Anatomic Comparison of Contralateral Premolars

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Abstract

Introduction: The comparative anatomy of contralateral premolars has not been previously studied. The purpose of this micro–computed tomography investigation was to qualitatively and quantitatively assess and compare the morphology of contralateral premolars in terms of length, canal width, dentinal thicknesses, accessory canals, root canal configurations, isthmi, C-shapes, root canal orifices, and apical foramina. The null hypothesis (H_0) is that contralateral premolars are more morphologically similar than randomly assigned pairs for simple morphometric measurements (lengths, canal widths, and dentinal thickness). **Methods:** Forty-one intact premolar pairs (n = 82) extracted from 28 patients were scanned with micro–computed tomography and reconstructed. Quantitative comparative assessment of measurements was performed by pairwise statistical analysis of contralateral and random pairs with Student t test and one-sample t test. All measured parameters (lengths, widths, and thicknesses) were normalized by Z score so that they could all be compared on a common scale. A correlation study was also performed. Canal configurations and isthmi were classified according to preexisting classification schemes. The number and location of accessory canals and apical foramina were registered and compared. **Results/Conclusions:** Contralateral premolar pairs demonstrated a high degree of similarity in terms of the linear measurements (lengths, widths, and thicknesses). The apical portion (foramina, C-shapes, and accessory canals) did not demonstrate bilateral symmetry. The comprehensive statistical analysis of the normalized parameters by Z score showed no statistically significant differences between the contralateral premolar pairs. The null hypothesis (H_0) was accepted. *(J Endod 2017;■:1–8)*

Significance

Contralateral premolars show a high degree of symmetry in linear measurements. There is also symmetry in terms of root canal configurations and orifice shapes. There are variations between contralaterals in the apical portion as well as instances of anatomic differences.

The internal intricacies of the human dentition have intrigued and astounded scholars of anatomy since the first *ex vivo* description of root canal anatomy was published by Georg Carabelli (1) in 1844. The first pulp pioneers scrutinized root canal anatomy by methodically sectioning and grinding teeth in all planes and describing the anatomy in detail by using the measurement data as well as illustrations (2, 3). Mesmerizing models of the pulp morphology were created by pouring metal or injecting materials such as celluloid or vulcanized rubber into the root canal system before the complete destructive decalcification of the dental hard tissues (4–6).

In 1927 Okumura (7) introduced a nondestructive technique of dyes to color the root canal system as well as dental diaphanization (tooth clearing technique). With this process, the root canal could now be visualized through the transparent tooth. This canal staining and clearing technique was used by Vertucci et al and Gulabivala et al in their seminal studies of permanent teeth (7–9) and for a long time was considered the gold standard method of studying root canal anatomy (10). Today, however, the generally accepted method of choice for *ex vivo* study of the root canal system is the use of high-resolution micro–computed tomography (micro-CT) (11).

Three-dimensional imaging of internal tooth structures is of interest not only from an anatomic and clinical perspective but is also important for producing reliable endodontic *ex vivo* research (12). Disagreement when it comes to the degree of similarity between contralateral premolars may be due to differing techniques and methodologies used for measurement (13, 14). To the best of our knowledge, there are no previous studies in the literature that have used micro-CT to compare anatomic features of contralateral premolars.

The aim of the present study was to use high-resolution micro-CT to measure and compare a wide array of anatomic parameters in contralateral premolars. The null hypothesis (H_0) is that contralateral premolars are more similar than randomly assigned pairs in terms of the following measurements: lengths, root canal widths, and dentinal thickness.

Materials and Methods

A total of 82 contralateral mandibular and maxillary premolars were selected from 28 volunteer patients (11 female, 17 male; mean age, 19.1 years; standard deviation [SD], 8.8 years; age span, 11–34 years) at the Faculty of Dentistry, Institute of Clinical Dentistry, University of Oslo, Norway. Patients were referred from the Department of Orthodontics for the extraction of premolars on the basis of orthodontic indications. Informed consent was given. Exclusion parameters included known congenital dental disorders, conditions predisposing to dental developmental disorders, and teeth with restorations and/or grave caries. This study was evaluated and found not to necessitate disclosure by the National Committee for Medical and Health Research Ethics and Health Research Ethics of Norway (reference number 2012/2092-Remit Assessment). Micro-CT scans were performed by using the desktop SkyScan 1172 (Bruker microCT, Kontich, Belgium) according to previously

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described settings (14). The CT image data were reviewed and analyzed by using the SkyScan CTan/CTVol (Bruker microCT).

Lengths (Fig. 1, *7a–f*) from cusp to apex, cementoenamel junction (CEJ) to apex, and the distance from cusp to pulp horn were measured, registered, and compared statistically. The buccal or palatal/lingual cusps were defined as the final coronal cross section with visible enamel, whereas the apex was defined as the last apical cross section with visible dentin. The CEJ was defined as the last micro-CT cross section with a continuous band of enamel before transitioning to dentin. Buccal/palatal cusp horns were defined as the first cross section with visible pulp chamber void surrounded by dentin. Premolars were categorized as being either single-rooted (SR) or double-rooted, and contralateral teeth were labeled as 1 and 2. Measurements taken from the buccal and palatal cusps were abbreviated as B and P, respectively. The shortest distance between buccal and palatal/lingual canal openings was measured at the level of CEJ in premolar contralateral pairs with 2 orifices.

The root canal widths (Fig. 1, *8a–b*) were measured as the longest distance in the mesiodistal (m-d) and the faciolingual/palatal (f-l) directions at the following 5 levels (Fig. 1, *1–5*): at the CEJ, 1.5 mm before and after furcation, halfway between the CEJ and apex, and 2.0 mm before apex.

The dentinal thicknesses (Fig. 1, *9a–b*) were measured as the shortest distances in the m-d and the f-l directions at the following 5 levels (Fig. 1, *1–5*): at the CEJ, 1.5 mm before and after furcation, halfway between the CEJ and apex, and 2.0 mm before apex.

The following 7 anatomic parameters were also described and/or measured:

1. Number and shape of root canal orifices at the level of the CEJ (15)
2. Root canal configurations according to accepted classification schemes (8, 9)
3. Number and localization of apical foramina (15)
4. Number and localization of accessory canals (16)
5. Type and localization of isthmi (17)
6. Type and localization of C-shaped canals (18)
7. Type and localization of incidental anatomical anomalies

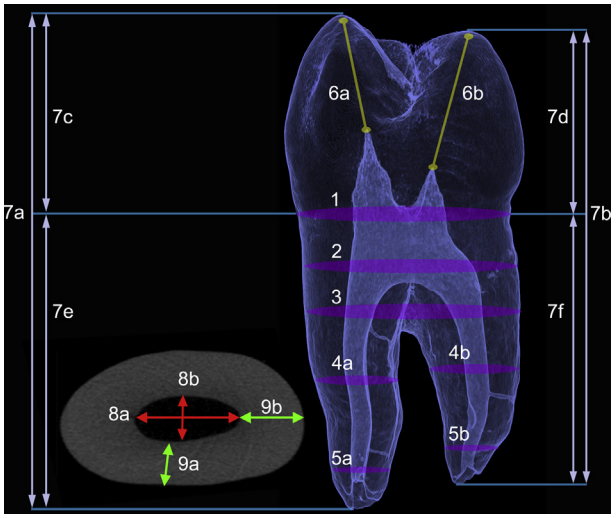

Figure 1. Linear measurements of contralateral premolars including lengths (cusp to pulp horn [*6a/b*], cusp to apex [*7a/b*], cusp to CEJ [*7c/d*], and CEJ to apex), smallest dentinal thicknesses in the m-d and f-l (*9a/b*) and longest root canal widths in the m-d and f-l directions at 5 different levels: *1*, CEJ; *2*, 1.5 mm before furcation; *3*, 1.5 mm after furcation; *4a/b*, halfway between CEJ and apex; *5a/b*, 2.0 mm before apex.

Statistical Analysis

All data sets were examined for parametric or non-parametric distributions (Shapiro-Wilk test). Because all data were found parametric, data were presented as the mean with SD. All groups and mean differences for both contralaterals and randomized pairs were tested pairwise with Student *t* test. Random pairs were acquired with an online randomizer (19). The statistical software package SigmaPlot 13.0 (San Jose, CA) was used for these analyses. Significance level was set to $P < .05$.

A correlation study was performed with a bivariate regression analysis, Spearman two-tailed, by using the computer software Statistical Package for Social Sciences (SPSS Inc, Chicago, IL) version 22.0 for Windows. The results were interpreted as follows: no correlation if $|r| < 0.3$, correlation if $0.3 < |r| < 0.5$, and strong correlation if $0.5 < |r| < 1$ (20). Significance level was set to $P < .05$.

Finally, a comprehensive evaluation of all the measurements for each of 3 main categories (length, width, thickness) and their combined total weighted sum was conducted after normalization with a Z score. This was done to determine degree of bilateral symmetry with Student *t* test between contralaterals by using a commercially available statistical software (SPSS Inc) version 22.0 for Windows (13). Significance level was set to $P < .05$.

Results

Lengths, Widths, and Thicknesses

The statistical analysis of the difference of means between contralateral parameters resulted in 88.89% of the parameters (40 of 45) having no significant difference ($P > .05$) (Supplemental Table 1 is available online at www.jendodon.com).

Significant differences were shown for all parameters ($P < .05$) when comparing differences in length, width, and thickness between contralateral means versus the hypothesized means.

A total of 86% of the parameters (38 of 45) for the randomized pairs were statistically significantly different. That is in contrast to the contralaterals, where only 15.56% (7 of 45) were statistically significantly different (Supplemental Table 1 is available online at www.jendodon.com). It was noted that 71% of the parameters (5 of 7) with statistically significant differences for contralaterals were found in the apical 2 millimeters.

Correlation and Z-Score Analysis. The correlation analysis (Table 1) demonstrated no correlation for 91.1% of the measurements (41 of 45). Correlation was only found for the mesiodistal canal width measurement at the CEJ in palatal roots and for 3 dentinal thicknesses ($0.3 < |r| < 0.5$) (Table 2).

The Z-score (Table 2) analysis of the normalized and weighted sums of all the measurements and their differences demonstrated no statistically significantly differences for any of the individual groups (length, width, thickness) or for the total differences.

Anatomic Parameters

Root Canal Orifice Shapes and Types. Listed in order from most to least common, the following 7 different orifice shapes were identified: oval (57.1%), circular (16.1%), triangular (7.1%), kidney (7.1%), hourglass (6.3%), bowling pin (4.5%), and fish (1.8%) (Fig. 2, *a–g*). In terms of similarity, 30 of 41 pairs (73.2%) had the same orifice shape. The premolars examined in this study had either one (59.8%) or two (40.2%) orifices.

Root Canal Configuration. Visual inspection of three-dimensional reconstructions as well as micro-CT slices revealed a total of 8 root canal configurations (Fig. 3, *a–h*). The most prevalent type was Vertucci type I (1) (96 of 114 roots, 84.2%), followed by type V (1-2-3)