Original Article

Cone-beam computed tomographic evaluation to estimate the prevalence of palatogingival groove in the maxillary anterior teeth and its radiographic characteristics: An institutional retrospective study

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Abstract

Aim: The purpose of the study was to radiographically evaluate the prevalence of palatogingival groove (PG) in the East Indian population in the maxillary anterior teeth in different genders, its unilateral/bilateral presentation, classified based on its radiographic characteristics, to determine the prevalence of different types, which could help in future treatment planning.

Study Design: The design of the study was a retrospective study.

Materials and Methods: Analysis of 429 maxillary anterior teeth (144 central incisors, 145 lateral incisors, and 139 canines) in 72 cone-beam computed tomography scans was done (31 males and 41 females, mean age 27.3 ± 7.63). Demographic details of patients and characteristics of PG, i.e. location, extension, depth, and type, were recorded. The presence of alveolar bone loss and periapical pathology was noted.

Results: An overall prevalence of PG was found to be 2.33% (n = 10), with PG being detected in 2 (1.388%) central incisors, 8 (5.51%) lateral incisors, and 0 (0%) canines. Eight of the patients had a unilateral presence, while one patient reported with bilateral presence, implying a significantly higher predilection of unilateral occurrence ($P = 0.02$). The prevalence was found to be higher in females (n = 8). The teeth were categorized as either having Type I (6 teeth), Type II (3 teeth), or Type III (1 teeth). Three of the 10 PGs were present in the mesial, six in the mid-palatal, and one in the distal portion of the palatal surface.

Conclusions: The prevalence of PG in the maxillary incisors in this cohort is 2.33%. The maxillary lateral incisors are the most affected teeth. Unilateral presentation is more common.

Keywords: Bilateral; cone-beam computed tomography; maxillary anterior teeth; palatogingival groove; unilateral

INTRODUCTION

Among the very many reasons of failure of endodontic treatment, missed diagnosis of anatomical and morphological variations of roots and root canals remains the most significant.[1] One such anatomical variation, most often overlooked, seen mostly in the maxillary incisor teeth, particularly the lateral incisors, is the palatogingival groove (PG). In literature, this groove has also been named as radicular groove, distolingual groove, vertical developmental groove, and cinguloradicular groove.[2]

Most of the anatomical variations in the maxillary incisor region are associated with lateral incisors, which include

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peg-shaped lateral incisors, dens invaginatus, dens evaginatus, and PG. Seldom do these anomalies occur solely; most of the cases show the concurrent existence of more than one such anomaly.

The PG was first described by Black in 1908. It usually originates from the palatal surface of the maxillary anterior teeth, from the cingulum, extending apically beyond the cementoenamel junction, along the root surface up to varying lengths and depths.[3] The etiology of such defects is unknown; however, studies suggest the enfolding of the embryonic enamel organ and Hertwig's epithelial root sheath that leads to such grooves.[4]

These grooves act as a portal of entry for microorganisms and the accumulation of plaque.[5] The presence of such grooves leads to endodontic and periodontal problems, leading to pulpal necrosis, apical periodontitis, periodontal pocket formation, and the presence of sinus tracts.[6] Unless the groove is repaired, the disease progression cannot be controlled, even after the endodontic treatment is done adequately. Hence, a proper diagnosis and appropriate treatment plan become necessary to overcome the negative clinical outcomes.[7]

In such cases, diagnosis depends on clinical and radiographic examinations. Clinically, sometimes, only the origin of a PG is seen on the palatal surface, which may or may not be associated with a periodontal pocket. The length and the apical extent of the groove on the radicular surface remain unclear. Hence, radiographic examination is relied on for definite diagnosis.

Two-dimensional radiographs, like intraoral periapical radiographs, when taken with multiple angulations, can detect the presence of the PG. On intraoral periapical radiographs, they usually present as a radiolucent line traveling close to the pulp, imitating the presence of extra canals.[8] Determination of exact position, length, depth, and hence, severity becomes difficult due to overlapping and inadequate detailing of such radiographs. A three-dimensional examination, for example, using cone-beam computed tomography (CBCT) helps overcome these shortcomings. When viewed in various axial, sagittal, and coronal sections, the exact nature of the groove can be assessed.[9]

Based upon these findings the PG can be classified according to their location (mesial, mid-palatal, distal), the complexity of the groove (mild, moderate, severe) , the depth of invagination (shallow, deep or closed tube). The presence of any alveolar bone loss or periapical pathology can be assessed.[8] A proper diagnosis and associated classification can help decide the treatment plan. Usually, short and shallow PGs may not require any groove repair or surgical intervention.

Previously, various studies have been done for estimating the prevalence of PG. The value ranges from 0.5% to 18%,[10] which is highly variable depending on the race and ethnicity of the given population. The prevalence of PG in the Indian population was found to be 1.88% (with respect to the maxillary anterior teeth) and 2.88% (in the maxillary incisors).[9] There are no similar studies that evaluate the prevalence of PG in the Kolkata cohort.

In the present study, CBCT evaluation will be done to estimate the prevalence of PG in the East Indian population in the maxillary anterior teeth in different genders, the unilateral/bilateral presentation of PGs, and classification will be done based on the radiological characteristics of the PG, to determine the prevalence of the most common type of PG in the said population, which could help in future treatment planning of the clinicians practicing in the topographical region.

MATERIALS AND METHODS

This study was done after receiving ethical clearance from the Institutional Ethical Committee (Ethics Committee Reg. no.-ECNEW/INST/2023/3191). For the present retrospective study, Cochrane's formula for an unknown prevalence and infinite population was used to estimate the sample size, with *Z* value-1.96 and sampling error maintained at 5%. Accordingly, the minimum sample size required to estimate the prevalence in the said population was 385 teeth.

To conduct this study, 100 good-quality CBCT scans of the maxillary teeth were taken. These scans were obtained from the department of conservative dentistry and endodontics, of patients who had previously undergone endodontic surgical and nonsurgical procedures that required CBCT evaluation. None of the scans were done keeping this study in mind. Scans with scattering or artifacts were not included in the study. The collected data were scanned to exclude teeth with incomplete roots, coronal/root fractures, caries, displaced or malposed teeth, internal/external resorption, endodontically treated teeth, or having any prosthesis to avoid any errors. A total number of 429 teeth (using 72 CBCT scans) were examined that fulfilled the inclusion criteria.

A total number of 144 maxillary central incisors, 145 maxillary lateral incisors, and 139 maxillary canines were examined in the study for the presence of PG. Only grooves that extended beyond the CEJ or onto the root surface were included as PGs in this study.

The CBCT machine used in the present study was SkyView 3D (MyRay, Cefla Dental Group, Imola, Italy). The Digital Imaging and Communications in Medicine format image was exported from Skyview CBCT Scanner TM and imported into iRYS viewer software to view the scan. It had a tube voltage of 90 kVp and a pulsed beam current of 1–10 mA.

All measurements and observations were done by two expert endodontists and verified by a senior endodontist, on two different occasions, 2 weeks apart. All the maxillary anterior teeth were initially screened for the presence of PGs. In axial sections, PGs appear as a depression that appears as a break in the continuity of the palatal root surface. Once the presence of a PG is identified, its location is noted (mesial, mid-palatal, and distal). This is done by orienting the longitudinal plane along an imaginary line perpendicular to the line that connects the incisal edge and midpoint of the cingulum of the tooth being examined [Figure 1].

The apical extent of the PG is noted on the corresponding sagittal section, till the most apical point on the axial section where the groove ends. The length of the PG is then noted, as the vertical distance from the point of origin on the tooth to the endpoint. Through the axial sections, the depth of the groove can be evaluated. While strolling through the axial sections, the deepest invagination of the groove is noted. The depth is measured as the horizontal distance from the deepest point of invagination to the imaginary outer circumference of the palatal root surface. Based on the depth, the PG is classified as shallow/flat (1 mm), deep (>1 mm), or a closed tube that forms a tunnel-like channel [Figure 1].

Based on the length and the depth of the PG, the groove can be classified according to its complexity and severity (Gu's Classification and Goon's Classification).

The height of the labial and palatal alveolar bone of the tooth to be examined was noted, to examine the associated bone loss (if any) with the defect. The presence or absence of any associated periapical pathology was also noted in all three planes – axial, coronal, and sagittal, to identify the plane of the maximum dimension of radiolucency (anteroposterior, mesiodistal, and supero-inferior).

Statistical analysis

The collected data were tabulated in a spreadsheet using Microsoft Excel 2019, and then, statistical analysis was carried out using GraphPad Prism for Windows, Version 9.5 (GraphPad Software, La Jolla, California, USA). Descriptive statistics were used to report the categorical variables in terms of frequencies and percentages and were tested using the Chi-square test. Cohen's kappa statistics were used to evaluate the intra- and inter-operator reliability for interpreting the CBCT scans. $P \leq 0.05$ was considered as the level of significance.

RESULTS

A total of 429 teeth (144 central incisors, 145 lateral incisors, and 139 canines) in 31 males (43.05%) and 41 females (56.94%) were assessed for the presence of PG. The mean age of the study subjects was found to be 27.3 ± 7.63, with an age range of 17–37 years. Cohen's kappa coefficient for intra- and inter-operator reliability was found to be 0.84 and 0.82, respectively, indicating an almost perfect agreement between the examiners. An overall prevalence of PG was found to be 2.33% ($n = 10$), with PG being detected in 2 (1.388%) central incisors, 8 (5.51%) lateral incisors, and 0 (0%) canines. Eight of the patients had a unilateral presence of PG, while one patient reported with bilateral presence of PG, implying a significantly higher predilection of unilateral occurrence in the current study population ($P = 0.02$) [Table 1].

The prevalence of PG was found to be higher in females ($n = 8$). The distribution of the PGs according to gender did not significantly differ ($P = 0.11$). Out of the 10 PGs detected, three were present in the mesial, one in the distal, and the rest six in the mid-palatal aspect of the teeth. The distribution of PGs according to the site did not significantly differ ($P = 0.14$). Four of the

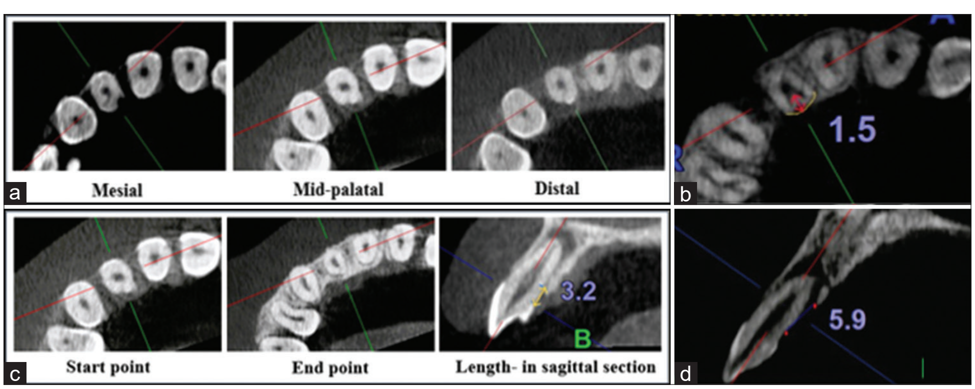

Figure 1: (a) Identification of the location of the palatogingival groove (PG) on the axial sections. (b) Measuring the depth of invagination of PG. (c) Measuring the length of PG in the corresponding sagittal section. (d) Measuring the alveolar bone loss, and detection of periapical pathology

PGs detected had a depth <1 mm, while the rest six had a depth >1 mm, with a depth ranging from 0.6 to 2.2 mm, indicating no significant difference concerning the proportion distributions ($P = 0.75$). Concerning the length of the PG, three of the PG had a length <2 mm and the rest seven >2 mm, with a length ranging from 1.8 to 7.9 mm. However, the distribution of the PGs according to length did not significantly differ ($P = 0.34$). Six teeth were classified to be belonging to Gu's Type I/mild (according to Goon's classification), three teeth were classified to be belonging to Gu's Type II/moderate (according to Goon's classification), and one tooth was classified to be belonging to Gu's Type III/severe (according to Goon's classification). No significant difference was noted in the distribution of the same ($P = 0.14$) [Table 2 and Figure 2]. Alveolar bone loss was detected in nine of the total PGs detected, ranging from 1 to 5.9 mm. No significant difference was noted regarding the absence or presence of periapical pathology, with the presence of a pathology detected in three of the teeth.

DISCUSSION

Successful endodontic treatment depends on accurate diagnosis of various morphological and endodontic variations. Knowledge of the prevalence of these anomalies in the population helps identify them, directing the clinicians toward appropriate treatment care and a favorable treatment outcome.

Various methods help diagnose PGs. That includes *in vivo* clinical examination, examination of extracted teeth (microscopically or micro-computed tomographic examination), two-dimensional radiographic imaging intraoral periapical (IOPA), or three-dimensional radiographic imaging like CBCT.[11]

In vivo clinical examination has limited value because the PGs although evident clinically, the mucoperiodontium hinders the evaluation of the length, depth, and hence, the complexity of the PGs. Microscopic examination of

Table 1: Frequency distribution of palatogingival groove

Tooth type	Number of teeth analyzed (total=429)	Number of teeth with PG (%)	Unilateral PGs	Bilateral PGs
Maxillary central incisor	144	2 (1.388)	1	1 (central incisor on one side and lateral incisor on the other)
Maxillary lateral incisor	145	8 (5.51)	7	
Maxillary canine	138	0	0	0

PGs: Palatogingival grooves

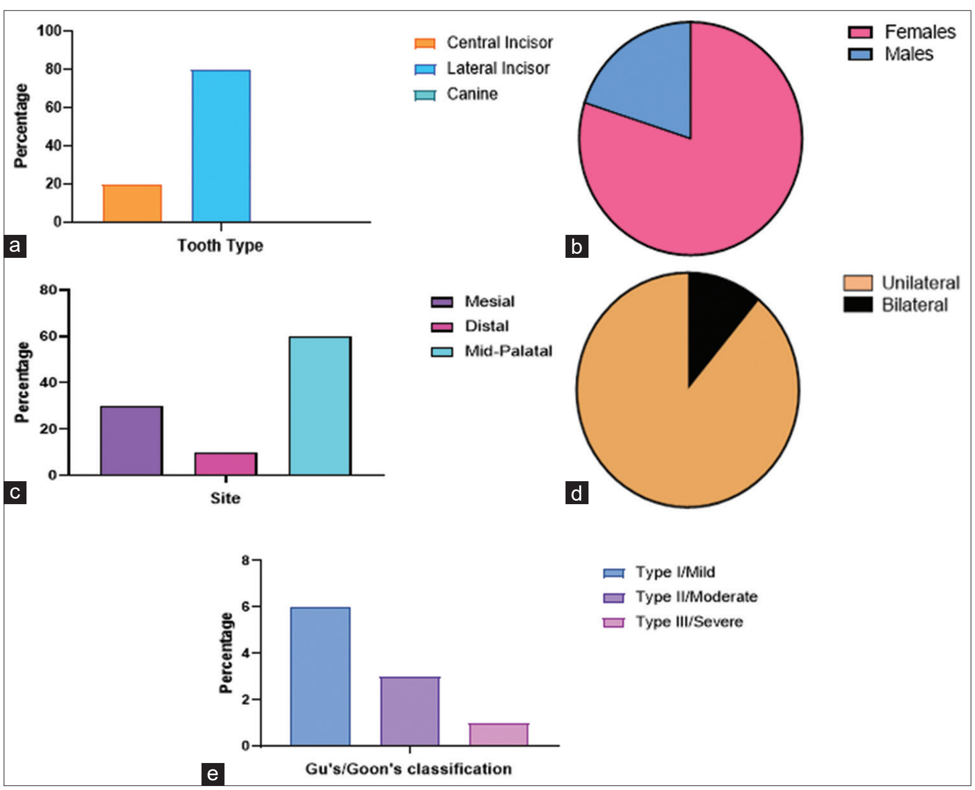

Figure 2: (a) Bar graph showing the distribution of palatogingival groove (PG) according to the type of teeth. (b) Pie chart showing the distribution of PG according to gender. (c) Bar graph showing the distribution of PG according to location. (d) Pie chart showing the distribution of PG according to occurrence. (e) Bar graph showing the distribution of PG according to classification

Table 2: Characteristics of palatogingival grooves in the study

S. no.	Age	Sex	Tooth number	Location of PG	Depth†	Length‡	Goon's	Gu's Classification of root canal anomalies	Alveolar bone loss§	Periapical radiolucency
1	20	F	22	Mid pal	2.2 (II)	3.2	Moderate II	(PGG^{II})^1 22	1.5	Present
2	33	F	12	Mid pal	0.6 (I)	1.8	Mild I	(PGG^{I})^1 12	1	Absent
3	25	M	12	Distal	1.4 (II)	3.5	Moderate II	(PGG^{II})^1 12	1.5	Absent
4	29	F	22	Mid pal	1.5(II)	2.9	Moderate II	(PGG^{II})^1 22	1.9	Present
5	17	F	11	Mesial	1.1 (I)	3.1	Mild I	(PGG^{I})^1 11	1.6	Absent
	17	F	22	Mesial	2.1(II)	3.3	Mild I	(PGG^{I})^1 22	1	Absent
6	35	F	22	Mid pal	1.2(II)	2.9	Mild I	(PGG^{I})^1 22	1	Absent
	35	F	21	Mesial	0.8(I)	1.9	Mild I	(PGG^{I})^1 21	0	Absent
7	25	F	22	Mid pal	1.5(II)	7.9	Severe III	(PGG^{III})^1 22	5.9	Present
8	37	M	12	Mid pal	0.7 (I)	1.9	Mild I	(PGG^{I})^1 12	1	Absent
P^a	-	0.11ns	-	0.14ns	0.75ns	0.34ns	0.14ns		0.0005**	0.08ns

[a]analyzed by the Chi-Square(χ^2) test for proportions †: classified as<1mm/>1mm; ‡: classified as<2mm/>2mm; §: classified as Present/Absent ns: not statistically significant (P>0.05); **highly statistically significant (P<0.001) PG: Palatogingival Groove

teeth after extraction reveals inconclusive data, where the reason for extraction cannot be assessed. Most anterior teeth are extracted due to periodontal reasons, but the cause for exfoliation may not be the presence of PGs. Two-dimensional radiographs (IOPA) mask a lot of anatomical variations due to the inevitable overlapping of various structures, with inadequate detailing. Three-dimensional radiographic imaging appears to be the appropriate diagnostic tool for studying the intricacies of such anomalies. CBCT, as a diagnostic aid, helps identify the location, extent, severity, complexity, and associated alveolar bone loss of such defects, noninvasively, at a lower radiation dose, when compared to the conventional CT. Hence, a CBCT scan was used in the study to evaluate the prevalence of PGs in the population, its association with gender, the unilateral or bilateral occurrence of the defect, and the associated complexity and severity of the defect.

Prevalence represents the proportion of the population affected by a disease or event at a specific time. It includes the old and the new cases reported in the population over a period of time. Studies have been done previously to determine the prevalence of PGs in the Indian population, which showed a 1.88% prevalence in maxillary anterior teeth. The prevalence of PG in the maxillary anterior teeth in the Kolkata cohort was found to be 2.33%, which is in accordance with the study by Lekshmi *et al*.[9] Studies of PG in various populations reported a prevalence that ranges from 0.05% to 18%.

The present study showed a prevalence of PGs in the maxillary central incisors and lateral incisors to be 1.38% and 5.51%, respectively, which can be correlated with the results obtained by Withers *et al*.[12] (in the Turkish population, 0.6% and 2.3%, respectively), Hou and Tsai[10] (in the American population, 0.28% and 4.4%, respectively), Zhang *et al*.[13] (in the Chinese population, 0.29% and 4.5%, respectively), and Alkahtany *et al*. examined the maxillary lateral incisors in the Saudi Arabian population and reported a prevalence of PG of 4.9%.[14] Shreshta *et al*. reported a 2.4% prevalence of PG in the maxillary canines, in contrast to our study where no PGs were identified in the maxillary canines.[15] This diverse range of prevalence may be due to the use of different diagnostic tools and methodologies, ethnicity, and racial considerations.

Our retrospective study indicated a higher prevalence in females (n = 8); this could be due to a higher proportion of scans of female patients (63.8%), when compared to males, were included in the study. Studies indicate that females are more likely to seek dental treatment. However, there was no statistically significant difference in the prevalence of PG in males and females, in accordance with the study by Aksoy *et al*.[16] and Alkahtany *et al*.[14]

According to our study, out of the 10 PGs identified (in eight patients), only one bilateral occurrence was noted (one central incisor on one side and a lateral incisor on the other side). Moreover, other eight patients showed unilateral occurrence. One patient specifically exhibited PGs in both the left maxillary central and lateral incisors. The results were statistically significant (P = 0.02) indicating a higher prevalence for unilateral occurrence. This result is in accordance with all the previous studies.

Variations exist with respect to the location, length, depth, and hence, the severity of the PGs, when seen in various populations. In our study, most of the PGs were detected in the mid-palatal aspect (n = 6), followed by mesial (n = 3) and distal (n = 1). Analogous results were seen in studies done by Lekshmi *et al*.[9] and Hou and Tsai,[10] which showed 50% and 42.55% occurrence of PG in the mid-palatal aspect. However, Bacic *et al*.[11] reported a higher occurrence of PGs in the distal aspect – 45% and 70%, respectively.

According to severity, the results in the present study showed the occurrence of Type I, II, and III PGs to be 60%, 30%, and 10%, respectively. Lekshmi *et al*. reported 58% occurrence of Type I, 42% type II, with no reported cases of Type III.[9] Aksoy *et al*. reported the occurrence of Type I PGs only.[16] Arslan *et al*. reported that Type I, Type II, and Type III PGs were detected in 68.4%, 15.7%, and 15.7% of teeth, respectively.[17]

The presence of PGs enhances the accumulation of plaque, leading to periodontal breakdown, attachment loss, apical periodontitis, and associated periapical pathology. In this study, alveolar bone loss was seen in 90% of teeth with PGs, with associated periapical pathology in only 30% of them, analogous to the study by Bacic *et al*.[11] These results are in contrast to the study by Pécora and da Cruz Filho, who reported alveolar bone loss in 52% of teeth with PGs; the reason could be attributed to the fact that the age of the sample population ranged from 7 to 15 years.[18]

This study included the scans of patients undergoing other surgical and nonsurgical endodontic procedures. The scans were not done to examine PGs, implying that diagnosis of PG based on clinical examination, cannot be relied on, solely. PGs with apical extensions into the root surface, deeper and more complex PGs appear to be associated with periodontal destruction, resulting in unpredictable treatment outcomes, Early diagnosis and appropriate treatment can help prevent and cure the periodontal breakdown, enhancing the success rate of dental treatment of such teeth. Patients with PGs should be educated about the maintenance of oral hygiene and should be encouraged for periodic recall visits.

Type I PGs are difficult to be diagnosed only by clinical examination because the patients rarely present with any clinical symptoms. Teeth with type II/III PGs do present with clinical signs like attachment loss, but the length and complexity of the groove are best interpreted by CBCT imaging. CBCT, although a noninvasive tool for diagnosing PGs, cannot be used for population-based screening, due to radiation-based hazards. Hence, clinicians should be aware of the prevalence of such conditions in the population and routinely check for the presence of PGs, especially teeth with minor periodontal pocket, or periapical radiolucency. Most commonly, the maxillary anterior teeth that test negative to pulp vitality testing, without any history of trauma, visible fracture, cracks, or caries, may indicate the presence of PGs.

The management of PGs requires an interdisciplinary approach. The treatment plan revolves around the elimination of the causative factor (PG) to achieve a favorable treatment outcome. Not all teeth with PGs present with periapical pathology, but accessory foramina and lateral canals act as a pathway for secondary endodontic involvement.[19] In cases with primary pulpal involvement (due to caries/trauma), enhanced periodontal breakdown is seen when associated with PGs. CBCT imaging helps in determining the depth of the invagination of the groove into the root surface, the remaining dentin thickness between the root canal wall and the deepest point of the groove. This should be considered when biomechanical preparation is done for root canal treatment, and during postspace preparation, to avoid communication with the groove, which could negate the probability of a favorable prognosis.

The management of PGs solely depends on the depth, severity, and accessibility of the groove. Shallow and short grooves can be treated with odontoplasty alone. Continuous recalls and frequent oral prophylaxis procedures are required to monitor the periodontal health of the teeth with short PGs. Deeper ones require surgical correction. They should be repaired with appropriate biocompatible materials, such as glass ionomer cement (GIC), mineral trioxide aggregates (MTA), and newer calcium silicate cement. Composites and MTA do not allow regeneration of attachment apparatus and fibroblast growth. Resin-modified GIC and newer calcium silicate cement, like Biodentine, appear to be better alternatives for the same, with better handling properties. In cases with alveolar bone loss, bone grafting with the use of barrier membranes like guided tissue regeneration membranes (resorbable like collagen and platelet-rich fibrin membranes and nonresorbable like polytetrafluoroethylene) is recommended to achieve periodontal regeneration.[20] For deeper and more complex grooves, which are inaccessible from the palatal aspect, intentional replantation can be considered, although it is associated with a risk of external root resorption and ankylosis. When prosthetically restoring teeth with PGs, it should be noted that the restoration margins lie on sound tooth structure, using such teeth as abutments for fixed prosthesis is best avoided.

CONCLUSIONS

The prevalence studies help clinicians with knowledge of intricate toot morphological variations, guiding them with better treatment planning. The prevalence of PGs in the East Indian cohort was found to be 2.33%, with no statistically significant gender predilection. The maxillary lateral incisors appear to be the most commonly affected tooth, more commonly present in the mid-palatal aspect, with unilateral presentation being more prevalent in the population. Most teeth with PGs showed some degree of alveolar bone loss, while the presence of periapical pathology was not significant.

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Conflicts of interest
There are no conflicts of interest.

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