crown on the buccal and lingual surfaces (Figure 1).

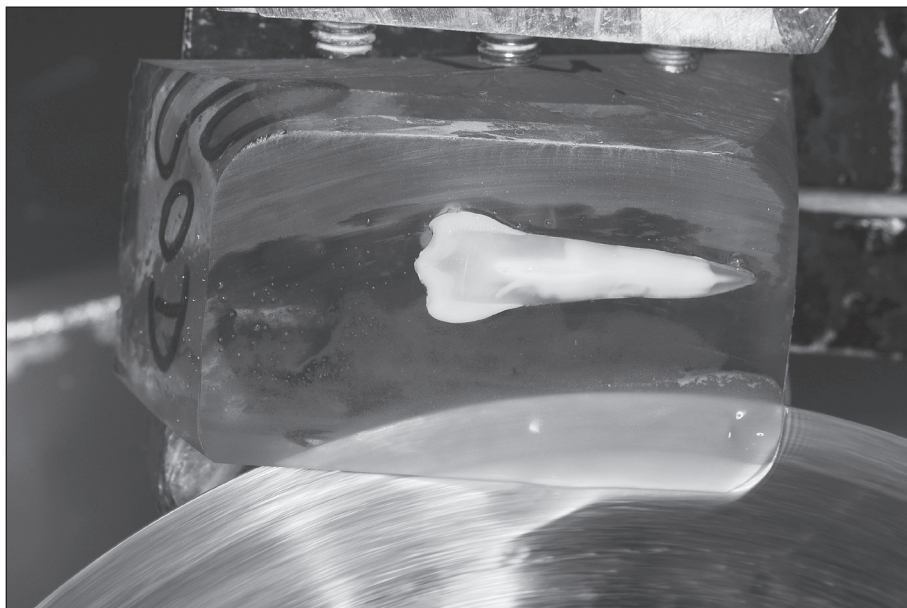
## Specimen preparation

To estimate the proximal enamel thickness, the teeth were fixed in plastic containers with utility wax. The buccal surface of each tooth was kept in contact with the wax at the bottom of the container. Then, the teeth were embedded in acrylic resin (ARAZYN 1.0, Redelease®, São Paulo, Brazil). All the specimens were taken out of the containers and the occlusal and apical points were determined on the resin, which served as the reference for tracing the long axes of the teeth.

The specimens were cut along their long axes through the proximal surfaces, parallel to the buccal surfaces, to obtain 0.7 mm-thick central sections. During sectioning, the occlusal surfaces of the specimens were kept facing the operator. Each cut section corresponded to the central area of the proximal surface, in that it encompassed the greater crown width and the thicker enamel portion. The cut sections were obtained using a 4-inch diameter, high concentration diamond wafering blade (Exttec® Corp., Enfield, USA), mounted onto a high precision Lab Cut 1010 saw (Exttec® Corp., Enfield, USA), under water cooling to prevent organic component loss (Figure 2). To avoid damaging the specimens, the diamond disc speed was set to 225 rotations per minute.



**Figure 1** - Schematic drawing illustrating crown measurements.



**Figure 2** - Sectioning the specimen to obtain cut central sections for measuring proximal enamel thickness.

### Enamel thickness estimation

Enamel thickness on the proximal surfaces was measured using millesimal precision equipment, the perfilometer (Mitutoyo®, Kawasaki, Japan). The cut sections were manipulated, to allow standardization of the measurements, by aligning the Cartesian axes (X and Y) of the perfilometer with the long axis of the tooth. The Y axis was placed in the mesial direction, up to the most external point of the enamel, establishing “point A”. The caliper of the perfilometer was set to the zero position, and then placed parallel to the most external point of the dentin on the mesial surface, establishing “point B”. Sequentially, readouts were made of the mesial enamel thickness, expressed in millesimal parts of millimeters. To perform the estimates on the distal surfaces, the Y axis was placed up to the most external point of the dentin, establishing “point C”. Next, it was placed parallel to the most external point of the enamel on the distal surface, establishing “point D”. The measured distances were A-B and C-D, representative of the enamel thickness on the mesial and distal surfaces, respectively.

### Statistical analyses

Some measures of central tendency and dispersion were calculated for the mesiodistal, cervico-occlusal and buccolingual crown dimensions, as

well as proximal enamel thickness, of right and left mandibular second bicuspids. Possible differences between mean crown dimensions of the studied teeth, considering the side of the dental arch, were assessed using the non-paired Student's-*t* test. Mean enamel thickness values on the mesial and distal surfaces were compared using the paired Student's-*t* test. The significance level was set at 5%. Statistical analyses were carried out using IBM SPSS Statistics 17.0 (IBM®, Chicago, USA).

### Results

Measures of central tendency and dispersion for dental crown dimensions and proximal enamel thickness are shown in Table 1. The differences between the mean values of the crown dimensions for right and left teeth were approximately 0.1 mm. The mean mesiodistal width ranged from 7.7 mm to 7.8 mm. The mean values of cervico-occlusal height varied from 8.3 mm to 8.4 mm. Variation along the buccolingual dimension was within the range from 8.6 mm to 8.7 mm. Mean enamel thickness estimates on the mesial surfaces were 1.40 mm for right teeth and 1.35 mm for left teeth. The values corresponding to the distal surfaces were 1.46 mm and 1.44 mm for right and left teeth, respectively.

Based on the coefficients of variation, it may be assumed that there was greater variability of data in

**Table 1** - Measures of central tendency and dispersion relative to crown dimensions and proximal enamel thickness of mandibular second bicuspid.

Variables	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation	Coefficient of Variation (%)
Right teeth (n = 20)					
Mesiodistal width	6.91	8.80	7.79	0.47	6.03
Cervico-occlusal height	7.22	9.99	8.31	0.75	9.08
Buccolingual dimension	7.41	9.87	8.67	0.70	8.08
Mesial enamel thickness	1.16	1.86	1.40	0.17	12.43
Distal enamel thickness	1.24	1.71	1.46	0.12	8.37
Left teeth (n = 20)					
Mesiodistal width	6.67	8.65	7.70	0.51	6.57
Cervico-occlusal height	6.07	9.98	8.38	0.85	10.16
Buccolingual dimension	7.60	9.80	8.65	0.54	6.19
Mesial enamel thickness	1.03	1.92	1.35	0.22	16.29
Distal enamel thickness	1.10	1.92	1.44	0.21	14.79

**Table 2** - Comparative analysis of the measurements obtained for right (n = 20) and left (n = 20) mandibular second bicuspid.

Variables	t value*	p value	Significance
Mesiodistal width	0.64	0.26	Not significant
Cervico-occlusal height	-0.28	0.39	Not significant
Buccolingual dimension	0.10	0.46	Not significant
Mesial enamel thickness	0.72	0.24	Not significant
Distal enamel thickness	0.46	0.33	Not significant

\*Critical value of two-tailed "t" test (38 degrees of freedom),  $t_{critical(0.05;38)} = 2.024394$

relation to the mean values for the left teeth, mainly with regard to the proximal enamel thickness. On the other hand, data for the right teeth appeared to show more homogeneity as the coefficients of variation were below 10%, except for the mesial enamel thickness (12.4%). Although the coefficients of variation for the proximal enamel thickness of the left teeth ranged from 14.8% to 16.3%, they may still be considered relatively low.

For all the comparisons shown in Table 2, the critical value of the two-tailed "t" test was 2.024394 / -2.024394. The calculated values of "t" were within the range of critical "t", resulting in non-significant p values. Hence, data in Table 2 affirm the homogeneity of the measurements obtained

**Table 3** - Comparative analysis of the mean values for mesial and distal enamel thickness on right (n = 20) and left (n = 20) mandibular second bicuspid.

Enamel thickness	t value*	p value	Significance
Right side			
Mesial surface versus distal surface	-2.42	0.03	Significant (p < 0.05)
Left side			
Mesial surface versus distal surface	-3.90	0.0009	Highly significant (p < 0.01)

\*Critical value of two-tailed "t" test (19 degrees of freedom),  $t_{critical(0.05;19)} = 2.09302405$

and indicate that there were no significant differences between the crown dimensions and enamel thicknesses for right and left mandibular second bicuspid. However, the mean values relative to enamel thickness were significantly higher on the distal surfaces in comparison with the mesial surfaces, for both sides of the dental arch (Table 3).

## Discussion

Acknowledgement of dental crown dimensions and enamel thickness on proximal surfaces is really useful to establish diagnosis and proper planning for orthodontic treatment; specifically, with regard to decisions about performing either tooth extraction or interproximal enamel stripping. This proce-

sure may avoid extractions, reduce treatment time and yield more favorable final results.<sup>2-5</sup> From a clinical point of view, many patients may not be willing to undergo tooth extraction, which should be taken into account.<sup>12</sup>

Interproximal enamel stripping may be used to solve cases of mild to moderate crowding.<sup>1,2,4,8</sup> This therapeutic alternative may be performed in cases of Class I arch-length discrepancies with orthognathic profiles; minor Class II dental malocclusions, especially those in which patients have stopped growing; and Bolton tooth-size discrepancies.<sup>12</sup> A space gain of 8.9 mm may be achieved in the dental arches by using enamel stripping techniques, not limited to the anterior teeth.<sup>13</sup> The estimate of the amount of enamel to be removed must depend on the degree of dental discrepancy.<sup>4,10,14</sup> Enamel removal can be substantial on teeth with deviating morphology; whereas, incisors with parallel proximal surfaces, screwdriver-shaped teeth and round bicuspid might not be candidates for any stripping.<sup>1</sup>

Periapical and bite-wing radiographs, as well as computed tomography images, are suitable adjuncts to the clinical assessment of dental crown dimensions and proximal enamel thickness.<sup>15,16</sup> Nevertheless, interestingly, one of the restrictions with computed tomography was the blurred limits for enamel thicknesses smaller than 1.1 mm. This makes it difficult to determine the point from which the measurement begins, despite the high resolution of this imaging modality.<sup>16</sup> The present study provided data pertaining to proximal enamel thickness of mandibular second bicuspid (Table 1). Mean values for enamel thickness on the mesial and distal surfaces ranged from 1.35 mm to 1.40 mm, and from 1.44 mm to 1.46 mm, respectively. Proximal enamel was significantly thicker on the distal surfaces, in comparison with the mesial surfaces (Table 3). This finding is in agreement with a similar Brazilian study<sup>8</sup> and other investigations that suggested thresholds for proximal enamel reduction, in the interval of 0.4-0.5 mm, irrespective of the side.<sup>5,6,9</sup>

A study in which dental crown dimensions were measured directly in the patient's mouth with a compass reported that aligned teeth had smaller mesiodistal widths and larger buccolingual mea-

surements.<sup>17</sup> In another study, an index to assess morphological deviations of teeth, for eliminating crowding in the mandibular incisors region, was developed.<sup>4</sup> The sample comprised young, white adult women, assigned to two groups: one group presenting satisfactory alignment of mandibular incisors; the second group consisting of patients diagnosed with crowding (control). Measurements were also made directly in the patients' mouths. When comparing the mesiodistal width with the buccolingual dimension of the same tooth, it could be observed that the first measurement was always smaller than the second one.<sup>4</sup> The findings of these clinical investigations are in agreement with the results of the present study, since the mean mesiodistal width (7.70-7.79 mm) corresponded to the smallest crown dimension of the right and left mandibular second bicuspid, compared with the buccolingual (8.65-8.67 mm) and cervico-occlusal (8.31-8.38 mm) measurements (Table 1). However, it should be pointed out that this study design provided greater fidelity because the measurements were performed with an accurate digital caliper directly on the extracted teeth. Factors that could have interfered with the measurements of crown dimensions in previous studies, such as proximal restorations, alterations of axial inclination, misalignments and movement of the patients during registrations, were eliminated.

According to Table 1, among the mean values relative to crown dimensions, the cervico-occlusal height showed the highest standard deviations and coefficients of variation for the right (standard deviation:  $\pm 0.75$ ; coefficient of variation: 9.08%) and left (standard deviation:  $\pm 0.85$ ; coefficient of variation: 10.16%) mandibular second bicuspid. Probably, some crown heights were reduced by occlusal wear. Tooth banks do not provide information about age group, gender or ethnicity. Nonetheless, since this sample comprised only sound human teeth, one can speculate that they were from adolescents or young adults. Although mastication also influences the reduction of proximal enamel, its more pronounced effect occurs on occlusal wear. Furthermore, considering that people have adopted a pattern of predominantly semisolid diet consistency since the 20<sup>th</sup> century, significant loss of proximal

enamel due to masticatory forces is seen more frequently in elderly patients.<sup>18-20</sup>

Concerning sexual dimorphism, a study reported that mesiodistal crown measurements were larger for men, compared with the dimensions obtained for women.<sup>21</sup> Some authors assessed the mesiodistal and buccolingual crown dimensions in North Americans, Egyptians and Mexicans.<sup>22</sup> All these populations showed significant differences between the measurements for men and women, which corroborated the findings of that previous study.<sup>21</sup> Men had larger canines and first molars.<sup>22</sup> Other authors found that dentin thickness appeared to be greater in men.<sup>9,15</sup> Accordingly, sexual dimorphism in crown mesiodistal width might presumably be due to dentin thickness. In the present study, the crown mesiodistal, buccolingual and cervico-occlusal dimensions, as well as the proximal enamel thicknesses, were assessed irrespective of the gender. Moreover, the mandibular second bicuspid selected were donated by patients from the Midwestern region of Brazil, where there is a highly miscegenetic population. However, for all of the measurements taken, there were no statistically significant differences between the right and left teeth. This suggests symmetry in dental crown morphology and proximal enamel thickness of the mandibular second bicuspid studied (Table 2).

Morphological imaging modalities, such as radiography, tomography and particularly cone-beam computed tomography, may be used in clinical practice for estimating the amount of proximal enamel

that can be removed safely, considering each patient's individual variations.<sup>8</sup> Nevertheless, it is also clinically relevant to carry out experimental studies that provide accurate estimate numbers relative to the crown dimensions and proximal enamel thickness for, at least, the anterior teeth and bicuspid. These values may serve as parameters for performing stripping during orthodontic treatment. After stripping, the use of precision measuring devices is recommended equally for estimating the magnitude of dental reduction.<sup>23</sup>

In spite of the valid contribution represented by the measurements of the mandibular second bicuspid, some caution is needed when interpreting these results because of possible ethnic differences. Therefore, the marked influence of intrinsic factors on tooth formation justifies the conduct of future studies involving tooth crown measurements in different ethnic groups.

## Conclusions

1. Based on the estimated mean values, the mesiodistal width (7.7-7.8 mm) was the smallest dimension of the dental crown in comparison with the cervico-occlusal height (8.3-8.4 mm) and buccolingual dimension (8.6-8.7 mm).
2. The mean enamel thickness was significantly greater on the distal surfaces (right side, 1.46 mm; left side, 1.44 mm) in comparison with the mesial surfaces (right side, 1.40 mm; left side, 1.35 mm).

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