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Systematic Review

Mapping Root and Canal Anatomy in Saudi Populations Using Cone-Beam Computed Tomography: Prevalence, Classification, and Clinical Implications for Endodontic Practice

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Abstract

Objective: To synthesize CBCT based evidence on root and canal morphology in Saudi subpopulations and outline the clinical implications for access, scouting, and preparation. **Methods:** We followed PRISMA aligned methods to identify English original studies from Saudi centers reporting CBCT findings on permanent teeth. Eligibility included observational designs describing root number, Vertucci configuration, second mesiobuccal canal (MB2), C shaped canals, and relevant inter orifice measurements. Due to heterogeneity in tooth types, reporting schemes, and CBCT parameters, we conducted a structured narrative synthesis. **Results:** in included studies, mandibular molars most commonly exhibited two roots with three canals, with Vertucci type IV frequent in mesial roots and type I in distal roots. C shaped morphology was reported in mandibular molars, with notable regional and sex related variation. In maxillary molars, MB2 was detected in first molars and less often in second molars; inter-orifice spatial relationships were mapped at the pulp floor level, reinforcing the need for methodical troughing and magnification. Premolars were predominantly single-rooted/single-canal in mandibular arches, whereas maxillary first premolars commonly showed two roots; taxonomy influenced reporting. **Conclusions:** CBCT guided, tooth specific strategies integrating demographic

Keywords : Cone Beam Computed Tomography; Root Canal Anatomy; Mesiobuccal Second Canal; C shaped Root Canal; Premolar Morphology; Maxillary Molars; Saudi Arabia; Endodontics

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risk cues, standardized interpretation, and meticulous clinical exploration, can reduce missed anatomy and optimize endodontic outcomes.

Introduction

Successful endodontic therapy depends on accurate recognition of root and canal anatomy, because missed treated canals are a major cause of failure (1). Three-dimensional cone beam computed tomography (CBCT) overcomes key limitations of 2D radiography, projection, geometric distortion, and anatomical noise, by enabling multiplanar navigation and a systematic, reproducible interpretation workflow that improves diagnostic precision and treatment planning (1).

Population and tooth specific variation is substantial, a study of Saudi studies on mandibular teeth shows predominantly single canal incisors and canines, high frequencies of Vertucci type I configurations in second premolars (96.9%), and common three canal mesial distal patterns in first molars; C-shaped canals appear in 9.8% of mandibular second molars and mid mesial canals in 4.2% of first molars. These findings indicate regional heterogeneity and the influence of imaging modality on reported morphologies (2).

In a CBCT series from northern Saudi Arabia, two roots were frequent in maxillary first premolars (62% on the maxillary left), with Vertucci type IV often observed; mandibular premolars were typically type I (3). Maxillary molars demand particular vigilance for a second mesiobuccal canal (MB2). A systematic review focused on the Indian population show that MB2 detection varies by method, pooled prevalence 64.8% with CBCT, 26.5% with direct vision, higher with magnification and ultrasonic troughing, with male sex associated with greater detection. These method dependent gradients underscore the need to combine careful clinical exploration with appropriate imaging (4).

Saudi CBCT data on maxillary molars show that first molars most often present with three roots and four canals, whereas second molars exhibit more variability (including 3 root, 3 canal patterns) and high bilateral symmetry; such distributions have direct implications for access design and canal scouting (5).

Anterior teeth display simpler patterns, yet precise knowledge is essential. In a Saudi subpopulation, canines were overwhelmingly single rooted, single canal, with Vertucci type I predominating and an impacted canine prevalence around 7.9%; sex and arch differences were also observed (6). These data inform expectations for canal negotiation and the diagnostic role of CBCT in orthodontic and endodontic planning (6).

Methods

Protocol and reporting

This review was conducted and reported in accordance with PRISMA 2020.

Eligibility criteria

We included original studies conducted in Saudi Arabia that used CBCT to describe root and canal morphology of permanent teeth. Eligible designs were observational cross sectional or cohort analyses reporting at least one of the following: number of roots, Vertucci canal configuration, presence of a second mesiobuccal canal (MB2), C shaped canal prevalence, and intra orifice measurements. Studies focused on primary dentition, non-Saudi populations, cadaveric or in vitro and ex vivo experiments, case reports without CBCT-based prevalence, systematic reviews, editorials, letters, conference abstracts without full data, and duplicates were excluded.

Information sources and search strategy

We searched electronic databases to identify eligible articles and supplemented this with manual screening of reference lists and forward citation tracking of included papers. No prespecified limits on publication year were applied at the search stage. free-text terms and controlled vocabulary were combined around three concepts: tooth and region (maxillary molar, mandibular premolar), morphology (root, canal, Vertucci, MB2, C-shaped), and imaging modality. Full-text screening was limited to studies available in English or Arabic.

Study selection

Records were screened at title and abstract level, followed by full text assessment against eligibility criteria. All inclusion and exclusion decisions were re checked after a cooling off period to reduce selection error. Reasons for full text exclusion were documented (wrong population, wrong design, not CBCT based, inadequate outcomes, duplicate) (Fig 1).

Data extraction

A standardized form was used to extract study characteristics (first author, year, region, center), design, sample size (patients and teeth), participant characteristics (sex distribution, age where available), CBCT acquisition parameters, tooth type, and outcomes: roots and canals counts, Vertucci types, MB2 prevalence and inter orifice distances, C shaped prevalence and external morphological markers, side, sex differences, and notable measurement definitions. When data were presented only in figures, values were transcribed directly; no study authors were contacted.

Risk of bias assessment

Methodological quality of prevalence and observational studies was appraised using an established checklist appropriate for cross sectional prevalence research (sampling frame, sample size justification, measurement validity, assessor reliability, and completeness of reporting). Given the single reviewer workflow, risk of bias judgments were self audited for consistency.

Synthesis methods

Heterogeneity in tooth type, outcomes, and measurement definitions precluded metaanalysis. A structured narrative synthesis was undertaken, grouping findings by jaw and tooth (maxillary molars, MB2; mandibular molars, Cshaped and Vertucci; premolars, root canal counts and Vertucci). subgroup patterns by sex, side, and region were summarized descriptively.

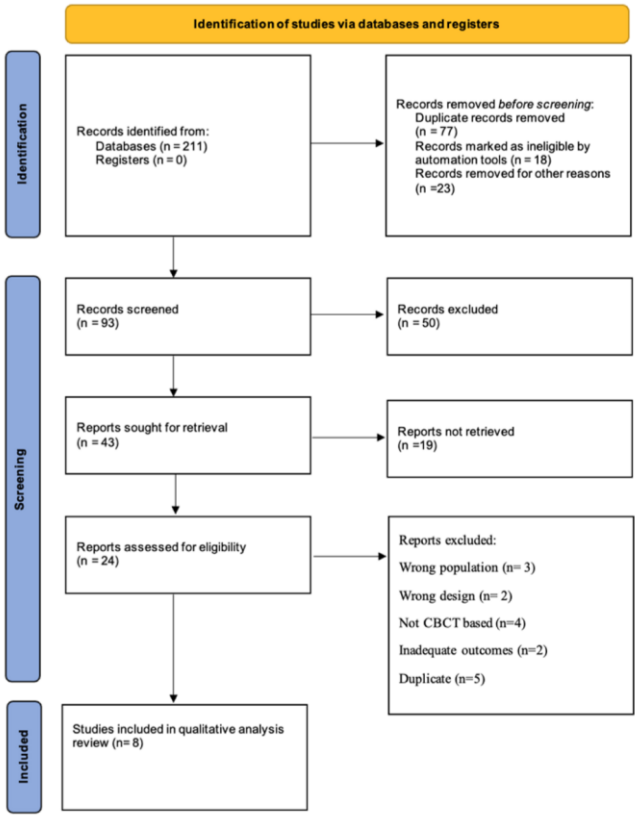

Fig 1: PRISMA consort chart of selection

Results

In the included CBCT based cross sectional studies from Saudi centers, mandibular molars show two roots with three canals, and characteristic mesial distal configuration patterns. In a Makkah cohort, 96.5% of mandibular first molars and 96.3% of second molars had two roots; three canals were present in 77.7% and 82.7%, respectively. Vertucci type IV predominated in mesial roots (first molars 75.6%; second molars 48%), while type I predominated in distal roots (first molars 71.7%; second molars 99.1%). C shaped canals were detected in 5.7% of first and 4.0% of second mandibular molars.

A large Jeddah CBCT series reported a higher overall incidence of C shaped morphology (27.3%), with 24.3% in mandibular first molars and 30.3% in second molars. The longitudinal groove was most commonly lingual (53.3%), and prevalence was higher in males for second molars.

Maxillary molar assessments identified an MB2 canal frequently in maxillary first molars, but less often in second molars. MB2 was found in 46.7% of first and 17.7% of second maxillary molars, located palatal to MB1 or along the line connecting MB1 and the palatal canal. In a Riyadh region CBCT study focused on maxillary first molars, the MB2 prevalence reached 86.8%, with a mean MB1 MB2 inter orifice distance of 2.52 ± 0.57 mm at the pulp floor level.

Mandibular premolar morphology was largely simple and showed clinically relevant variability, especially in first premolars. In a Jazan cohort of 776 teeth, 99.5% of first premolars and 100% of second premolars had one root; however, two canals occurred in 29.5% of first premolars versus 2.1% of second premolars. Distributions were: first premolars, type I 69.5%, type III 6.3%, type V 22.2%, type VII 0.3%; second premolars, type I 96.8%, type III 1.6%, type V 0.8%; with no right, left differences. Additional regional work from Hail inspected 1000 mandibular premolars using standardized CBCT protocols, reinforcing the need to anticipate anatomic variation when planning access and instrumentation.

A Taibah University study concluded that maxillary premolars presented with two roots and type IV configurations, whereas mandibular premolars typically had one root with type I, underscoring CBCT value for case difficulty assessment.

These studies indicate a predictable two root and three canal patterns in mandibular molars with notable, but regionally variable, burdens of C-shaped anatomy; clinically important MB2 prevalence in maxillary first molars (with defined intra orifice spatial relationships) and lower rates in second molars; and simple mandibular premolar anatomy with two canal frequency in first premolars. These distributions emphasize careful pre operative imaging and targeted exploration to avoid missed canals and to tailor canal preparation.

Table 1: characteristics of the studies included

Citation	Study Design	Sample Size	Country	Study Aim	Outcomes

Kody et al., 2020 [8]	Cross-sectional using national database (2008–2017)	National estimates of ED visits	USA	To evaluate trends and diagnoses in dermatology-related ED visits	Dermatologic visits accounted for 3.5–4.3% of ED cases; cellulitis and abscess most common diagnoses
Özkur et al., 2020 [4]	Retrospective chart review (2017–2018)	444 patients	Turkey	To investigate profile of ED dermatology consultations	Skin infections (86.9%) most common; peak cases in April ; urticaria/angioedema also frequent
Bin Rubaian et al., 2024 [3]	Retrospective chart review (2021–2023)	301 patients	Saudi Arabia	To describe epidemiology and patterns of dermatologyrelated ED cases	Maculopapular rashes most common (35.6%); majority triaged as non-urgent; seasonal variations observed
Jack et al., 2011 [6]	Retrospective chart review (2004–2007)	204 patients	USA	To identify common cutaneous diseases leading to dermatology	18% admitted; Stevens–Johnson syndrome, pemphigus vulgaris, severe drug eruptions frequent in admitted cases

Table 2: demographics and clinical findings of dermatology ED studies

Citation	Demographics	Duration of Rash	Associated Symptoms	Most Common Diagnosis	Main Findings
Kody et al., 2020 [8]	National US ED sample; all ages	Not specified	Not detailed; focus on cellulitis/abscess	Cellulitis, cutaneous abscess	Dermatology-related visits 3.5–4.3% of ED; infections most frequent
Özkur et al., 2020 [4]	Mean age 44.6 years; 56% male	Varied; peak in April	Not specified in detail	Skin infections (86.9%)	Infections dominated; viral most common; urticaria/angioedema also seen
Bin Rubaian et al., 2024 [3]	Median age 12 years; 50% male/female	Median visit duration 312 minutes	Not detailed; triage data available	Maculopapular rash (35.6%)	Majority non-urgent; seasonal variation; topical steroids, antihistamines used
Jack et al., 2011 [6]	204 patients, adult ED, urban US	Acute (< 1 month) more common in admitted cases	Pain, blistering, mucosal involvement in severe cases	Eczematous dermatitis, scabies, drug eruption	18% admitted; severe drug eruptions, SJS, pemphigus vulgaris most serious
AlKhater et al., 2017 [1]	2070 pediatric ER cases (≤13 years)	Not reported	Not specified	Atopic dermatitis (10.8%) , urticaria (9.7%)	High frequency of infectious (25.2%) and allergic dermatoses; 10.5% undiagnosed
Temel et al., 2023 [5]	639 consultations,	Not specified	COVID-19 related eruptions noted	Herpes zoster, urticaria, dermatitis	Pandemic shifted profiles; increased vasculitis,

	mean age 44–46 yrs				pruritus, impetigo/folliculitis
Kilic et al., 2019 [9]	859 patients; mean age 39 yrs; 59.5% female	Not detailed	Pruritus, allergic reactions	Urticaria, drug eruptions (84.5%)	Most patients discharged; only 6.4% hospitalized; few emergent cases
Ansorge et al., 2018 [7]	1552 consultations; mean age 41 yrs; 53% female	>1 week on average	Itching, rash most frequent complaints	Eczema, urticaria, scabies	8% hospitalized; many non-urgent diagnoses; 72% self-referrals
Alshibani et al., 2024 [2]	11,443 patients; mean age 22.4 yrs; 54.9% male; 55% <18 yrs	Not specified	Varied; systemic data not detailed	Rash/unspecified eruption (16%), cellulitis (13.6%), urticaria (12.2%)	Children formed majority; wide range of dermatology emergencies
Hines et al., 2021 [10]	450 consultations; mix of adults/peds at Mayo Clinic	Varied; acute vs chronic compared	Severe cases: blistering, systemic illness	Dermatitis (24.7%), infection (20.4%), drug reaction (10.3%)	Teledermatology effective; in-person linked with higher admission and diagnostic changes

ED, Emergency Department; SJS, Stevens–Johnson Syndrome; TEN, Toxic Epidermal Necrolysis; NOS, Newcastle–Ottawa Scale; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; COVID-19, Coronavirus Disease 2019; MeSH, Medical Subject Headings

Discussion

Dermatological conditions represent a considerable proportion of ED visits. The spectrum of presentations and outcomes differ in regions and healthcare systems. The present review, consistent with prior analyses, shows that most cases are benign or non-urgent, although a subset herald severe or lifethreatening disorders. Several recent systematic reviews show that rashes are the most frequent ED dermatology presentations, the key challenge lies in distinguishing innocuous eruptions from early manifestations of severe drug reactions, autoimmune bullous disorders, or infections that can rapidly progress without timely intervention [11].

Regional studies found significant epidemiological diversity. In Morocco, a twoyear case series reported infectious dermatoses, mainly erysipelas, as the leading cause of dermatological emergencies, followed by drug eruptions and autoimmune bullous diseases [12]. Australian studies show a predominance of cellulitis and abscesses, with the majority of patients discharged directly from the ED, underscoring that only a small proportion required inpatient care [13,14]. Data from Switzerland confirmed that infections and eczema were the most frequent ED diagnoses, and many visits were deemed unjustified, pointing to inappropriate utilization of emergency services [15].

Clinical severity markers have been identified in studies. In a U.S. cohort, admitted patients had acute eruptions of less than one month's duration, with features including pain, blistering, mucosal involvement, and systemic illness, which strongly predicted hospitalization [6]. These findings align with broader reviews noting that Stevens–Johnson syndrome, toxic epidermal necrolysis, and pemphigus vulgaris is the main dermatological emergencies requiring admission and carry the highest morbidity and mortality risks [11].

Viral and bacterial infections are central to ED dermatology, with emerging infectious diseases and globalization introducing novel clinical challenges [16]. The growing role of teledermatology, though slightly less accurate than in-person consultations, offers a promising adjunct to improve access and diagnostic support in overstretched EDs [11].

These findings indicae the need for standardized triage pathways, improved dermatology training for emergency physicians,
and public health initiatives to reduce inappropriate ED utilization. Early recognition of high-risk features, integration of telemedicine, and context-specific strategies tailored to regional epidemiology improve outcomes and optimize resource use in dermatological emergencies.

Conclusion

Dermatological conditions represent a notable proportion of emergency department visits, though most are non-urgent and managed on an outpatient basis. Infections, urticaria, eczema, and drug eruptions are frequent, while Stevens–Johnson syndrome and toxic epidermal necrolysis account for most admissions. Early recognition of clinical severity markers is important to avoid adverse outcomes.

Standardized triage systems, physician training, and teledermatology integration improve diagnostic accuracy, reduce unnecessary ED utilization, and optimize management of dermatological emergencies.

Ethical & Transparency Statements

Ethical Approval: This systematic review did not involve human or animal subjects; therefore, ethical approval was not required.

Conflict of Interest: The authors declare no conflicts of interest.

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Data Availability: All data generated or analyzed during this study are included in this published article.

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