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ORIGINAL ARTICLE

Prevalence of palatogingival groove affecting maxillary anterior teeth in Saudi subpopulation: A cone-beam computed tomographic study with literature review

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KEYWORDS

Palatogingival groove (PGG);
Anomaly;
Maxillary lateral incisors;
Maxillary central incisors

Abstract *To investigate the prevalence of palatogingival groove (PGG) affecting maxillary anterior teeth, bilateral occurrence, and distribution among sex in the Saudi subpopulation and to review the literature on the prevalence of PGG.Introduction:* Palatogingival groove (PGG) primarily affects maxillary lateral incisors and, when present, may contribute to the pathogenesis of periodontal and endodontic lesions.

Materials & methods: A total of 509 CBCT scans of Saudi patients with 2747 maxillary anterior teeth were included in the study. Patients' information, the tooth type, the presence/absence, the unilateral/bilateral distribution, and the type of PGG according to Gu's classification (type I, II, or III) were recorded.

Results: The prevalence of the PGG in maxillary anterior teeth was 1.3%, affecting 32 (6.3%) patients. The PGGs were mostly detected in lateral incisors 25 (2.77%). The PGG was found to be unilateral in most patients (96.9%), with higher frequency in males than in females without significance for sex.

Conclusion: PGG is not a rare anomaly in the Saudi population and is most frequently found in maxillary lateral incisors. Type I Gu's classification was mostly detected.

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1. Introduction

Palatogingival groove (PGG) is one of the numerous morphologic anomalies associated with maxillary anterior teeth. It mainly affects the palatal aspect of the lateral incisor (Kim et al., 2017; Lara et al., 2000). This anomaly was referred to in the dental literature as a developmental radicular anomaly, disto-lingual groove, radicular lingual groove, palatoradicular groove, radicular groove, and cingulo-radicular groove (Kim et al., 2017). It typically occurs on the palatal surface, coronally in the central fossa in most cases, and extends to the root in varying degrees of depth and lengths (Kim et al., 2017; Lara et al., 2000). Albaricci *et al*. showed that only 8.6% of PGG that affected maxillary lateral incisors reached the root apex, and 57.1% originated from the central fossa (Albaricci et al., 2008). Kogon reported that 54% of all the PGGs terminated on the root, and root involvement in central incisors was much more frequent and severe than in the lateral incisors (70% and 47%, respectively) (Kogon, 1986). PGG might be either unilateral or bilateral (Everett and Kramer, 1972; Jeng et al., 1992; Peikoff et al., 1985; Peikoff and Trott, 1977). Though the exact etiology of this anomaly is unclear, it has been suggested that it could be alterations during tooth development and growth, a mild form of dens invaginatus, or tooth attempts to form another root (Gu, 2011; Kim et al., 2017; Peikoff et al., 1985; Pinheiro et al., 2020). The clinical presentation of the defect is often on the palatal root surface, but, on some occasions, the involvement of the facial aspect has been reported (Brin and Ben-Bassat, 1989; Goon et al., 1991; Kerezoudis et al., 2003; Kozlovsky et al., 1988). Two studies found that the labial radicular grooves were limited only to maxillary central incisors, and none of the patients or samples had facial surface involvement of the lateral incisors (Pécora et al., 1991; Pécora and Filho, 1992). However, Goon *et al*. reported a maxillary right lateral incisor associated with labial involvement that extended to the apex (Goon et al., 1991). Multipalatal grooves have also been reported (Nanba and Ito, 2001; Smith and Carroll, 1990). Smith & Carroll presented a case of maxillary lateral incisor with labial and palatal developmental grooves (Smith and Carroll, 1990). Some studies indicated a tendency for proximal localization of PGG (Albaricci et al., 2008; Gu, 2011; Pinheiro et al., 2020).

Different classifications had been described according to the PGGs' location, extent, and complexity along the root surface, and the degree of invagination of the groove towards the pulp cavity (Goon et al., 1991; Kim et al., 2017; Kogon, 1986). Gu (Gu, 2011) examined 11 extracted maxillary lateral incisors with PGG that were scanned by micro-CT scans. The specimens were reconstructed three-dimensionally, and the grooves were classified into three types based on severity (Gu, 2011). A type I groove is short (apically not beyond the coronal third of the root), type II is long (beyond the coronal third) but shallow corresponding to a normal or simple root canal, and type III is long (beyond the coronal third) and deep corresponding to a complex root canal system (Gu, 2011).

The relevance of the PGG to the onset of localized inflammatory processes in the periodontal tissues is clinically significant (Al-Rasheed, 2011; Gu, 2011; Withers et al., 1981). The presence of PGG does not condemn a tooth to periodontal diseases; as long as the epithelial attachment remains intact, the periodontium remains healthy (Simon et al., 2000). However, when the epithelial attachment is breached, a self-sustaining isolated infra-bony pocket can be formed along the length of the groove (Attam et al., 2010; Simon et al., 2000). Additionally, this developmental groove may cause pulp necrosis due to the invasion of bacteria and the establishment of combined periodontal and endodontic lesions (Attam et al., 2010; Simon et al., 2000).

Literature reported a range of 0.9%–20% of occurrence of PGG (Table 1). In 2011, AL-Rasheed (Al-Rasheed, 2011) studied the relationship between PGGs presence and periodontal health by conducting a clinical examination of maxillary lateral incisors in a selected sample of Saudi adults. He observed the defect in 10.3% of the sample and concluded that the teeth with PGGs, particularly those with apical groove extension, were significantly associated with poorer periodontal health status (Al-Rasheed, 2011). Cone-beam computed tomography (CBCT) is an invaluable research tool that has recently been used to study root and root canal morphology. Alkahtany *et al*. studied the prevalence of PGG using CBCT on a sample of Saudi patients, and they found a prevalence of 4.9% (Alkahtany et al., 2022). This paper aims to investigate the prevalence of PGG affecting maxillary anterior teeth, bilateral occurrence, and distribution among sex in the Saudi subpopulation and review the literature reported on the prevalence of PGG.

2. Materials and methods

2.1. Study sample

CBCT scans of 878 patients were retrieved from the Oral and Maxillofacial Radiology Department, Dental Clinics Center archive at Qassim University, Qassim, Saudi Arabia, between October 2017 and October 2022. 509 CBCT images of patients (317 males, 192 females) between 10 and 66 years who attended the University Dental Hospital were included in the study (Mean ± standard deviation (SD) = 37.7 ± 17.8). This study was conducted based on the radiographic assessment of the available CBCT digital images in the dental files obtained for other diagnostic purposes, and none were obtained specifically for the purpose of this study. CBCT radiographs were acquired using the Galileos® ComfortPLUS System Sidexis software (SIDEXIS XG) (Sirona 3D, Germany) with the following specifications: 0.25/0.125-mm voxel size, 14 s/2–5-s scan time/exposure time, 98 kV, and 3–6 mA. The Galileos software was used for image examination.

2.2. Sample size estimation

The sample size was calculated using G*Power (Version 3.1) based on the prevalence of PGGs in a previously published article (Al-Rasheed, 2011). The anticipated population proportion for the PGG was 10.3%; it was used to calculate the effect size, which was found to be 0.232. Based on the effect size and power of the study (95%), and considering a 95% confidence interval, a total number of 367 patients were required to reject the null hypothesis. As we were expecting the prevalence of the PGG to be less in the Qassim region, and our study was based on CBCT evaluation, we raised the sample size to 450. A sample of 509 patients was achieved that fit the inclusion criteria.

Table 1 Summary of Studies Reported on the Prevalence of PGG.

	Author Name, Year	Country	Population Number (Teeth Number)	Study Method	Teeth Examined (Number)	Overall Prevalence by patients	Overall Prevalence by teeth	Maxillary Central Incisor (MCI)	Maxillary Lateral Incisor (MLI)	Maxillary Canine (MC)	Bilateral PGG (%)*
1	Everett & Kramer. 1972 (Everett and Kramer, 1972)	**USA**	NR (625)	In vitro, Examination of extracted teeth using loupe	MLI (625)	NR	18 (2.9%)	NS	18 (2.9%)	NS	–
2	Withers et al. 1981 (Withers et al., 1981)	**USA**	531 (2099)	Clinical examination	MCI (1054) MLI (1,045)	45 (8.5 %)	49 (2.33%)	3 (0.28%)	46 (4.4%)	NS	4 (0.75%)
3	Kogon. 1986(Kogon, 1986)	**NR**	NR (3168)	In vitro, Evaluation of radiographed and photo-graphed. extracted teeth	MCI (1382) MLI (1786)	NR	147 (4.6%)	47 (3.4%)	100 (5.6%)	NS	–
4	**Brin & Y. Ben-Bassat. 1989**[#](Brin and Ben-Bassat, 1989)	**Jerusalem**	1880 (3760)	Clinical examination	MCI (NR)	123 (6.5 %)	NR*	123 (6.5 %) *	NS	NS	24 (1.7 %)
5	**Bacic. 1990**(Bačić et al., 1990)	**NR**	1715 (NR)	Clinical examination	MCI (NR) MLI (NR)	16 (0.93 %)	20 (NR)*	5 (NR)*	15 (NR)*	NS	NR
6	**Pecora et al. 1991**[@] (Pécora et al., 1991)	**Brazil**	NR (921)	In vitro, Examination of extracted teeth	MCI (500)[$] MLI (421)	NR	21 (2.3%)	10 (2%) **	11 (2.6%)	NS	–
7	**Pecora & da Cruz Filho. 1992**(Pécora and Filho, 1992)	**Brazil**	642 (NR)	Clinical examination	MCI (NR)[$] MLI (NR)	25 (3.9 %) **	NR	NR*	NR*	NS	NR
8	Hou & Tsai. 1993(Hou and Tsai, 1993)	**China**	101 (404)	Clinical, radiographic & surgical	MCI (202) MLI (202)	45 (44.6 %)	73 (18.1%)	12 (5.9%)	61 (30.2%)	NS	NR
9	Albaricci et al. 2008@ (Albaricci et al., 2008)	**–**	(376)	In vitro, Evaluation of extracted teeth by a magnifying glass	–	–	–	–	(11.1%)	NS	–
10	AL-RASHEED. 2011 (Al-Rasheed, 2011)	**Saudi**	276 (552)	Clinical examination	MLI (552)	NR	57 (10.3%)	NS	57 (10.3%)	NS	NR
11	**Iqbal el al. 2011**(Iqbal et al., 2011)	**Pakistan**	200 (400)	Clinical examination	MCI (NR) MLI (NR)	NR	40 (10 %)	NS	40 (10 %)	NS	23 (57.5 %) [&]
12	**Hakan et al. 2014** (Arslan et al., 2014)	**Turkey**	416 (1969)	CBCT evaluation	MCI (674) MLI (651) MC (644)	17 (4.1 %)	19 (0.96%)	4 (0.6%)	15 (2.3%)	0 (0 %)	2 (11.8 %)
13	Hamagharib et al. 2015 (Hamagharib et al., 2015)	**NR**	100 (200)	Clinical examination	MLI (200)	NR	40 (20%)	NS	40 (20%)	NS	18 (45 %) [&]
14	**Shrestha et al, 2014** (Shreshta et al., 2014)	**Nepal**	231 (1362)	Clinical examination	MCI (456) MLI (450) MC (456)	NR	90 (6.6%)	7 (1.5%)	73 (15.7%)	11 (2.4%)	NR (26.6 %)
15	Aksoy et al. 2017 (Aksoy et al., 2017)	**Turkey**	191 (993)	CBCT evaluation	MCI (348) MLI (315) MC (330)	8 (4.9 %)	9 (0.9 %)	2 (0.57 %)	7 (2.22 %)	0 (0 %)	1 (12.5 %)
16	Ghahramani et al. 2018 (Ghahramani et al., 2018)	**Iran**	300 (1800)	CBCT evaluation	MCI (600) MLI (600) MC (600)	17 (5.6 %)	20 (1.11 %)	3 (0.5 %)	16 (2.6 %)	1 (0.16 %)	3 (17.6 %)

(*continued on next page*)

Table 1 (*continued*)

	Author Name, Year	Country	Population Number (Teeth Number)	Study Method	Teeth Examined (Number)	Overall Prevalence by patients	Overall Prevalence by teeth	Maxillary Central Incisor (MCI)	Maxillary Lateral Incisor (MLI)	Maxillary Canine (MC)	Bilateral PGG (%)*
17	Lekshmi et al. 2021 (Lekshmi et al., 2021)	**India**	119 (636)	CBCT evaluation	MCI (204) MLI (212) MC (220)	11 (9.24 %)	12 (1.88%)	3 (1.47 %)	9 (4.2 %)	0 (0 %)	1 (9.1 %)
18	Varun et al. 2022(Varun et al., 2022)	**North India**	163 (326)	CBCT evaluation	MLI (362)	12 (7.4 %)	12 (3.7 %)	NS	12 (3.7%)	NS	0 (0 %)
19	Alkahtany et al. 2022 (Alkahtany et al., 2022)	**Saudi**	264 (NR)	CBCT evaluation	MLI (NR)	13 (4.9 %)	NR	NS	NR*	NS	5 (38.5 %)
20	**Present study**	**Saudi**	509 (2747)	CBCT evaluation	MCI (928) MLI (904) MC (915)	32 (6.3 %)	35 (1.3 %)	10 (1.1 %)	25 (2.77 %)	0 (0 %)	1 (3.13 %)

MCI = Maxillary Central Incisor, MLI = Maxillary Lateral Incisor, MC = Maxillary Canine, NR = Not Reported, NS = Not Studied, # = studied the prevalence of labial notch of MCI * = The Prevalence Reported by number of patients affected, ** = Pecora et al. 1991;1.

2.3. Ethic al approval

This cross-sectional retrospective study was reviewed and approved by the Research Ethics Committee of the College of Dentistry, Qassim University (Code #: EA/6134/2021).

2.4. Inclusion and exclusion criteria

High-quality CBCT images of Saudi subjects were included. Low-quality images, such as those with scattering or artifacts due to patient movement, were excluded. Teeth with crown restorations, root canal fillings and posts, internal/external resorption, and deep caries or restorations were excluded. Primary incisors or canines and impacted teeth were also excluded. Overall, 509 CBCT examinations fitted the inclusion criteria and 369 were excluded.

2.5. Image assessment

All CBCT images were independently evaluated by an endodontist (RA) and a senior dental student (AA). In case of disagreement after discussions, a third evaluator [a radiologist (SH)] was asked to perform the third evaluation, and further discussions were conducted to reach the final consensus. For calibration purposes, a detailed description of the CBCT figures of PGG from previous reports (Arslan et al., 2014; Gu, 2011) was prepared by one of the examiners (RA) to standardize the examination protocol. Axial sections were mainly used for the evaluation of PGGs along with other sections. Intra- and inter-examiner reliabilities were tested by evaluating the CBCT scans of 100 maxillary anterior teeth. All readings were performed on HUAWEI Matebook D (Huawei Technologies Co., Ltd.) on a 15-inch screen with a resolution of 1920 × 1080 pixels.

The following were recorded: (i) patients' age and sex, (ii) tooth type (central/lateral incisor, canine), (iii) PGG present/absent, (iv) bilateral/unilateral presence of PGG, and (v) PGG type. PGGs were categorized using Gu's classification (Gu, 2011) (type I, II, or III) as described in section 1.

2.6. Statistical analysis

Descriptive statistics (frequencies, percentages, and means) were used to describe the prevalence of PGG. The chi-square was used to assess the association between the presence of PGG and other variables such as sex and tooth type. The intra- and inter-examiner reliabilities were determined using the Cohen kappa test. The significance level was set at $P < 0.05$. All statistical analyses were performed using the SPSS software version 28.0 (SPSS Inc., Chicago, USA).

3. Results

Data from CBCT examinations of 2747 teeth (928 central incisors, 904 lateral incisors, 915 canines) in 509 patients (317 males, 192 females) between 10 and 66 years (Mean ± standard deviation (SD) = 31.9 ± 12.9) were analyzed retrospectively. CBCT images of 369 patients did not meet the inclusion criteria. The Cohen's kappa coefficient val-

ues for both the intra and inter-examiner reliabilities for CBCT scan assessment were 0.80.

PGGs were detected in 10 (1.1%) central incisors and 25 (2.77%) lateral incisors, but there were none detected in any of the canine teeth. There is a significant difference among the different tooth types in terms of the presence of PGGs ($p < 0.001$). The prevalence of the PGG was 1.9 % in maxillary incisors and 1.3% in maxillary anterior teeth. Type I, type II, and type III PGGs were detected in 32 (91.4% of the teeth with PGG), 3 (8.6%), and 0 (0%) teeth, respectively (Figs. 1 & 2). The distribution of teeth with PGGs is presented in Table 2.

The PGG affected 32 (6.3%) patients without significance for sex ($p > 0.05$; Table 3). There were 22 (6.9%) PGGs found in males and 10 (5.2%) found in females. Only one male patient (3.13%) had bilateral PGG detected in the central incisor; the rest were unilateral (96.9%) (Table 3 & Fig. 3).

4. Discussion

The discrepancies in the reported prevalence of PGG are likely attributed to the descriptive criteria of the groove (Kogon, 1986) and the different techniques used to evaluate it. The findings of Kogon (Kogon, 1986) reflect the teeth with the groove terminated on the cingulum, cementoenamel root junction, and the root, which give an overall prevalence of 4.6% in maxillary central and lateral incisors. However, Everett and Kramer reported a frequency of 2.9% that reflect only those defects which involve the root (Everett and Kramer, 1972). Withers et al. included those grooves at or apical to the cementoenamel junction(Withers et al., 1981). Hou & Tsai, in 1993 (Hou and Tsai, 1993), included the cases with distinct PGG situated at or apical to the cementoenamel junction (CEJ). Several techniques have been used to assess PGG, including in vivo clinical observations (Al-Rasheed, 2011; Bačić et al., 1990; Brin and Ben-Bassat, 1989; Hamagharib et al., 2015; Hou and Tsai, 1993; Iqbal et al., 2011; Pécora and Filho, 1992; Shreshta et al., 2014; Withers et al., 1981), in vitro examinations of extracted teeth (Albaricci et al., 2008; Everett and Kramer, 1972; Kogon, 1986; Pécora et al., 1991), and retrospective assessments of CBCT images (Aksoy et al., 2017; Alkahtany et al., 2022; Arslan et al., 2014; Ghahramani et al., 2018; Lekshmi et al., 2021; Varun et al., 2022) (Table 1). Generally, the race and sex of the patients may affect the teeth morphology and prevalence of dental anomalies (Khalaf et al., 2014; Martins et al., 2021, 2018); however, Pecora *et al.* & Withers e*t al.* studied the effect of race and sex on the prevalence of PGG and found no significant relationship (Pécora and Filho, 1992; Withers et al., 1981).

The results of this study were within the prevalence range reported in the literature (Table 1). The present findings showed that 1.3% of maxillary anterior teeth have PGGs. This was almost like the previous CBCT investigations (Aksoy et al., 2017; Arslan et al., 2014; Ghahramani et al., 2018; Lekshmi et al., 2021). Alkahtany et al. (Alkahtany et al., 2022) studied the prevalence of PGG in Saudi patients and found that PGG was present in 13 (4.9%) of the 264 patients, slightly lower than the current study (6.3%). The PGG was more prevailed in the maxillary lateral incisors and this predominance was frequently reported in the previous studies (Table 1). PGG was not detected in any canine tooth in the present study; however, one study that used CBCT for assessment reported a single canine affected with PGG (Ghahramani et al., 2018). Findings showed that Gu's type I classification had the highest prevalence of 91.4% amongst the teeth with PGGs (32 out of 35 teeth with PGG). In line with our results, previous studies reported that type I PGG was the most common classification detected (Aksoy et al., 2017; Alkahtany et al., 2022; Arslan et al., 2014; Ghahramani et al., 2018). Type III PGG was not detected in the current study in any maxillary incisors. Hakan *et al.* reported three central incisors affected by type III PGG. Alkahtany *et al.* reported two maxillary lateral incisors presented with unilateral type III PGG (Alkahtany et al., 2022). Limited detection of type III PGG and higher occurrences of type I PGG in this study and other studies based on CBCT could be attributed to those teeth affected with severe PGGs that are being either extracted or endodontically treated due to periodontal and endodontic symptoms. So, the teeth could be extracted before the time of CBCT scan exposure or excluded from the study due to endodontic treatment.

Our retrospective study showed that PGG occurred more frequently unilaterally and only one patient presented with bilateral PGGs detected in the maxillary central incisor. Studies investigating the prevalence of PGG frequently reported a higher occurrence of unilateral PGGs (Aksoy et al., 2017; Alkahtany et al., 2022; Arslan et al., 2014; Ghahramani et al., 2018.; Lekshmi et al., 2021). Hakan *et al.* reported that two patients presented with bilateral PGGs in lateral incisors, while the remaining were unilateral (Arslan et al., 2014). Moreover, the literature reported fewer cases that described the bilateral occurrence of PGG compared to unilateral case reports (Everett and Kramer, 1972; Goon et al., 1991; Jeng

Fig. 1 Axial CBCT sections showing type I palatogingival groove.

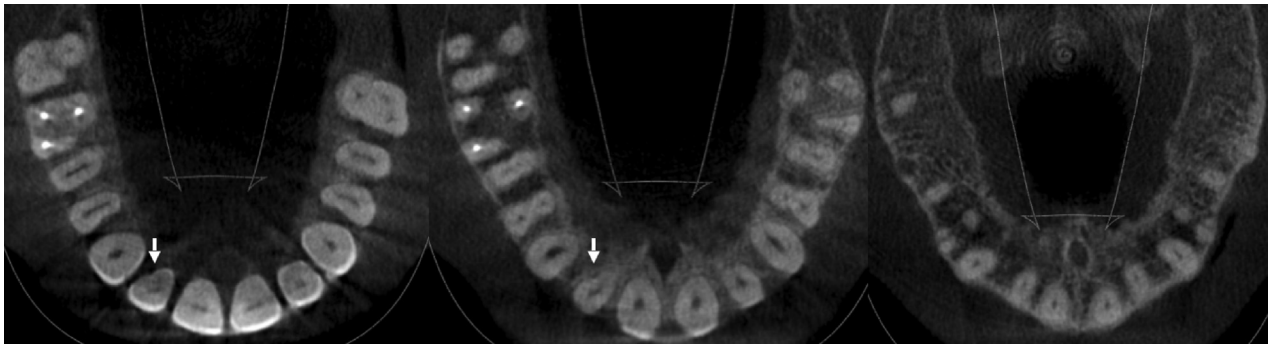

Fig. 2 Axial CBCT sections showing type II palatogingival groove.

Table 2 The Total Number of Teeth with PGG.

Tooth Type	Total number	Teeth with PGGs (%)	Type of PGG (%)			p Value
			I	II	III	
Permanent Maxillary Central Incisor	928	10 (1.1%)	10 (1.1%)	0 (0%)	0 (0%)	P < 0.001*
Permanent Maxillary Lateral Incisor	904	25 (2.77%)	22 (2.43%)	3 (0.33%)	0 (0%)	
Permanent Maxillary Canine	915	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	2747	35 (1.3%)	32 (91.4%)	3 (8.6%)	0 (0%)	

* There were statistically significant differences among the different tooth types in terms of the presence of PGGs ($p < 0.001$).

Table 3 The total number of patients with PGG.

Patient Sex	Total number	Prevalence of PGGs	Unilateral*$	Bilateral*	p Value
Male	317	22 (6.9%)	19 (5.99%)	1 (0.3%) #	p = 0.435
Female	192	10 (5.2%)	10 (5.2%)	0 (0%)	
Total	509	32 (6.3%)	29 (96.9%)	1 (3.13%)	

*Statistical analysis revealed a non-significant difference between the males and females in terms of the presence of PGGs ($p = 0.435$)., One of the maxillary lateral incisors of ~~each~~ two male patients were excluded from the sample so bilateral presence of PGG couldn't be evaluated so they are not included for bilateral occurrence assessment. $ = Two male patients have unilateral involvement of both central and lateral incisors. #, Detected in the maxillary central incisor.

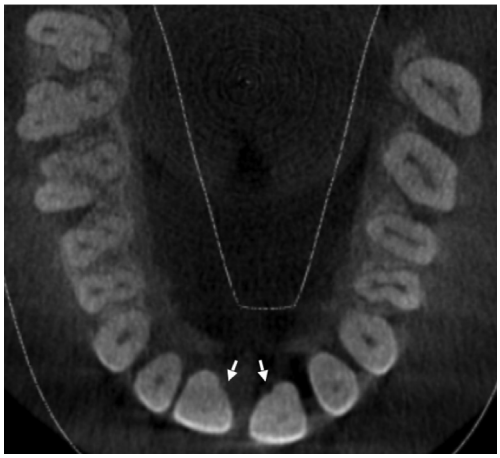

Fig. 3 Axial CBCT section showing bilateral palatogingival groove.

et al., 1992; Kozlovsky et al., 1988; Peikoff et al., 1985; Smith and Carroll, 1990). However, Iqbal *et al.* found higher cases of bilateralism, which was found in 57.5% of the affected patients (Iqbal et al., 2011). The prevalence of PGG among males and females was calculated at 6.9% and 5.2%, respectively, but this was not statistically significant. Hakan *et al.* and Hou & Tasi reported a higher prevalence of PGG in males, which was statistically significant (Arslan et al., 2014; Hou and Tsai, 1993). However, the study by Alkhahtany *et al.* and Shreshta *et al.* showed a higher frequency of PGG in females (Alkahtany et al., 2022; Shreshta et al., 2014).

Gu analyzed maxillary lateral incisors affected by PGG and found that radicular grooves show a broad spectrum of morphologic variations (Gu, 2011). The defect varies in depth, length, location, and complexity (Everett and Kramer, 1972; Gu, 2011). The groove may extend in depth and apically for varying distances, and in severe invagination, forming an accessory root, additional canal, or C-shaped root canal beneath the invagination (Gu, 2011; Peikoff et al., 1985; Peikoff and Trott, 1977; Schäfer et al., 2000; Wei et al.,

1999; Yavuz et al., 2008). Moreover, the dentin wall thickness corresponding to the groove is thinner than usual, and it could be as thin as 360 μm in some parts along the defect (Gao et al., 1989; Gu, 2011). Enamel projections or enamel-lined grooves may be found at the cervical area of these defects (Gu, 2011; Kogon, 1986; Simon et al., 2000). Pinheiro *et al*. examined 20 extracted human maxillary incisors affected with PGG using scanning electron microscopy analysis (SEM) and reported that communications between the root canal and PGG occurred in 35% of the teeth (Pinheiro et al., 2020). These communications occurred in the form of foraminas and dentinal tubules (Pinheiro et al., 2020). Gao *et al*. evaluated 14 human lateral incisors and found that the accessory canals could be found either in the crown part or the root part of the groove (Gao et al., 1989). They suggested that the accessory canals are the main way of communication between the pulp and the periodontium, so the infectious materials may get into the pulp cavity in the periodontally involved tooth (Gao et al., 1989).

Withers *et al*. and others studied the relationship between PGG and periodontal health, and they reported that the presence of PGG is associated with poorer periodontal health (Al-Rasheed, 2011; Bačić et al., 1990; Hou and Tsai, 1993; Lee et al., 1968; Withers et al., 1981). This relevance is because it promotes the accumulation of food debris and bacterial plaque and contributes to localized periodontitis (Gu, 2011; Simon et al., 2000). In cases where the PGG extended to the apex, the progression of periodontal disease apically may result in pulpal disease (Attam et al., 2010; Ballal et al., 2007; Estrela et al., 1995; Sharma et al., 2015). Furthermore, the bacteria may colonize the defect and escape the host's defenses resulting in a self-perpetuating periodontal problem secondary to endodontic involvement (Gu, 2011; Simon et al., 2000). However, other study found that there was no significant association between PGG and gingival disease (Shreshta et al., 2014).

Patients with PGG, in most cases, present with gingival inflammation, isolated narrow pockets along the groove, sinus tracts, and sensitivity to percussion (Castelo-Baz et al., 2015; Mittal et al., 2013; Peikoff et al., 1985; Peikoff and Trott, 1977; Schäfer et al., 2000). However, in some cases, the patients remain asymptomatic with no clinical signs of periodontal breakdown (Everett and Kramer, 1972; Withers et al., 1981). Radiographically attention is drawn to the presence, in some but not all cases, of a radiolucent, parapulpal radiolucent line (dark vertical line) representing a radicular extension of the groove (Everett and Kramer, 1972; Simon et al., 2000). Furthermore, vertical bone destruction or a radiolucent area follows the groove (Goon et al., 1991; Simon et al., 2000). The pulp may remain vital with no sign of pulpal involvement (Kozlovsky et al., 1988; Simon et al., 2000; Suchetha et al., 2012), but if the pulp is secondarily involved, the patient may have a periapical radiolucency (Simon et al., 2000).

A PGG may be difficult to identify as an etiological factor. It may resemble a vertical fracture that gives the same radiographic appearance (Goon et al., 1991; Simon et al., 2000). When PGG is identified, the prognosis depends on the extension of the groove (Everett and Kramer, 1972; Kim et al., 2017; Simon et al., 2000). Previously, extraction was frequently recommended for the treatment of the involved tooth (Everett and Kramer, 1972; Goon et al., 1991; Kim et al., 2017; Simon et al., 2000). If the tooth is to be saved, it should be first treated endodontically in case the pulp is involved in the pathologic state (Kim et al., 2017). Careful root canal manipulation is required due to the reduced dentin thickness of the palatal surface of the canal near the groove (Gao et al., 1989; Gu, 2011; Pinheiro et al., 2020). Literature is rich with successful case reports on periodontal management of teeth with periodontal involvement associated with PGG (Al-Hezaimi et al., 2009; Attam et al., 2010; Forero-López et al., 2015; Johns et al., 2014; Mittal et al., 2013; Sharma et al., 2015; Suchetha et al., 2012; Yavuz et al., 2008).

CBCT is a valuable diagnostic tool that aids in precisely detecting the possibility of the existence of the PGG (Giner-Lluesma et al., 2020). Careful clinical examination and proper knowledge of the possible anatomical variations of maxillary incisors with CBCT evaluation will help in the early diagnosis of PGG. CBCT archive offers a sufficient sample size to be evaluated in cross-sectional studies but using CBCT alone is not without limitations. In the current study, the pulpal involvement in some excluded endodontically treated anterior teeth is possibly due to infection caused by severe PGGs. Heavily restored or destructed teeth and blurry CBCT images because of artifacts resulting from adjacent restorations or crowns were also excluded. So, this will reduce the probability of detection of PGGs. In future studies, clinical and CBCT assessments for all maxillary anterior teeth of patients who underwent CBCT exposure for various reasons may allow more accurate PGG prevalence findings. The study's results represent sample from Qassim region of Saudi Arabia, and more studies should be undertaken to reflect the prevalence of PGG among the Saudi population in various regions across the Kingdom.

5. Conclusion

The prevalence of PGGs was 6.3% in the Saudi population. PGGs that were detected in the maxillary anterior teeth were of milder types and none were detected extending to the apex. Most of the PGGs were detected in maxillary lateral incisors and were unilateral with higher frequency in males than in females without significance for sex. CBCT scanning can be helpful for the detection and treatment planning of PGG along with the clinical examination.

CRediT authorship contribution statement

Ali Aljuailan: Conceptualization, Project administration, Resources, Methodology, Software, Investigation, Writing – original draft. **Roqayah Aljuailan:** Methodology, Investigation, Software, Formal analysis, Data curation, Writing – review & editing, Visualization, Supervision. **Rahul Gaikwad:** Methodology, Validation, Formal analysis, Supervision. **Shaul Kolarkodi:** Resources, Investigation. **Nasser Alamri:** Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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