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ORIGINAL ARTICLE

Cone-beam computed tomography evaluation of palatogingival grooves: a retrospective study with literature review

Umut Aksoy[1] · Fatma Kermeoğlu[1] · Atakan Kalender[1] · Hakan Eren[2] · Mehmet Eray Kolsuz[2] · Kaan Orhan[2]

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Abstract

Objectives The purpose of the present study was to radiographically evaluate the prevalence and characteristics of palatogingival grooves (PGs) in maxillary anterior teeth on cone-beam computed tomography (CBCT) to better understand the nature of these defects.

Methods The CBCT examinations of 993 teeth (330 canines, 315 lateral incisors, 348 central incisors) in 191 patients (87 males, 104 females; age range 16–80 years) were evaluated retrospectively. The diagnosis and radiographic condition of PGs were obtained by consensus among all observers. Verification of PGs was achieved from the patients' clinical records, which were stored in a database after their clinical evaluation. Differences in age, sex, occurrence, and location were evaluated by the Chi-square test. The level of significance was set at $p < 0.05$.

Results Among the 993 teeth examined, nine PGs were observed in seven lateral incisors and two central incisors in eight patients (four males and four females). There was one bilateral case in the lateral incisors. The frequencies of PG occurrence and affected patients were 0.90 and 4.18%, respectively, without significance for sex and location ($p > 0.05$).

Conclusions PGs were a relatively infrequent anomaly of teeth in this population, but when present, clinicians should understand the clinical features of these root variations.

Keywords Palatogingival groove · CBCT · Endodontics · Maxillary incisors · Dental anomaly

Introduction

Accurate understanding of the morphology of the root canal system and its variations is important for favorable endodontic treatment outcomes, because true diagnosis and management are critical. Lack of knowledge of the system and its variations may lead to failure of endodontic preparation and obturation [1].

The region of the maxillary lateral incisors is an area of embryologic hazard [2]. A large number of major and minor malformations occur in this area, including cleft palate [3], mucogingival deformities and conditions around teeth [4], and missing [5], supernumerary [6], dens invaginatus [7], and peg-shaped [8] lateral incisors.

Another mild anomaly or variant occurring in the upper lateral incisors is the palatogingival groove (PG). The PG, which was first described by Black in 1908, is a developmental malformation that occurs near the cingulum of a tooth and extends along the root to varying lengths [9]. Internally, the pulp cavity contour may be altered, with sparse enamel and dentin and increased cementum thickness. Occasionally, the pulp cavity may communicate with the periodontal space [10, 11]. The groove may be so deep that a bifurcation and a small additional proximal root may be present. Furthermore, the cementoenamel junction is irregular and distorted in the region of the groove [12].

This malformation is also described in the dental literature as a distolingual groove [2], radicular lingual groove [13], radicular groove [14], and palatal groove [15]. The groove results from a superficial folding of the tooth germ, the cause of which is unknown, and parallels the

✉ Umut Aksoy
umut.aksoy@neu.edu.tr

[1] Department of Endodontics, Faculty of Dentistry, Near East University, Dikmen, Lefkosa, 90392 Mersin 10, Turkey

[2] Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Ankara University, Besevler, 06500 Ankara, Turkey

pathogenesis of dens invaginatus, although it is less extensive. While some investigators claim that the malformation results from an undesirable location of the lateral incisor tooth germ "surrounded" by the central incisor, canine, and first premolar [16], others believe that this anomaly may be an attempt by the body to form another root on the affected tooth [17].

Radicular grooves are mainly seen at the palatal aspect of the maxillary lateral or central incisors, and rarely in the posterior teeth [18]. Among the incisors, the maxillary lateral incisors are the most commonly affected teeth [2, 15].

Different classifications of PGs have been suggested according to their location, origin, and termination. Recently, Gu [19] classified radicular grooves into three types according to the degree of severity based on micro-computed tomography studies: type I, the groove is short (not beyond the coronal third of the root); type II, the groove is long (beyond the coronal third of the root) but shallow, corresponding to a normal or simple root canal; type III, the groove is long (beyond the coronal third of the root) and deep, corresponding to a complex root canal system.

The prevalence of PGs was reported to range from 0.93 to 44.6% in previous studies [2, 15, 20–24]. This wide range of reported prevalences may be caused by variations in study design, participant ethnicity, region, sample size, and/or diagnostic criteria.

The purpose of the present study was to radiographically evaluate the prevalence and characteristics of PGs in maxillary anterior teeth on cone-beam computed tomography (CBCT), together with a literature review.

Materials and methods

Patients or their legal guardians provided informed consent prior to radiography, and the study was reviewed and approved by the Institutional Ethical Board of our faculty (YDU/2015/28-183). Data from CBCT examinations of 993 teeth (330 canines, 315 lateral incisors, 348 central incisors) in 191 patients (87 males, 104 females; age range 16–80 years) were analyzed retrospectively. The CBCT scans were undertaken to evaluate the anterior region of the maxilla for endodontic and surgical intervention purposes such as minor oral surgery and dental implant surgery. All of the CBCT images were obtained with a NewTom 3G CBCT machine (QR, Verona, Italy) and a Planmeca 3D MAX unit (Planmeca, Helsinki, Finland). Teeth with crown restorations, root canal fillings and posts, and deep caries were excluded. Low-quality images, such as those with scattering or insufficient accuracy of bony borders in the anterior region and patient movement artifacts, were also excluded. Furthermore, patients with evidence of bone disease, relevant drug consumption, skeletal asymmetries or trauma, congenital disorders, or anamnesis of previous surgical procedures and syndromic patients were excluded. Overall, 38 CBCT examinations were excluded.

The CBCT images were 12- and 14-bit gray-scale images with voxel sizes of 0.200, 0.250, and 0.400 mm^3. Axial, coronal, cross-sectional, and three-dimensional (3D) reconstructed images were used for evaluation of PGs. All evaluations were performed on a 21.3-inch flat-panel color-active-matrix thin-film-transistor medical display (MultiSync MD215MG; NEC, Munich, Germany) with resolution of 2048 $\times$ 2560 pixels, 75 Hz, and 0.17-mm dot pitch operated at 11.9 bits, and a Nio Color 3MP medical display (Barco, Kontich, Belgium).

All CBCT images were evaluated retrospectively by two endodontists (FB, AK) and three oral and maxillofacial radiologists (HE, MEK, KO) with at least 10 years of experience in using the software of the CBCT machine. Before starting the radiographic examinations in the study, the examiners were calibrated to recognize PGs and to identify the affected teeth and surrounding structures. For this purpose, a PowerPoint presentation containing PGs from previous reports [7, 19, 24] was prepared by another investigator (UA) who was not involved in the examination procedure. As part of the calibration phase, the examiners were provided with explanations about CBCT imaging. The examiners only evaluated the radiographs and were blinded to any other patient data during the radiographic examination procedure. The final diagnosis and radiographic condition of each tooth was obtained by consensus among the examiners. The examiners reviewed the images during 6 months. The examiners reviewed the images independently in a darkened examination room, and were permitted to use enhancements and orientation tools such as magnification, brightness, and contrast to improve the visualization of landmarks. The following data were recorded for the CBCT images: (1) patient age and sex; (2) tooth type (central incisor, lateral incisor, canine); (3) PG presence or absence; (4) PG type using the Gu classification (type I, II, or III) [19].

Verification of PGs was achieved from the patients' clinical records, which were stored after their clinical evaluation. The clinical evaluation included inspection of the oral mucosa, probing, and periodontal assessment. The final diagnosis and verification of PGs were confirmed both radiographically and clinically. A PG was defined according to the American Academy of Periodontology (AAP) International Workshop for Classification held in 1999 [4] as a fine groove that started at the cingulum and traveled apically and laterally, as shown in Fig. 1.

Statistical analyses were performed using SPSS ver. 17 software (SPSS Inc., Chicago, IL, USA). Differences in age, sex, occurrence, and location were evaluated by the

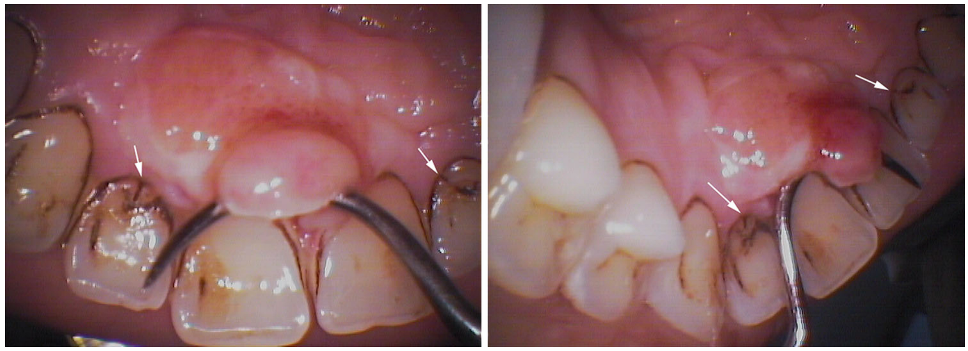

Fig. 1 Intraoral photographs of bilateral PGs

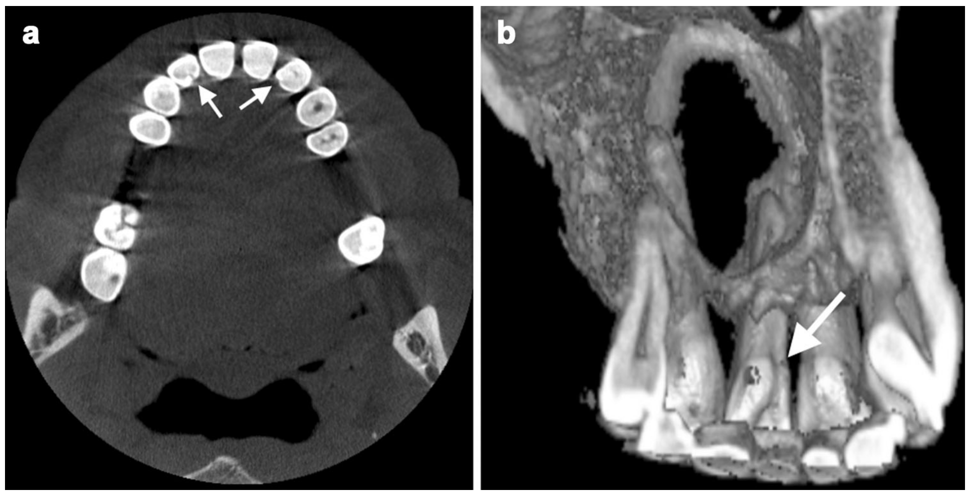

Fig. 2 **a** Axial CBCT image showing bilateral type 1 PGs in teeth 12 and 22. **b** A 3D reconstructed image showing the PG in tooth 22. *Arrows* indicate PGs

Chi-square test. Differences were considered significant for values of $p < 0.05$.

Results

Among the 993 teeth evaluated in this study, nine PGs were observed in seven lateral incisors and two central incisors in eight patients (four males and four females). There was one bilateral case in the lateral incisors (Figs. 1, 2). No PGs were found in canine teeth. The frequencies of PG occurrence and affected patients were 0.90 and 4.18%, respectively, without significance for sex and location ($p > 0.05$; Table 1). The frequency of PGs was higher in the maxillary lateral incisors than in the central incisors. There were significant differences among the different tooth types for the presence of PGs ($p < 0.001$). All PGs found in this study were type I.

Discussion

Palatogingival grooves on the palatal surfaces of maxillary anterior teeth can lead to severe periodontal complications. In addition, secondary endodontic infections can be expected based on communication between the pulp canal system and the periodontium through accessory canals [25]. Evaluation of clinical signs and appropriate diagnostic tests are important to prevent incorrect diagnosis and treatment. The treatment is challenging and requires a multidisciplinary approach [26]. Clinicians must have knowledge and skills to overcome such cases.

The prevalence of PGs has been assessed by various techniques, including in vivo clinical observations [15, 20, 22, 23], in vitro examinations of extracted teeth

Table 1 Patients' sex, age, and tooth number with type of palatogingival groove

Patient	Sex	Age	Tooth	Classification
1	M	23	22	Type I
2	M	38	12	Type I
			22	Type I
3	F	19	12	Type I
4	F	41	12	Type I
5	M	65	11	Type I
6	M	24	22	Type I
7	F	36	21	Type I
8	F	18	22	Type I

Table 2 Characteristics of the included studies

Study	Year	Population	Mean age/age range	Method	Rate of central incisors with PG (%)	Rate of lateral incisors with PG (%)	Rate of canines with PG (%)	Total teeth	Rate of males having at least one tooth with PG (%)	Rate of females having at least one tooth with PG (%)	Rate of bilateral PG occurrence (%)	Rate of total patients having at least one tooth with PG (%)
Everett and Kramer [2]	1972	USA	NS	Extracted teeth	–	18/625 (2.88)	–	18/625 (2.88)	NS	NS	NS	Total number of patients was not specified
Withers et al. [20]	1981	White and Black, USA	19.37/ 17–35	Clinical examination	3/1054 (0.28)	45/1045 (4.4)	–	48/2099 (2.28)	33/347 (9.5)	12/184 (6.5)	4/531 (0.75)	45/531 (8.5) total 41/453 (9.1) Caucasian 4/78 (5.2) Black
Kogon [21]	1986	NS	NS	Extracted teeth	47/1382 (3.4)	100/1786 (5.6)	–	147/ 3168 (4.64)	NS	NS	NS	Total number of patients was not specified
Bacić et al. [15]	1990	NS	NS/ 20–50	Clinical examination	Total number of teeth was not specified. Of 20 teeth with PG, 15 (75%) were lateral incisors, and 5 (25%) were central incisors		–	NS	NS	NS	NS	16/1715 (0.93)
Pécora and da Cruz Filho [22]	1992	White and Black, Brazil	NS/ 7–68	Clinical examination	Total number of teeth was not specified. Of 25 teeth with PG, 19 (76%) were lateral incisors and 6 (24%) were central incisors		–	NS	15/267 (5.61)	10/375 (2.66)	NS	25/642 (3.9) total 10/207 (4.83) Black 15/435 (3.44) White
Hou and Tsai [23]	1993	China	NS/NS	Clinical examination	12/202 (5.9)	61/202 (30.2)	–	73/404 (18.06)	29/64 (45.3)	16/37 (43.2)	4/101 (4)	45/101 (44.6)
Arslan et al. [24]	2014	Turkey	NS/ 8–68	CBCT	4/674 (0.6)	15/651 (2.3)	0/644 (0)	19/1969 (0.96)	15/219 (6.9)	2/197 (1.02)	2/416 (0.48)	17/416 (4.08)
Present study	2016	Turkey	28.14/ 16–80	CBCT	2/348 (0.57)	7/315 (2.22)	0/330 (0)	9/993 (0.50)	4/87 (4.59)	4/104 (3.84)	1/191 (0.52)	8/191 (4.18)

PG palatogingival groove, *NS* not specified

[2, 21], in vitro micro-computed tomography analyses [19], and retrospective investigation of CBCT images [24]. CBCT scanning was introduced into the field of dentistry in 1990. This noninvasive 3D imaging technique has many dental applications, including morphologic analyses of teeth. CBCT images can also provide personal data, such as sex, age, and tooth position [27]. CBCT-aided treatments of PGs comprise only a few case reports in the dental literature. Castelo-Baz et al. [26] used 3D imaging to determine the precise depth and length of a radicular groove, and evaluated the internal anatomy of the canal. In their case report, CBCT helped to clarify the diagnosis that the lesions of endodontic and periodontal origin were independent and without communication. In another case report, Rajput et al. [28] described that use of CBCT was greatly advantageous because it revealed the dimensions of the groove, the nature of the groove communication, and the volume of bone loss, thus indicating the approximate amount of graft required to fill the defect.

Arslan et al. [24] used CBCT to assess and classify PGs, and concluded that CBCT was effective for identification of this morphological anomaly. To the best of our knowledge, the present study is the second attempt to investigate the prevalence of PGs using CBCT.

Previous studies described that the prevalence of PGs varied from 0.93% to 44.6% [2, 15, 20–24] (Table 2). Everett and Kramer [2] evaluated 652 extracted maxillary lateral incisors, and reported that 18 (2.8%) had a radicular groove. In their study, three teeth presented with a deep radicular groove that extended to the apex. Withers et al. [20] carried out a clinical examination on 531 individuals aged 17–35 years, and reported that 45 (8.5%) had teeth with a PG. In addition, they observed that the anomaly was dominantly found in the maxillary lateral incisors (93.8%). Kogon [21] examined 3168 extracted maxillary central and lateral incisors, and reported that 147 teeth (4.6%) had a PG. In another clinical study, Bacić et al. [15] divided 1715 individuals into two groups comprising young adults (age 20–22 years) and adults with periodontal disease (age 35–50 years), and reported PG incidences of 1.01 and 0.79%, respectively. They explained this difference by early loss of such teeth through periodontal disease or endodontic complications in older subjects. Pécora and da Cruz-Filho [22] performed clinical evaluations on 642 individuals of black and white ethnicities, of whom 25 had teeth with a PG. They did not observe any notable differences in relation to sex and race. Interestingly, the results of a clinical study by Hou and Tsai [23] revealed a high incidence of PGs, in contrast to other similar studies. In their examination, this type of anomaly was seen in 45 of 101 patients (44.6%). A relatively recent study by Arslan et al. [24] examined CBCT images of 416 patients (age 8–68 years) in a Turkish population. Their results indicated that the PG incidence in the lateral incisors (2.3%) was approximately four times higher than that in the central incisors (0.6%), and that 17 patients have this type of anomaly (4.08%). In our results, the incidence of patients with at least one tooth having a PG was approximately 2%. Racial or genetic factors may play a role in these variations of incidence in different studies.

Our literature review showed similarities for the PG prevalences in six series [2, 15, 20–22, 24] and the present study, with the exception of Hou and Tsai [23]. The PG prevalences in the previous reports and the present study were 2.88, 8.5, 4.64, 0.93, 3.9, 44.6, 4.08%, giving an average of 4.22% in 3596 patients [2, 15, 20–24]. The age ranges of the patients in these previous studies [2, 15, 20–24] were consistent with the present study.

Similar to previous studies [20–22], lateral incisors were more affected by this type of anomaly in the present study. It is likely that the difference between the lateral and central incisors arises from the undesirable location of the lateral incisor tooth germ [16]. In the same way, morphological anomalies are less likely to occur in the canine teeth. In the present study, no PGs were observed in the canine teeth. Although two previous case reports presented unusual facial locations of radicular grooves in teeth [17, 29], the present study did not reveal any facial radicular grooves.

A limitation of this study was the use of various field of view (FOV) sizes in the CBCT unit. The ratio of scattered and primer photons increases in CBCT when the bevel angle is increased [30]. In addition, the voxel sizes in CBCT units can be changed and tested in fixed FOVs. Depending on variation in FOV sizes, scattered radiation can affect the quality of the images. However, this issue was not considered in the present study. Further studies need to be conducted to test the voxel sizes with fixed FOV sizes.

PGs were a relatively infrequent anomaly of teeth in this particular population, but when present, clinicians should understand the clinical features of these root variations and adjust the treatment according to the root canal system variations.

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Compliance with ethical standards

Conflict of interest Umut Aksoy, Fatma Kermeoğlu, Atakan Kalender, Hakan Eren, Mehmet Eray Kolsuz, and Kaan Orhan declare that they have no conflict of interest.

Human rights statement and informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions.

Patients or their legal guardians gave their informed consent prior to radiography and the study was reviewed and approved by the institutional ethics board of the faculty (YDU/2015/28-183).

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