CLINICAL RESEARCH

Worldwide Anatomic Characteristics of the Mandibular Canine—A Multicenter Cross-Sectional Study with Meta-Analysis

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SIGNIFICANCE

The mandibular canine is a tooth prone to a few anatomic variations. The present study noticed a worldwide prevalence of 2 root canals in 7.5% of cases, and of 2-rooted configurations in 1.9%. Europe, South Asia, and the Middle East, plus Caucasian, Indian, female, and older patients tend to present significantly higher number of both roots and root canals.

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ABSTRACT

Introduction: This study aimed to examine the global prevalence of root and root canal morphologies in mandibular canines and analyze potential influences of region, ethnicity, sex, and age on the proportion of a second root and root canal configuration. **Methods:** Observers from 44 countries screened 13,200 canines using cone-beam computed tomographic exams and gathered data on the percentages of 2 root canal morphologies and 2-rooted configurations (primary outcomes), as well as the root canal configurations (secondary outcome). Demographic factors (ethnicity, sex, and age) were collected for each participant. Primary outcomes were represented as odds ratios and untransformed proportions accompanied by 95% confidence interval (CI) forest plots. Meta-analysis compared subgroups and identified sources of heterogeneity. Intra- and inter-rater tests were conducted. Statistical significance was set at 5%. **Results:** The worldwide prevalence of a second canal was 7.5% (95% CI, 6.3%–8.7%), ranging from 0.7% in Nigeria to 17.7% in Uruguay. The meta-analysis also revealed significant variations when comparing ethnicity, gender, and age ($P < .05$). The global prevalence of a second root was 1.9% (95% CI, 1.5%–2.3%), with the highest proportion observed in Spain (6.7%). Caucasian and Indian (south Asian) ethnic groups, females, and older patients exhibited higher proportions of 2 roots ($P < .05$). Meta-regression excluded side, voxel size, and field of view as sources of heterogeneity ($P > .05$). **Conclusions:** The prevalence of 2 root canals and 2-rooted configurations in the mandibular canine exhibited variations based on geographic location, ethnicity, sex, and age. The global prevalence of 2 root canals and 2-root configuration was 7.5% and 1.9%, respectively. *(J Endod 2024;50:456–471.)*

KEY WORDS

Anatomy; cone-beam computed tomography; endodontics; mandibular canine; prevalence study

A comprehensive understanding of the internal morphology of teeth, widely acknowledged as crucial for the success of endodontic treatment, has consistently attracted the attention of researchers in the study of root and root canal anatomy. These studies are important because clinicians often face challenges in identifying subtle variations in root canal configuration, with the recognition of missed canals having profound implications for the outcome of endodontic treatment and long-term prognosis of the tooth[1]. The mandibular canine is one of those teeth in which variations in the root canal configuration may be overlooked by clinicians, as this group of teeth is typically characterized by a single root and a single root canal. The prevalence of a second root in mandibular canines, reported as high as 6%[2], includes instances of root bifurcations below the middle third of the root[3], whereas the occurrence of a second root canal, reaching up to 10.3%[4], is most commonly associated with Types II and III configurations[2]. As some clinicians may lack awareness of the presence of 2 root canals within 1 or 2 roots in mandibular

canines, it is not uncommon to come across articles in the literature that report treatment failure in this group of teeth because of a missed second canal[5,6]. According to previous studies, teeth with untreated root canals have been associated with 3.1[1] to 6.3[7] times higher likelihood of being linked to periapical pathosis. In addition, another study reported that 82.6% of teeth with periapical lesions had untreated canals from previous endodontic treatments[1].

The initial attempt to assess the anatomy of mandibular canines across different countries was undertaken in a systematic review that focused on selecting *in vivo* studies that used cone-beam computed tomography (CBCT) as the analytical tool[8]. During this review, only 9 studies were identified in which the voxel size resolution was considered reliable ($\leq$200 μm) for recognizing anatomical variations. Consequently, these studies encompassed a limited number of countries (Brazil, China, Iran, Israel, Portugal, and Turkey), resulting in a low statistical power, especially in the comparison between sexes (6 studies) or age subgroups (4 studies). In a recent review on the anatomy of mandibular canines[9], authors pooled data from 28 studies, but the diverse methodologies and diagnostic tools used may lead to assessment discrepancies. However, this review solely assessed the prevalence of a second root canal, lacking sufficient data on 2-rooted canines, and also omitted a thorough analysis and comparison of demographic data, presuming the summation of the studies to represent the global prevalence of the morphologies related to mandibular canines. This approach may hinder accurate generalization of the results, particularly if differences truly exist across demographic variables.

Previous worldwide studies on other groups of teeth such as mandibular incisors[10], premolars[11], and molars[12] have demonstrated differences when comparing groups from different geographic regions, ethnic groups, sexes, or even age subgroups. There is also evidence suggesting that 2-rooted mandibular canines are an anthropological ethnic trait among Spanish Basque Country Europeans[13], but an understanding of its global prevalence and the influence of demographic variables on this morphology are still lacking. Although the overall knowledge of mandibular canine anatomy is scientifically grounded, with some studies providing valuable insights, its universal applicability may not be consistent across all regions of the world. Therefore, the current study aimed to examine the global prevalence of root and root canal morphologies in mandibular canines and analyze potential influences of geographic region, ethnicity, sex, and age on the proportion of a second root and root canal configuration. The null hypothesis tested posited that demographic factors would not impact the prevalence of a second root and root canal in mandibular canines.

MATERIALS AND METHODS

Research Protocol

The research protocol for this multicenter cross-sectional study was approved by the Ethics Committee of the Faculdade de Medicina Dentária da Universidade de Lisboa (registration number CE-FMDUL202239). All CBCT examinations screened in this research were preexisting at the time of field observations and were not acquired solely for the purpose of this study, and the patients' identities were neither accessed nor disclosed. Moreover, the imaging acquisitions adhered to the position statement outlined by the American Association of Endodontists[14] and aligns with the preferred reporting items guidelines for epidemiologic cross-sectional

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0099-2399

https://doi.org/10.1016/j.joen.2024.01.016

studies on root and root canal anatomy using CBCT technology[15].

Research Outcomes, Observers' Calibration, and Methodology Validation

A total of 44 experienced observers, including academics and/or endodontist specialists, representing 44 different countries across 5 continents, conducted a worldwide assessment of mandibular canine morphology in order to determine the prevalence of both the second root and root canal (primary outcomes) and root canal configuration (secondary outcome). An extensive effort was undertaken to ensure uniform conditions for all field observers. They received detailed written guidelines encompassing the research goals, relevant scientific literature references, outcomes of interest, illustrative examples using CBCT scan images, definitions of anatomic features of interest, CBCT screening methodology, and individual and group timelines. In addition, a tutorial video, outlining the step-by-step screening protocol for analyzing 3-dimensional volumes, was shared with the entire research group. The study coordinator (J.M.) prepared and compiled this supporting material, which underwent a preliminary assessment by 2 external reviewers (M.A.V. and J.B.I.) who were not serving as field observers in the study. This step sought to secure a consensus-based scientific validation of the research goals and methodology. The supplementary information was then used for the simultaneous calibration of all 44 field observers during the initial stage of the research timeline. No additional field observer was added to the study once the initial calibration was concluded. The 2 external reviewers consistently monitored the activities to ensure the accomplishment of both individual and group deadlines and objectives.

Sample Size Calculation

To address the null hypothesis, a sample size calculation was performed using data collected in a pilot assessment of 35 canines from all 44 screened regions. The countries with the highest discrepancies for each primary outcome in the pilot study were compared. With a power of 80%, a confidence interval (CI) of 95%, and effect sizes of 3.33% (England vs Brazil) and 3.67% (India vs Chile) for the prevalence of a second root and root canal, respectively, the final sample size was determined to be 293 and 266 canines for each primary outcome. To ensure superior statistical power and account for regions not considered in this calculation (although all were screened in the pilot assessment), the final sample size was increased to 300 canines per region.

Specimen Selection and Screening Methodology

A single field observer was assigned to each region, with permission for the use of multiple CBCT scanners using both small and large field-of-view (FOV) volumes, as long as their voxel size was equal to or less than 200 μm. Each participant was instructed to screen consecutive (numeric or alphabetic chart order starting from the beginning of the database, in order to avoid selection bias, on a nonrandom process) preexisting CBCT volumes from their local datasets until data for 300 canines were collected. The representativeness of each subpopulation was ensured by a convenience sample of patients attending the health centers (imaging centers, private clinics, or academic institutions) in each region (Table 1). Although no patient identities were screened or accessed, demographic information, including age and sex (male/female), was recorded and associated with each tooth. Patients without demographic data were also excluded. Included canine teeth were screened in a consecutive manner, and teeth presenting root resorption or incomplete root formation, previous root canal therapy, root decay, unsalvageable roots (such as root fractures), uncertainty in tooth numbering, and compromised imaging visualization due to artifacts were also excluded. Table 1 summarizes the dataset sources, CBCT models and settings, and reasons for exclusions in each region.

The CBCT imaging screening protocol included aligning the long axis of the analyzed canine with the reference lines in the visualization software. Then, anatomic interpretation on the coronal, sagittal, and axial planes was performed based on the supporting material provided during the initial calibration process. Field observers were permitted to adjust volume settings, such as applying specific filters or noise reduction tools, to enhance anatomic interpretation. To prevent individual assessment bias, all 44 field observers were blinded to the outcomes of the other participants. Each included canine was recorded with the following data: tooth numbering (Universal Numbering System), presence of a second root (yes/no) (primary outcome), presence of a second root canal (yes/no) (primary outcome), and root canal configuration (single canal/2 independent canals [multiple foramina]/2 confluent canals [single foramen]/more than 2 root canals) (Fig. 1) (secondary outcome). In addition to patient demographic data, the ethnic group(s) to which each specimen belonged was/were recorded (ethnic group[s] of patients attending the health center unit and not necessarily the one(s) more represented in the country and known by the local observer). Observers were instructed to contact the study coordinator if any uncertainty arose during the anatomical interpretation, allowing for a final consensus to be reached. All observers documented their data using a standardized Excel sheet template (Microsoft Office v15.0.5537, Redmond, WA) to facilitate cross-checking for any discrepancies in the most relevant information. If any nonconformities were identified, participants were communicated for a thorough review and necessary corrections. The dataset nonconformities cross-checking results are shown in Supplemental Table S1.

Reliability Measurements and Score Limits

Before the final data collection, 3 individual and 2 group intra- and inter-rater assessments were conducted to improve the reliability of the outcomes. Intra-rater reliability was assessed by comparing the results of 2 evaluations on the same 35 canines (11.7% of the sample) acquired from the regional dataset within a 30-day interval, focusing on the presence of a second root canal. Each participant's individual reliability was calculated using Cohen's kappa score. For inter-rater reliability, all participants evaluated the same 18 mandibular canines from 14 CBCT images (not included in any of the regional datasets) regarding the presence of a second root canal. The intraclass correlation coefficient and percentage of agreement were used to calculate the entire group reliability. These latest scores were also individually compared with a consensus result obtained from the 2 external nonobserver reviewers using the Cohen's kappa value to provide an additional individual reliability measurement. The lower acceptable reliability limit for both the intraclass correlation coefficient and Cohen's kappa score was set at 0.61, indicating substantial agreement[16]. If this limit was not reached, the participant was asked to review the study protocol and repeat the assessments. All reliability measurements adhered to the preestablished CBCT imaging screening protocol and were conducted concurrently by all 44 participants.

Statistical Analysis

A meta-analysis using a random-effects model (OpenMeta [Analyst] v.10.10 software)[17] was conducted to represent the prevalence of both

TABLE 1 - Geographic Location, CBCT Scanners and Imaging Characteristics, Reasons for Exclusions, and Dates of Imaging Acquisition

Country	City	Continent	Dataset source	Observer ID	CBCT model (brand, city, country)	Visualization software (brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Excluded teeth (reasons)	Date of CBCT imaging acquisition
Argentina	Salta	Americas	IC/PC	P.E.	CS 8100 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Large	75, 60–80, 2–15	15 (edentulous, 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	59 (artifacts, RCT, open apex, resorptions, unclear number)	2011–2022
Azerbaijan	Baku	Asia	AI	N.B.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	200, 90, 5–6	8 (artifacts, RCT, unclear number)	2016–2022
Belgium	Brussels	Europe	PC	M.Z.	Newtom Giano (Newtom, Verona, Italy)	NNT (Newtom)	Small Large	150, 90, 4	2 (artifacts, unclear number)	2016–2022
Brazil	Campinas	Americas	PC	L.B.	i-CAT FLX (i-CAT, Hatfield, England)	i-CAT Vision (i-CAT)	Large	200, 90, 5	4 (artifacts)	2017–2022
Canada	Toronto	Americas	IC/PC	E.L.	CS 9300 (Carestream, Atlanta, USA)	Invivo (Anatomage, Santa Clara, CA)	Small	90, 84, 5	None	2010–2020
Chile	Santiago do Chile	Americas	IC	M.A.	CS 8100 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Large	150, 82, 5	110 (artifacts, edentulous, 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	2 (artifacts, edentulous, RCT)	2017–2022
Colombia	Bogota	Americas	IC/PC	C.E.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small	75, 90, 14	None	2017–2022
Costa Rica	San Jose	Americas	PC	W.V.	X Mind Trium (Acteon, Merignac, France)	X Mind Trium (Acteon)	Large	200, 85–90, 8	None	2022
Ecuador	Quito	Americas	PC	J.C.	Scanora 3Dx (Soredex, Helsinki, Finland)	On demand (Soredex)	Large	150–200, 90, 6	15 (artifacts)	2022
Egypt	Cairo	Africa	PC	M.B.A.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	150, 90, 12	102 (artifacts, 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	13 (artifacts, edentulous)	2019–2022
France	Paris	Europe	PC	F.S.	Orthophos SL (Dentsply, Ballaigues, Switzerland)	Sidexis 4 (Dentsply)	Small Large	160, 85, 6	3 (artifacts)	2020–2022
Germany	Bab Kreuznach	Europe	PC	H.H.	X800 (Morita, Kyoto, Japan) CS 9300 (Carestream, Atlanta, USA) 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	None	2012–2022
Greece	Athens	Europe	IC	A.C.	Newtom VGI (Newtom, Verona, Italy)	NNT (Newtom)	Large	150, 110, 8	None	2022

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TABLE 1 - Continued

Country	City	Continent	Dataset source	Observer ID	CBCT model (brand, city, country)	Visualization software (brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Excluded teeth (reasons)	Date of CBCT imaging acquisition
Hungary	Budapest	Europe	PC	G.B.	Promax 3D (Planmeca, Helsinki, Finland) CS 9300 (Carestream, Atlanta, USA) 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	None	2018–2022
Iceland	Hafnarfjördur	Europe	PC	M.R.	i-CAT FLX (i-CAT, Hatfield, England)	i-CAT Vision (i-CAT)	Large	200, 120, 4	5 (artifacts, RCT)	2017–2021
India	Palakkad	Asia	PC	J.K.	Newtom Giano (Newtom, Verona, Italy)	NNT (Newtom)	Small Large	150, 90, 4–9	6 (artifacts, edentulous, 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	6 (artifacts)	2018–2020
Italy	Rome	Europe	IC	R.C.	Accuitomo 170 (Morita, Kyoto, Japan)	i-Dixel (Morita)	Small	200, 88, 8	None	2021–2022
Jamaica	Kingston	Americas	PC	S.T.	OP 300 (Kavo, Charlotte, USA)	Invivo (Anatomage, Santa Clara, USA)	Large	85, 57–90, 4–16	8 (artifacts, edentulous)	2021–2022
Japan	Tokyo	Asia	AI	S.M.	Accuitomo F17 (Morita, Kyoto, Japan)	Infinitt Pacs (Infinitt Medical, Phillipsburg, USA)	Small Large	80, 90, 7	1 (artifacts)	2018–2022
Kuwait	Salmiya	Asia	PC	H.O.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	150, 90, 10	67 (artifacts, edentulous, RCT)	2018–2022
Kyrgyzstan	Bishkek	Asia	PC	Ar.M.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	75–150, 90, 8–10	8 (artifacts, edentulous, open apex)	2022
Malaysia	Kuala Lumpur	Asia	AI	A.P.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Small Large	200, 60–120, 1–14	None	2019–2022
Mexico	León	Americas	IC/PC	R.A.	OP 300 (Kavo, Charlotte, USA) Promax 3D (Planmeca, Helsinki, Finland)	OnDemand 3D (Kavo) Romexis (Planmeca)	Small Large	75–200, 85–120, 8–12	10 (artifacts, edentulous)	2016–2022
Nigeria	Lagos	Africa	PC/AI	O.O.	CS 8100 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Small	150, 90, 3	1 (artifacts, fractured teeth)	2018–2022
Pakistan	Karachi	Asia	PC	M.N.	Promax 3D (Planmeca, Helsinki, Finland) CS 9600 (Carestream, Atlanta, USA)	Romexis (Planmeca) CS 3D Imaging (Carestream)	Large	180–200, 85–90, 4–6	9 (artifacts)	2018–2021
Paraguay	Asunción	Americas	IC	C.H.	Imax 3D (Owandy, Beaubourg, France)	CS 3D Imaging (Carestream)	Large	170, 84, 5	37 (artifacts, RCT)	2019–2022
Peru	Lima	Americas	IC	C.N.	OP 300 (Kavo, Charlotte, USA)	OnDemand 3D (Kavo)	Large	200, 57–90, 4–16	1 (artifacts)	2021

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TABLE 1 - Continued

Country	City	Continent	Dataset source	Observer ID	CBCT model (brand, city, country)	Visualization software (brand)	CBCT FOV	CBCT settings (μm, kV, mA)	Excluded teeth (reasons)	Date of CBCT imaging acquisition
Portugal	Lisbon	Europe	PC	J.M.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 84, 15	12 (artifacts, edentulous, RCT)	2019–2022
Romania	Bucharest	Europe	PC	S.N.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 85, 12	None	2022
Russia	Yekaterinburg	Asia	PC	E.L.	CB 500 (Gendex, Hatfield, England)	i-CAT Vision (i-CAT)	Small Large	200, 120, 3–8	73 (artifacts, edentulous, RCT)	2021–2022
Saudi Arabia	Riyadh	Asia	AI	H.A.	Promax 3D (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 84, 15	None	2022
South Africa	Durban	Africa	PC	H.S.	CS 8100 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Small Large	75–150, 90, 3	2 (artifacts)	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	None	2018–2022
Spain	Barcelona	Europe	PC	J.G.	CS 8100 (Carestream, Atlanta, USA) Promax 3D (Planmeca, Helsinki, Finland)	InteleViewer (InteleRad, Montreal, Canada)	Large	150–200, 84–90, 4–6	10 (artifacts)	2016–2022
Syria	Damascus	Asia	PC	Z.A.	Viso G5 (Planmeca, Helsinki, Finland)	Romexis (Planmeca)	Large	200, 60–120, 1–16	10 (edentulous)	2018–2022
Thailand	Bangkok	Asia	AI	D.B.	Accuitomo 170 (Morita, Kyoto, Japan)	OneVolumeViewer (Morita)	Small	125, 90, 5	18 (artifacts, open apex, RCT)	2021–2022
Turkey	Istanbul	Europe	AI	A.K.	5 G XL (Newtom, Verona, Italy)	(Newtom, Verona, Italy)	Small Large	100–200, 110, 3–6	17 (artifacts, RCT, open apex)	2019–2022
Uruguay	Montevideo	Americas	IC	I.M.	Tropypan (Trophy, Atlanta, USA) CS 9000 (Carestream, Atlanta, USA)	Trophy Imaging (Trophy) CS 3D Imaging (Carestream)	Small Large	100–150, 70–90, 3–10	43 (artifacts, open apex, RCT, resorption)	2020–2022
USA	Vista	Americas	PC	Ad.M.	CS 9000 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Small	76, 80–85, 10	1 (artifacts)	2022
Venezuela	Caracas	Americas	PC	C.B.	CS 9000 (Carestream, Atlanta, USA)	CS 3D Imaging (Carestream)	Small	76, 60–90, 2–15	19 (artifacts, open apex, resorption)	2012–2022

AI, academic institution; IC, imaging center; PC, private clinic; RCT, root canal treated.

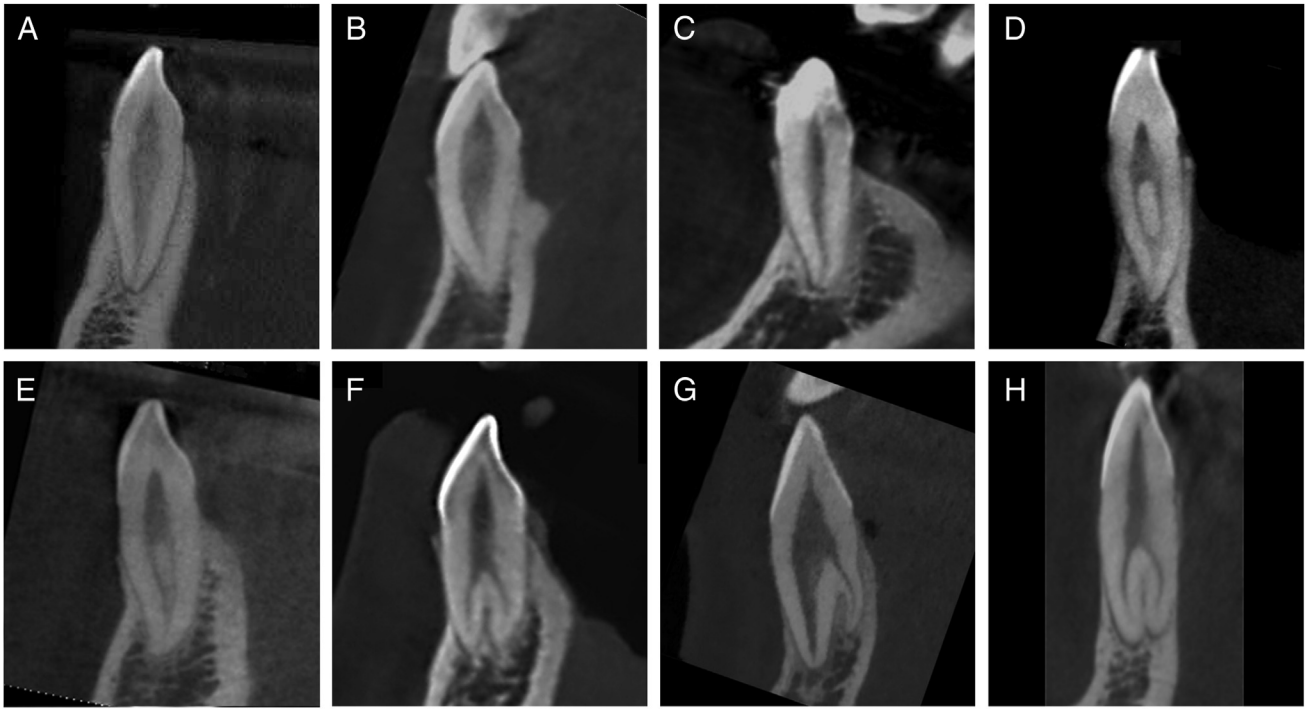

FIGURE 1 – Representative cone-beam computed tomography images of the root and root canals of mandibular canines assessed in the present study: single canal configuration from England (*A*), India (*B*), and Malaysia (*C*); 2 confluent canals (single foramen) from Venezuela (*D*) and the United States (*E*); and 2 independent canals (multiple foramina) from Hungary (*F*), Turkey (*G*), and Kuwait (*H*).

the second root and second root canal through proportions with 95% CI forest plots and odds ratios. In addition, meta-regression was performed to explore potential sources of heterogeneity. The threshold for statistical significance was set at 5%.

RESULTS

A total of 13,200 mandibular canines from 7929 patients across 44 countries were evaluated, with 3348 male (42.2%) and 4581 female individuals (57.8%), presenting an average age of 43 years (Table 2). The worldwide prevalence of a second canal was 7.5% (95% CI, 6.3%–8.7%), ranging from 0.7% in Nigeria (95% CI, 0%–1.6%) to 17.7% in Uruguay (95% CI, 13.4%–22.0%) (Figs. 2 and 3). The most frequent configuration for multiple canals was the presence of 2 confluent canals with a single foramen (4.9%), followed by 2 independent canals with multiple foramina (2.9%). The screened sample did not exhibit any 3-root canal configuration (Table 2).

The meta-analysis revealed significant variations among geographic regions regarding the prevalence of a second canal, with the Americas (5.2% [95% CI, 3.6%–6.9%]) and Africa (5.2% [95% CI, 0%–10.6%]) displaying the lowest proportions, whereas South Asia and the Middle East (10.5% [95% CI, 7.8%–13.1%]) exhibited the highest proportions ($P < .05$) (Fig. 3). Disparities were also evident in ethnic comparison, with the Hispanic subgroup (4.4% [95% CI, 2.2%–6.5%]) exhibiting the lowest prevalence and Indians (from south Asia) (5.2% [95% CI, 7.5%–14.5%]) displaying the highest ($P < .05$) (Supplemental Fig. S1). Females were also more likely to exhibit a second root canal, as evidenced by both a significantly higher odds ratio (1.443 [95% CI, 1.210–1.720]) and proportions (8.5% [95% CI, 7.0%–10.0%]) compared with males (5.6% [95% CI, 4.6%–6.6%]) ($P < .05$) (Supplemental Figs. S2 and S3). Younger patients (<20 years) exhibited a lower prevalence of this anatomic feature (5.8% [95% CI, 4.4%–7.2%]) compared with older groups ($P < .05$) (Fig. 4). No statistically significant difference was observed between the left and right sides ($P > .05$) (Supplemental Fig. S4).

The global prevalence of a second root in mandibular canines was 1.9% (95% CI, 1.5%–2.3%), with the highest proportion observed in Spain (6.7% [95% CI, 3.8%–9.5%]) (Figs. 2 and 5). Jamaica, Nigeria, and Ecuador reported no 2-rooted configuration. Statistical analysis also indicated significant differences between geographic regions, with Asia (0.6% [95% CI, 0.1%–1.1%]) exhibiting the lowest proportions and Europe (3.5% [95% CI, 2.9%–4.2%]) the highest ($P < .05$) (Fig. 5). Caucasian and Indian ethnic groups (Supplemental Fig. S1), females (Supplemental Fig. S2), and older patients (Fig. 4) exhibited significantly higher proportions of a second root in mandibular canines ($P < .05$). No differences were observed between sides ($P > .05$) (Supplemental Fig. S4).

The meta-regression excluded both voxel size and FOV as potential sources of heterogeneity for both root (Omnibus *P* values for voxel size of .687 and FOV of 0.572) and root canal (Omnibus *P* values for voxel size of .071 and FOV of 0.164) proportions. The intra-rater and external observer consensus reliability tests demonstrated that all observers exhibited at least substantial agreement (0.61–0.80), and the inter-rater assessment indicated that the group achieved a high percentage of agreement (97.8%) with almost perfect agreement (0.866) (Supplemental Table S1).

DISCUSSION

Differences in anatomic characteristics associated with various mineralized tissues, including the size or morphology of the femur, tibia, or mandible, have been documented in comparisons among population groups from diverse regions or ethnic backgrounds[18-20]. Likewise, variations in both the coronal and

TABLE 2 - Patient Demographics and Anatomic Features of the Mandibular Canine

Demographics							Anatomic configuration						
							Number of roots			Root canal configuration			
Region	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of male individuals	Proportion of female individuals	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than 2 canals
Argentina	152	Mixed (Hispanic and American Natives)	49 ± 14 [22–76]	73 (48.0%)	79 (52.0%)	300	286 (95.3%)	14 (4.7%)	—	286 (95.3%)	14 (4.7%)	—	—
Australia	199	Mixed (Asians and Caucasians)	51 ± 17 [12–84]	83 (41.7%)	116 (58.3%)	300	288 (96.0%)	12 (4.0%)	—	270 (90.0%)	15 (5.0%)	15 (5.0%)	—
Azerbaijan	153	Mostly Caucasians	44 ± 13 [14–70]	77 (50.3%)	76 (49.7%)	300	298 (99.3%)	2 (0.7%)	—	276 (92.0%)	4 (1.3%)	20 (6.7%)	—
Belgium	151	Mixed (Asians, Caucasians and Africans)	52 ± 14 [15–81]	51 (33.8%)	100 (66.2%)	300	292 (97.3%)	8 (2.7%)	—	273 (91.0%)	8 (2.7%)	19 (6.3%)	—
Brazil	150	Mixed (Caucasians [non-Hispanic] with Africans, American Natives and Asians)	40 ± 17 [16–85]	46 (30.7%)	104 (69.3%)	300	287 (95.7%)	13 (4.3%)	—	279 (93.0%)	17 (5.7%)	4 (1.3%)	—
Canada	154	Mixed (Caucasian, Asian and African Canadian)	34 ± 16 [11–80]	74 (48.1%)	80 (51.9%)	300	288 (96.0%)	12 (4.0%)	—	278 (92.6%)	14 (4.7%)	8 (2.7%)	—
Chile	151	Mostly Caucasians (Hispanic origin)	40 ± 17 [10–80]	48 (31.8%)	103 (68.2%)	300	289 (96.3%)	11 (3.7%)	—	285 (95.0%)	11 (3.7%)	4 (1.3%)	—
China	300	Asians (Han ethnicity)	36 ± 11 [14–78]	140 (46.7%)	160 (53.3%)	300	298 (99.3%)	2 (0.7%)	—	285 (95.0%)	2 (0.7%)	13 (4.3%)	—
Colombia	172	Mostly Caucasians (Hispanic origin)	55 ± 15 [18–84]	66 (38.4%)	106 (61.6%)	300	298 (99.3%)	2 (0.7%)	—	295 (98.3%)	2 (0.7%)	3 (1.0%)	—
Costa Rica	151	Mostly Caucasians (Hispanic origin)	37 ± 6 [24–49]	42 (27.8%)	109 (72.2%)	300	293 (97.7%)	7 (2.3%)	—	254 (84.7%)	8 (2.7%)	38 (12.6%)	—
Ecuador	151	Mostly Caucasians (Hispanic origin)	52 ± 16 [19–86]	57 (37.7%)	94 (62.3%)	300	300 (100%)	—	—	294 (98.0%)	—	6 (2.0%)	—
Egypt	157	Africans (Egyptians)	44 ± 14 (16–77)	72 (45.8%)	85 (54.2%)	300	298 (99.3%)	2 (0.7%)	—	282 (94.0%)	4 (1.3%)	14 (4.7%)	—
England	157	Mostly Caucasians	63 ± 12 [20–86]	63 (40.1%)	94 (59.9%)	300	285 (95.0%)	15 (5.0%)	—	265 (88.3%)	18 (6.0%)	17 (5.7%)	—
France	153	Mostly Caucasians	49 ± 15 [15–86]	69 (45.1%)	84 (54.9%)	300	294 (98.0%)	6 (2.0%)	—	279 (93.0%)	6 (2.0%)	15 (5.0%)	—
Germany	206	Caucasians	58 ± 16 [15–93]	70 (34.0%)	136 (66.0%)	300	285 (95.0%)	15 (5.0%)	—	268 (89.4%)	16 (5.3%)	16 (5.3%)	—
Greece	150	Caucasians	48 ± 16 [10–86]	67 (44.7%)	83 (55.3%)	300	288 (96.0%)	12 (4.0%)	—	288 (96.0%)	12 (4.0%)	—	—
Hungary	152	Mostly Caucasians	47 ± 13 [15–81]	63 (41.4%)	89 (58.6%)	300	290 (96.7%)	10 (3.3%)	—	277 (92.3%)	11 (3.7%)	12 (4.0%)	—
Iceland	300	Mostly Caucasians	33 ± 14 [16–76]	138 (46.0%)	162 (54.0%)	300	286 (95.3%)	14 (4.7%)	—	262 (87.3%)	17 (5.7%)	21 (7.0%)	—
India	292	Asians (Indian origin)	39 ± 9 [21–71]	135 (46.2%)	157 (53.8%)	300	284 (94.7%)	16 (5.3%)	—	267 (89.0%)	15 (5.0%)	18 (6.0%)	—
Israel	167	Mixed (Jewish, Arabs, and Africans)	34 ± 11 [15–64]	82 (49.1%)	85 (50.9%)	300	290 (96.7%)	10 (3.3%)	—	250 (83.4%)	10 (3.3%)	40 (13.3%)	—
Italy	156	Mostly Caucasians	31 ± 13 [10–93]	69 (44.2%)	87 (55.8%)	300	292 (97.3%)	8 (2.7%)	—	265 (88.3%)	10 (3.3%)	25 (8.4%)	—
Jamaica	153	Mixed (Africans, Asians, and Caucasians)	31 ± 9 [16–61]	44 (28.8%)	109 (71.2%)	300	300 (100%)	—	—	289 (96.3%)	11 (3.7%)	—	—
Japan	300	Asians	53 ± 14 [20–87]	126 (42.0%)	174 (58.0%)	300	299 (99.7%)	1 (0.3%)	—	282 (94.0%)	6 (2.0%)	12 (4.0%)	—

(*continued on next page*)

TABLE 2 - Continued

Demographics							Anatomic configuration						
							Number of roots			Root canal configuration			
Region	Sample size (patients)	Ethnic groups	Age in years (mean ± SD) [range]	Proportion of male individuals	Proportion of female individuals	Sample size (teeth)	One root	Two roots	Three roots	Single canal	Two independent canals (multiple exits)	Two confluent canals (single exit)	More than 2 canals
Kuwait	159	Mixed (Asians and Caucasians)	42 ± 15 [12–78]	72 (45.3%)	87 (54.7%)	300	293 (97.7%)	7 (2.3%)	—	256 (85.3%)	6 (2.0%)	38 (12.7%)	—
Kyrgyzstan	157	Mostly Asians	38 ± 13 [14–77]	53 (33.8%)	104 (66.2%)	300	286 (95.3%)	14 (4.7%)	—	266 (88.6%)	17 (5.7%)	17 (5.7%)	—
Malaysia	264	Mostly Asians	38 ± 15 [15–78]	116 (43.9%)	148 (56.1%)	300	298 (99.3%)	2 (0.7%)	—	278 (92.6%)	5 (1.7%)	17 (5.7%)	
Mexico	153	Mostly Caucasians (Hispanic origin)	43 ± 13 [17–76]	53 (34.6%)	100 (65.4%)	300	299 (99.7%)	1 (0.3%)	—	295 (98.3%)	—	5 (1.7%)	—
Nigeria	155	Africans	42 ± 15 [14–83]	73 (47.1%)	82 (52.9%)	300	300 (100%)	—	—	298 (99.3%)	—	2 (0.7%)	—
Pakistan	156	Asians	36 ± 13 [16–65]	77 (49.4%)	79 (50.6%)	300	289 (96.3%)	11 (3.7%)	—	267 (89.0%)	12 (4.0%)	21 (7.0%)	—
Paraguay	158	Mostly Caucasians (Hispanic origin)	46 ± 17 [13–82]	68 (43.0%)	90 (57.0%)	300	296 (98.7%)	4 (1.3%)	—	284 (94.7%)	4 (1.3%)	12 (4.0%)	—
Peru	151	Mixed (Hispanic origin and American Natives)	35 ± 16 [16–87]	59 (39.1%)	92 (60.9%)	300	296 (98.7%)	4 (1.3%)	—	293 (97.7%)	4 (1.3%)	3 (1.0%)	—
Portugal	154	Mostly Caucasians	53 ± 12 [25–86]	58 (37.7%)	96 (62.3%)	300	289 (96.3%)	11 (3.7%)	—	270 (90.0%)	12 (4.0%)	18 (6.0%)	—
Romania	162	Mostly Caucasians	43 ± 12 [12–73]	72 (44.4%)	90 (55.6%)	300	292 (97.3%)	8 (2.7%)	—	277 (92.3%)	9 (3.0%)	14 (4.7%)	—
Russia	152	Mixed (Russians, Ukrainians, Tatars, Bashkirs, Jews, Belarusians, and Kazakh)	33 ± 12 [12–73]	57 (37.5%)	95 (62.5%)	300	299 (99.7%)	1 (0.3%)	—	293 (97.6%)	2 (0.7%)	5 (1.7%)	—
Saudi Arabia	156	Mostly Arabs	39 ± 13 [17–81]	82 (52.6%)	74 (47.4%)	300	296 (98.7%)	4 (1.3%)	—	280 (93.3%)	6 (2.0%)	14 (4.7%)	—
South Africa	155	Mixed (Asians of Indian origin, Caucasians, and Africans)	45 ± 16 [10–92]	78 (50.3%)	77 (49.7%)	300	293 (97.7%)	7 (2.3%)	—	272 (90.7%)	6 (2.0%)	22 (7.3%)	—
South Korea	300	Asians	34 ± 14 [12–84]	163 (54.3%)	137 (45.7%)	300	299 (99.7%)	1 (0.3%)	—	283 (94.3%)	2 (0.7%)	15 (5.0%)	—
Spain	152	Caucasians	40 ± 15 [15–87]	71 (46.7%)	81 (53.3%)	300	280 (93.3%)	20 (6.7%)	—	253 (84.4%)	28 (9.3%)	19 (6.3%)	—
Syria	151	Arabs	41 ± 15 [16–74]	67 (44.4%)	84 (55.6%)	300	299 (99.7%)	1 (0.3%)	—	279 (93.0%)	1 (0.3%)	20 (6.7%)	—
Thailand	180	Asians	47 ± 20 [12–85]	71 (39.4%)	109 (60.6%)	300	298 (99.3%)	2 (0.7%)	—	263 (87.7%)	3 (1.0%)	34 (11.3%)	—
Turkey	163	Mostly Caucasians	33 ± 12 [14–63]	60 (36.8%)	103 (63.2%)	300	289 (96.3%)	11 (3.7%)	—	284 (94.6%)	11 (3.7%)	5 (1.7%)	—
Uruguay	155	Mixed (Hispanic origin and Africans)	48 ± 15 [12–82]	63 (40.6%)	92 (59.4%)	300	288 (96.0%)	12 (4.0%)	—	247 (82.3%)	15 (5.0%)	38 (12.7%)	—
USA	238	Mostly Caucasians	59 ± 16 [13–93]	90 (37.8%)	148 (62.2%)	300	298 (99.3%)	2 (0.7%)	—	290 (96.6%)	3 (1.0%)	7 (2.4%)	—
Venezuela	231	Mostly Caucasians (Hispanic origin)	49 ± 15 [13–84]	90 (39.0%)	141 (61.0%)	300	296 (98.7%)	4 (1.3%)	—	290 (96.6%)	4 (1.4%)	6 (2.0%)	—
Total	7929	Multi-ethnic	43 ± 9 [10–93]	3348 (42.2%)	4581 (57.8%)	13.200	12881 (97.6%)	319 (2.4%)	—	12167 (92.2%)	381 (2.9%)	652 (4.9%)	—

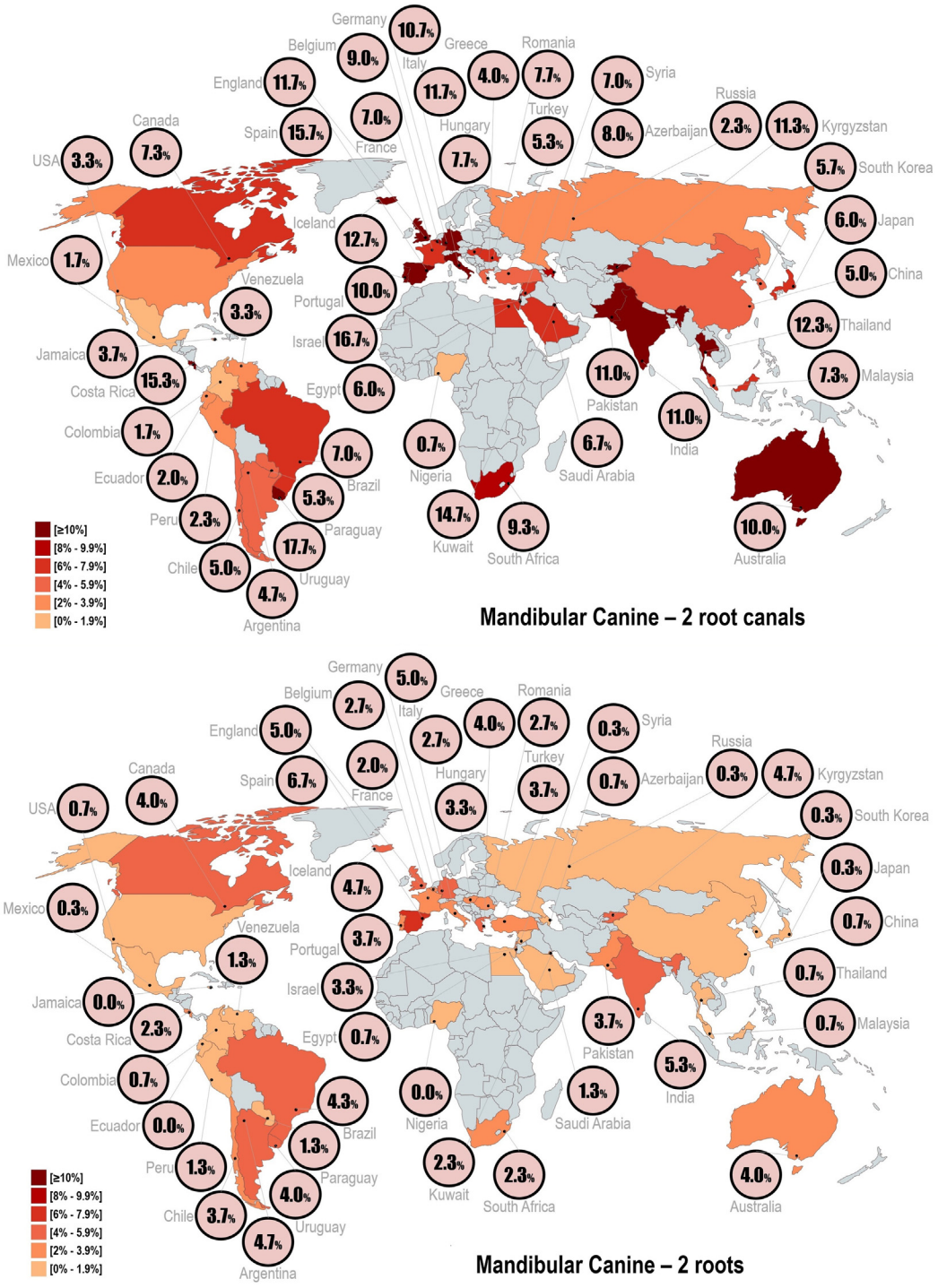

FIGURE 2 – Worldwide maps showing the prevalence of the mandibular canine 2 root canal configurations (*top*) and of 2-rooted morphologies (*bottom*). Higher percentages were noted in Europe, Oceania, and South Asia and Middle East regions.

root aspects of different groups of teeth have also been reported, and some of them have been classified as ethnic traits,[13,21,22] such as the high frequency of the Bushman canine among southwestern African individuals[23], the presence of Carabelli's cusp in maxillary first molars in European Caucasian individualss[13], Tome's root in mandibular first premolars in sub-Saharan African individuals[24], and the groove pattern in mandibular second molars[22]. Although certain variations are of considerable anthropological importance, enabling the investigation and tracking of population movements in the past, there are also anatomic differences directly influenced by demographic factors. This is particularly evident in instances like the increased prevalence of single-rooted mandibular second molars[25] and a second distal root in mandibular first molars[26] observed in Asian sub-populations. These anatomic distinctions carry considerable relevance in the context of clinical dental practice. However, the significance of these variations becomes

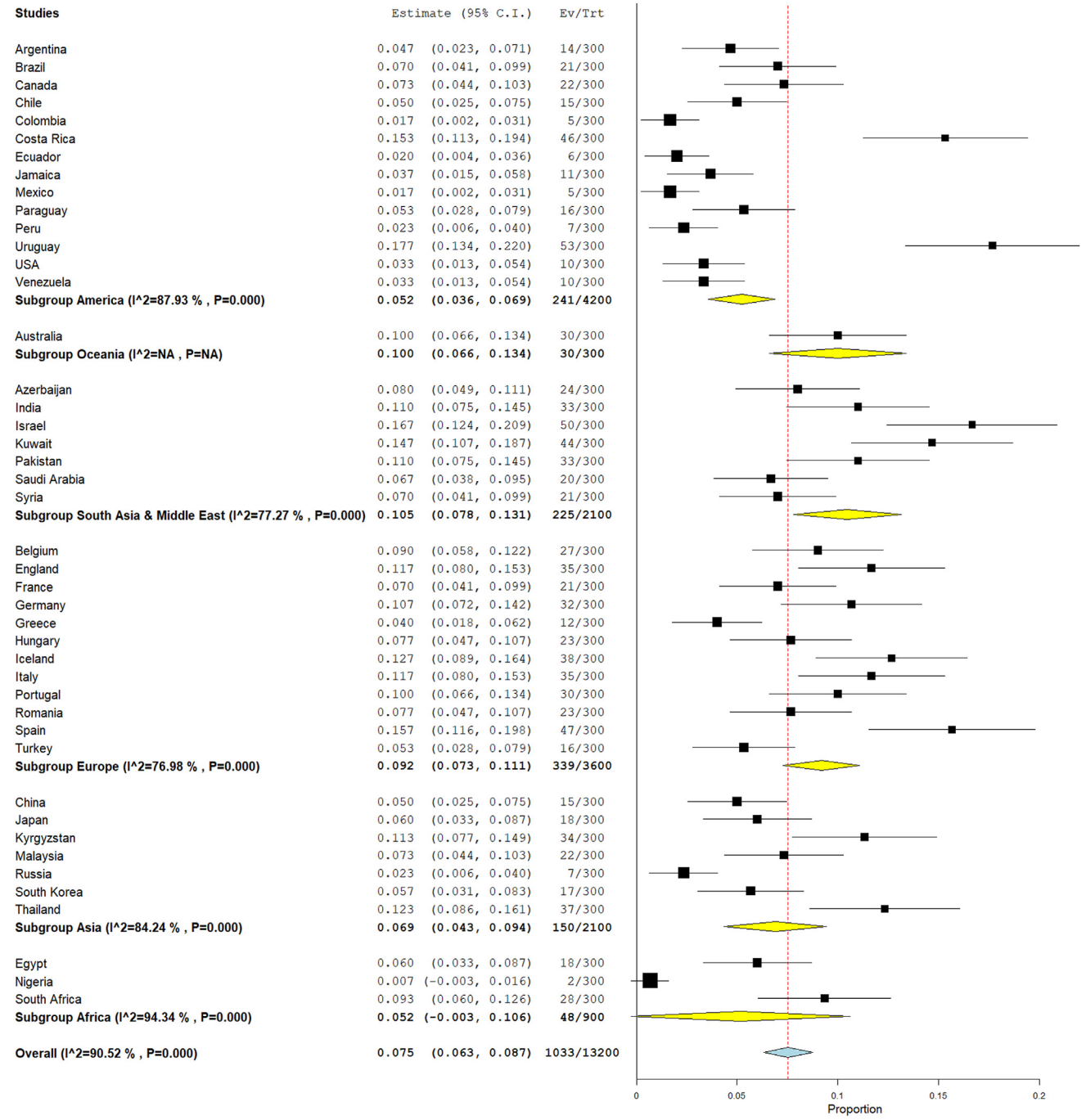

FIGURE 3 – Proportion forest plots chart revealing the prevalence of 2 root canals configuration in the mandibular canine according to geographic location. Each *black square*, whose size reflects the region weight, represents the region's point estimate and the *horizonal line* crossing it indicates the 95% confidence interval. The *yellow diamond* represents the sum of the results in that particular subgroup, and the *blue square* represents the overall results. The Americas, Asia, and Africa showed proportions below the average, whereas Europe, Oceania, and South Asia and the Middle East had proportions above the average.

particularly noteworthy in the field of endodontics when demographic differences are identified in the root canal system, such as the high proportions of C-shaped morphology in the mandibular second molars found in both Asian and female individuals[12], or the increased prevalence of lingual canals in both mandibular incisors and premolars in male individuals and younger patients[10,11]. The present research unveils new insights into how demographic characteristics affect the anatomy of the mandibular canine. The findings not only reject the null hypothesis but also underscore the importance of recognizing that the observed characteristics within a specific sub-population may not be universally applicable to others.

The results of the geographic region analysis regarding the prevalence of a second root canal in the mandibular canine indicate that the Americas (5.2%) and Africa (5.2%) exhibit lower proportions, whereas Europe (9.2%) and South Asia and the Middle East

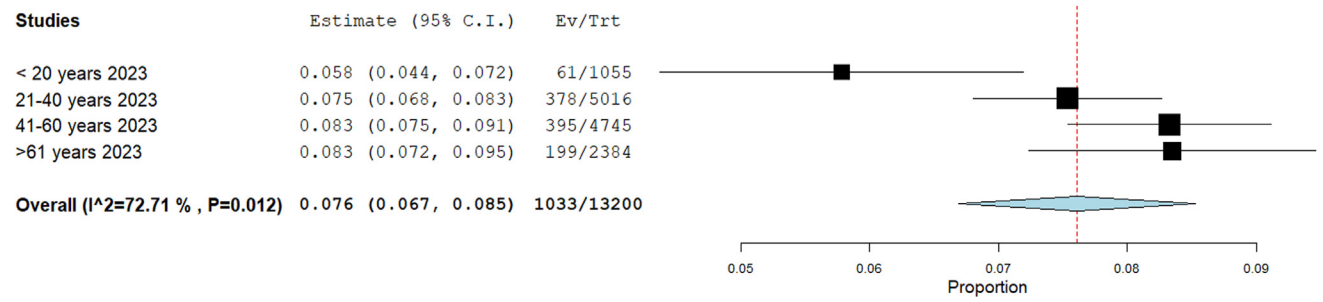

FIGURE 4 – Forest plot graphs comparing proportions of multiple canals morphology in the mandibular canines among patients of different age groups. The results made it evident that the percentages tend to increase with aging.

(10.5%) show higher percentages (Fig. 3). These findings are in line with previous reports using CBCT assessment with equivalent imaging resolution, documenting proportions of 6.1% (Europe [Turkey])[27], 9.8% (Europe [Portugal])[28], and 10.3% (Middle East [Israel])[4]. Notably, these results appear consistent with the individual outcomes of the current study (Turkey 5.3%, Portugal 10.0%, Israel 16.7%) (Fig. 2). Similarities are also observed when comparing the previous findings for Brazil (9.5%)[29] with the present ones (7.0%). Asian countries showed a lower proportion (6.9%) of multiple root canals, with Chinese sub-populations presenting the lowest results (5.0%), corroborating previous studies reporting proportions of 3.0%[30], 4.2%[31], and 6.3%[3]. Drawing from recently compiled data in a systematic review[8], it becomes evident that East Asian countries generally exhibit lower proportions of mandibular canines with 2 root canals compared with West Asian and European individuals, which corroborates the present findings. It is remarkable that most of the countries included in the current study lack prior data on this particular dental characteristic, rendering direct comparisons impossible. However, given that the present research supports the limited existing data, there is an expectation that the new data from the newly measured regions can be considered reliable.

The lowest prevalence of the number of roots in mandibular canines was observed in Asia (0.6%) and Africa (0.8%), and the highest was noted in Europe (3.5%) and Oceania (4.0%) (Fig. 5). Although there are limited data on this information, previous findings seem to support these results, as proportions of 0.8%[31] and 1.3%[3] were documented in China, whereas 3.0% (Portugal) and 3.1% (Turkey) were observed in European countries[27,28]. It is important to acknowledge that within the American region, where some disparity is evident, the 4 higher proportions in this subgroup (Argentina, Brazil, Canada, and Uruguay) were derived from sub-populations with ethnic mixtures (Table 2), indicating a potential ethnic influence on the results. The examination of ethnic groups is connected to the geographic region under analysis and essentially confirmed that African individuals (3.2%) and Middle and South American Hispanic individuals (4.4%) constitute subgroups with a lower prevalence of a second root canal in the mandibular canine (number of root canals assessment in Supplemental Fig. S1). The results for the number of roots identified Caucasian (3.2%) and Indian individuals (from south Asia) (5.3%) as having higher percentages, whereas all other ethnic subgroups exhibited proportions equal to or below 1.0% (number of roots assessment in Supplemental Fig. S1).

The results for both region and ethnicity reveal a pattern that can be partially explained by events occurring in the early stages of human species' global colonization. It is widely accepted that human origins may have occurred near Nairobi, Kenya, and subsequent world colonization from the African continent likely took place through 2 major migration routes, one through the Levant corridor (northern route bordering the Mediterranean Sea) and/or the Horn of Africa (southern route bordering the Indian Ocean coastline). After departing from Africa, prehistoric humans spread across the globe, leading to the emergence of 3 major ethnic groups: Caucasian (resulting from subsequent expansion via the northern Eurasian route), Asian (resulting from subsequent expansion via the eastern Asian route), and African, who remained in Africa[32]. These major ethnic branches further diversified into numerous ethnic subgroups, with some bearing significance to the South Asia and Middle East region. This area, a geographic triangulation influenced by the 3 major ethnic groups, primarily carries the most substantial genetic influence from Caucasian individuals[13]. The present findings show a higher prevalence of both multiple roots and root canal configurations in European and South Asian and Middle Eastern regions (and among Caucasian and Indian ethnicities). Considering the close relationship between these 2 regions and their most relevant ethnic and genetic backgrounds, one might hypothesize that genetic modifications, possibly driven by adaptations to local environments, occurred during the migratory movements along the northern Eurasian route, leading to the higher documented proportions. Furthermore, the atypical higher prevalence of the 2-rooted mandibular canine in this specific area has been identified as an ethnic trait for Spanish Basque Country European individuals, supporting the highest percentage observed in Spain (6.7%) in this study. It is noteworthy that the present research was conducted in the Spanish area of Catalunya, situated in the northeast of the country similar to the Spanish Basque Country area (Fig. 2).

The process of expansion and establishment in new environments and habitats led the 3 major ethnic groups to develop, in part, independently from each other. This independence may account for the lower proportions of 2-rooted mandibular canines found in areas outside European and South Asian and the Middle Eastern regions, including the Americas, whose migration flow originates from the eastern Asian expansion route. Specifically, in this American subgroup (especially within their Hispanic ethnicity), the evolutionary genetic load derived from the Asian route might have been reinforced by its original African genetic load. This is attributed to the colonization of the New World by African populations after the year 1500, which helps to explain the similarities between Hispanic ethnicity and Asian and African ethnicities. This resemblance is further evident in local regions across these 2 continents, such as Jamaica (with a strong influence from sub-Saharan West African Ghana communities) and sub-Saharan West African Nigeria, where no cases of 2-rooted configurations were found (Fig. 2).

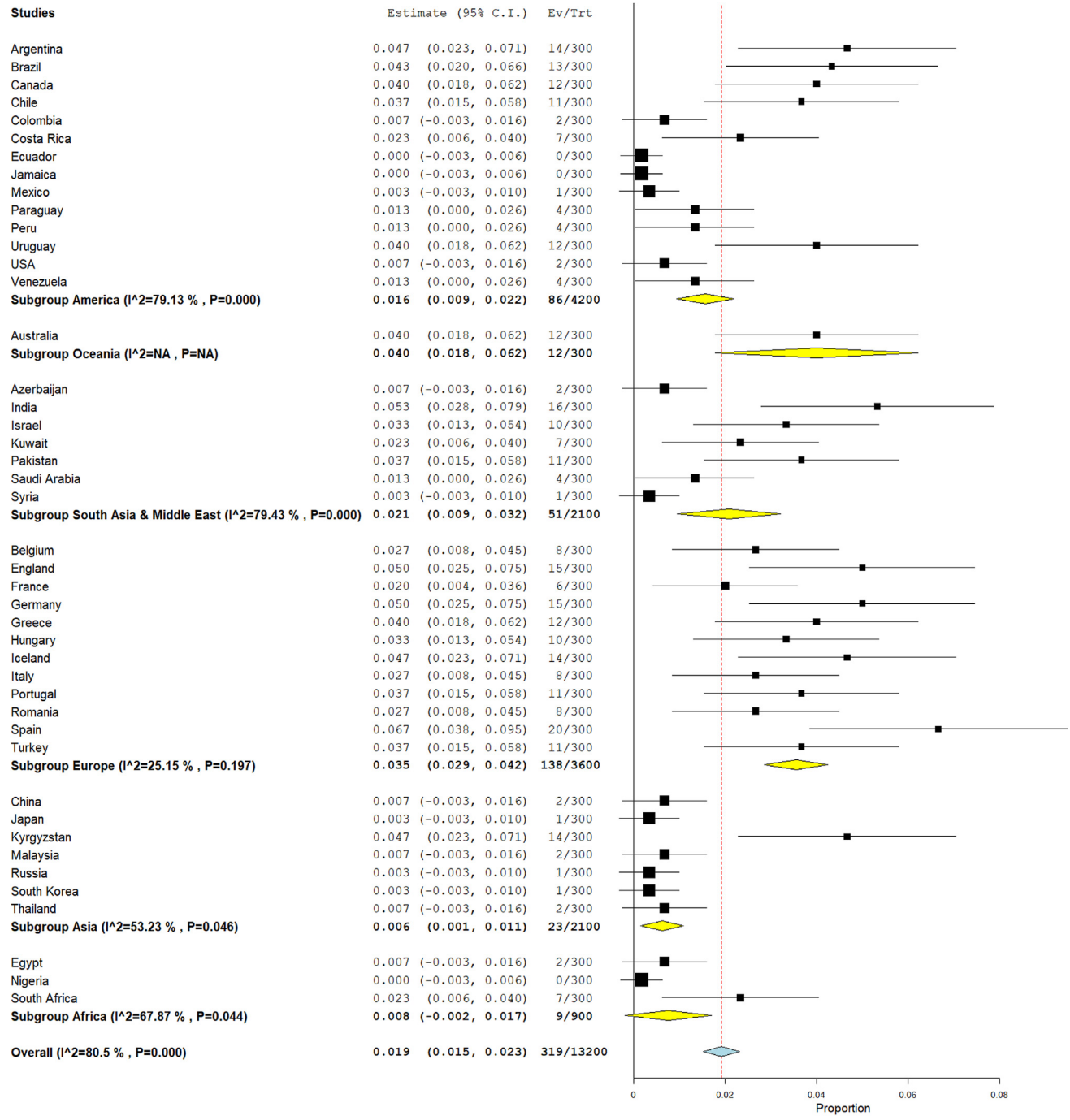

FIGURE 5 – Proportion forest plots with the 2-rooted morphologies percentages in the mandibular canine according to geographic region. The Americas, Asia, and Africa showed prevalences below the average, whereas Europe, Oceania, and South Asia and the Middle East showed results above the average.

The current research has revealed significantly higher occurrences of mandibular canine second roots and root canals in female individuals, evident in both proportions (Supplemental Fig. S3) and odds ratios (Supplemental Fig. S3). This heightened prevalence in female individuals contrasts with findings in other tooth groups, such as mandibular incisors[8,10,29] and mandibular premolars[11], which have demonstrated a lower number of root canals in female individuals. Nevertheless, these results align with a prior systematic review on anterior teeth anatomy that has documented for mandibular canines a global odds ratio of 0.769 for male individuals (a score below 1 favoring female individuals with higher results) and overall proportions favoring female individuals (male individuals with 6.0% and female individuals with 7.3%)[8] regarding multiple root canal configurations. Despite these similarities, that review was unable to document significant differences, potentially attributed to the lower number of pooled studies leading to lower statistical power. This limitation appears to have been overcome in the current worldwide assessment. This suggests that the global lower number of roots or root canals in female individuals may not be generalized to all groups of teeth and may be tooth-specific—a condition that only can be explained by sexual dimorphism, a well-established phenomenon in dental forensic sciences[33].

The analysis conducted on different age groups revealed significantly higher proportions of 2 root canal configurations in older patients (Fig. 4). This result can be attributed to the aging calcification process, which typically presents a calcification pattern in the mesio-distal direction in oval root canals[34]—a characteristic shared by the mandibular canine, known for having a buccolingually wider cross-section[35]. This calcification pattern may lead to the deposition of dentin in the center of the root canal, ultimately causing it to split in two[34]. The comparison between the left and right sides showed no differences, aligning with studies on other tooth groups such as incisors[10] and premolars[11]. The assessment of voxel size and FOV also indicated no differences, allowing their exclusion as possible sources of heterogeneity, in agreement with other studies[8,10,11].

One limitation of the current study is its multicenter design, which makes it challenging to completely eliminate the observer and CBCT scanner model as potential sources of heterogeneity. However, the study underwent 5 individual and group reliability tests, in addition to a thorough check for datasheet nonconformities. The results of these tests demonstrated very high agreement (Supplemental Table S1). Furthermore, the CBCT scanner resolution was deliberately limited to a higher value of 200 μm, a choice validated by a previous review[8] and supported by the present voxel size meta-regression results. This meticulous planning regarding the calibration of observers and CBCT characteristics significantly helped mitigate the potential limitation associated with the multicenter nature of the study. Another limitation of the present research is that ethnicity was determined based on the patient's profile from those visiting the screened health units, which may not necessarily represent the characteristics of the entire country, and molecular genetic tests were not used. Patient genetic assessments can be conducted through various models, some of which are robust molecular tests. However, applying such methodology to 7929 patients worldwide would be unfeasible. Therefore, the present study adopted a methodology consistent with previous publications in this matter[10,11,26]. The consistency of results documented in sub-populations sharing the same ethnic background appears to provide some support for the validity of this methodology for the purposes of the present investigation.

A distinctive strength of this paper lies in its introduction of original information that distinguishes it from conventional articles. This uniqueness stems from the incorporation of comprehensive anthropological details regarding the root and canal anatomy of mandibular canines. This approach goes beyond the typical clinical perspective, embracing a multidimensional framework that acknowledges the broader context of human diversity, thus elevating the discipline to a more encompassing level. Another strength was the possibility to gather a substantial amount of data, contributing to enhanced statistical robustness in the outcomes. Moreover, the study design facilitates the documentation of real-world data, creating global evidence. This strength, as emphasized by Makady et al[36], enables the study to capture a comprehensive picture and generate evidence that reflects real-world scenarios across the globe. In addition, the current investigation can be categorized as having high internal validity, primarily attributable to the obtained high reliability scores. Concurrently, it demonstrates a high external validity, primarily stemming from its global assessment, multicenter nature, and the application of meta-analysis statistics. Although the data generated by the present study are already capable of generalization, additional data from other regions, especially in sub-Saharan African regions or Oceania, and across various tooth groups, would be valuable for future research.

CONCLUSIONS

The findings of this study revealed a global prevalence of 2 root canals in the mandibular canine at 7.5%, ranging from 0.7% in Nigeria to 17.7% in Uruguay. The overall proportion of 2-rooted morphologies was 1.9%, varying from no findings in Jamaica, Nigeria, and Ecuador to 6.7% in Spain. High percentages of 2 roots were observed in Europe, South Asia, and the Middle East, as well as among Caucasian and Indian individuals (from south Asia), whereas lower percentages were evident in Asia, Africa, and the Americas. Female gender and older patients showed significantly higher proportions of both configurations, whereas the tooth side, voxel size, and FOV did not exert influence on the outcomes.

ACKNOWLEDGMENTS

The authors would like to acknowledge Yongchun Gu (Soochow University, China), Masashi Yamada (Tokyo Dental College, Japan), Masahiro Furusawa (Tokyo Dental College, Japan), Rodrigo Villanueva (Pontificia Universidad Católica de Chile, Chile), Danuchit Banamyong (Mahidol University, Thailand), András Mócz (private practitioner, Hungary), Uche Iheme (private practitioner, Nigeria), Amy Traore-Shumbusho (private practitioner, Nigeria), Yetunde Braithwaite (private practitioner, Nigeria), Javier De Lima (private practitioner, Uruguay), Guzman Pedreira (private practitioner, Uruguay), Sashi Nallapati (private practitioner, Jamaica), Alexander Soloshenko (private practitioner, Kyrgyzstan), and Tito Enrique Caballero Cruz (private practitioner, Peru) for their help on the development of this study. In addition, the authors thank the College of Dentistry Research Center, King Saud University, for their support in conducting this project.

The authors deny any conflicts of interest related to this study.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found in the online version at www.jendodon.com (https://doi.org/10.1016/j.joen.2024.01.016).

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