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ORIGINAL ARTICLE

Anatomical study of palatogingival groove on maxillary central incisors

Estudo anatômico do sulco palato-gengival em incisivos centrais superiores

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ABSTRACT

Palatogingival groove (PGG) is a developmental anomaly affecting mainly the maxillary incisors. PGG incidence, depth, and length are clinically important because it may cause severe and localized periodontitis; and it may divide the root canal resulting in accessory foramina. This study aimed to analyze the presence, shape, length, and depth of the palatogingival groove in maxillary central incisors. 1,668 maxillary central incisors were used. Each tooth had its root portion inspected in order to verify PGG presence and depth. The found palatogingival grooves were classified according to the system proposed by Gu [5], as follows: Type I (short and superficial), Type II (long and superficial), and Type III (long and deep). All teeth that showed the grooves were radiographed; five teeth had their root surface analyzed through Scanning Electron Microscopic (SEM); and four teeth corresponding to each PGG type were sent to obtain histological sections and then submitted to microscopic analysis. Of the 1.668 analyzed incisors, 27 (1.61%) showed the palatogingival groove: 8 (29.6%) Type I, 17 (63%) type II, and 2 (7.4%) Type III. Microscopic analysis revealed no communication between PGG and root canal. In conclusion, our results showed that PGG can be clinically and radiographically diagnosed on maxillary central incisors, with the type II being the most common. The professionals should be aware of the features of this groove due to its severe clinical consequences.

KEYWORDS

Incisor; Anatomical variation; Palatogingival groove.

RESUMO

O sulco palato-gengival (SPG) é uma anomalia de desenvolvimento que acomete principalmente os incisivos superiores. Inicia-se no ou perto do cíngulo dental, e sulca a raiz apresentando uma grande variedade de profundidades e comprimentos. Sua incidência, profundidade e comprimento, são de importância clínica, uma vez que em periodontia podem ser o agente causal de periodontites severas e localizadas, e na endodontia provocam a divisão do canal radicular e o aparecimento de forames acessórios. O objetivo deste trabalho foi realizar um estudo sobre a presença, forma, comprimento e profundidade do sulco palato-gengival em incisivos centrais superiores. Foram utilizados 1.668 dentes incisivos centrais superiores da coleção de dentes da Disciplina de Anatomia do ICT - SJCampos – UNESP. Cada dente teve a sua porção radicular inspecionada com a finalidade de verificar a presença e a profundidade do SPG. Os sulcos palato-gengivais encontrados foram classificados de acordo com o sistema proposto por Gu (2011), em: Tipo I (curto e superficial), Tipo II (longo e superficial) e Tipo III (longo e profundo). Concluída esta classificação, todos os dentes que apresentaram o SPG foram radiografados e cinco dentes tiveram sua superfície radicular avaliada através do uso de um Microscópio Eletrônico de Varredura (MEV). Finalmente foram separados quatro dentes representativos de cada tipo de SPG encontrado para a obtenção de cortes histológicos e subsequente análise microscópica.

PALAVRAS-CHAVE

Incisivo; Variação anatômica; Sulco palatogengival.

INTRODUCTION

The palatogingival groove (PGG), first described by Black in 1908, is a developmental anomaly that begins near the tooth cingulum and extends from the cementoenamel junction towards the apex, acquiring a wide range of depths and lengths along the root [1].

The exact PGG etiology is not yet fully understood. Some researchers consider the invagination of the epithelial root sheath of Hertwig during odontogenesis as the source of this anatomical variation [2-5]. Ennes and Lara [1] suggested that a modification of the genetic mechanisms may account for the groove occurrence.

The PGG prevalence rate in the population has been reported to be between 2.8% and 8.5% [1,5-7]. The PGG incidence of 18% in the Chinese population suggests that race possibly can play a role in the etiology [2,8].

PGG is most commonly found in the maxillary incisors, but its occurrence has also has been reported in molar teeth [8]. When we compare the PGG incidence in other teeth of both arches, several authors state that PGG occurs more on the maxillary lateral incisors (93.8%) than in central incisors (6%) [3,7,9-12].

Gu [5] proposed a PGG classification divided into three types according to the length and depth: type I, in which the groove is short (not exceeding the cervical third of the root) and superficial; type II, in which the groove is long (beyond the cervical third of the root) and superficial; and type III, in which the groove is long (beyond the cervical third of the root) and deep, and may relate to a complex system of root canals.

The evaluation of PGG dimensions is clinically important because long and deep grooves tend to plaque accumulation, culminating in the destruction of the sulcular epithelium, later evolving to severe and localized periodontitis [3,4,13,14].

The wide range of PGG depths also has important endodontic implications because the groove may communicate with the root canal through accessory canals and foramina [3]. In some cases, PGG may be seen on periapical radiographs as a thin radiolucent line that follows the pulp chamber and root canal [15,16].

Currently, PGG therapeutic options include curettage of the affected tissues; removal with round bur in case of shallower grooves; groove sealing using a variety of materials; primary or secondary endodontic therapy; surgical procedures, such as tooth extraction in the case of unsuccessful treatments [3,5]. The prognosis for the affected tooth depends on PGG depth and length, so that several authors consider the treatment as difficult [4,9,14,16,17].

The more detailed and accurate anatomical knowledge on PGG location and the variations on the maxillary central incisors will provide better operative approach by dentists and improve the prognosis of patients to be treated, allowing more satisfactory results.

MATERIAL AND METHODS

This study employed 1.668 maxillary central incisors from the collection of the Discipline of Anatomy, School of Dentistry of São José dos Campos – UNESP. The teeth were previously cleaned from debris and periodontal calculus with the aid of Le Cron spatula. Next, all teeth were immersed into 10 volume hydrogen peroxide solution for cleaning and whitening.

Then, each tooth root surface was thoroughly inspected to verify PGG presence or absence. When PGG was found, they were first numbered and then had their palatal surface photographed. Following, all teeth were macroscopically classified according to the system proposed by Gu [5], defined as follows:

- Type I: in which the groove is short (no more than the cervical third of the root) and superficial;

- Type II: where the groove is long (beyond the cervical third of the root) and superficial;

- Type III: in which the groove is long (beyond the cervical third of the root) and deep, and may relate to a complex system of canals.

Completed this classification, all teeth showing PGG were radiographed, according to each type found. For this, we used a radiographic device Gendex 765 DC (Dentsply International Inc., Des Plaines, IL USA) and 3x4 cm periapical film (Kodak insight). The teeth were exposed for 0.25 second using a focus-film distance of approximately 30 centimeters with the aim of analyzing and interpreting the possible radiographic implications of PGG presence.

Then, five teeth were separated and had their root surface measured through Scanning Electronic Microscopy (FeiCompany- Inspect Model S50), with speed and acceleration of 15 kV and electron beam of 15 keV. To evaluate the teeth in detail on SEM, first the sample was flatted by grinding the labial surface with the aid of sandpaper. Following, the selected specimens were dehydrated in a sequence of chemical baths at different concentrations in the following order:

- Washing in phosphate buffer solution several times;

- Post-fixation in 1 or 2% osmium tetroxide (OsO_4) buffered for 1 hour;

- Washing in buffering solution;

- Dehydration in double alcohol baths at 30, 50, 70, 80, 95% (15 min each concentration) and 100% concentration (per 24 h);

- Drying of the specimens;

- Metallization of the palatal root surface with a 8 nanometer layer of gold-palladium alloy (Au-Pd), using a Sputter Coater (model SC 7620, Emitech).

Finally, one tooth from each PGG type (n = 4) was sent to histological analysis. For this purpose, the teeth were previously prepared through a sequence of chemical baths in the following order:

- Dehydration by alcohol baths of increasing concentration: 50, 60, 70, 80 (2 h at each concentration) and 100% concentration, where the teeth were left for 24 h.

- Immersion of the teeth in xylene for 24 h.

- Xylene exchange and the immersion of the teeth into the solution for 4 days.

- Immersion of the teeth on methyl methacrylate and dibutyl solution (solution 1) for 3 days.

- Immersion of the teeth in methyl methacrylate solution, dibutyl and 1 g of benzoyl peroxide (solution A) for 3 days.

- Inclusion of samples in methyl methacrylate solution, dibutyl and 3 g of benzoyl peroxide, and storage in incubator at 37 °C, where the pieces remained for four days, until the solution reaches the solid state.

Cuts with 1 mm thickness were made on all the included samples using a cutting machine (LabCut1010 ExtecCorp. Enfield, CT, USA). The histological sections were ground and polished by sandpaper at decreasing grit (n° 500, 600, 1200, and 2500) to achieve the thickness of 60 to 90 microns, and mounted on laminas for examination under an optical microscope (Carl Zeiss Axioplan 2) to observe PGG depth and relationship with the root canal. The images were recorded through photomicrography.

RESULTS

Of the 1.668 incisors analyzed, 27 (1.61%) had the palatogingival groove, which may be located on the center of palatal root surface or slightly shifted to one of the proximal surfaces of the root. Thus, 1.641 (98.39%) teeth showed complete PGG absence.

Of the 27 PGG found, 8 (29.6%) were classified as Type I, 17 (63%) as Type II, and 2 (7.4%) as Type III according to the system proposed by Gu [5] according to their length and deepness. Based on the overall study sample (1.668 teeth), PGG percentage of each type was 0.47% for Type I, 1.02% for Type II, and 0.12% for Type III (Figures 1, 2 and 3).

PGG radiographic appearance was a thin radiolucent line parallel to the root canal, of variable extent compatible with the type classified. Type I PGG was the hardest groove to be radiographically observed; and type II and III PGG had the most significant radiographic implications (Figure 4). In certain cases, where PGG was located right on the center of the palatal surface, PGG image superimposed with root canal image, slightly hindering its observation.

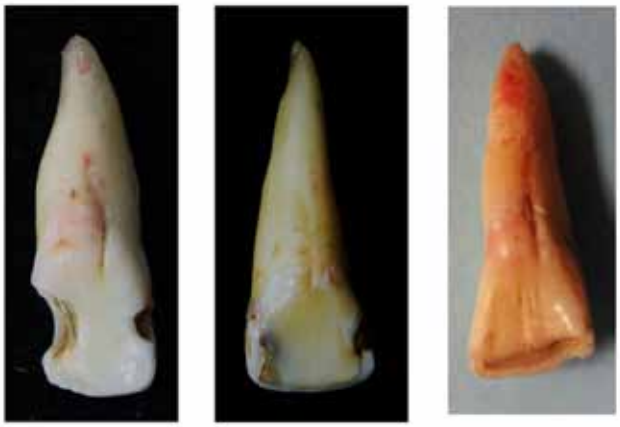

Figure 1 - a, b and c) Photographs of teeth showing Type I PGG.

Figure 2 - a, b and c) Photographs of teeth showing Type II PGG.

Five teeth were selected (two showing type I PGG, two showing type II PGG, and one showing Type III PGG) to be submitted to scanning electronic microscopy. 25 photomicrographs were obtained ranging from x26 to x1,050 magnification.

The SEM was operated under high vacuum at 15 Kv and 4.5 spot. The photomicrographs of the palatal surfaces were taken using the secondary electron detector (SED) and back-scattered electron detector (BSED). SED captures information about the sample's surface topography, which provided details about the

Figure 3 - a and b) Photographs of teeth showing Type III PGG.

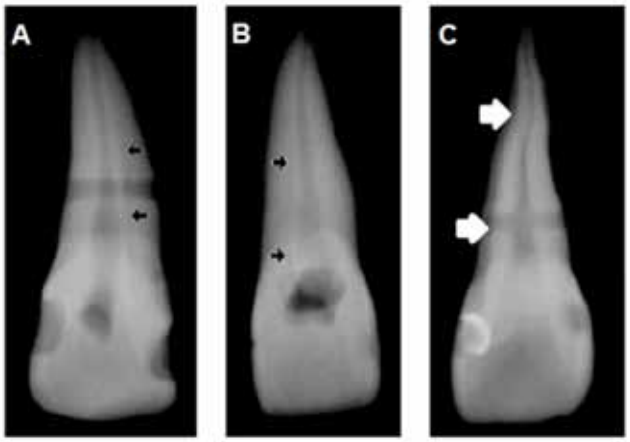

Figure 4 - a and b) Type II PGG radiographic aspect; c) Type III Radiographic aspect. PGG was a thin radiolucent line parallel to the root canal.

different PGG depths as well as of the entire root surface (Figure 5). Because BSED is based on phase contrast (Z) it allowed determining PGG limits more accurately.

By analyzing the images, was observed that PGG surface was rough and irregular, sometimes presenting cracks and very pronounced irregularities (Figure 6). Type III PGG exhibited a deep cleft along its surface (Figure 7).

Figure 5 - PGG Type I photomicrograph captured through the secondary electron detector (SED), providing details on the topography of the palatogingival groove. E: enamel surface of the cingulum area. C: Surface of the root cementum.IS: Beginning of palatogingival sulcus TS: Ending of palatogingival groove. x32 magnification.

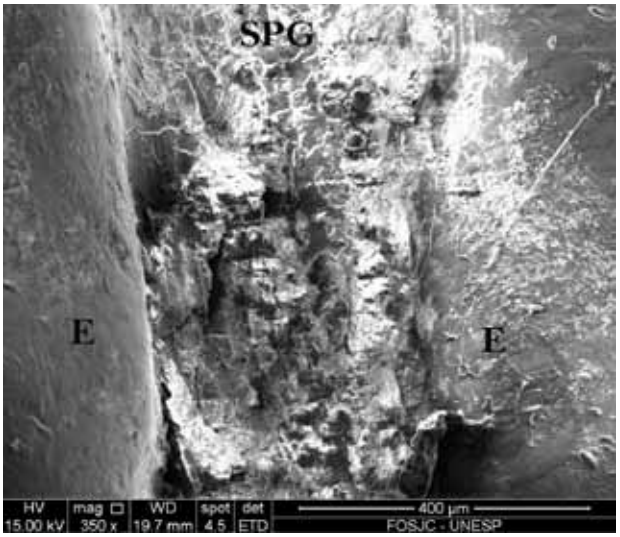

Figure 6 - Photomicrograph of cingulum area with Type I PGG (x350 magnification) showing rough and uneven surface E: enamel surface of the cingulum area SPG: palatogingival groove

The images obtained by histological processing showed that PGG had a varying degree of depth along the root surface, and type III had a higher degree of invagination of mineralized tissues, especially on the middle third of the root (Figure 8). Histologically, Types II and I PGG were shallower than Type III PGG; the deepest areas were observed at the level of the cingulum and coronal third of the root. In neither case, a direct communication between the pulp chamber and root canal with outer surface of incisors was observed.

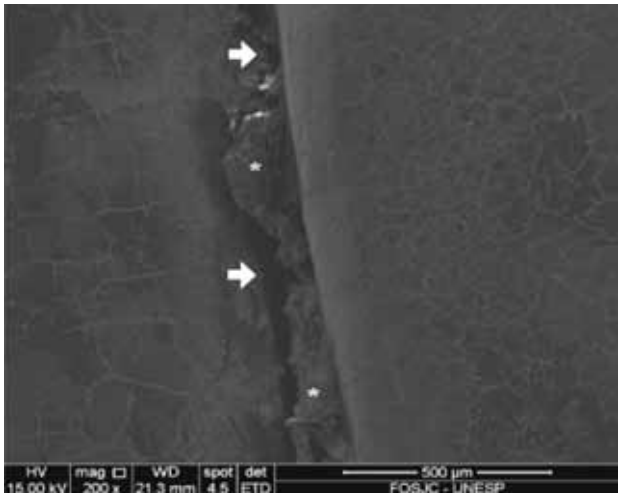

Figure 7 - Photomicrograph Type III PGG. The asterisks mark surface irregularities and the arrows point a deep fissure that follows the groove path. x200 magnification.

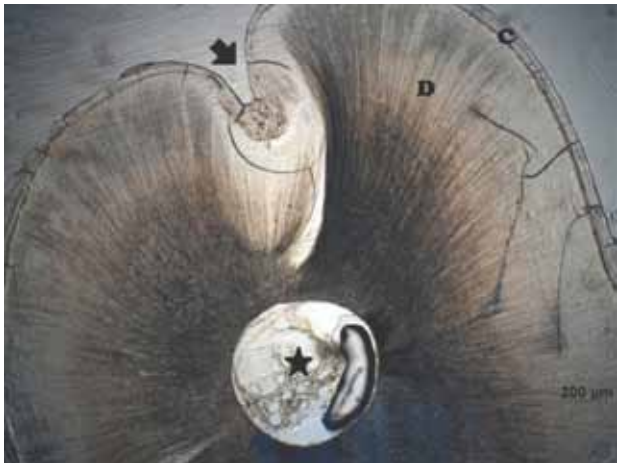

Figure 8 - Photomicrography of cross-sectional histological cut of Type III PGG on the middle third of the root. The arrow indicates the location of the groove, where invagination and increased thickness of cementum can be observed. The asterisk marks the root canal. C: cement. D: root dentin. x25 times magnification.

One tooth having Type III PGG and one having Type II PGG showed at level of cingulum and coronal third of the root deformation of the pulp chamber, which culminated in the emergence of two separate root canals separated by a dentin bridge (Figure 9). Type III PGG was the only the one to reach the apical third of the root, however, without close relationship with the root canal, which showed circular section and no deformation.

Images at higher magnification of PGG area allowed to verify the presence of tissue cracks and hypomineralized areas in association with PGG, as well as the deposition of amorphous mineralized material in the depressions due to the groove presence (Figures 10 and 11).

Teeth presenting type II PGG showed a slight increase in cementum thickness at the medium third of the root, while those with type III PGG had the cementum increased at both medium and apical third of the root (Figure 8).

DISCUSSION

The present study examined PGG prevalence, characteristics, and relationships with other dental structures in 1,668 maxillary central incisors to make the professionals aware of PGG clinical significance during dental therapies. Our study covered a macroscopic and microscopic analysis involving classical X-ray techniques, optical microscopy, and scanning electron microscopy (SEM), to verify possible correlations between PGG and the root canal.

Figure 9 - Figure 9 – Photomicrograph of cross-sectional histological cut of Type II PGG at the level of the coronal third of the root. Asterisks mark the primary and secondary canals. A dentin bridge can be observed between the two canals. E: enamel. D: dentin. x25 magnification.

Figure 10 - Photomicrography of cross-sectional histological section of Type II PGG at the level of the coronal third of the root. The arrow indicates the groove entry location. The asterisk indicates amorphous mineralized material filling the fissures caused by PGG. Note the thin enamel continuity. E: enamel at the cingulum area. D: dentin. x100 magnification.

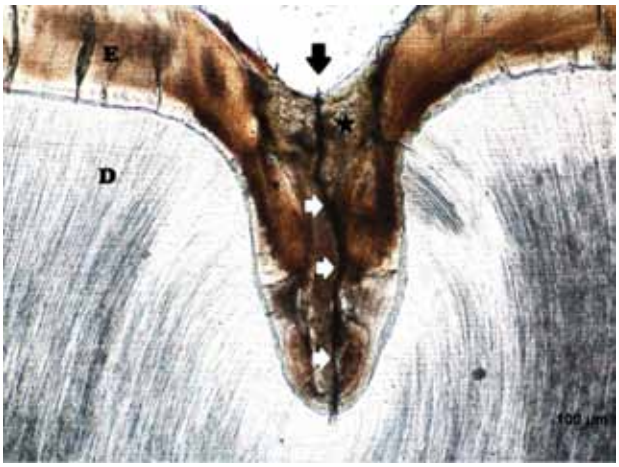

Figure 11 - Photomicrography of cross-sectional histological section of Type III PGG at the level of the coronal third of the root. The black arrow indicates the groove entry location. The asterisk indicates amorphous mineralized material filling the fissures caused by PGG. The white arrows indicate a enamel crack. enamel at the cingulum area. D: dentin. x100 magnification.

Several authors report a PGG prevalence rate in the population between 2.8% and 8.5% [1,5-7]. In this study, we used 1,668 dried human teeth without identification of sex or race. Some authors point out a significant PGG incidence of 18% in the Chinese population, suggesting a correlation between race and PGG etiology [2,8]. A clinical study conducted by Radhakrishnan et al. [18] on a group of patients showed PGG prevalence of 6.4% in males and 8.4% in females, but without statistically significant differences.

The literature is scarce in studies on PGG prevalence in maxillary central incisors, probably because PGG is more studied on the maxillary lateral incisor through a wide variety of methodologies, but previous studies show a prevalence ranging from 0.39% to 6% [3,7,9-12,18]. In this study, we found PGG prevalence on the maxillary central incisors of 1.61% (27 teeth), similar to that reported by Pécora et al. [19], where the prevalence was 2%. Kogon [20] found a PGG prevalence of 3.4% on maxillary central incisors. Radhakrishnan et al. [18], reported PGG occurrence on 0.39% of maxillary central incisors, differing from the studies cited above, including ours.

Of the 27 PGG found, 8 (29.6%) were classified as Type I, 17 (63%) as Type II, and 2 (7.4%) as Type III. By comparison, our results are similar to those of Gu [5] who found that Type II PGG (i.e., long and shallow) was more prevalent than the other types. Many authors agree that PGG length and depth are important factors to consider therapeutically because PGG directly affect the treatment and prognosis of the cases [3,9,14,16,17].

Concerning to the radiographic implications of PGG, we observed a thin radiolucent line parallel to the root canal, of variable length and compatible with the type classified. Type I PGG was the most difficult to be radiographically observed than Type II and III, which had the most significant radiographic implications. This finding confirms that described by Lara et al. [16] and Everett and Kramer [13], who obtained linear radiolucent images of PGG following the root canal. Attam et al. [8] affirmed that PGG radiographic diagnosis may be difficult because PGG can be mistaken by vertical root fractures or even by the root canal.

SEM allowed verifying that PGG presented an uneven surface and often cracks that follow the groove path. Type III PGG exhibited at the level of the middle third of the root a deep, narrow cleft, which was later confirmed by histological section. In the literature, we found only one study with a similar approach conducted by Gao et al. (1989), who evaluated fourteen maxillary lateral incisors through SEM and verified the occurrence of accessory foramen along the groove surface. Such finding differs from ours, since we did not find any accessory foramen in any of the specimens submitted to SEM.

The results obtained by histological analysis of PGG cross-sections allowed us to observe a varied morphology pattern along the root, so that Types I and II PGG showed deeper grooves at the level of the cingulum and coronal third of the root, whereas the Type III PGG presented deeper groove at the middle third of the root.

In line with the results obtained through the radiographic and SEM analysis, we did not verify histologically, a communication between PGG with the root canal, although the literature reports the occurrence of accessory canals directly communicating with the pulp with the periodontal ligament [16,22].

On one of Type II and one of Type III PGG, we observed pulp chamber and root canal deformation particularly at the coronal third of the root, which resulted in the emergence of a second canal. This finding is similar to that reported by Lara et al. [16], who verified in most of the sample, pulp chamber deformation along the groove especially in the tooth crown and the coronal third of the root. In this same study, the authors reported that in three specimens PGG

was accompanied by the occurrence of dens *invaginatus*, different from our findings where such morphological variation was not found in any specimen.

The microscopic examination revealed a reduction of the enamel thickness in the region corresponding to PGG in almost all cases. However, there was an increase in the cementum thickness, especially at the middle and apical thirds of the root, similarly to the results reported by Lara et al. [16] and Ennes and Lara, [1]. Likely to our study, these authors also found the deposition of amorphous mineralized material at the coronal portion of the palatogingival groove.

According to Gu [5], currently there are therapeutic modalities used for the treatment of the root groove, including curettage of the affected tissues; groove removal with round bur in case of shallower grooves; groove sealing through a variety of materials; primary or secondary endodontic therapy, surgical procedures; or even extraction of the tooth involved.

Periodontal and endodontic infectious processes are often associated with teeth presenting PGG, whose treatment will be planned according to their dimensional characteristics. Accordingly, if parameters for the accurate PGG recognition are available, injury can be avoided and an auxiliary treatment performed. Thus, our results provide a more detailed knowledge on the palatogingival groove, thereby contributing to a more conscious therapeutic approach by the dentist and consequently a more favorable prognosis for patients with this anatomical variation.

CONCLUSION

In conclusion, our results showed that PGG can be clinically and radiographically diagnosed on maxillary central incisors, and Type II PGG was the most common one. No communication between PGG and the root canal of maxillary central incisors. The professionals should be aware of PGG presence and features because of the serious clinical consequences.

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