CLINICAL RESEARCH

Worldwide Assessment of the Root and Root Canal Characteristics of Maxillary Premolars – A Multi-center Cone-beam Computed Tomography Cross-sectional Study With Meta-analysis

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ABSTRACT

Introduction: This worldwide study examined the root and root canal characteristics of maxillary premolars and explored how demographic factors impact the outcomes. **Methods:** Observers from 44 countries assessed 26,400 maxillary premolars using cone-beam computed tomography and employed a standardized screening method to gather data on multiple canal morphology and 3-rooted configuration (primary outcomes), as well as secondary outcomes related to root and root canal anatomies. Demographic factors such as ethnicity, sex, and age were collected for each participant. The intra- and inter-observer tests ensured observer reliability. Primary outcomes were represented as odds ratios and un-transformed proportions accompanied by 95% confidence interval (CI) forest plots. Meta-analysis compared sub-groups and identified sources of heterogeneity ($\alpha = 5\%$). **Results:** The overall prevalence of multiple canal morphology in the first premolar was 93.5% (95% CI, 93.3%–94.7%), while in the second premolar, it was 49.7% (95% CI, 44.9%–54.6%). The proportion of 3-rooted configuration was 1.8% (95% CI, 1.4%–2.1%) in the first premolar and 0.4% (95% CI, 0.3%–0.5%) in the second. Asian countries generally displayed fewer roots and root canals, while European nations showed higher counts ($P < .05$). Males exhibited higher percentages and odds ratios for both outcomes in both premolars. Younger patients demonstrated lower percentages of multiple root canal morphologies ($P < .05$). Factors such as tooth side, voxel size and field-of-view did not influence the outcomes ($P > .05$). **Conclusions:** The worldwide assessment of root and root canal characteristics of maxillary premolars has revealed a discernible influence of various factors such as tooth type, geographical region, ethnicity, sex, and age. *(J Endod 2024;50:31–54.)*

KEY WORDS

Anatomy; cone-beam computed tomography; endodontics; maxillary premolar; prevalence study

SIGNIFICANCE

This study conducted a comprehensive worldwide analysis of root and root canal morphologies in maxillary premolars, uncovering variations among different ethnic groups, geographic regions, sex, and age ranges. These findings can assist clinicians in anticipating anatomical differences and making informed choices regarding endodontic treatment.

The intricate patterns of the anatomical variability of human dentition have long captured the interest of researchers, clinicians, and anthropologists, all driven to unravel its complexities. Within the field of Endodontics, the morphologies of both the root and root canal system carry remarkable importance, as they wield a substantial influence over clinical procedures and, by extension, treatment outcomes. As demonstrated in previous studies, failure to adequately address all canals and their complexities can result in treatment failure and persistent infections[1-3]. Thus, endodontic treatments rely on a thorough understanding of these anatomical variations to ensure successful cleaning, shaping, and filling of the root canal system.

Amongst different groups of teeth, maxillary premolars have garnered particular attention in the context of dental anatomy, owing to their variations in root and canal configurations[4]. The first premolar

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typically presents with two roots: a buccal and a palatal root, whereas the second premolar usually has a single root. However, variations in root morphology are not uncommon, and the presence of three roots in maxillary first premolars or additional canals in maxillary second premolars have been documented. The canal systems within these roots may be equally complex. In maxillary first premolars, the two roots generally contain two canals: a buccal and a palatal canal[5]. However, the buccal canal can sometimes divide into two separate canals, giving rise to a total of three canals in a single-, double- or three-rooted tooth[6]. In the maxillary second premolar, the single root typically harbors a single canal. Yet, variations in canal morphology exist, with the potential for bifurcation into two separate canals or even the presence of multiple canals[5].

Historically, studies of dental anatomy have largely relied on macroscopic observations of extracted teeth. However, advances in imaging techniques, particularly cone-beam computed tomography (CBCT), have revolutionized the field by offering detailed three-dimensional insights into the internal structures of teeth. This technological leap has enabled researchers to investigate dental anatomy more comprehensively, allowing for more accurate assessments of root configurations, canal morphologies, and their variations. One of the key advantages associated with the utilization of CBCT lies in its capability to conduct *in vivo* anatomical investigations encompassing larger population groups. This technology permits the exploration of the influence exerted by various factors, including ethnicity, aging, gender, and tooth side (left or right), on root canal anatomy. Such comprehensive epidemiological data are typically absent in laboratory-based studies due to the unavailability or impracticality of gathering and comparing such variables with limited sample sizes. Consequently, the CBCT method emerges as a more dependable option for observational studies that involve the analysis of complete dentition from numerous patients drawn from a specific population in a consecutive manner, ensuring that outcomes are not influenced by the specific type of teeth under consideration or their potential for extraction[7].

A previous systematic review[4] identified only 8 *in vivo* anatomical studies on maxillary premolars assessed by CBCT. Among these, 4 originated from China and 3 from European nations. Despite the limited data available to be polled, notable trends emerged, suggesting that factors including tooth type, gender, and geographic location could potentially influence the outcomes. Regrettably, the same review failed to explore the potential impacts of variables such as ethnicity, age, and tooth side on the anatomical features of maxillary premolars. Furthermore, gaining a comprehensive understanding of the characteristics of these teeth on a global scale necessitates insights from geographic regions extending beyond Europe and China. Thus, this study addresses a significant gap in the current understanding of dental anatomy by investigating the prevalence of root and root canal configurations in maxillary premolars across 44 countries using pre-existing CBCT imaging volumes, establishing correlations between the observed outcomes and demographic factors such as geographic region, ethnicity, sex and age.

The aim of this investigation was to assess the prevalence of multiple canal morphology and the presence of three-rooted anatomy (primary outcomes to be determined), and the root and root canal configurations (secondary outcomes to be recorded) within both maxillary first and second premolars at a worldwide level. The null hypothesis under investigation posited that root and root canal

TABLE 1 - Geographic Location of the Screened Sub-populations, CBCT Imaging Characteristics, and Reasons for Teeth Exclusions

Country	City	Continent	CBCT source	Observer ID	CBCT model (brand, city, Country)	Visualization software (Brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Teeth excluded (reasons)	Date of CBCT exam acquisition
Argentina	Salta	America	IC/PC	P.E.	CS 8100 (Carestream, Atlanta)	CS 3D Imaging (Carestream)	Large	75, 60–80, 2-15	54 (RCT)	2021–2022
Australia	Melbourne	Oceania	IC	F.C.	Accuitomo 80 (Morita, Kyoto, Japan) i-CAT FLX (i-CAT, Hatfield, England)	InteleViewer (InteleRad, Montreal, Canada)	Small	80–160, 86–90, 6–8 200, 120, 5	236 (artefacts, RCT, open apex, unclear number)	2011–2022
Azerbaijan	Baku	Asia	AI	N.B.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	200, 90, 5–6	30 (artefacts, RCT)	2016–2022
Belgium	Brussels	Europe	PC	M.Z.	Newtom Giano (Newtom, Verona, Italy)	NNT (Newtom)	Small Large	150, 90, 4	6 (artefacts)	2016–2022
Brazil	Campinas	America	PC	L.B.	i-CAT FLX (i-CAT, Hatfield, England)	i-CAT Vision (i-CAT)	Large	200, 90, 5	17 (artefacts)	2017–2022
Canada	Toronto	America	IC/PC	E.L.	CS 9300 (Carestream, Atlanta)	Invivo (Anatomage, Santa Clara, USA)	Small	90, 84, 5	0	2010–2020
Chile	Santiago do Chile	America	IC	M.A.	CS 8100 (Carestream, Atlanta)	CS 3D Imaging (Carestream)	Large	150, 82, 5	442 (artefacts, RCT, open apex)	2016–2022
China	Suzhou	Asia	AI	F.P.	Kavo 3D eXame (Kavo Sybron, Munich, Germany)	eXame vision (Kavo)	Large	200, 120, 4	8 (RCT, artefacts)	2017–2022
Colombia	Bogota	America	IC/PC	C.E.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small	75, 90, 14	0	2017–2022
Costa Rica	San Jose	America	PC	W.V.	X Mind Trium (Acteon, Merignac, France)	X Mind Trium (Acteon)	Large	200, 85–90, 8	0	2022
Ecuador	Quito	America	PC	J.C.	Scanora 3Dx (Soredex, Helsinki, Finland)	On demand (Soredex)	Large	150–200, 90, 6	60 (artefacts)	2022
Egypt	Cairo	Africa	PC	M.B.A.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	150, 90, 12	411 (artefacts, RCT, open apex)	2017–2022
England	London	Europe	PC	T.P.	CS 8100 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Small Large	75–150, 90, 3-6	52 (artefacts)	2019–2022
France	Paris	Europe	PC	F.S.	Orthophos SL (Dentsply,	Sidexis 4 (Dentsply)	Small Large	160, 85, 6	10 (artefacts)	2020–2022

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TABLE 1 - Continued

Country	City	Continent	CBCT source	Observer ID	CBCT model (brand, city, Country)	Visualization software (Brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Teeth excluded (reasons)	Date of CBCT exam acquisition
					Ballaigues, Switzerland)					
Germany	Bab Kreuznach	Europe	PC	H.H.	X800 (Morita, Kyoto, Japan) CS 9300 (Carestream, Atlanta) Kavo OP 3D Pro (Kavo Sybron, Munich, Germany)	i-Dixel (Morita) CS 3D Imaging (Carestream) OnDemand 3D (Kavo)	Small Large	80, 100, 7 90, 84–90, 5-8 85, 90, 6	0	2012–2022
Greece	Athens	Europe	IC	A.C.	Newtom VGI (Newtom, Verona, Italy)	NNT (Newtom)	Large	150, 110, 8	0	2022
Hungary	Budapest	Europe	PC	G.B.	Promax 3D (Planmeca, Helsinki, Finland) CS 9300 (Carestream, Atlanta) Vatech Green (Vatech, Gyeonggi-do, Korea)	Romexis (Planmeca) CS 3D Imaging (Carestream) Vatech MAR (Vatech)	Large	200, 84, 15 200, 60–90, 2-15 200, 6–99, 9–16	0	2018–2022
Iceland	Hafnarfjördur	Europe	PC	M.R.	i-CAT FLX (i-CAT, Hatfield, England)	i-CAT Vision (i-CAT)	Large	200, 120, 4	20 (artefacts, RCT)	2017–2021
India	Palakkad	Asia	PC	J.K.	Newtom Giano (Newtom, Verona, Italy)	NNT (Newtom)	Small Large	150, 90, 4–9	22 (artefacts, open apex)	2018–2022
Israel	Jerusalem	Asia	AI	A.S.	Alioth (Asahi Roentgen, Kyoto, Japan)	RadiAnt Dicom Viewer (Medixant, Pozlan, Poland)	Large	155, 85, 6	22 (artefacts)	2018–2020
Italy	Rome	Europe	IC	R.C.	Accuitomo 170 (Morita, Kyoto, Japan)	i-Dixel (Morita)	Small	200, 88, 8	0	2021–2022
Jamaica	Kingston	America	PC	S.T.	OP 300 (Kavo, Charlotte)	Invivo (Anatomage, Santa Clara, USA)	Large	85, 57–90, 4–16	30 (artefacts)	2021–2022
Japan	Tokyo	Asia	AI	S.M.	Accuitomo F17 (Morita, Kyoto, Japan)	Infinitt Pacs (Infinitt Medical, Phillipsburg, USA)	Small Large	80, 90, 7	4 (artefacts)	2018–2022

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TABLE 1 - Continued

Country	City	Continent	CBCT source	Observer ID	CBCT model (brand, city, Country)	Visualization software (Brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Teeth excluded (reasons)	Date of CBCT exam acquisition
Kuwait	Salmiya	Asia	PC	H.O.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	150, 90, 10	266 (artefacts)	2018–2022
Kyrgyzstan	Bishkek	Asia	PC	Ar.M.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	75–150, 90, 8-10	31 (artefacts, open apex)	2022
Malaysia	Kuala Lumpur	Asia	AI	A.P.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	200, 60–120, 1–14	0	2019–2022
Mexico	León	America	IC/PC	R.A.	OP 300 (Kavo, Charlotte) Promax 3D (Planmeca, Helsinki, Finland)	OnDemand 3D (Kavo) Romexis (Planmeca)	Small Large	75–200, 85–120, 8–12	40 (artefacts)	2016–2022
Nigeria	Lagos	Africa	PC/AI	O.O.	CS 8100 (Carestream, Atlanta)	CS 3D Imaging (Carestream)	Small	150, 90, 3	19 (artefacts, fractured teeth)	2018–2022
Pakistan	Karachi	Asia	PC	M.N.	Promax 3D (Planmeca, Helsinki, Finland) CS 9600 (Carestream, Atlanta)	Romexis (Planmeca) CS 3D Imaging (Carestream)	Large	180–200, 85–90, 4–6	37 (artefacts)	2018–2021
Paraguay	Asunción	America	IC	C.H.	Imax 3D (Owandy, Beaubourg, France)	CS 3D Imaging (Carestream)	Large	170, 84, 5	146 (artefacts, RCT)	2019–2022
Peru	Lima	America	IC	C.N.	OP 300 (Kavo, Charlotte)	OnDemand 3D (Kavo)	Large	200, 57–90, 4–16	5 (artefacts)	2021
Portugal	Lisbon	Europe	PC	J.M.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 84, 15	22 (artefacts)	2019–2022
Romania	Bucharest	Europe	PC	S.N.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 85, 12	0	2022
Russia	Yekaterinburg	Asia	PC	E.L.	CB 500 (Gendex, Hatfield, England)	i-CAT Vision (i-CAT)	Small Large	200, 120, 3–8	73 (RCT, artefacts)	2021–2022
Saudi Arabia	Riyadh	Asia	AI	H.A.			Large	200, 84, 15	0	2022

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TABLE 1 - Continued

Country	City	Continent	CBCT source	Observer ID	CBCT model (brand, city, Country)	Visualization software (Brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Teeth excluded (reasons)	Date of CBCT exam acquisition
					Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)				
South Africa	Durban	Africa	PC	H.S.	CS 8100 (Carestream, Atlanta)	CS 3D Imaging (Carestream)	Small Large	75–150, 90, 3	7 (artefacts)	2017–2022
South Korea	Seoul	Asia	AI	S.C.	Alphard 300 (Asahi Roentgen Ind, Kyoto, Japan)	Zetta PACS Viewer (Asahi)	Large	200, 60–100, 2–15	0	2018–2022
Spain	Barcelona	Europe	PC	J.G.	CS 8100 (Carestream, Atlanta) Promax 3D (Planmeca, Helsinki, Finland)	InteleViewer (InteleRad, Montreal, Canada)	Large	150–200, 84–90, 4–6	40 (artefacts)	2016–2022
Syria	Damascus	Asia	PC	Z.A.	Viso G5 (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 60–120, 1–16	40 (absence of teeth)	2018–2022
Thailand	Bangkok	Asia	AI	D.B.	Accuitomo 170 (Morita, Kyoto, Japan)	OneVolumeViewer (Morita)	Small	125, 90, 5	70 (artefacts, RCT, open apex)	2021–2022
Turkey	Istanbul	Europe	AI	A.K.	5 G XL (Newtom, Verona, Italy)	(Newtom, Verona, Italy)	Small Large	100–200, 110, 3–6	66 (artefacts, RCT, open apex)	2019–2022
Uruguay	Montevideo	America	IC	I.M.	Tropypan (Trophy, Atlanta) CS 9000 (Carestream, Atlanta)	Trophy Imaging (Trophy) CS 3D Imaging (Carestream)	Small Large	100–150, 70–90, 3–10	173 (artefacts, RCT, open apex)	2020–2022
USA	Vista	America	PC	Ad.M.	CS 9000 (Carestream, Atlanta)	CS 3D Imaging (Carestream)	Small	76, 80–85, 10	3 (artefacts)	2022
Venezuela	Caracas	America	PC	C.B.	CS 9000 (Carestream, Atlanta)	CS 3D Imaging (Carestream)	Small	76, 60–90, 2-15	77 (artefacts, open apex)	2012–2022

IC Imaging Center, PC Private Clinic, AI Academic Institution, RCT Root Canal Treated anatomy would remain unaffected by the previously mentioned variables.

MATERIALS AND METHODS

Research Protocol

This cross-sectional study research protocol (CE-FMDUL202239) underwent review and received approval from the Ethics Committee of the Faculdade de Medicina Dentária da Universidade de Lisboa. CBCT examinations assessed in this study were conducted for treatment planning or surgical purposes and not acquired specifically for this research. The identities of the patients involved were neither accessed nor disclosed (CBCT images were anonymized for the purpose of the study). The collection of CBCT data involved the evaluation of pre-existing imaging volumes and followed the position statement outlined by the American Association of Endodontists[8] and the preferred reporting items guidelines for epidemiologic cross-sectional studies on root and root canal anatomy using CBCT technology[9].

Study Outcomes and Sample Size Calculation

Experienced observers (academics and/or endodontists) hailing from 44 different countries across five continents participated in the assessment of the prevalence of multiple canal morphology (primary outcome) and the presence of three-rooted anatomy (primary outcome). This evaluation also encompassed the examination of root and root canal configurations (secondary outcomes) within both the first and second maxillary premolars (Table 1). All participants were provided simultaneously with comprehensive written guidelines detailing the study's aims, primary and secondary outcomes, definitions of relevant anatomic landmarks, the method for screening CBCT volumes, research timelines, pertinent references from the literature, and illustrative examples using sagittal CBCT scan views. Furthermore, a tutorial video demonstrating the sequential assessment protocol for analyzing the 3D volumes was created and shared with the entire group. These supplementary materials were compiled by the study coordinator (J.M.), and they underwent prior assessment by two external reviewers (M.A.V. and J.B.I.), who were not participants in the study, to achieve a consensus-based scientific validation. Utilizing this information, all 44 field observers were simultaneously calibrated during the initial phase of the research timeline. No further participants were enlisted once this initial calibration period commenced.

The determination of the sample size was derived from an initial pilot assessment involving 35 teeth from all 44 included regions. For testing the null hypothesis, the two regions exhibiting the most significant disparities between them for each primary outcome to be determined were compared. Using parameters of an 80% statistical power, a 95% confidence level, and effect sizes of 28.6% (multiple canals: Israel vs. Azerbaijan) and 11.4% (3-rooted: Romania vs. China) for the proportions in the first premolar, as well as 34.3% (multiple canals: Australia vs. Venezuela) and 5.7% (3-rooted: Jamaica vs. China) for the second premolar, a final sample size was calculated to be 32, 100, 31, and 239, respectively (https://sample-size.net/). However, to ensure statistical robustness and to account for the fact that not all regions were directly compared, the final sample size was increased to 300 teeth for each group and region.

Sample Selection, Data Acquisition, and Screening Methodology

In order to ensure the representativeness of the studied sub-populations, this research incorporated a convenience sample of patients who sought dental care at health centers within the specified regions of interest. A single observer per region was permitted, while the utilization of multiple CBCT scanners was acceptable, provided that the voxel size remained equal to or less than 200 μm. Both small and large field-of-view (FOV) volumes, as well as various CBCT scanner brands, were considered valid. The observers received instructions to systematically evaluate existing CBCT volumes, following either an alphabetic or numeric chart order, until the desired sample size of 300 premolars per group was attained. Premolars that fulfilled the exclusion criteria were excluded from the study. These criteria encompassed teeth that had undergone prior root canal therapy, exhibited severe decay, displayed incomplete root formation or root resorption, had issues with uncertain tooth numbering, suffered from compromised imaging clarity due to artifacts, had roots that were beyond salvageable condition, exhibited root fractures, or were lacking essential demographic information. Table 1 provides an overview of the quantity of exclusions and the corresponding reasons for each geographic region.

The CBCT imaging assessment methodology involved orienting the long axis of the tooth under examination with the reference lines within the visualization software in a 3D manner. This was succeeded by an anatomical interpretation performed across the coronal, sagittal, and axial planes. The observers were given the liberty to fine-tune the visualization settings, which might involve applying noise reduction techniques or employing specialized filters, to enhance the quality of the images and facilitate their interpretation. Each selected premolar was recorded with the following information: tooth numbering (Universal Numbering System), presence multiple canal morphology (more than 1 root canal) (yes/no; primary outcome), root canal configuration (single canal, 2 independent canals [multiple foramina], 2 confluent canals [single foramen], or more than 2 root canals; secondary outcome)[10], number of roots (1, 2, or 3; secondary outcome), and 3-root configuration (yes/no; primary outcome). In addition, pertinent demographic details including gender (male or female), age, and ethnic group (pertaining to the ethnic group(s) of individuals seeking care at health centers and not necessarily corresponding to the country) were also documented. It is noteworthy that the ethnic group classification relies on the patient profiles within the health center unit, rather than representing the ethnic composition of the entire country. The classification encompassed three categories: "all (ethnicity)" when all patients belonged to a specific ethnic group, "mostly (ethnicity)" when the vast majority of individuals were from a particular ethnic group, with only a few exceptions from other ethnicities, and "mixed (ethnicity)" when multiple ethnicities were observed, irrespective of the presence or absence of a dominant ethnic group. The mixed ethnic groups were excluded from the statistical analysis.

Each observer documented and consolidated their acquired data using a standardized Excel sheet template (Microsoft Office v15.0.5537, Redmond, WA), which was identical for all participants. This sheet was structured to facilitate crossreferencing and double-checking the accuracy of key information and to enable direct export to the statistical software. If any discrepancies were identified in the recorded Excel sheet entries, they were communicated back to the respective regional observer with a request for clarification and/or correction. The outcomes of the assessment for dataset nonconformities are outlined in Supplemental Table S1. In the event of encountering any uncertainty during the classification of anatomical parameters, observers were directed to communicate with the research coordinator to achieve a conclusive consensus. Moreover, to minimize the risk of individual assessment bias, all observers remained unaware of the outcomes produced by other participants. To guarantee consistent adherence to the initially set intermediary and ultimate deadlines and protocols, the two external nonobserver reviewers consistently monitored the activities of the field participants.

FIGURE 1 – Illustrative CBCT images depicting the root and root canal anatomy assessed within the context of the analyzed datasets for maxillary first and second premolars in different countries: single-rooted premolar with a single root canal, originating from (*A*) Argentina and (*B*) England; (*C*) single-rooted premolar displaying two confluent canals from Peru; (*D*) single-rooted premolar showcasing two separate canals at the apical level from Turkey; (*E*) premolar with a single root and two independent canals from Venezuela; (*F*) premolar with two roots and two independent canals from France; (*G*) two-rooted premolar with independent canals from Greece; (*H*) coronal and sagittal views of a premolar with 3 roots and 3 independent canals from Portugal. CBCT, cone-beam computed tomography.

Reliability Measurements

Due to the diverse backgrounds of the observers, a rigorous oversight of data reliability was necessary and five reliability assessments were carried out within this research at both the individual and group levels. Prior to the conclusive data collection phase, both intra- and inter-observer reliability tests were conducted. The intraobserver reliability was established by comparing the results of two evaluations performed on the same regional dataset with a 30-day interval. A total of 35 maxillary first premolars and 35 maxillary second premolars (11.7% of the final sample size) were subjected to double screening in each geographic region focusing on the identification of multiple canal morphology and 3-root configuration (primary outcomes). The individual reliability of each participant was determined through the calculation of Cohen's kappa coefficient. Regarding interobserver reliability, all 44 participants engaged in an assessment of the identical 18 maxillary first premolars present in 14 CBCT volumes, which were not included in any regional dataset. The evaluation focused on the presence of multiple canal morphology and 3-root configuration (primary outcomes). The agreement percentage and intraclass correlation coefficient were employed to compute group reliability. Furthermore, each individual outcome was compared against a consensus score derived from evaluations conducted by two experienced external raters (the non-observer reviewers), using Cohen's kappa test. The established minimum threshold for acceptability was set at 0.61 (substantial agreement)[11] for both the intraclass correlation coefficient and Cohen's kappa value. In the event that this limit was not attained, participants were asked to revisit the study protocol and reassess the datasets. Both intra- and inter-observer evaluations adhered to the predetermined CBCT screening procedure and were executed within the same time interval by all 44 participants.

Statistical Analysis

Considering the multicenter nature of this research, the statistical analysis of the recorded data were carried out utilizing a meta-analysis based on a random-effects model (OpenMeta [Analyst] v.10.10 software; available at www.cebm.brown.edu/openmeta)[10,12]. The primary outcomes for both premolars (proportions of multiple canal morphology and 3-root configuration) were represented as odds ratios and untransformed proportions accompanied by 95% confidence interval forest plots. Additionally, specific secondary outcomes, such as 3-root canal morphology and single-root configuration, underwent meta-analysis to enable a comparison of results based on geographic location and ethnic groups. Furthermore, to explore potential sources of bias or heterogeneity stemming from varying voxel sizes and FOV parameters, meta-regression analyses were also performed. The threshold for statistical significance was set at 5%.

RESULTS

Worldwide Prevalence

A total of 26,400 maxillary premolars (13,200 in each group) underwent screening (Fig. 1). The data collected from the first premolar encompassed 8,700 individuals (42.3% male and 57.7% female) with an average age of 42 years (Table 2), while data from the second premolar pertained to 8,839 patients (42.5% male and 57.5% female) with a mean age of 41 years (Table 3). The worldwide prevalence of multiple canal morphology for the maxillary first premolar was 93.5% [93.3%–94.7%], ranging from 71.3% in Azerbaijan

TABLE 2 - Patient Demographics and Anatomical Characteristics of the Maxillary First premolar

							Anatomic configuration						
	Demographics						Number of roots			Root canal configuration			
Region	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of males	Proportion of females	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than two canals
Argentina	159	Mixed (Hispanic and American Natives)	46 ± 14 [22--76]	74 (46.5%)	85 (53.5%)	300	96 (32.0%)	197 (65.7%)	7 (2.3%)	11 (3.7%)	200 (66.7%)	82 (27.3%)	7 (2.3%)
Australia	282	Mixed (Asians and Caucasians)	51 ± 16 [14–84]	93 (33.0%)	189 (67.0%)	300	152 (50.6%)	140 (46.7%)	8 (2.7%)	22 (7.3%)	211 (70.4%)	55 (18.3%)	12 (4.0%)
Azerbaijan	154	Mostly Caucasians	43 ± 13 [14–70]	80 (51.9%)	74 (48.1%)	300	183 (61.0%)	117 (39.0%)	0 (0%)	86 (28.7%)	123 (41.0%)	91 (30.3%)	0 (0%)
Belgium	184	Mixed (Asians, Caucasians and Africans)	51 ± 13 [15–93]	75 (40.8%)	109 (59.2%)	300	119 (39.6%)	176 (58.7%)	5 (1.7%)	7 (2.3%)	241 (80.4%)	42 (14.0%)	10 (3.3%)
Brazil	153	Mixed (Caucasians (non-hispanic) with Africans, American Natives and Asians)	40 ± 18 [13–85]	46 (30.0%)	107 (70.0%)	300	137 (45.7%)	159 (53.0%)	4 (1.3%)	18 (6.0%)	244 (81.3%)	32 (10.7%)	6 (2.0%)
Canada	157	Mixed (Caucasian, Asian and African-Canadian)	35 ± 17 [11–76]	74 (47.1%)	83 (52.9%)	300	111 (37.0%)	181 (60.3%)	8 (2.7%)	32 (10.7%)	198 (66.0%)	62 (20.6%)	8 (2.7%)
Chile	160	Mostly Caucasians (Hispanic origin)	33 ± 15 [10–65]	64 (40.0%)	96 (60.0%)	300	166 (55.3%)	120 (40.0%)	14 (4.7%)	33 (11.0%)	148 (49.3%)	105 (35.0%)	14 (4.7%)
China	300	Asians (Han ethnicity)	36 ± 11 [14–72]	141 (47.0%)	159 (53.0%)	300	187 (62.3%)	113 (37.7%)	0 (0%)	30 (10.0%)	183 (61.0%)	87 (29.0%)	0 (0%)
Colombia	251	Mostly Caucasians (Hispanic origin)	50 ± 15 [18–86]	82 (32.7%)	169 (67.3%)	300	198 (66.0%)	98 (32.7%)	4 (1.3%)	50 (16.7%)	185 (61.6%)	57 (19.0%)	8 (2.7%)
Costa Rica	151	Mostly Caucasians (Hispanic origin)	33 ± 7 [18–49]	55 (36.4%)	96 (63.6%)	300	152 (50.6%)	146 (48.7%)	2 (0.7%)	20 (6.7%)	184 (61.3%)	94 (31.3%)	2 (0.7%)

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TABLE 2 - Continued

							Anatomic configuration						
	Demographics						Number of roots			Root canal configuration			
Region	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of males	Proportion of females	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than two canals
Ecuador	151	Mostly Caucasians (Hispanic origin)	51 ± 16 [19–83]	57 (37.7%)	94 (62.3%)	300	228 (76.0%)	72 (24.0%)	0 (0%)	10 (3.3%)	102 (34.0%)	188 (62.7%)	0 (0%)
Egypt	189	Africans (Egyptians)	40 ± 14 [16–78]	72 (38.1%)	117 (61.9%)	300	150 (50.0%)	147 (49.0%)	3 (1.0%)	23 (7.7%)	187 (62.3%)	85 (28.3%)	5 (1.7%)
England	195	Mostly Caucasians	61 ± 14 [19–89]	79 (40.5%)	116 (59.5%)	300	123 (41.0%)	172 (57.3%)	5 (1.7%)	10 (3.3%)	227 (75.7%)	54 (18.0%)	9 (3.0%)
France	174	Mostly Caucasians	45 ± 16 [11–86]	80 (46.0%)	94 (54.0%)	300	120 (40.0%)	169 (56.3%)	11 (3.7%)	4 (1.3%)	206 (68.7%)	75 (25.0%)	15 (5.0%)
Germany	277	Caucasians	55 ± 15 [19–91]	122 (44.0%)	155 (56.0%)	300	110 (36.7%)	178 (59.3%)	12 (4.0%)	10 (3.3%)	233 (77.7%)	39 (13.0%)	18 (6.0%)
Greece	156	Caucasians	47 ± 16 [10–76]	77 (49.4%)	79 (50.6%)	300	160 (53.3%)	140 (46.7%)	0 (0%)	8 (2.7%)	248 (82.6%)	44 (14.7%)	0 (0%)
Hungary	200	Mostly Caucasians	44 ± 14 [13–81]	80 (40.0%)	120 (60.0%)	300	111 (37.0%)	181 (60.3%)	8 (2.7%)	6 (2.0%)	224 (74.7%)	56 (18.6%)	14 (4.7%)
Iceland	300	Mostly Caucasians	33 ± 15 [16–80]	138 (46.0%)	162 (54.0%)	300	112 (37.3%)	179 (59.7%)	9 (3.0%)	15 (5.0%)	208 (69.3%)	65 (21.7%)	12 (4.0%)
India	294	Asians (Indian origin)	39 ± 13 [21–71]	140 (47.6%)	154 (52.4%)	300	162 (54.0%)	137 (45.7%)	1 (0.3%)	4 (1.3%)	231 (77.0%)	64 (21.4%)	1 (0.3%)
Israel	179	Mixed (Jewish, Arabs and Africans)	35 ± 14 [15–64]	88 (49.2%)	91 (50.8%)	300	100 (33.3%)	192 (64.0%)	8 (2.7%)	0 (0%)	231 (77.0%)	61 (20.3%)	8 (2.7%)
Italy	155	Mostly Caucasians	30 ± 14 [14–94]	68 (43.9%)	87 (56.1%)	300	90 (30.0%)	210 (70.0%)	0 (0%)	4 (1.3%)	220 (73.4%)	76 (25.3%)	0 (0%)
Jamaica	162	Mixed (Africans, Asians and Caucasians)	30 ± 12 [16–61]	47 (29.0%)	115 (71.0%)	300	24 (8.0%)	254 (84.7%)	22 (7.3%)	13 (4.3%)	254 (84.7%)	11 (3.7%)	22 (7.3%)
Japan	300	Asians	53 ± 11 [20–87]	126 (42.0%)	174 (58.0%)	300	211 (70.3%)	89 (29.7%)	0 (0%)	63 (21.0%)	108 (36.0%)	129 (43.0%)	0 (0%)
Kuwait	175	Mixed (Asians and Caucasians)	41 ± 14 [12–78]	73 (41.7%)	102 (58.3%)	300	96 (32.0%)	194 (64.7%)	10 (3.3%)	11 (3.7%)	221 (73.6%)	57 (19.0%)	11 (3.7%)
Kyrgyzstan	185	Mostly Asians	37 ± 13 [11–77]	63 (34.1%)	122 (65.9%)	300	165 (55.0%)	127 (42.3%)	8 (2.7%)	24 (8.0%)	201 (67.0%)	66 (22.0%)	9 (3.0%)
Malaysia	263	Mostly Asians	38 ± 12 [15–77]	115 (43.7%)	148 (56.3%)	300	188 (62.7%)	112 (37.3%)	0 (0%)	65 (21.7%)	162 (54.0%)	71 (23.6%)	2 (0.7%)

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TABLE 2 - Continued

Region							Anatomic configuration						
	Demographics						Number of roots			Root canal configuration			
	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of males	Proportion of females	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than two canals
Mexico	156	Mostly Caucasians (Hispanic origin)	43 ± 14 [17–76]	56 (35.9%)	100 (64.1%)	300	131 (43.7%)	163 (54.3%)	6 (2.0%)	49 (16.3%)	163 (54.4%)	82 (27.3%)	6 (2.0%)
Nigeria	166	Africans	39 ± 14 [13–83]	81 (48.8%)	85 (51.2%)	300	69 (23.0%)	225 (75.0%)	6 (2.0%)	10 (3.3%)	245 (81.7%)	39 (13.0%)	6 (2.0%)
Pakistan	169	Asians	35 ± 10 [15–65]	81 (47.9%)	88 (52.1%)	300	130 (43.3%)	167 (55.7%)	3 (1.0%)	25 (8.3%)	214 (71.4%)	58 (19.3%)	3 (1.0%)
Paraguay	178	Mostly Caucasians (Hispanic origin)	44 ± 12 [13–81]	71 (39.9%)	107 (60.1%)	300	179 (59.6%)	107 (35.7%)	14 (4.7%)	11 (3.7%)	190 (63.3%)	79 (26.3%)	20 (6.7%)
Peru	167	Mixed (Hispanic origin and American Natives)	34 ± 12 [16–71]	70 (41.9%)	97 (58.1%)	300	214 (71.3%)	84 (28.0%)	2 (0.7%)	79 (26.3%)	98 (32.7%)	121 (40.3%)	2 (0.7%)
Portugal	191	Mostly Caucasians	50 ± 12 [19–86]	63 (33.0%)	128 (67.0%)	300	136 (45.3%)	158 (52.7%)	6 (2.0%)	11 (3.7%)	229 (76.3%)	49 (16.3%)	11 (3.7%)
Romania	207	Mostly Caucasians	39 ± 13 [12–86]	88 (42.5%)	119 (57.5%)	300	116 (38.7%)	170 (56.6%)	14 (4.7%)	9 (3.0%)	214 (71.3%)	63 (21.0%)	14 (4.7%)
Russia	156	Mixed (Russians, Ukrainians, Tatars, Bashkirs, Jews, Belarusians and Kazakh)	34 ± 9 [12–73]	59 (37.8%)	97 (62.2%)	300	15 (5.0%)	279 (93.0%)	6 (2.0%)	7 (2.3%)	283 (94.4%)	4 (1.3%)	6 (2.0%)
Saudi Arabia	171	Mostly Arabs	35 ± 14 [18–72]	73 (42.7%)	98 (57.3%)	300	131 (43.7%)	161 (53.6%)	8 (2.7%)	15 (5.0%)	199 (66.4%)	76 (25.3%)	10 (3.3%)
South Africa	168	Mixed (Asians of Indian origin, Caucasians and Africans)	45 ± 14 [11–92]	84 (50.0%)	84 (50.0%)	300	101 (33.7%)	193 (64.3%)	6 (2.0%)	7 (2.3%)	233 (77.7%)	54 (18.0%)	6 (2.0%)
South Korea	300	Asians	34 ± 12 [12–84]	163 (54.3%)	137 (45.7%)	300	219 (73.0%)	81 (27.0%)	0 (0%)	35 (11.7%)	143 (47.6%)	122 (40.7%)	0 (0%)
Spain	152	Caucasians	40 ± 13 [15–87]	71 (46.7%)	81 (53.3%)	300	106 (35.3%)	176 (58.7%)	18 (6.0%)	4 (1.3%)	224 (74.7%)	54 (18.0%)	18 (6.0%)

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TABLE 2 - Continued

Region	Demographics						Anatomic configuration						
							Number of roots			Root canal configuration			
	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of males	Proportion of females	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than two canals
Syria	152	Arabs	41 ± 12 [16–74]	68 (44.7%)	84 (55.3%)	300	200 (66.7%)	90 (30.0%)	10 (3.3%)	21 (7.0%)	120 (40.0%)	149 (49.7%)	10 (3.3%)
Thailand	204	Asians	44 ± 11 [12–82]	73 (35.8%)	131 (64.2%)	300	167 (55.7%)	130 (43.3%)	3 (1.0%)	24 (8.0%)	157 (52.4%)	115 (38.3%)	4 (1.3%)
Turkey	185	Mostly Caucasians	32 ± 11 [14–68]	79 (42.7%)	106 (57.3%)	300	124 (41.3%)	161 (53.7%)	15 (5.0%)	10 (3.3%)	211 (70.4%)	63 (21.0%)	16 (5.3%)
Uruguay	184	Mixed (Hispanic origin and Africans)	45 ± 12 [11–79]	78 (42.4%)	106 (57.6%)	300	65 (21.7%)	223 (74.3%)	12 (4.0%)	3 (1.0%)	234 (78.0%)	54 (18.0%)	9 (3.0%)
USA	259	Mostly Caucasians	54 ± 10 [12–92]	116 (44.8%)	143 (55.2%)	300	158 (52.7%)	135 (45.0%)	7 (2.3%)	18 (6.0%)	206 (68.7%)	66 (22.0%)	10 (3.3%)
Venezuela	229	Mostly Caucasians (Hispanic origin)	45 ± 12 [11–81]	99 (43.2%)	130 (56.8%)	300	140 (46.7%)	150 (50.0%)	10 (3.3%)	18 (6.0%)	201 (67.0%)	69 (23.0%)	12 (4.0%)
Total	8,700	Multi-ethnic	42 ± 13 [10–93]	3682 (42.3%)	5018 (57.7%)	13.200	6052 (45.9%)	6853 (51.9%)	295 (2.2%)	935 (7.1%)	8744 (66.2%)	3165 (24.0%)	356 (2.7%)

(66.2%–76.5%) to 100% in Israel (99.4%–100.3%). For the second premolar, the worldwide proportion was calculated to be 49.7% (44.9%–54.6%), varying from 15.3% in Peru (11.3%–19.4%) to 79.3% in Nigeria (74.8%–83.9%) (Figure 2 and Supplemental Fig. S1A). The worldwide prevalence of 3-rooted configuration in the first and second premolars was 1.8% (1.4%–2.1%) and 0.4% (0.3%–0.5%) ($P < .05$), respectively, with the highest prevalence recorded in Jamaica for both the first (7.3% [4.4%–10.3%]) and second (3.7% [1.5%–5.8%]) premolars (Figure 3 and Supplemental Fig. S1B). In the first premolar, the prevailing root and root canal configurations encompassed the 2-rooted configuration (51.9%) and two independent canals (multiple exits) (66.2%), whereas the second premolar predominantly displayed single-rooted (87.1%) and a single-canal (50.3%) morphologies (Tables 2 and 3).

Geographic Region

The conducted meta-analysis indicated statistically significant variations among geographic regions for several outcomes ($P < .05$). The analyses of the root canal anatomy of maxillary first premolar showed that Asia exhibited the lowest proportion of multiple canal morphology (88.4% [83.3%–93.5%]), whereas Europe displayed the highest proportion (97.6% [97.0%–98.2%]) (Supplemental Fig. S2A). A comparable trend was noted when examining 3-root canal morphology in this group of teeth, albeit with significantly lower overall proportions for Asia (0.6% [0.1%–1.1%]) and for Europe (3.6% [2.3%–4.8%]) (Supplemental Fig. S2C). In the maxillary second premolar, the lowest prevalence for both multiple canal morphology and 3-root canal morphology was also noted in Asia with 41.2% [35.4%–47.1%] and 0.3% [0.1%–0.5%], respectively (Supplemental Fig. S2B and S2D). The root morphology evaluation of the maxillary first premolar indicated that Asia exhibited the lowest percentages of 3-rooted configuration (0.4% [0%–0.8%]), whereas Europe (2.5% [1.6%–3.5%]) and Oceania (2.7% [0.8%–4.5%]) displayed the highest proportions (Supplemental Fig. S3C). Africa (35.5% [20.2%–50.8%]) and Europe (39.6% [36.4%–42.8%]) had the lowest scores for the single-rooted morphology, while Asia (54.8% [29.5%–80.1%]) had the highest ones (Supplemental Fig. S3A). A comparable pattern in root morphology was observed for the second premolar (Supplemental Fig. S3B and 3D). Figure 4 illustrates the worldwide distribution of the single-rooted morphology.

TABLE 3 - Patient Demographics and Anatomical Characteristics of the Maxillary Second Premolar

	Demographics						Anatomic configuration						
							Number of roots			Root canal configuration			
Region	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of males	Proportion of females	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than two canals
Argentina	160	Mixed (Hispanic and American Natives)	46 ± 14 [22–76]	78 (48.8%)	82 (51.2%)	300	273 (91.0%)	27 (9.0%)	0 (0%)	226 (75.3%)	35 (11.7%)	39 (13.0%)	0 (0%)
Australia	290	Mixed (Asians and Caucasians)	52 ± 16 [14–88]	115 (39.7%)	175 (60.3%)	300	276 (92.0%)	21 (7.0%)	3 (1.0%)	158 (52.7%)	61 (20.3%)	76 (25.3%)	5 (1.7%)
Azerbaijan	154	Mostly Caucasians	43 ± 13 [14–70]	82 (53.2%)	72 (46.8%)	300	172 (57.3%)	128 (42.7%)	0 (0%)	62 (20.7%)	148 (49.3%)	90 (30.0%)	0 (0%)
Belgium	197	Mixed (Asians, Caucasians and Africans)	51 ± 13 [15–93]	78 (39.6%)	119 (60.4%)	300	266 (88.7%)	34 (11.3%)	0 (0%)	130 (43.3%)	100 (33.3%)	68 (22.7%)	2 (0.7%)
Brazil	153	Mixed (Caucasians (non-hispanic) with Africans, American Natives and Asians)	40 ± 18 [13–85]	47 (30.7%)	106 (69.3%)	300	254 (84.7%)	45 (15.0%)	1 (0.3%)	166 (55.4%)	97 (32.3%)	34 (11.3%)	3 (1.0%)
Canada	158	Mixed (Caucasian, Asian and African-Canadian)	35 ± 16 [11–74]	74 (46.8%)	84 (53.2%)	300	237 (79.0%)	60 (20.0%)	3 (1.0%)	197 (65.7%)	61 (20.3%)	39 (13.0%)	3 (1.0%)
Chile	165	Mostly Caucasians (Hispanic origin)	33 ± 15 [11–72]	72 (43.6%)	93 (56.4%)	300	276 (92.0%)	19 (6.3%)	5 (1.7%)	188 (62.7%)	43 (14.3%)	64 (21.3%)	5 (1.7%)
China	300	Asians (Han ethnicity)	36 ± 12 [14–78]	141 (47.0%)	159 (53.0%)	300	292 (97.3%)	8 (2.7%)	0 (0%)	175 (58.4%)	46 (15.3%)	79 (26.3%)	0 (0%)
Colombia	249	Mostly Caucasians (Hispanic origin)	47 ± 14 [18–84]	90 (36.1%)	159 (63.9%)	300	288 (96.0%)	12 (4.0%)	0 (0%)	212 (70.7%)	53 (17.7%)	35 (11.6%)	0 (0%)
Costa Rica	157	Mostly Caucasians	33 ± 7 [18–49]	57 (36.3%)	100 (63.7%)	300	284 (94.7%)	16 (5.3%)	0 (0%)	182 (60.7%)	40 (13.3%)	78 (26.0%)	0 (0%)

(*continued on next page*)

TABLE 3 - Continued

Region	Demographics: Sample size (patients)	Demographics: Ethnic groups	Demographics: Age in years (mean ± SD) [range]	Demographics: Proportion of males	Demographics: Proportion of females	Sample size (teeth)	Anatomic configuration – Number of roots: One root	Number of roots: Two roots	Number of roots: Three roots	Root canal configuration: Single canal	Root canal configuration: Two independent canals (multiple exits)	Root canal configuration: Two confluent canals (single exit)	Root canal configuration: More than two canals
		(Hispanic origin)											
Ecuador	152	Mostly Caucasians (Hispanic origin)	50 ± 16 [19–83]	60 (39.5%)	92 (60.5%)	300	291 (97.0%)	9 (3.0%)	0 (0%)	93 (31.0%)	21 (7.0%)	186 (62.0%)	0 (0%)
Egypt	191	Africans (Egyptians)	40 ± 14 [16–82]	70 (36.6%)	121 (63.4%)	300	255 (85.0%)	44 (14.7%)	1 (0.3%)	114 (38.0%)	57 (19.0%)	127 (42.3%)	2 (0.7%)
England	200	Mostly Caucasians	61 ± 14 [19–89]	80 (40.0%)	120 (60.0%)	300	273 (91.0%)	27 (9.0%)	0 (0%)	156 (52.0%)	72 (24.0%)	71 (23.7%)	1 (0.3%)
France	184	Mostly Caucasians	45 ± 16 [11–86]	83 (45.1%)	101 (54.9%)	300	251 (83.6%)	41 (13.7%)	8 (2.7%)	118 (39.3%)	83 (27.7%)	89 (29.7%)	10 (3.3%)
Germany	278	Caucasians	54 ± 14 [19–89]	121 (43.5%)	157 (56.5%)	300	257 (85.6%)	41 (13.7%)	2 (0.7%)	127 (42.3%)	101 (33.7%)	69 (23.0%)	3 (1.0%)
Greece	155	Caucasians	47 ± 17 [10–86]	75 (48.4%)	80 (51.6%)	300	288 (96.0%)	12 (4.0%)	0 (0%)	177 (59.0%)	42 (14.0%)	81 (27.0%)	0 (0%)
Hungary	209	Mostly Caucasians	44 ± 14 [13–81]	89 (42.6%)	120 (57.4%)	300	264 (88.0%)	32 (10.7%)	4 (1.3%)	137 (45.6%)	69 (23.0%)	86 (28.7%)	8 (2.7%)
Iceland	300	Mostly Caucasians	33 ± 15 [16–80]	138 (46.0%)	162 (54.0%)	300	262 (87.3%)	36 (12.0%)	2 (0.7%)	154 (51.3%)	71 (23.7%)	71 (23.7%)	4 (1.3%)
India	293	Asians (Indian origin)	39 ± 13 [21–71]	139 (47.4%)	154 (52.6%)	300	266 (88.7%)	34 (11.3%)	0 (0%)	148 (49.3%)	144 (48.0%)	8 (2.7%)	0 (0%)
Israel	184	Mixed (Jewish, Arabs and Africans)	35 ± 14 [15–64]	91 (49.5%)	93 (50.5%)	300	279 (93.0%)	14 (4.7%)	7 (2.3%)	80 (26.7%)	85 (28.3%)	128 (42.7%)	7 (2.3%)
Italy	160	Mostly Caucasians	30 ± 14 [14–93]	68 (42.5%)	92 (57.5%)	300	236 (78.7%)	64 (21.3%)	0 (0%)	82 (27.3%)	100 (33.3%)	118 (39.4%)	0 (0%)
Jamaica	170	Mixed (Africans, Asians and Caucasians)	30 ± 12 [16–61]	46 (27.1%)	124 (72.9%)	300	123 (41.0%)	166 (55.3%)	11 (3.7%)	76 (25.3%)	168 (56.0%)	45 (15.0%)	11 (3.7%)
Japan	300	Asians	53 ± 11 [20–87]	126 (42.0%)	174 (58.0%)	300	287 (95.7%)	13 (4.3%)	0 (0%)	201 (67.0%)	26 (8.7%)	73 (24.3%)	0 (0%)
Kuwait	186		41 ± 14 [12–78]	73 (39.2%)	113 (60.8%)	300	247 (82.4%)	49 (16.3%)	4 (1.3%)	111 (37.0%)	80 (26.7%)	104 (34.6%)	5 (1.7%)

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TABLE 3 - Continued

Region	Demographics: Sample size (patients)	Demographics: Ethnic groups	Demographics: Age in years (mean ± SD) [range]	Demographics: Proportion of males	Demographics: Proportion of females	Sample size (teeth)	Anatomic configuration: Number of roots: One root	Number of roots: Two roots	Number of roots: Three roots	Root canal configuration: Single canal	Root canal configuration: Two independent canals (multiple exits)	Root canal configuration: Two confluent canals (single exit)	Root canal configuration: More than two canals
		Mixed (Asians and Caucasians)											
Kyrgyzstan	192	Mostly Asians	36 ± 13 [11–79]	67 (34.9%)	125 (65.1%)	300	277 (92.4%)	22 (7.3%)	1 (0.3%)	159 (53.0%)	68 (22.7%)	71 (23.6%)	2 (0.7%)
Malaysia	264	Mostly Asians	38 ± 12 [15–77]	118 (44.7%)	146 (55.3%)	300	289 (96.3%)	11 (3.7%)	0 (0%)	213 (71.0%)	31 (10.3%)	54 (18.0%)	2 (0.7%)
Mexico	154	Mostly Caucasians (Hispanic origin)	43 ± 14 [17–76]	52 (33.8%)	102 (66.2%)	300	256 (85.3%)	38 (12.7%)	6 (2.0%)	209 (69.7%)	46 (15.3%)	39 (13.0%)	6 (2.0%)
Nigeria	164	Africans	39 ± 14 [13–83]	82 (50.0%)	82 (50.0%)	300	163 (54.4%)	133 (44.3%)	4 (1.3%)	62 (20.7%)	173 (57.7%)	61 (20.3%)	4 (1.3%)
Pakistan	172	Asians	35 ± 10 [15–65]	85 (49.4%)	87 (50.6%)	300	262 (87.3%)	36 (12.0%)	2 (0.7%)	135 (45.0%)	71 (23.7%)	92 (30.6%)	2 (0.7%)
Paraguay	186	Mostly Caucasians (Hispanic origin)	43 ± 11 [13–85]	75 (40.3%)	111 (59.7%)	300	275 (91.7%)	24 (8.0%)	1 (0.3%)	144 (48.0%)	85 (28.4%)	67 (22.3%)	4 (1.3%)
Peru	165	Mixed (Hispanic origin and American Natives)	32 ± 12 [16–71]	65 (39.4%)	100 (60.6%)	300	290 (96.7%)	10 (3.3%)	0 (0%)	254 (84.7%)	15 (5.0%)	31 (10.3%)	0 (0%)
Portugal	192	Mostly Caucasians	49 ± 12 [19–82]	67 (34.9%)	125 (65.1%)	300	282 (94.0%)	18 (6.0%)	0 (0%)	114 (38.0%)	94 (31.3%)	92 (30.7%)	0 (0%)
Romania	208	Mostly Caucasians	39 ± 13 [12–86]	76 (36.5%)	132 (63.5%)	300	269 (89.7%)	28 (9.3%)	3 (1.0%)	121 (40.3%)	72 (24.0%)	104 (34.7%)	3 (1.0%)
Russia	157	Mixed (Russians, Ukrainians, Tatars, Bashkirs, Jews, Belarusians and Kazakh)	32 ± 9 [12–73]	58 (36.9%)	99 (63.1%)	300	272 (90.7%)	25 (8.3%)	3 (1.0%)	170 (56.7%)	73 (24.3%)	53 (17.7%)	4 (1.3%)
Saudi Arabia	175	Mostly Arabs	35 ± 14 [16–72]	81 (46.3%)	94 (53.7%)	300	270 (90.0%)	28 (9.3%)	2 (0.7%)	180 (60.0%)	53 (17.6%)	65 (21.7%)	2 (0.7%)

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TABLE 3 - Continued

	Demographics						Anatomic configuration: Number of roots			Anatomic configuration: Root canal configuration			
Region	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of males	Proportion of females	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than two canals
South Africa	175	Mixed (Asians of Indian origin, Caucasians and Africans)	43 ± 14 [11–92]	82 (46.9%)	93 (53.1%)	300	238 (79.3%)	56 (18.7%)	6 (2.0%)	111 (37.0%)	99 (33.0%)	83 (27.7%)	7 (2.3%)
South Korea	300	Asians	34 ± 12 [12–84]	163 (54.3%)	137 (45.7%)	300	289 (96.3%)	11 (3.7%)	0 (0%)	167 (55.7%)	27 (9.0%)	106 (35.3%)	0 (0%)
Spain	152	Caucasians	40 ± 13 [15–87]	71 (46.7%)	81 (53.3%)	300	256 (85.3%)	42 (14.0%)	2 (0.7%)	144 (48.0%)	64 (21.4%)	88 (29.3%)	4 (1.3%)
Syria	151	Arabs	41 ± 12 [16–74]	69 (45.7%)	82 (54.3%)	300	279 (93.0%)	21 (7.0%)	0 (0%)	205 (68.4%)	29 (9.6%)	66 (22.0%)	0 (0%)
Thailand	208	Asians	44 ± 11 [12–82]	74 (35.6%)	134 (64.4%)	300	274 (91.3%)	26 (8.7%)	0 (0%)	148 (49.3%)	45 (15.0%)	105 (35.0%)	2 (0.7%)
Turkey	181	Mostly Caucasians	31 ± 11 [14–68]	75 (41.4%)	106 (58.6%)	300	254 (84.7%)	43 (14.3%)	3 (1.0%)	147 (49.0%)	75 (25.0%)	71 (23.7%)	7 (2.3%)
Uruguay	193	Mixed (Hispanic origin and Africans)	45 ± 12 [11–79]	86 (44.6%)	107 (55.4%)	300	249 (83.0%)	47 (15.7%)	4 (1.3%)	117 (39.0%)	75 (25.0%)	104 (34.7%)	4 (1.3%)
USA	265	Mostly Caucasians	55 ± 10 [12–92]	118 (44.5%)	147 (55.5%)	300	284 (94.7%)	12 (4.0%)	4 (1.3%)	170 (56.7%)	55 (18.3%)	69 (23.0%)	6 (2.0%)
Venezuela	240	Mostly Caucasians (Hispanic origin)	44 ± 13 [12–85]	100 (41.7%)	140 (58.3%)	300	276 (92.0%)	23 (7.7%)	1 (0.3%)	196 (65.3%)	56 (18.7%)	46 (15.3%)	2 (0.7%)
Total	8839	Multiethnic	41 ± 13 [10–93]	3757 (42.5%)	5082 (57.5%)	13.200	11501 (87.1%)	1606 (12.2%)	93 (0.7%)	6636 (50.3%)	3109 (23.5%)	3325 (25.2%)	130 (1.0%)

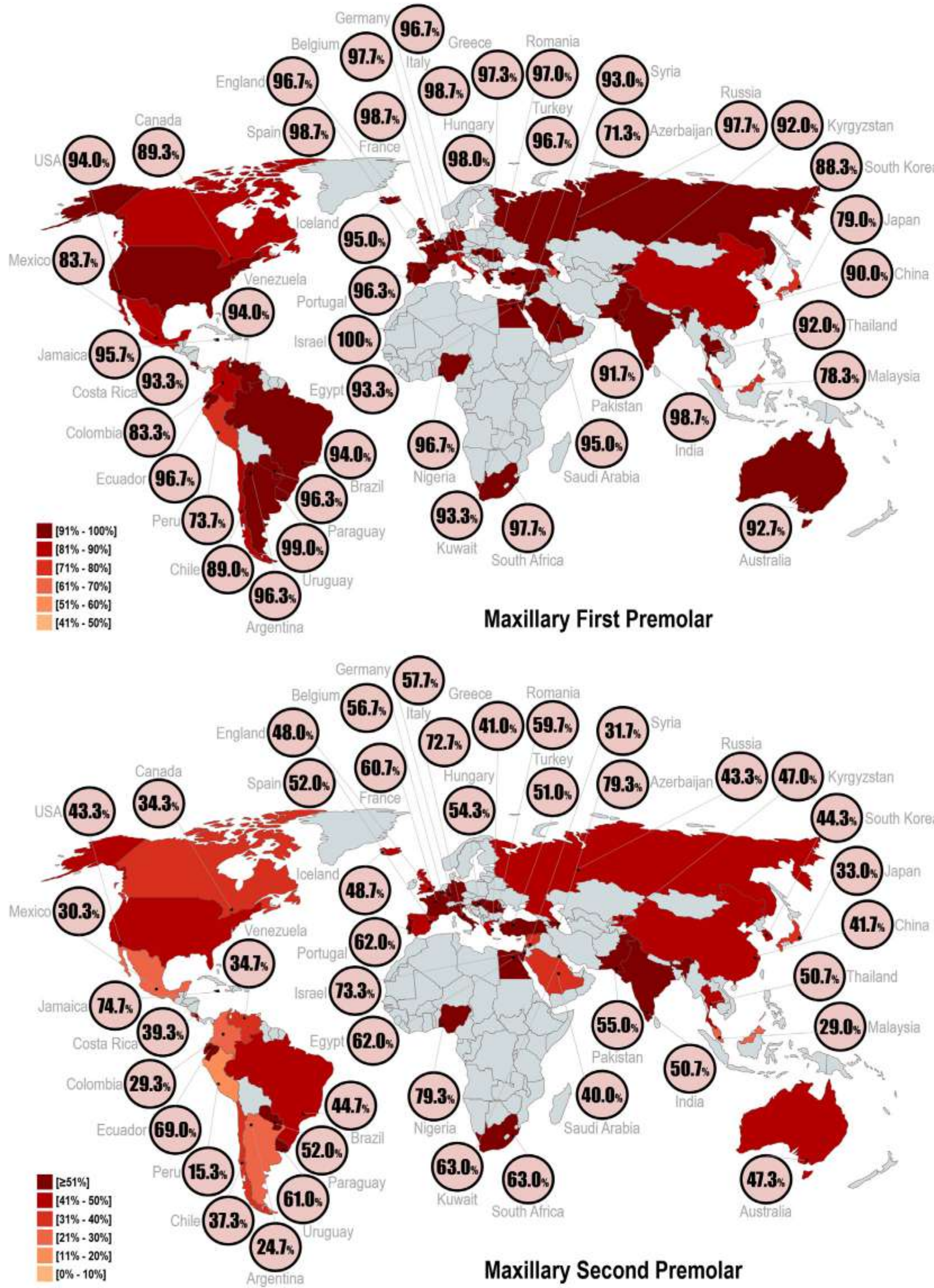

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FIGURE 2 – Worldwide prevalence of multiple canal morphologies (primary outcome) in maxillary first (top) and second (bottom) premolars. The color gradient indicates the relative occurrence of the findings. An observable trend across both teeth depicts lower percentages in Asian countries and higher percentages in African and European countries.

Ethnicity

The statistical analyses revealed significant differences among ethnic groups concerning root and root canal anatomy for both maxillary premolars ($P < .05$). In terms of canal morphology, the Asian (87.6% [83.8%–91.4%]) and Hispanic (91.2% [87.6%–94.8%]) groups displayed the lowest proportions of multiple canals in first premolars. For second premolars, the lowest percentages of multiple canals were not only observed in the Asian (42.9% [35.9%–49.9%]) and Hispanic (41.7% [31.0%–52.4%]) groups but were also present in patients of Arabian ethnicity (35.8% [27.6%–44.0%]). In contrast, ethnicities such as Caucasians, Africans, and Indians exhibited higher prevalence rates of multiple canal morphology, reaching 98.7% for the first premolar (Indians) and 70.7% for the second premolar (Africans) (Supplemental Fig. S4A and B). The lowest prevalence of 3-root canal

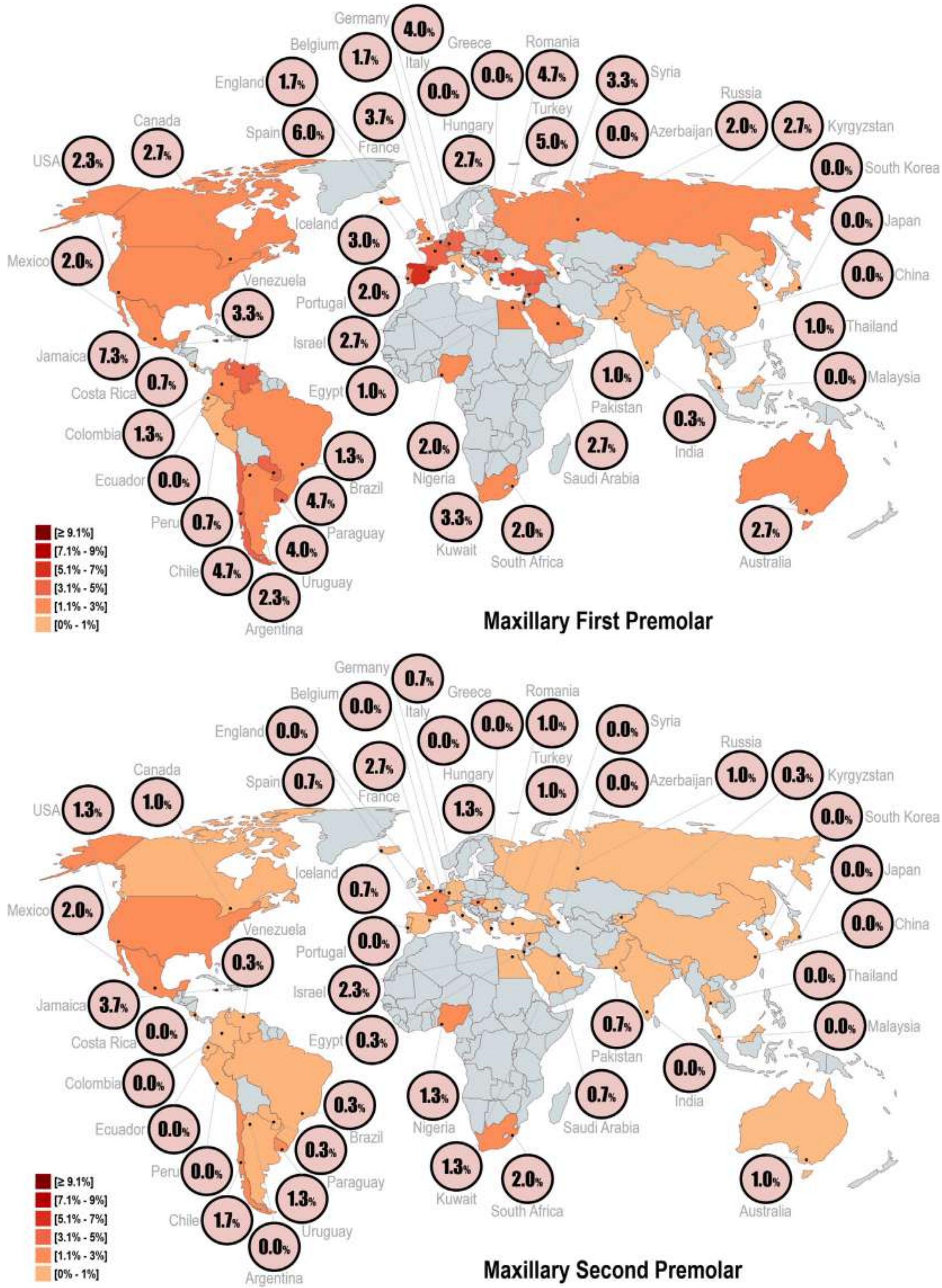

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FIGURE 3 – Worldwide prevalence of 3-rooted configuration (primary outcome) in maxillary first (top) and second (bottom) premolars. For the first premolar, higher proportions were observed in European, Oceania, and American countries, whereas lower percentages were noted in Asian countries. No distinct trend was evident in the second premolar.

morphology in the maxillary first premolar was noted in Indians (0.3% [0%–1.0%]) and Asians (0.5% [0.1%–0.9%]), in contrast to the highest prevalence observed in Caucasians (3.1% [2.1%–4.1%]) and Arabs (3.3% [1.9%–4.8%]) (Supplemental Fig. S4C). There were no significant differences among ethnic groups regarding the prevalence of 3-root canal morphology in the second premolar ($P > .05$) (Supplemental Fig. S4D). Regarding the 3-rooted configuration in the first premolar, the lowest proportion (0.3%) was observed in Asians and Indians, while the highest was observed in Caucasians (2.3% [1.5%–3.1%]) and Arabs (3.0% [1.6%–4.3%]) (Supplemental Fig. S5C). No statistically significant difference among groups was observed for the second premolar ($P > .05$) (Supplemental Fig. S5D). The African ethnicity showed the lowest proportions of single-rooted morphology for both premolars, while

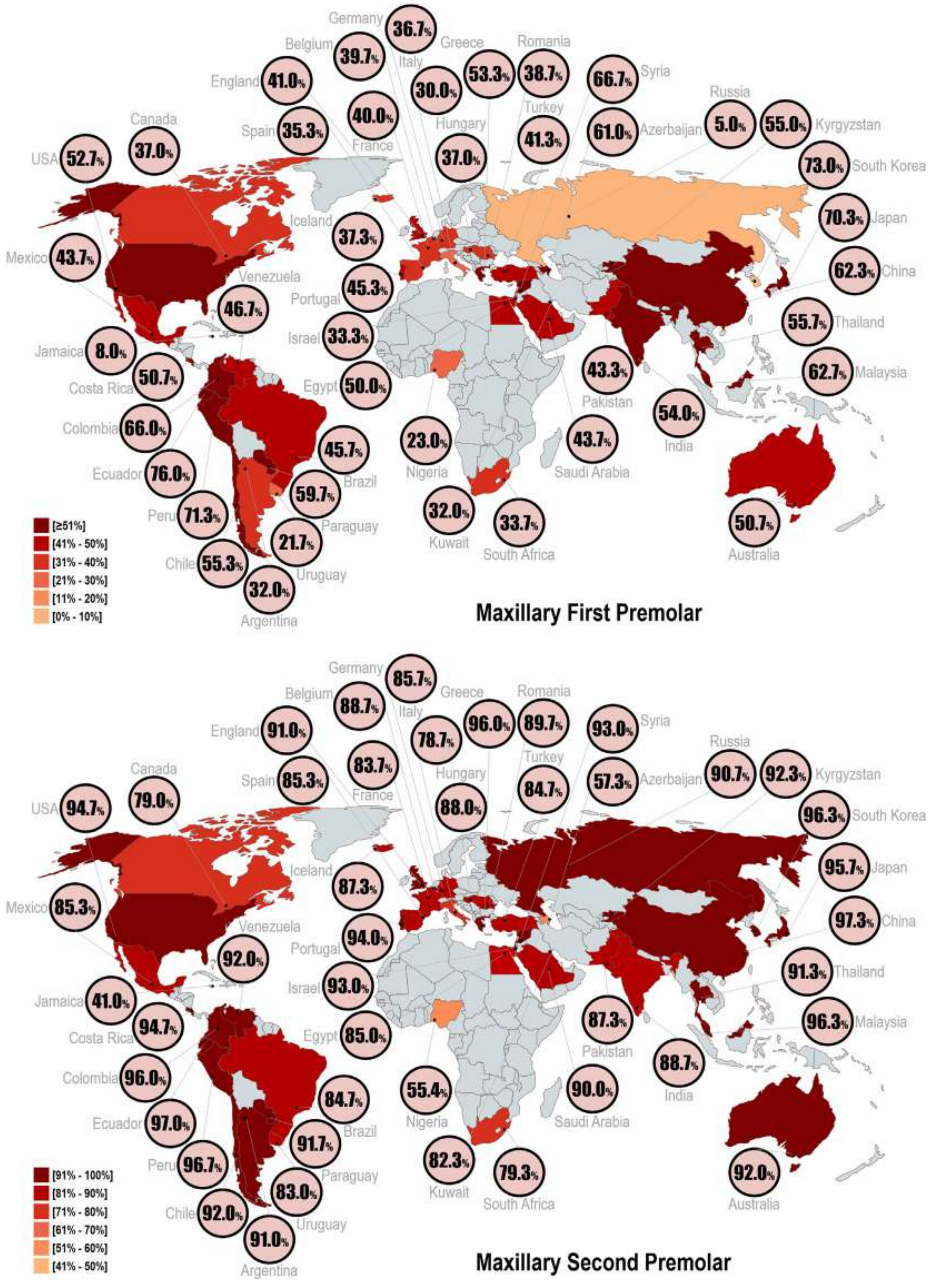

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FIGURE 4 – Worldwide prevalence of single-rooted configuration (secondary outcome) in maxillary first (top) and second (bottom) premolars. Asian countries showed a trend toward higher percentages in both groups of teeth.

Asians had the highest scores (Supplemental Fig. S5A and B).

Sex

The forest plot analyses revealed that, in the first maxillary premolar, males had significantly higher percentages of multiple canal morphology (male: 96.2% [95.4%–97.1%]; female: 92.6% [91.2%–94.0%]) and 3-rooted configuration (male: 2.4% [1.8%–3.0%]; female: 0.9% [0.6%–1.1%]) ($P < .05$) (Supplemental Figs. S6A and S7A), while no difference was observed in the second premolar ($P > .05$) (Supplemental Figs. S6B and S7B). Nonetheless, in both groups of teeth, males exhibited significantly higher odds ($P < .05$) of displaying multiple canals (first premolar: 1.542 [1.252–1.900]; second premolar: 1.436 [1.295–

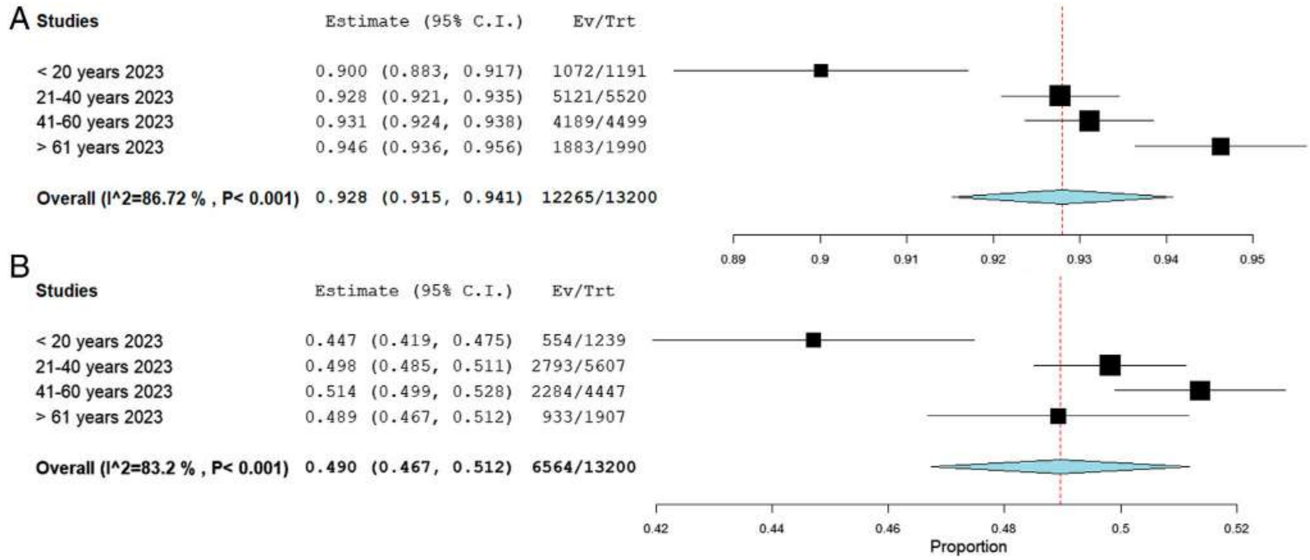

FIGURE 5 – Forest plot graphs that compares the proportions of multiple canal morphology (primary outcome) in maxillary first (*A*) and second (*B*) premolars among patients of varying ages. An observable trend indicates lower percentages among younger individuals and higher percentages among older individuals for both premolars.

1.592]) and 3-rooted configuration (first premolar: 2.254 [1.754–2.896]; second premolar: 2.268 [1.498–3.433]) (Supplemental Fig. S6C, D and S7C, D).

Age

The meta-analysis was tested only for multiple canal morphology, since the number of root are not supposed to change with aging, and revealed that younger patients (<20 years) exhibited lower proportions in comparison to older patients in both first (<20 years: 90.0% [88.3%–91.7%] vs > 61 years: 94.6% [93.6%–95.6%]) and second (<20 years: 44.7% [41.9%–47.5%] vs 41–60 years: 51.4% [49.9%–52.8%]) premolars ($P < .05$) (Fig. 5A and B).

Side

The prevalence of multiple canal morphology and 3-rooted configuration was similar between sides ($P > .05$) (Supplemental Fig. S8).

Voxel Size and FOV

A metaregression was conducted to explore the potential impact of different voxel sizes and FOVs on the outcomes using global data. The Omnibus *P* values indicated that these variables were not likely sources of heterogeneity in results for both the first premolar (multiple canals: 0.916 [voxel] and 0.545 [FOV]; 3-root canals: 0.154 [voxel] and 0.907 [FOV]; 3-roots: 0.154 [voxel] and 0.749 [FOV]; single-root: 0.213 [voxel] and 0.608 [FOV]) and the second premolar (multiple canals: 0.380 [voxel] and 0.961 [FOV]; 3-root canals: 0.458 [voxel] and 0.523 [FOV]; 3-roots: 0.606 [voxel] and 0.751 [FOV]; single-root: 0.481 [voxel] and 0.378 [FOV]) (Supplemental Figs. S9 and S10).

Reliability

The assessments of individual intrarater reliability and external observer consensus yielded substantial to perfect agreement results, ranging from 0.625 to 1.000. In terms of group evaluation, the interrater test result reached almost perfect agreement at 0.863, with an agreement percentage of 97.3%. The occurrences of datasheet nonconformities ranged from 0% to 2.78% (Supplemental Table S1).

DISCUSSION

Experimental research offers ideal conditions to establish causal relationships between interventions and specific outcomes of interest. Nevertheless, the highly selective nature of participants in such studies might not fully encompass the inherent variability within the broader population[13]. Apart from investigations that contrast interventions under distinct root canal morphologies[6], the conventional approach for examining root and root canal anatomy relies on observational studies employing either *in vivo* or *ex vivo* methods. While observational *ex vivo* approaches, which involve methodologies like tooth sectioning and micro-CT scanning[14], enable the acquisition of morphological and morphometric insights into particular anatomical features of the root canal system[15], they share the same inherent limitations as experimental studies, influenced by factors such as the circumstances behind tooth extraction or the selection criteria target toward specific anatomical characteristics. As a result, the chosen samples might not accurately represent the spectrum of tooth specimens found within the studied population. This situation has prompted researchers, academics, and clinicians to explore a more practical approach, seeking real-world evidence[13]. While a universally agreed-upon definition of real-world data remains elusive, a prevailing perspective among researchers is that it involves observational evaluations conducted within a noninterventional/noncontrolled context of health conditions, largely sourced from extensive electronic health records, health databases, or patient records[13]. These data are routinely collected, ultimately contributing to clinical evidence rooted in real-world scenarios. The primary objective of the present investigation was to examine the root and root canal anatomy of maxillary premolars from a real-world data perspective, aiming to understand the impact of some demographic aspects on outcomes within real-world scenarios. As demonstrated in previous studies[7,10], certain demographic factors can impact dental morphology within specific boundaries, a trend analogous to other nondental anatomical traits[16-18]. This study reveals that the root and root canal anatomy of maxillary premolars display variations linked to geographic region, ethnicity, gender, and age, thereby refuting the null hypothesis associated with these variables.

The analysis of the geographic regions revealed a consistent pattern of fewer roots and root canals in Asia, whereas European and African nations exhibited a higher prevalence for both premolars (Supplemental Figs. S2 and S3). Remarkably, there is a lack of information concerning the worldwide prevalence of these specific anatomical features, particularly when employing the same range of CBCT resolution (200 μm or less) as in this study[4]. Current findings from China demonstrate lower prevalence of multiple root configurations in maxillary premolars (37.7%), corroborating a previous publication that reported percentages of 16.8%[19] and 30.3%[20,21]. Similarly, the higher proportions of this morphological feature across European nations (60.4%) align with prior investigations in Portugal (51.2%)[22] and Germany (63.6%)[23]. Notably, the outcomes for multiple root configuration in Brazil appear to be intermediate, as the current result (54.3%) closely mirror a previous report (55.9%)[24]. Concerning multiple canal morphology, existing research has presented diverse prevalence rates, ranging from 54% in Spain[25] to 87.8%[19] and 88.2%[21] in China, as well as 90.4% in Germany[23] and 96.6% in Portugal[22]. Except for Spain, the results reported in the literature align with the present findings.

The current study introduces data from 39 additional countries unexplored in a previous comprehensive systematic review on the anatomy of maxillary premolars assessed by CBCT imaging[4]. Thus, notwithstanding this new information clearly contribute to the topic, it also precludes direct comparisons with earlier findings. The collective outcomes from the 44 countries exhibit a remarkable consistency within their respective geographic regions, even though a few divergent results may be noted as the higher proportions of 3-rooted configuration in Jamaica (Supplemental Fig. S3C and S3D). This outcome could stem from potential deviations in observer interpretations of the standard anatomical definition, or it might indeed reflect genuine variations due to potential ethnic characteristics within a population limited to this Caribbean island. The absence of preceding published data avoids the comparison of these divergent results with prior studies, underscoring the necessity for further research.

The number of roots of maxillary premolars has been recognized as a relevant anthropological trait[26]. According to Schroer & Wood[27], the number of roots in these teeth has diminished among modern humans, leading to predominantly single-rooted forms and occasionally two- or even three-rooted morphologies in the first premolar, while the second premolar tends to exhibit single-rooted anatomy[28]. For the purpose of comparison, premolars from Australopithecus, an extinct genus of hominids that lived approximately 4.2–1.95 million years ago, typically exhibited two-rooted morphologies and occasionally displayed 3-rooted configurations[27]. The Australopithecus genus is significant in the study of human evolution because it is believed to be an early ancestor of modern humans. Australopithecus species, such as *Australopithecus afarensis* (famous for the "Lucy" fossil), had a combination of ape-like and human-like characteristics. They were bipedal and exhibited some evidence of tool use, which suggests a transition toward more human-like behaviors[27]. Evidence from early Homo supports the notion that certain modern human traits related to cuspid teeth, such as reduced crown sizes and a decrease in the number of roots, emerged relatively later in the evolutionary timeline of the human species[27].

A significant milestone in human evolution could be linked to specific crown and root traits evident in specimens from different time periods or even particular modern ethnic groups. This event corresponds to the emergence of agriculture, signifying the transition from the Paleolithic to the Neolithic era, occurring around 10,000 BC. Despite inconclusive genetic evidence concerning the extent of Paleolithic lineage in European DNA[29], certain studies suggest that the genetic diversity in modern European individuals predominantly stems from the Paleolithic era, with the Neolithic influence accounting for no more than 23.0%[29,30]. This dynamic could signify a blend of demic diffusion, involving the migration of populations, and cultural diffusion, encompassing the transmission of knowledge, stemming from early farming communities originating from Anatolia (now Turkey). This phenomenon fostered the expansion of agriculture into Europe while concurrently retaining elements of their previous genetic pool tied to hunting and gathering practices. Conversely, East Asia emerged as a notable center for the origin of agriculture, with evidence of human activity dating back to the Paleolithic era. Nevertheless, a more substantial migration of humans during the Neolithic period has been suggested, possibly facilitating the spread of agricultural practices throughout the region[31]. The shift in dietary practices, transitioning from Paleolithic hunting and gathering to Neolithic farming, is likely accountable for distinct morphological patterns in cuspid teeth. This transformation might underlie the previously noted smaller crown sizes and reduced root numbers among populations exhibiting a stronger Neolithic genetic heritage. This phenomenon could elucidate the higher prevalence of single-rooted morphologies in both premolars (and correspondingly fewer root canals) in Asians, as well as the increased root numbers (and consequently more root canals) in Europeans. As a footnote, the migration of Neolithic populations back to Africa could have contributed to intriguing diversities. This might have prompted Neolithic humans to preferentially settle in areas like present-day Egypt, drawn by the Nile river valleys and their proximity to Anatolia. Conversely, challenges in establishing settlements in sub-Saharan regions may partly account for the higher prevalence of single-rooted configurations observed in Egypt, as compared to Nigeria and South Africa, in the current study. These countries have a greater influence of Paleolithic lineage, as the introduction of agriculture occurred primarily through cultural diffusion[32]. The outcomes for single-rooted configurations in the Americas and Oceania appear to bear a resemblance to the Asian results, possibly due to the shared migration routes taken by humans in these regions, which could have originated from Asia[33].

Concerning the potential influence of sex on the outcomes, this study provides strong evidence supporting the claim that males show a higher prevalence of multiple root canal morphologies and 3-rooted configurations in both premolars (Supplemental Figs. S6 and S7). This finding holds not only statistical significance but also carries clinical importance, especially for the second premolar, where the proportion of multiple canal morphologies in males exceeds that in females by 8.4%. Furthermore, it represents an advancement over the insights derived from a previous systematic review[4], which, constrained by a restricted pool of studies, was only capable of revealing odds ratio disparities favoring males in multiple root configurations of the maxillary first premolar. The tendency for males to exhibit an increased count of roots and root canals aligns with findings from research focused on other categories of teeth[7,10]. This phenomenon is likely attributed to sexual dimorphism, as males typically display larger teeth[34], possibly influenced by enhanced enamel and dentin development induced by the Y chromosome[35].

In this study, a higher prevalence of multiple canal morphologies was evident among older patients. This novel insight is particularly significant since the preceding systematic review[4] lacked sufficient data for the analysis of this variable. Moreover, it corroborates with a prior study[36] that reported a reduction in Vertucci type I configurations accompanied by an increase in type II morphologies among older patients and, consequently, a rise in the number of root canals over time. These results could be attributed to the ongoing production of dentin and the gradual calcification process that occurs over the course of years, rendering the root canal system a dynamic entity[37,38], particularly concerning the mesial-distal direction of oval root canals[38], which is the case of maxillary premolars. Side, voxel size, and FOV had no influence on the results, confirming the acceptance of the null hypothesis regarding these factors. These findings are consistent with previous studies[7,10] and support the suitability of the chosen CBCT settings for conducting the present analysis, ruling out their potential as sources of bias in the outcomes (Supplemental Figs. S9 and S10).

The multi-center nature of this research offers both strengths and limitations. On one hand, it provides the advantage of collecting real-world data from an extensive sample size, encompassing 26,400 maxillary premolars acquired from 17,539 patients spanning across 44 countries of 5 continents, an accomplishment unparalleled in the endodontic literature; on the other hand, it also introduces the potential for observer deviations in standard anatomical definitions and variations in the types of CBCT scanners. To mitigate the former limitation, the research team diligently addressed the concern by implementing a rigorous 5-month reliability assessment process for both individual and group evaluations prior to final data collection. This approach yielded reliable observer performance, as evidenced by the higher outcomes in these tests (Supplemental Table S1), and on the assessment of dataset nonconformities which underscored the reliability of documentation quality (Supplemental Table S1). Regarding CBCT scanners, the study adopted a maximum voxel size of 200 μm due to the challenges of achieving uniformity across a global level, aligning with successful methodologies used in previous studies[7,10]. Furthermore, a comprehensive meta-regression analysis was performed on both voxel and FOV sizes, effectively eliminating them as potential sources of results heterogeneity (Supplemental Figs. S9 and S10). Thus, this study boasts a strong internal and external validity, offering a reliable foundation for result generalization. One limitation of this study is the limited number of evaluations carried out in regions such as Africa, notably the sub-Saharan area, and Oceania, which require further studies. Another constraint was the categorization of ethnic groups relying on patients' profiles. It is worth noting that conducting genetic tests on the vast number of individuals included in the study would have been unfeasible. Nevertheless, despite this limitation, the consistency of results observed across sub-populations sharing the same ethnic group lends support to the validity of this methodology. Unfortunately, the inclusion of only one observer per country was also a limitation in this study. However, future research endeavors could potentially overcome this limitation by engaging two observers per region, thereby requiring a consensus between them. While this approach might demand extra efforts for observer calibration, it holds the potential to bolster the overall reliability of the study's findings.

Incorporating anthropological insights into an endodontic journal may be seen also as a study strength. This paper's unique strength lies precisely in introducing original information that sets it apart from the customary content found in conventional articles. By providing comprehensive anthropological information about the root and canal anatomy of maxillary premolars, an article in the endodontic field serves to elevate the discipline beyond a clinical perspective, embracing a multidimensional approach that respects the broader context of human diversity. The scientific comprehension of the internal anatomy of teeth is subsequently enriched as these anthropological insights shed light on how factors such as geographic region, ethnicity, gender, and age intertwine to shape the spectrum of root and canal configurations. Future research would benefit from expanding the dataset to include additional groups of teeth and regions, particularly from the African continent, to enhance the existing body of evidence.

CONCLUSIONS

The findings of this study reveal that the occurrence of multiple canal morphology and 3-rooted configuration (primary outcomes) in the maxillary first premolar was 93.5% and 1.8%, respectively, while in the second premolar, it was 49.7% and 0.4%, respectively. Asian countries typically exhibit lower number of root and root canals, whereas European and African populations tend to display higher proportions of these anatomical characteristics. Males tend to present higher proportions and odds ratios for multiple canal morphology and 3-rooted configuration in both premolars. Conversely, younger individuals demonstrated a lower prevalence of multiple canal morphology. Tooth side (left and right), voxel size and FOV did not interfere with the outcomes, thereby enhancing the validity of the results.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Jorge N.R. Martins: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, preparation. **Marco A. Versiani:** Conceptualization, Validation, Supervision, Writing – original draft, preparation, Writing – review & editing.

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The authors deny any conflicts of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found in the online version at www.jendodon.com (10.1016/j.joen.2023.10.009).

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