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The role of clinical examination in the detection of permanent maxillary molars with two palatal roots

Running head: Detection of molars with 2 palatal roots

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Abstract

Background: To determine whether the presence of two palatal roots in permanent maxillary molars (PMMs) could be predicted by observing dental morphological traits during the clinical examination.

Materials and method: A total of 18 second and 26 third PMMs with two palatal roots (2PR) were examined from the collection of extracted teeth. The reference sample of 44 extracted PMMs with one palatal root was selected such that pairs of morphologically matching PMMs with one and 2PR were formed. The external morphology of these tooth pairs was examined under a stereomicroscope and distinguishing traits were registered. The Fisher's exact test was applied to examine differences between second and third PMMs. Additionally, the external morphology of 17 PMM with 2PR in 15 patients was analyzed retrospectively.

Results: Extracted PMMs with 2PR possessed the following distinguishing morphological traits: crown wider on the palatal half (55.3%), double Carabelli cusps (23.7%), pronounced palatal indentation of the crown (20.5%), thick palatal enamel extension (16.3%), palato-radicular groove (11.6%) and palatal enamel pearl (2.3%).

Differences between second and third PMMs were not statistically significant ($P > .05$). At least one distinguishing trait was present on 63.4% and 94.1% of extracted and clinically evaluated PMMs with 2PR, respectively. Omega-shaped deformation of the dental arch may be the first clinically observable clue to this root constellation.
Conclusions: Clinical examination of tooth morphology and shape of the dental arch is essential for the detection PMMs with 2PR.
Key words: dental morphology, supernumerary root, radix mesiolingualis, radix distolingualis

INTRODUCTION

Permanent maxillary molars (PMMs) occasionally possess two palatal roots (2PR), located mesiopalatally and distopalatally. One of them is a normal palatal root and the other a supernumerary root; however, distinction between them is not always straightforward [26, 5]. Previous research indicates that 2PR only rarely develop on the first PMM (0.06%−0.91%) [29, 19, 34, 13, 30], but with increasing frequency on the second (1.12%−1.46%) [34, 13, 20, 16, 23] and third PMM (2.31%) [35]. The occurrence of such teeth has not been linked to specific ethnic groups and there is no significant difference between left and right teeth and between males and females [34, 7].

Christie et al. [7] defined three morphological types of PMMs with 2PR (Fig 1). Type I PMM has four separate roots, of which the palatal two are long and widely divergent. Type II PMM has four separate, parallel, and approximately equally long roots. Type III PMM has a separate distobuccal root and fused mesiopalatal, distopalatal and mesiobuccal roots. Recent studies have revealed other types of root fusion [5]. To this end, Baratto-Filho et al. [2] suggested that a variant with fused mesiopalatal and mesiobuccal roots should be included as Type IV.

The presence of 2PR has clinical implications in endodontics, periodontology, and oral surgery; however, PMMs with 2PR can be very difficult to identify using a periapical radiograph as palatal and buccal roots overlap. This root constellation might be predicted by observing the external tooth morphology during the clinical

examination [5], but this has not been empirically tested. According to Carlsen and Alexandersen [5], PMMs with 2PR possess a very pronounced mesiopalatal and/or distopalatal part of the crown and in most cases a thick enamel extension between the palatal roots. Moreover, cases with a palato-radicular groove [3, 9, 17, 1], one or two enamel pearls in the furcation area of palatal roots [7, 17, 24, 28], double Carabelli cusp [3, 26], and triple Carabelli cusp [18] have been documented.

In the light of the above, we aimed to determine the distinguishing morphological tooth traits in a comparative analysis of extracted PMMs with one and 2PR and in a retrospective analysis of patients possessing PMMs with 2PR. This study was approved by the Slovenian National Medical Ethics Committee (Approval No. 0120-167/2018/8).

MATERIALS AND METHODS

A study on extracted teeth

The sample studied consisted of 44 PMMs with 2PR (18 second and 26 third PMMs) from the collection of extracted teeth at the Department of Dental Diseases and Dental Morphology, Faculty of Medicine, University of Ljubljana. A total of 28 teeth were from the right side and 16 teeth from the left side. The root morphology was scored according to Christie et al. [7] and Baratto-Filho et al [2]. The reference sample consisted of 44 PMMs with one palatal root (18 second and 26 third PMMs) from the same dental collection, selected in such a way that pairs of morphologically matching PMMs with one and 2PR were formed.

Mesiodistal diameters of the buccal and lingual halves of the crown were measured using a digital caliper with a resolution of .01 mm (ABS Digimatic, Mitutoyo, Japan). Measurements were made independently by both authors and average values were used in statistical analysis.

The external morphology of extracted teeth was examined under a stereomicroscope (with a maximum magnification of ×15) to identify morphological traits associated with the presence of 2PR. Where feasible, the trait expression was scored using the definitions of the Arizona State University dental anthropology system

(ASUDAS) [31]. Traits were scored independently by both authors; in the case of disagreement a third, joint evaluation was conducted until a consensus was reached.

A retrospective clinical study

Since 2010, the authors treated 15 patients who had a total of 17 PMMs with 2PR. Periapical and bitewing radiographs, cone-beam computed tomography (CBCT) scans, and clinical photographs were collected from the dental records of these patients at the Centre for Operative Dentistry and Endodontics, University Medical Centre Ljubljana. Additionally, dental stone models were available for some patients. The distinguishing morphological traits, identified in the first part of this study were registered. Personal details including sex and age at the time of treatment were recorded.

Statistical analysis

Data analysis was executed utilizing the SPSS computer software (v 23.0, IBM). The prevalence of distinguishing morphological traits was determined for extracted PMMs with one and 2PR. Fisher's exact test was used to determine if there was a statistically significant difference in the occurrence of traits between second and third PMMs. Paired samples *t* test was used to compare widths of buccal and palatal halves of the crown. A *P* value of $< .05$ was considered significant.

RESULTS

A study on extracted teeth

In twelve (27.3%) PMMs with 2PR, all four roots were separated: nine were classified as Type I PMMs and three as Type II PMMs. In 32 (72.7%) PMMs with 2PR, root fusion was present. Two of these teeth had unseparated mesiopalatal and mesiobuccal roots (Type IV PMMs), whereas the remaining 30 (68.2%) teeth could not be classified into Types I−IV.

The crown of PMMs with 2PR was statistically significantly wider on the palatal half (mean diameter ± SD = 10.0 ± 1.24 mm) than on the buccal half (mean diameter ± SD = 9.33 ± 1.03 mm) ($P < .001$) (Fig 1A', left tooth). In contrast, the crown of PMMs with one palatal root was statistically significantly wider on the buccal half (mean diameter ± SD = 9.44 ± 0.55 mm) than on the palatal half (mean diameter ± SD = 8.72 ± 0.65 mm) ($P < .001$) (Fig 1A', right tooth).

This study identified six distinguishing morphological traits, i.e. traits which were present only on PMMs with 2PR (Table 1). A statistically significant difference with respect to tooth type (second vs. third PMMs) was not detected for any of them. Most frequently was the crown wider on the palatal half (Figs 1A and 1A'); this was followed by double Carabelli cusp (Figs 1B and 1B'), pronounced palatal indentation of the crown (Figs 1C and 1C'), thick palatal enamel extension (Figs 1D and 1D'), palato-radicular groove (Figs 1E and 1E') and palatal enamel pearl (Figs 1F and 1F'). The number of traits per tooth varied from zero to four; however, at least one trait was present in 63.4% of the examined PMMs with 2PR (Fig 2). With the exception of enamel extension, these traits are not among those used in the ASUDAS [31]. Palatal enamel extension of any length was observed in 93.0% of PMMs with 2PR (40 out of 43). It was classified according to ASUDAS, as faint extension (Grade 1) in 12 (27.9%) teeth, as medium-sized extension (Grade 2) in 11 (25.6%) teeth and as lengthy extension (Grade 3) in 17 (39.5%) teeth. Seven lengthy palatal enamel extensions were unusually thick and would be observed even during the clinical examination of the tooth. Conversely, only 2.3% of PMMs with one palatal root (one out of 44) exhibited palatal enamel extension which was scored as faint (Grade 1).

A retrospective clinical study

Altogether 15 patients (eight males and seven females) with a mean age of 45.3 years (ranging from 22 to 73 years) were included in this study. A total of 17 PMMs with 2PR (three first, 13 second, and one third PMM) were examined clinically and radiographically. This sample consisted of 10 right and seven left PMMs with 2PR.

The second PMM in patient B was the only tooth without clinically or radiographically observable clues to the presence of 2PR; other teeth possessed one to four distinguishing traits, with the modal number of traits per tooth being two (Table 2). The most prevalent distinguishing traits were crown wider on the palatal half (82.4%) and pronounced palatal indentation of the crown (47.1%). Figures 3 and 4 show representative examples of distinguishing traits observed clinically and radiographically. In two patients PMMs with 2PR occurred bilaterally: both first PMMs were affected in patient M and both second PMMs in patient N. In both patients, the maxillary dental arch was deformed into omega shape as a consequence of the enlarged palatal part of the molar crown (Figs 1G and 3G).

DISCUSSION

The present study demonstrates that it is possible to differentiate PMMs with 2PR from those with one palatal root by observing specific morphological traits on the palatal aspect of the tooth. These distinguishing traits include crown wider on the palatal half, double or triple Carabelli cusp, pronounced palatal indentation of the crown, thick palatal enamel extension, palato-radicular groove, and palatal enamel pearl.

In our sample of extracted PMMs with 2PR crown wider on the palatal half (55.3%) and double Carabelli cusp (23.7%) were most frequently observed distinguishing traits. The distinguishing morfological traits of 2PR are also considered to be clinical clues for this root constellation, as they can be observed during the clinical examination. The only exception is enamel pearl, which is visible only radiographically (Figs 4F and 4G) unless periodontal tissue has receded (Fig 3F). In clinical part of the study, crown wider on the palatal half (82.4%) and pronounced palatal indentation of the crown (47.1%) were most frequently observed. Moreover, in two patients (patients M and N) enlarged palatal half of the affected PMMs resulted in omega-shaped deformation of the dental arch (Fig 3G). The omega-shaped deformation of the dental arch might actually be the first clue observed by clinicians while performing the oral examination.

At least one of these distinguishing traits was observed in 63.4% and 94.1% of extracted and clinically examined PMMs with 2PR, respectively. On one side, this pronounced difference is most likely due to poorer crown preservation of extracted teeth in comparison with clinically examined teeth. On the other side, the frequency of traits in clinically examined PMMs with 2PR might be overestimated, since teeth without any distinguishing traits might have been overlooked.

First PMMs with 2PR were not found in our dental collection, reflecting the rarity with which they occur. However, during our clinical work four such teeth were identified. The aforementioned list of clinical clues can therefore also be applied to the first PMM with 2PR. The first PMM is an exception as the crown is often wider on the palatal half even when the root number is normal [33]. However, the first PMM with enlarged palatal half of the crown, resulting in omega-shaped deformation of the dental arch should always be given due consideration, since the unseen 2PR root constellation might be the cause for this deformation.

The results of the present study indicate that morphological traits under consideration are highly specific to double-palatal-rooted PMMs. In the PMMs with 2PR, the palatal half of the crown was statistically significantly wider than its buccal half, whereas in PMMs with one palatal root the widest portion of the crown was always toward the buccal surface.

As early as 1915, Bolk [4] mentioned the co-existence of multiple Carabelli cusps and 2PR in second PMMs. Nevertheless, these extreme variants have not yet been incorporated into the ASUDAS Carabelli's trait standard. In the present study, double Carabelli cusp was observed exclusively on PMMs with 2PR. In clinically examined teeth with double Carabelli cusp the presence of 2PR was in some cases confirmed only by using CBCT, as they were not identifiable from the periapical radiograph.

Another such trait is palato-radicular groove, which originates on the palatal aspect of the crown and often continues down the root [31]. This groove occasionally develops on permanent maxillary incisors where the deepest forms are associated with small accessory root formation [14]. Palato-radicular groove on a PMM is very unusual and was so far only documented in a couple of cases with 2PR [3, 9, 17, 1].

Several studies addressed the prevalence and distribution of enamel extensions and enamel pearls on permanent molars, unfortunately without reference to the number of roots. These studies indicate that on PMMs long enamel extensions show a strong predilection for the buccal surface [29, 25, 10] whereas enamel pearls show a strong predilection for mesial and distal surfaces [24, 11]. Here, a long enamel extension (Grade 3) on the palatal surface was present on almost 40% of extracted PMMs with 2PR but was not noted on PMMs with one palatal root.

Few studies have considered the prevalence of the morphological traits in PMMs with 2PR. Carlsen and Alexandersen [7] observed thick palatal enamel extension on almost 70% of the extracted specimens. This is substantially more than our results; however, it agrees with our observed prevalence of medium-sized (Grade 2) and lengthy palatal enamel extensions (Grade 3), which was 65.1%. The difference in results likely reflects subjectivity in scoring enamel extension thickness. Here, the enamel extension was only considered thick if it could be reliably detected during the clinical examination with a periodontal probe. Versiani et al. [32] found enamel pearl in the furcation of the palatal roots in 8.0% of the affected second PMMs (2 out of 25) and this is in agreement with the present study (2.3% and 11.8% for extracted and clinically examined PMMs with 2PR, respectively).

Clinically, the identification of 2PR is a fundamental prerequisite for a proper treatment of such teeth and for understanding the problems that may occur when such teeth become pulpally and/or periodontally involved. The untreated canal system of the mesiopalatal or distopalatal root may be cause endodontic treatment failure. A typically short distance between the enamel line and palatal furcation in PMMs with two separate palatal roots should be considered when planning crown lengthening on such teeth [8]. For the same reason, the palatal furcation may become involved early during the progression of periodontal disease. Thick palatal enamel extension, palato-radicular groove and palatal enamel pearl may also be predisposing factors for furcation involvement. If periodontal destruction predominantly affects the palatal aspect of a PMM than the presence of 2PR should be taken into consideration [6]. A deep palato-radicular groove on the second PMM may allow microorganisms to penetrate from periodontal pocket into the pulp tissues and cause irreversible pulpitis [3]. Pathohistological studies [22, 21, 12] and a micro-CT study of the affected teeth [14]

indeed confirmed the existence of tiny communications between deep grooves and the pulp cavity. Lastly, there is an increased risk of fracturing the maxillary tuberosity during extraction of the maxillary third molar with 2PR [15].

Therefore, whenever the clinician identifies one or more clinical clues indicating the presence of 2PR, various diagnostic procedures can be employed. Periodontal probing of the cervical root may reveal palatal root bifurcation, especially if accompanied by gingival recession and/or periodontal destruction. The preoperative radiographs should be examined carefully. If necessary, periapical radiography from different directions and CBCT scanning can also be used as an additional diagnostic tool. The clinician should also bear in mind that the root morphology of PMMs with 2PR varies considerably and cannot be classified according to the existing classifications in over two thirds of cases.

CONCLUSIONS

Clinical examination plays an important role in the detection of PMMs with 2PR. A major clinical clue is crown width greater on the palatal half. Other, less frequent clinical clues are: double Carabelli cusp, pronounced palatal indentation of the crown, thick palatal enamel projection, palato-radicular groove, and enamel pearl in the area of palatal furcation. It is therefore clinically possible to differentiate PMMs with 2PR from those with one palatal root by observing the presence or absence of these traits. The clinical part of our study indicates that the enlarged palatal half of PMM crown can result in omega-shaped deformation of the maxillary dental arch, which may indeed represent the first clue observed by clinician while performing the oral examination.

Conflict of interest: None

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Table 1. Prevalence of distinguishing morphological traits in a sample of 44 extracted permanent maxillary molars (PMMs) with two palatal roots.

Table legend: N, number of examined PMMs; n, number of PMMs with a distinguishing trait; %, percentage of PMMs with a distinguishing trait; FET, Fisher's exact test

Morphological trait	PMMs	N	n	%	P value (FET)
Crown wider on the paltal half	Second	15	10	66.7	0.3264
	Third	23	11	47.8	
	All	38	21	55.3	
Double Carabelli cusp	Second	15	1	6.7	0.0611
	Third	23	8	34.8	
	All	38	9	23.7	
Pronounced palatal indentation	Second	17	4	23.5	0.7089
	Third	22	4	18.2	
	All	39	8	20.5	
Thick palatal enamel extension	Second	18	3	16.7	1
	Third	25	4	16.0	
	All	43	7	16.3	
Palato-radicular groove	Second	18	1	5.6	0.3801
	Third	25	4	16.0	
	All	43	5	11.6	
Palatal enamel pearl	Second	18	1	5.6	0.4091
	Third	26	0	0.0	
	All	44	1	2.3	

Table 2. Distinguishing morphological traits in a sample of 17 clinically and radiographically examined permanent maxillary molars with two palatal roots.

Patient	Age	Sex	Tooth (FDI notation)	Imaging method	Traits								Number of traits per tooth
					Crown wider on the lingual half	Palatal indentation	Omega-shaped maxillary dental arch	Thick palatal enamel extension	Palatal enamel pearl	Double Carabelli cusp	Palato-radicular groove		
A	62	F	17	PR									0
C	28	M	27	PR	+								1
B	58	M	17	PR	+	n.s.	n.s.			n.s.			1
D	34	M	28	CBCT				+					1
E	55	F	26	CBCT		+							1
F	42	F	27	PR	+			+					2
G	35	F	17	BW	+				+				2
H	56	F	17	PR, CBCT	+	n.s.	n.s.		+	n.s.			2
J	45	M	17	PR	+	+							2
I	73	M	17	PR	+	+	n.s.						2
K	37	M	17	PR	+					+			2
L	22	F	17	CBCT	+					+			2
M	56	M	16	PR	+	+	+						3
			26	PR	+	+	+						3
N	39	F	17	PR, CBCT	+	+	+			n.s.			3
			27	PR	+	+	+						3
O	38	M	27	PR, CBCT	+	+				+	+		4
Teeth with a trait				**N**	14	8	4	2	2	3	1		
				%	82.4	47.1	23.5	11.8	11.8	17.6	5.9		

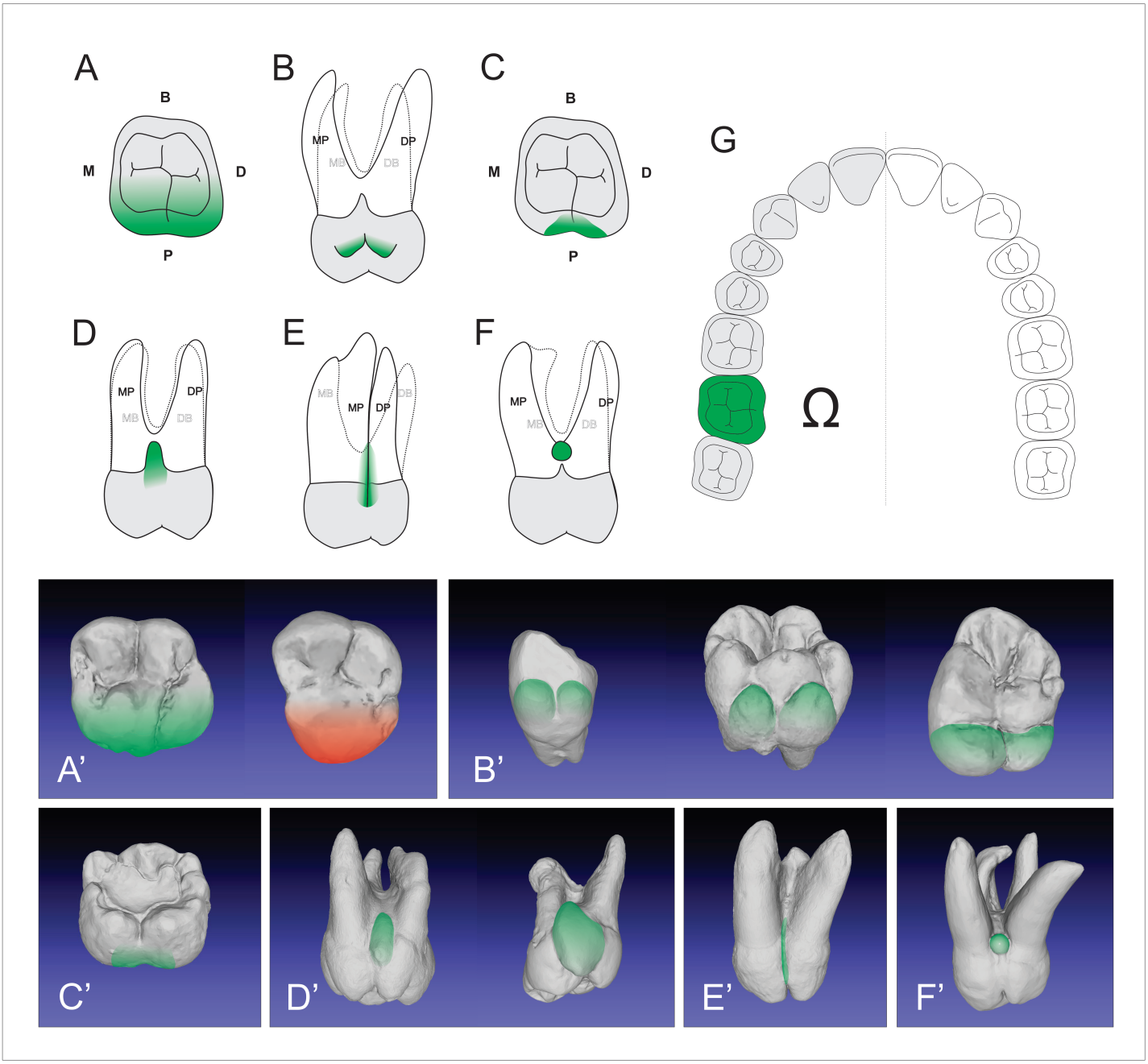
Table legend: PR, periapical radiography; BW, bitewing radiography; CBCT, cone-beam computed tomography; n.s., trait not scored because of caries, fracture, wear, etc.

Figure 1. Morphological traits (green) to distinguish PMMs with 2PR from those with one palatal root presented schematically (A−F) and on 3D scans of extracted teeth (A'−F'). (A, A') crown wider on the palatal half (The left crown, which belongs to a PMM with one palatal root, is wider towards the buccal surface). (B, B') double Carabelli cusp. (C, C') pronounced palatal indentation of the crown. (D, D') palatal enamel extension. (E, E') palato-radicular groove. (F, F') palatal enamel pearl. (G) Enlarged palatal half of the tooth, resulting in omega-shaped deformation of the maxillary dental arch. Morphological types of PMMs with 2PR: (B) Type I, (D) Type II, (E) Type III, and (F) Type IV.

Figure 2. Distribution of PMMs with 2PR according to the number of distinguishing morphological traits per tooth.

Figure 3. Representative clinical photographs of distinguishing morphological traits (marked with arrows) on PMMs with 2PR. (A) crown wider on the palatal half. (B) double Carabelli cusp. (C) pronounced palatal indentation of the crown. (D) thick palatal enamel extension. (E) palato-radicular groove. (F) palatal enamel pearl. (G) omega-shaped deformation of the maxillary dental arch caused by the enlarged palatal part of both maxillary second molars.

Figure 4. CBCT scans (A−F), bitewing (G) and periapical radiographs (H) showing distinguishing morphological traits (arrowed) on PMMs with 2PR. (A) crown wider on the palatal half. (B) double Carabelli cusp. (C) pronounced palatal indentation of the crown. (D and H) thick palatal enamel extension. (E) palato-radicular groove. (F, G) palatal enamel pearl.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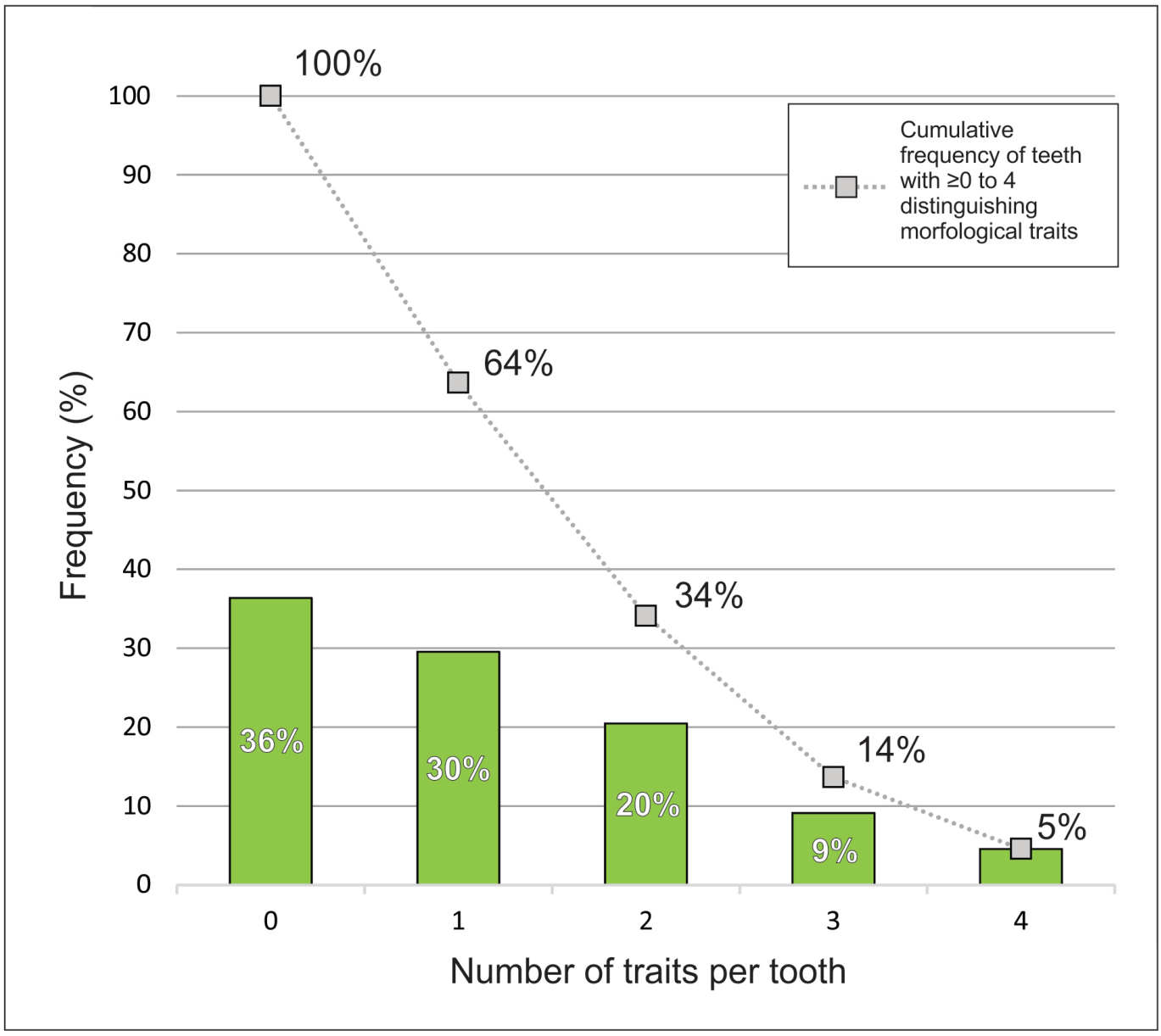
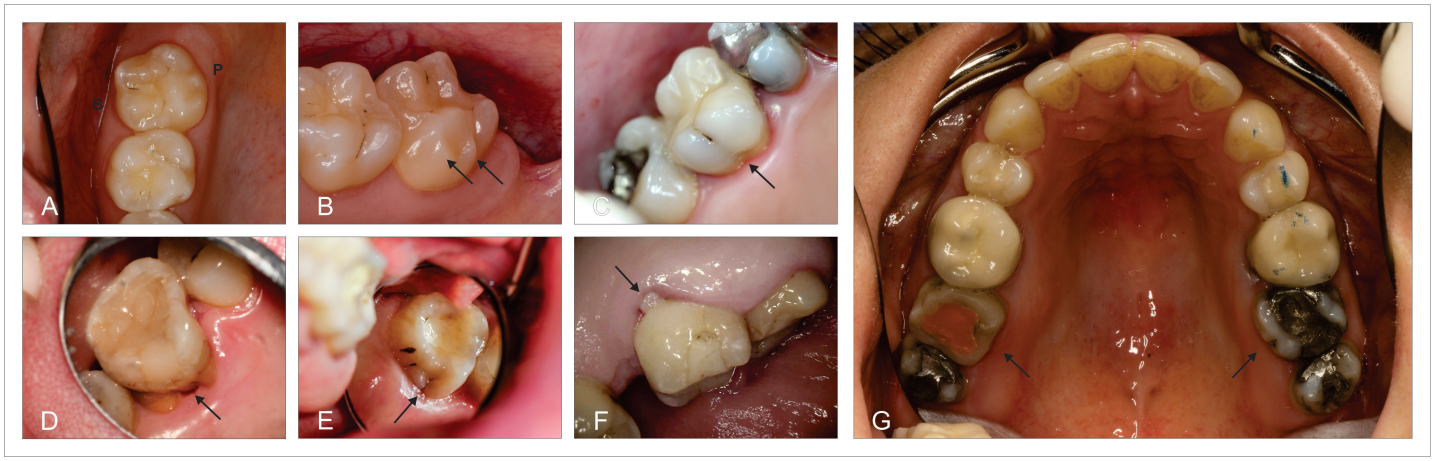

100%
64%
34%
14%
5%
36%
30%
20%
9%
Cumulative frequency of teeth with ≥0 to 4 distinguishing morfological traits
Frequency (%)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
Number of traits per tooth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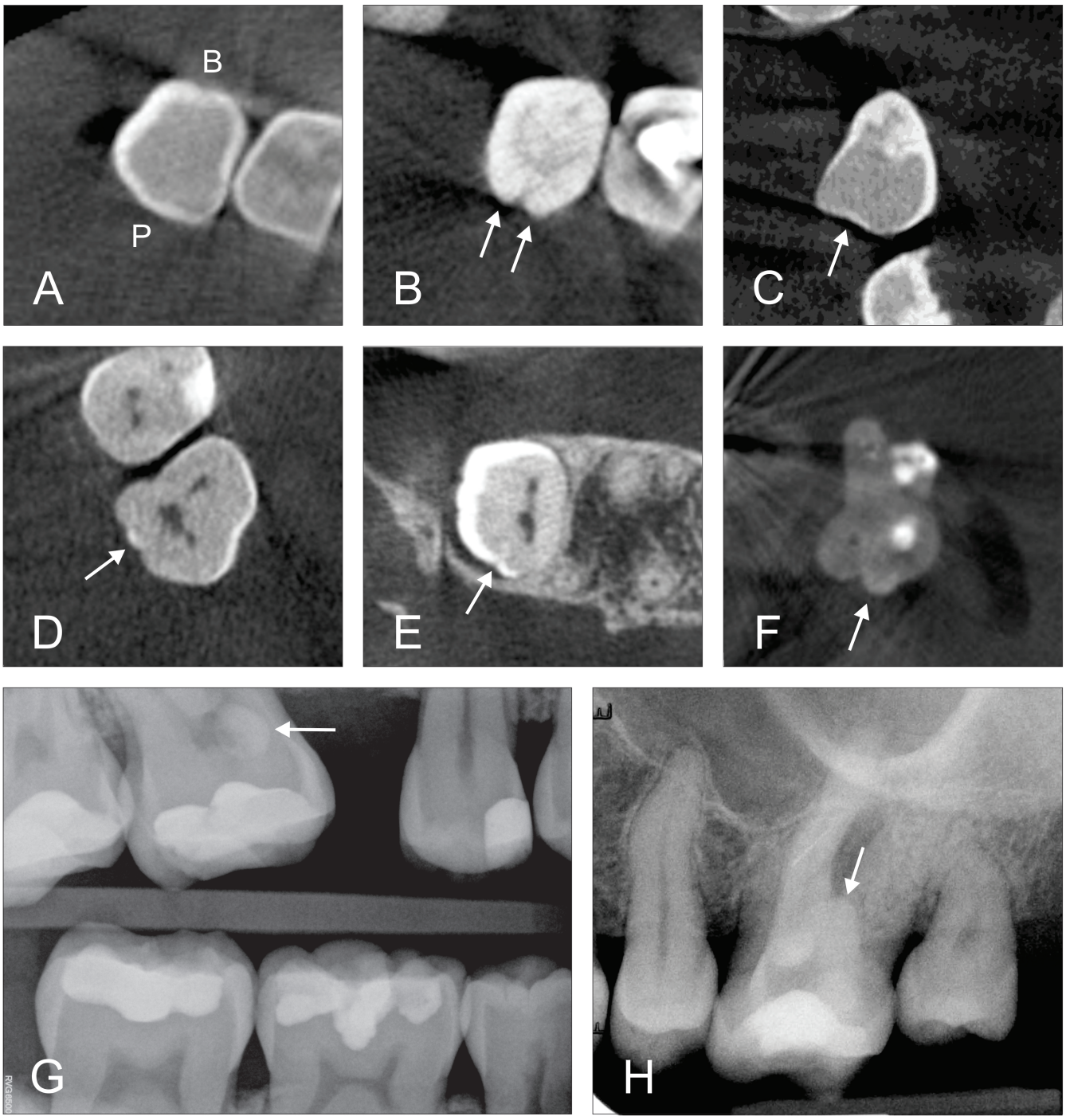
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