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Prevalence of Developmental Anomalies Related to the Shape of Teeth in the Indian Population: A Systematic Review

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Abstract

Developmental anomalies related to the shape of teeth may complicate diagnosis and dental treatment. Indian prevalence estimates vary across populations and diagnostic methods. Reported prevalence varies widely between populations. Differences may reflect genetic and environmental influences, but may also arise from age, dentition, sampling frame, diagnostic criteria, and the use of clinical examination, panoramic radiography, or cone-beam computed tomography (CBCT). Indian studies are geographically dispersed and have used variable anomaly lists and denominators, making their findings difficult to interpret collectively. The present systematic review aimed to evaluate the prevalence and distribution of nine developmental tooth-shape anomalies in Indian populations. PubMed/Medical Literature Analysis and Retrieval System Online (MEDLINE), Scopus, ScienceDirect, and Google Scholar were searched from inception through 17 September 2026. The first 200 Google Scholar results, ranked by relevance, were screened according to a prespecified limit, and supplementary reference-list searching and source verification were completed on the same date. Observational studies reporting an eligible anomaly with a usable denominator were included. Two teams of three reviewers independently selected studies and extracted data. Risk of bias was assessed using the Joanna Briggs Institute prevalence checklist. An outcome-specific adaptation of the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) was used to assess certainty. Findings were synthesized narratively because of clinical and methodological heterogeneity. Thirty-two studies reported in 33 publications were included; summed study samples totaled 98,110, although possible overlap between record-based cohorts precluded confirmation of a unique-participant total. Participant-level prevalence ranges, including separately reported case and control subgroup estimates with their own denominators, were 0%-1.41% for gemination, 0%-1.2% for fusion, 0%-0.09% for concrescence, 0%-29.24% for dilaceration, 0%-15.6% for talon cusp, 0%-13.5% for dens invaginatus, 0%-7% for dens evaginatus, and 0%-11.8% for taurodontism. Tooth-level estimates were summarized separately and were not included in these ranges. Unclassified double teeth were retained separately. One study reported no enamel pearls. Seventeen studies had low risk of bias, and 15 had moderate risk. Certainty was low for seven anomalies and very low for concrescence and enamel pearls. Prevalence varied substantially across sampled Indian populations. Sampling limitations, inconsistent diagnostic methods, and uncertain detection of root-surface anomalies limited certainty and prevented estimation of nationally representative prevalence.

Categories: Dentistry
Keywords: dental morphology, developmental dental anomalies, epidemiology, india, prevalence, risk of bias, systematic review, tooth shape anomalies

Introduction And Background

Human dentition develops through a precisely regulated sequence of interactions between the oral epithelium and neural crest-derived ectomesenchyme. These interactions control initiation, morphogenesis, mineralization, eruption, and the final form of each tooth [1-3]. Disturbance at any stage may produce developmental dental anomalies involving tooth number, size, shape, structure, or eruption. Shape-related anomalies are especially relevant because altered crown or root morphology may remain unnoticed until clinical or radiographic examination [2,4].

Although many developmental anomalies are asymptomatic, their presence may influence aesthetics, occlusion, plaque retention, caries susceptibility, and periodontal health. Complex crown and root forms may also complicate extraction, orthodontic movement, and endodontic access, cleaning, and obturation [4]. Early identification is therefore important for diagnosis, prevention of complications, and appropriate treatment planning.

The principal shape anomalies include gemination, fusion, concrescence, dilaceration, talon cusp, dens invaginatus, dens evaginatus, taurodontism, and enamel pearl. Gemination results from attempted division of one tooth germ, whereas fusion is the union of two developing germs [5]. Concrescence refers to union

through cementum, while dilaceration is an abnormal bend in the crown or root [6,7]. Talon cusp and dens evaginatus are outward projections of dental tissues; dens invaginatus represents an infolding of enamel and dentine into the tooth [8-10]. Taurodontism is characterized by an enlarged pulp chamber with apical displacement of the pulpal floor, and enamel pearls are ectopic enamel deposits, usually located on root surfaces [11,12].

Accurate differentiation between these anomalies is clinically important because superficially similar presentations may arise through different developmental processes. Fusion and gemination may both produce an enlarged or bifid crown, although their differentiation depends on tooth count, crown morphology, and radiographic findings [5]. Concrescence and dilaceration primarily involve the roots and may remain clinically undetected without appropriate imaging [6,7]. Similarly, talon cusp and dens evaginatus represent external projections of dental tissues, whereas dens invaginatus involves an infolding of enamel and dentine [8-10]. Taurodontism and enamel pearls are also predominantly radiographic findings unless they are detected during extraction or direct root-surface examination [11,12]. Consequently, the apparent prevalence of these anomalies may depend substantially on the diagnostic method used.

Reported prevalence varies widely between populations. Differences may reflect genetic and environmental influences but may also arise from age, dentition, sampling frame, diagnostic criteria, and the use of clinical examination, panoramic radiography, or cone-beam computed tomography [13]. Indian studies are geographically dispersed and have used variable anomaly lists and denominators, making their findings difficult to interpret collectively. An earlier Indian synthesis in 2020 addressed shape-related developmental anomalies, but an updated assessment incorporating subsequent studies and explicit appraisal of prevalence evidence was warranted [14]. This systematic review aimed to summarize the reported prevalence and distribution of nine developmental tooth-shape anomalies across sampled Indian populations and to assess the risk of bias and certainty of the available evidence. It was not intended to derive a nationally representative prevalence estimate.

Review

Materials and methods

The present systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [15]. The review question was structured according to the condition, context, and population framework: among people residing in India, what is the prevalence and distribution of the various developmental anomalies related to the shape of the teeth? The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (Registration ID: CRD420261486770)

Eligibility Criteria

Original observational studies reporting prevalence data for at least one eligible anomaly in a living Indian population were included. Participants of any age or sex and studies of primary, mixed or permanent dentition were eligible. Community-, school-, hospital-, dental outpatient-, dental college- and radiographic record-based samples were considered. Comparative or condition-specific populations were eligible when the Indian sample and its denominator were reported separately.

Eligible reports were required to state, or permit calculation of, a participant- or tooth-level denominator and to identify anomalies by clinical examination, conventional radiography or cone-beam computed tomography. Cross-sectional surveys, retrospective record reviews and comparative cross-sectional studies were included. Case reports, case series without a defined denominator, reviews, editorials, conference abstracts without usable data, laboratory studies, studies of extracted or archaeological teeth, and multinational studies without separable Indian data were excluded. Reports from the same or potentially overlapping cohort were collated; complementary anomaly data were retained, while participants were counted only once. Supernumerary or accessory roots were outside the final review scope and were excluded. The inclusion and exclusion criteria according to the Population, Intervention, Comparison, Outcomes and Study (PICOS) framework are summarized in Table *1*.

Eligibility component	Inclusion criteria	Exclusion criteria
Population	Living human participants residing in India, irrespective of age or sex; primary, mixed or permanent dentition	Populations outside India; multinational studies without separately extractable Indian data; studies involving extracted teeth, archaeological material or non-human samples
Condition	Developmental tooth-shape anomalies comprising gemination/twinning, fusion, concrescence, dilaceration, talon cusp, dens invaginatus, dens evaginatus, taurodontism and enamel pearl	Anomalies limited to tooth number, size, structure or eruption; supernumerary/accessory roots; acquired morphological alterations
Context/setting	Community-, school-, hospital-, dental outpatient department-, dental college- or radiographic record-based populations	Studies in which the sampling setting or source population could not be determined
Exposure/assessment	Identification of eligible anomalies through clinical examination, dental casts, conventional radiography, orthopantomography, intraoral periapical radiography or cone-beam computed tomography	Studies without a defined or reproducible method for identifying developmental tooth anomalies
Comparator	No comparator was required. Comparative studies were eligible when the Indian group and its denominator were reported separately	Comparative or multinational studies in which data for the eligible Indian population could not be separated
Outcomes	Participant- or tooth-level prevalence of at least one eligible anomaly, reported directly or calculable using an identifiable numerator and denominator	Reports without a usable screened-population or tooth-level denominator; studies reporting only the distribution of anomalies among anomaly-positive participants
Study design	Cross-sectional surveys, retrospective cross-sectional studies, radiographic record reviews, clinical record reviews and comparative cross-sectional studies	Case reports; case series without a defined denominator; randomized or non-randomized intervention studies; reviews; editorials; letters; conference abstracts without sufficient data; laboratory studies
Report characteristics	Full-text reports with sufficient methodological and outcome data; no restriction by publication year or language at the search stage	Reports with insufficient information for eligibility assessment or data extraction
Overlapping reports	Reports from the same or potentially overlapping cohort were collated; complementary eligible outcomes were retained, and participants were counted only once.	Repeated estimates from the same cohort were not counted as independent studies.

TABLE 1: Eligibility criteria for study selection

Information Sources and Search Strategy

PubMed/Medical Literature Analysis and Retrieval System Online (MEDLINE), Scopus, ScienceDirect, and Google Scholar were searched from database inception through 17 September 2026. No restrictions were applied according to publication year or language. For Google Scholar, the first 200 results returned in the default relevance ranking were screened. This limit was specified before screening because the relevance of Google Scholar results generally decreases progressively and later-ranked results frequently represent duplicates or records unrelated to the review question. No additional eligible report was identified among the later-ranked records within the prespecified 200-result set. Screening nevertheless stopped at the predefined limit rather than according to a formal saturation criterion. Reference lists of the included studies and relevant reviews were also screened, and supplementary reference checking and source verification were completed on 17 September 2026.

Search terms combined population, dental, and anomaly concepts. The representative search structure was: (India OR Indian) AND (tooth OR teeth OR dental) AND (gemination OR twinning OR fusion OR concrescence OR dilaceration OR “talon cusp” OR “dens invaginatus” OR “dens evaginatus” OR taurodontism OR “enamel pearl”) AND (prevalence OR epidemiology OR cross-sectional). Syntax was adapted for each source. The source-specific strategies and documented screening scope are presented in Table *2*.

Information source	Search strategy	Search period and restrictions
PubMed/MEDLINE	(India[Title/Abstract] OR Indian[Title/Abstract]) AND (tooth[Title/Abstract] OR teeth[Title/Abstract] OR dental[Title/Abstract]) AND (gemination[Title/Abstract] OR twinning[Title/Abstract] OR fusion[Title/Abstract] OR concrescence[Title/Abstract] OR dilaceration[Title/Abstract] OR "talon cusp"[Title/Abstract] OR "dens invaginatus"[Title/Abstract] OR "dens evaginatus"[Title/Abstract] OR taurodontism[Title/Abstract] OR "enamel pearl"[Title/Abstract]) AND (prevalence[Title/Abstract] OR epidemiology[Title/Abstract] OR "cross-sectional"[Title/Abstract])	From database inception to 17 September 2026; no language or publication date restrictions.
Scopus	TITLE-ABS-KEY ((India OR Indian) AND (tooth OR teeth OR dental) AND (gemination OR twinning OR fusion OR concrescence OR dilaceration OR "talon cusp" OR "dens invaginatus" OR "dens evaginatus" OR taurodontism OR "enamel pearl") AND (prevalence OR epidemiology OR "cross-sectional"))	From database inception to 17 September 2026; no language or publication date restriction.
ScienceDirect	(India OR Indian) AND (tooth OR teeth OR dental) AND (gemination OR twinning OR fusion OR concrescence OR dilaceration OR "talon cusp" OR "dens invaginatus" OR "dens evaginatus" OR taurodontism OR "enamel pearl") AND (prevalence OR epidemiology OR "cross-sectional")	From database inception to 17 September 2026; no language or publication date restriction.
Google Scholar	"India" AND ("dental anomaly" OR "tooth anomaly" OR gemination OR twinning OR fusion OR concrescence OR dilaceration OR "talon cusp" OR "dens invaginatus" OR "dens evaginatus" OR taurodontism OR "enamel pearl") AND (prevalence OR epidemiology)	Searched through 17 September 2026; the first 200 results in the default relevance ranking were screened according to a prespecified limit.
Supplementary searching	Reference lists of included studies and relevant reviews were screened to identify additional eligible reports	Supplementary reference checking and source verification were completed on 17 September 2026.

TABLE 2: Database-specific search strategies used in the present systematic review

MEDLINE: Medical Literature Analysis and Retrieval System Online

Study Selection

Retrieved records were compiled, and duplicates were removed by comparing titles, authors, year, journal, and digital identifiers. Two teams of three reviewers each independently screened titles and abstracts, followed by full-text assessment of potentially relevant reports. Disagreements were resolved through discussion and, when necessary, consultation with an expert reviewer. Reasons for full-text exclusion were documented.

Data Collection and Data Items

Two teams of three reviewers each independently extracted data using a piloted form. The extracted variables included author, publication year, state or city, design, setting, sampling approach, sample size, age, sex, dentition, diagnostic method, imaging modality, anomaly assessed, numerator, denominator, overall anomaly prevalence and anomaly-specific prevalence. Participant-level and tooth-level denominators were retained separately. Disagreements were reconciled against the source report.

Where prevalence had been calculated using only anomaly-positive participants rather than the complete screened sample, it was recalculated using the total eligible denominator when the raw numbers permitted this. A value was entered as zero only when the anomaly had been assessed, and no case was reported. An anomaly that was not assessed or not reported was treated as missing rather than zero. The principal

outcome was participant-level prevalence of each of the nine anomalies. Tooth-level prevalence and distribution by age, sex, dentition, geographic location, setting, and diagnostic method were treated as additional outcomes when available. Reports using the combined term double teeth without separating fusion from gemination were described as a combined category and were not entered as separate estimates for both anomalies. Where participant counts were internally inconsistent, a participant-level prevalence was not reconstructed; an unambiguous tooth-level estimate was retained separately.

Risk of Bias Assessment

The Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data was used because all included reports contributed prevalence estimates [16]. Its nine domains address the appropriateness of the sample frame, participant sampling, adequacy of sample size, description of participants and setting, coverage of the identified sample, validity of anomaly identification, reliability of measurement, appropriateness of statistical analysis, and adequacy of the response rate. The same two reviewer teams that performed study selection and data extraction independently assessed the risk of bias. Each team comprised three reviewers. Disagreements were resolved through discussion and, when necessary, consultation with the expert reviewer. Each domain was judged as yes, no, unclear, or not applicable.

Overall judgments followed prespecified decision rules, with particular emphasis on four key domains: appropriateness of the sample frame, participant sampling, validity of anomaly identification, and reliability of measurement. A study was classified as having low risk of bias when no major limitation in these key domains was expected to materially alter the prevalence estimate. Moderate risk was assigned when one important concern involving representativeness, diagnostic coverage, measurement reliability, or reporting could influence the estimate, but sufficient information remained for interpretation. High risk was assigned when multiple major concerns affected both sampling and ascertainment or when the methodological limitations made the prevalence estimate unreliable. An unclear domain judgment did not automatically determine the overall category; its number, importance, and likely influence on the prevalence estimate were considered. Numerical scores were not used to determine eligibility or the overall judgment. Studies lacking a usable denominator or an identifiable diagnostic method had already been excluded, which partly explains why none of the included studies received a high-risk judgment.

Data Synthesis

Prevalence was expressed as the number of affected participants divided by the total number examined and was summarized separately for each anomaly. Participant-level and tooth-level estimates were retained separately and were not combined. Ranges were calculated only from studies that had explicitly assessed the anomaly and provided a usable denominator. Separately reported case and control subgroups were eligible for inclusion in the ranges when each subgroup had its own numerator and denominator. These subgroups were treated as separate descriptive strata and were not recombined to construct a whole-study estimate.

Before synthesis, studies were classified according to sampling context as community or school-based, general dental or institution-based, referral or imaging-record based, or condition-specific. Referral-based cone-beam computed tomography (CBCT) and radiographic cohorts and condition-specific populations were regarded as selected samples. Their findings were retained but were interpreted within their sampling context and were not considered representative of the general Indian population.

Owing to substantial differences in population selection, age, dentition, diagnostic method, anomaly definition, and denominator convention, statistical pooling was not considered appropriate. Findings were therefore synthesized narratively and in structured tables and were grouped according to diagnostic method, population and setting, age or dentition, and unit of analysis. Formal funnel-plot or regression-based assessment of publication bias was not undertaken because no pooled effect estimates were generated and evidence was sparse for several outcomes. Publication bias was considered qualitatively but could not be assessed reliably.

Certainty of Evidence

Certainty was assessed separately for each anomaly using an adaptation of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework for prevalence evidence [17]. The same two teams of three reviewers independently performed the certainty assessment. Disagreements were resolved through discussion and, when necessary, consultation with the expert reviewer.

Because cross-sectional studies are the appropriate design for estimating prevalence, each outcome initially entered the assessment at high certainty. Certainty was then downgraded by one or, when appropriate, two levels across five domains. Risk of bias was downgraded when a substantial proportion of the evidence arose from selected sampling frames or studies with important ascertainment or reporting concerns. Inconsistency was downgraded when prevalence estimates varied markedly across comparable studies without an adequate methodological or clinical explanation. Indirectness was considered when the sampled

populations, settings, or diagnostic methods did not adequately represent the review question, particularly when clinically occult anomalies were assessed without systematic radiographic examination. Imprecision was considered when the evidence was based on few studies, small denominators, or very few detected events. Publication bias was downgraded only when it was reasonably suspected; inability to assess publication bias did not itself result in downgrading. No upgrading criteria were applied. Final certainty was categorized as high, moderate, low, or very low.

Results

The database and supplementary searches identified 744 records, of which 488 remained after the removal of 256 duplicates. After 448 records were excluded during title and abstract screening, 40 reports were sought for retrieval. Three reports could not be retrieved, leaving 37 reports for full-text assessment. Four reports were excluded after full-text evaluation. The remaining 33 reports represented 32 studies [18-50], as the two reports by Narain et al. described the same potentially overlapping cohort but provided complementary anomaly outcomes [48,49]. These reports were retained as companion publications, although the 5,000 participants were counted only once. The study-selection process is presented in Figure *1*, and the reasons for full-text exclusion are listed in the Appendix.

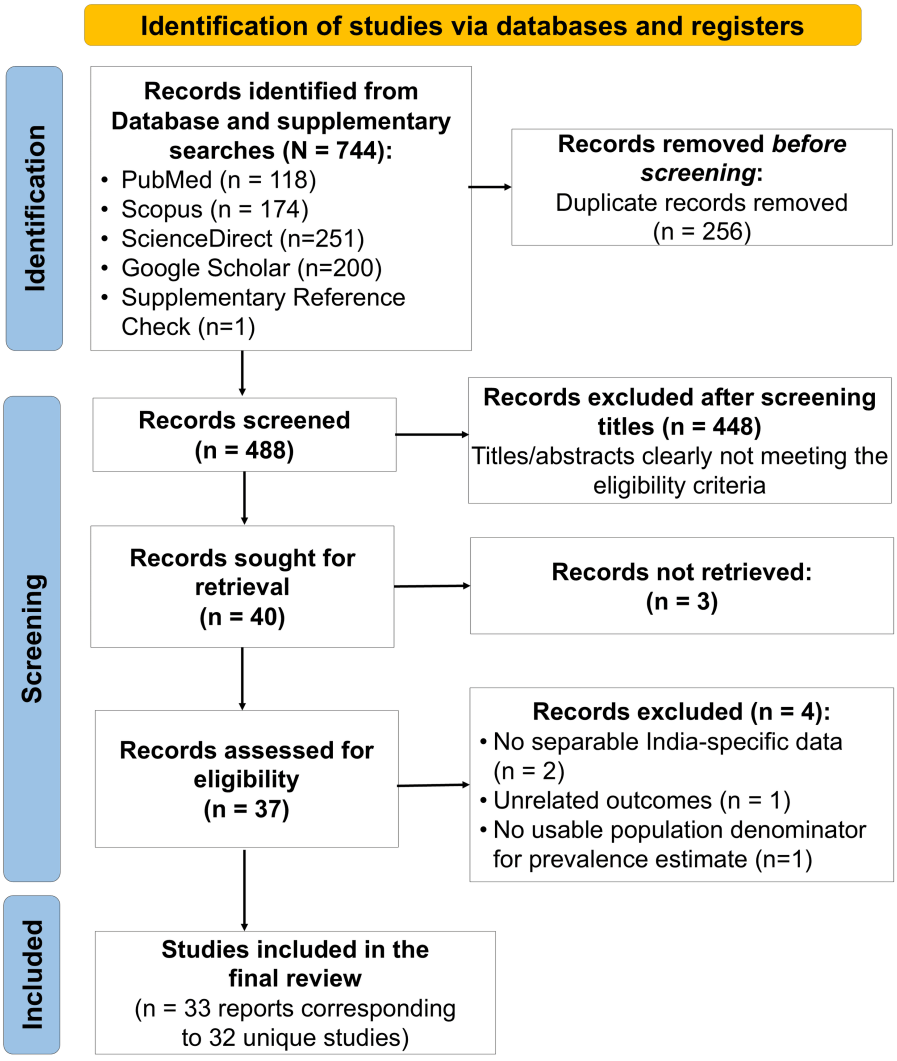

FIGURE 1: PRISMA flow diagram indicating the selection process of the studies in the present systematic review

Study Characteristics

The studies were published from 2010 to 2025 and represented 14 Indian states. Rajasthan contributed five studies and Karnataka four, while Uttar Pradesh, Tamil Nadu, Maharashtra, and Andhra Pradesh contributed three studies each. The remaining evidence came from Bihar, Jharkhand, Madhya Pradesh, Odisha, West

Bengal, Telangana, Haryana, and Arunachal Pradesh. None of the studies used a nationally representative sample.

The included studies used direct clinical examination, retrospective radiographic assessment, combined clinical and radiographic examination, or clinical record review. Samples were obtained from schools, communities, dental outpatient departments, teaching institutions, orthodontic services, and radiographic archives. One study separately evaluated children with neurodevelopmental disorders and unaffected controls. For synthesis, the studies were considered according to whether they represented community or school populations, general institution-based populations, selected referral or imaging-record populations, or condition-specific groups. Referral-based CBCT cohorts, orthodontic samples, and other radiographic archives were interpreted as selected populations rather than as estimates of prevalence in the general Indian population.

Sample sizes ranged from 156 to 20,182 participants. The summed study samples totaled 98,110 after the two Jaipur reports were counted as one cohort. Definite overlap was present between the two Narain et al. reports [48,49], which described the same 5,000 children but reported different developmental anomalies. These reports were therefore treated as one study with complementary outcomes.

Potential overlap could not be excluded between Patil and Doni [23] and Patil et al. [24]. Both reports were published in 2013, shared authors, and evaluated radiographic samples from dental outpatient populations in Jodhpur. They reported different anomalies and were therefore retained, but their samples were not regarded as confirmed unique individuals. Because no meta-analysis was performed, possible overlap could not influence a pooled prevalence estimate. It could, however, affect the summed descriptive sample size and the apparent volume of available evidence. The total of 98,110 should therefore not be interpreted as a verified count of unique participants.

Age, dentition, diagnostic coverage, and reporting of sex varied across studies (Table 3). The reported overall anomaly percentages were based on different anomaly lists, frequently including abnormalities outside the nine eligible outcomes. These values were retained as study descriptors and were not interpreted as the combined prevalence of the nine anomalies. One report provided conflicting overall values of 64.6% and 68.26%; these values were not used to define an overall prevalence range [38].

No.	Author, year	Study design	Region/state	Setting/population	Total N	Age range	Sex distribution (M/F)	Source-reported overall anomaly prevalence
1	Guttal et al., 2010 [18]	Prospective cross-sectional	Dharwad, Karnataka	Oral Medicine and Radiology OPD	20,182	≥14 years	Among participants with anomalies: 201 M/149 F	1.73% (350/20,182)
2	Gupta et al., 2011 [19]	Cross-sectional clinical and radiographic assessment	Indore, Madhya Pradesh	Dental OPD	1,123	≥14 years	572 M/551 F	34.28% (385/1,123)
3	Nayak and Nayak, 2011 [20]	Cross-sectional clinical examination	Jodhpur, Rajasthan	Schools	500	6–15 years	290 M/210 F	Dental-form anomalies: 1.2%; enamel hypoplasia: 18.8%
4	Prabhu et al., 2012 [21]	Cross-sectional clinical examination; radiographs of affected teeth	Mangalore, Karnataka	Oral Medicine OPD	2,740	4–60 years	1,523 M/1,217 F	Talon-cusp-specific study: 0.58% (16/2,740)
5	Kathariya et al., 2013 [22]	Cluster cross-sectional	Karad, Maharashtra	Schools	600	School-age; NR	NR	39.2%
6	Patil and Doni, 2013 [23]	Retrospective radiographic cross-sectional	Jodhpur, Rajasthan	Dental OPD; periapical radiographs	3,320 participants; 18,754 teeth	15–60 years; mean 27.3 years	1,994 M/1,326 F	DI-specific study: 2.41%
7	Patil, Doni, Kaswan and Rahman, 2013 [24]	Retrospective radiographic cross-sectional	Jodhpur, Rajasthan	Dental OPD; panoramic radiographs	4,133	13–38 years; mean 21.8 years	2,145 M/1,988 F	36.7% (1,519/4,133)
8	Vibhute et al., 2013 [25]	Retrospective cross-sectional record review	Western Maharashtra	Rural private orthodontic OPD	220	8–14 years; mean 11.6 years	98 M/122 F	27.7% (61/220)
9	Solanki et al., 2014 [26]	Cross-sectional	Rural Jodhpur, Rajasthan	School health camps	6,000	5, 12 and 15 years	3,000 M/3,000 F	28.8% (1,731/6,000)

10	Javali and Meti, 2015 [27]	Cross-sectional clinical and radiographic assessment	Bagalkot, northern Karnataka	Dental OPD and dental students	3,000	10–30 years	1,719 M/1,281 F	15.9% (477/3,000)
11	Shah et al., 2015 [28]	Retrospective cross-sectional OPG study	Pune, Maharashtra	Dental teaching hospital; archived OPGs	525 participants; 9,022 teeth	15–63 years; mean 27.5 years	317 M/208 F	Taurodontism-specific study: 11.8%
12	Yamunadevi et al., 2015 [29]	Cross-sectional clinical assessment with review of available radiographs	Namakkal, Tamil Nadu	Dental college; female students	244	17–21 years	244 F	31.55% (77/244)
13	Goutham et al., 2017 [30]	Retrospective radiographic cross-sectional	Bhubaneswar, Odisha	Dental college OPD; archived OPGs	1,080	18–62 years	540 M/540 F	35.27% (381/1,080)
14	Shilpa et al., 2017 [31]	Cross-sectional	Nellore, Andhra Pradesh	64 nursery and primary schools	4,180	2–6 years; deciduous dentition	2,473 M/1,707 F	2.27% (95/4,180)
15	Chandrika et al., 2018 [32]	Retrospective cross-sectional record review	Visakhapatnam, Andhra Pradesh	Two dental colleges and two private orthodontic clinics	600	12–30 years	Among participants with anomalies: 30 M/104 F	22.3% (134/600)
16	Das et al., 2018 [33]	Cluster cross-sectional	Pasighat, Arunachal Pradesh	Adi tribal community; oral examination	156	>21 years	NR	35% (55/156)
17	Bandaru et al., 2019 [34]	School-based cross-sectional clinical examination	Chittoor and Kadapa, Andhra Pradesh	Schools	5,000	3–15 years	Among participants with anomalies: 337 M/231 F	11.4% (568/5,000)
18	Khan et al., 2019 [35]	Retrospective radiographic cross-sectional	Garhwa, Jharkhand	Dental OPD; archived OPGs	2,062	13–38 years; mean 21.7 years	1,031 M/1,031 F	39.23% (809/2,062)
19	Kishore and Kumar, 2019 [36]	Cross-sectional clinical examination	Muzaffarpur, Bihar	Schools	6,182	5–12 years	3,364 M/2,818 F	0.12% (8/6,182)
20	Sharma et al., 2019 [37]	Cross-sectional clinical assessment; radiographs when indicated	Patna, Bihar	Paediatric dental OPD	3,000	6–13 years	1,783 M/1,217 F	4.86% (146/3,000)
21	Khurana et al., 2021 [38]	Cross-sectional	Greater Noida, Uttar Pradesh	Oral Medicine OPD	2,250	Adults; NR	NR	68.26%
22	Mohan et al., 2021 [39]	Cross-sectional clinical and radiographic examination	Ranchi, Jharkhand	Dental OPD	2,385	15–60 years	1,169 M/1,216 F	5.83% (139/2,385)
23	Jain et al., 2022 [40]	Retrospective cross-sectional observational	Indore, Madhya Pradesh	Dental casts and IOPA records	3,000	10–40 years	1,500 M/1,500 F	17.9% (538/3,000)
24	Varun et al., 2022 [41]	Retrospective CBCT record review	Karnal and Rohtak, Haryana	Archived CBCT scans from implant/pathology referrals	163	NR	96 M/67 F	DI-specific study: 13.5%
25	Kadtan and Kalla, 2023 [42]	Cross-sectional survey	Hyderabad, Telangana	Corporate offices and schools	7,966	8–40 years	NR	2.76% (220/7,966)
26	Panwar et al., 2023 [43]	Retrospective cross-sectional OPG study	Meerut, Uttar Pradesh	Dental OPD	5,140	8–60 years	NR	40.46% (2,080/5,140)
27	Varalakshmi et al., 2024 [44]	Cross-sectional clinical and radiographic assessment	Kalaburgi, Karnataka	Dental OPD; maxillary lateral-incisor assessment	1,116	15–50 years	602 M/514 F	3.85% (43/1,116)
28	Batra et al., 2025 [45]	Cross-sectional epidemiological	Ghaziabad, western Uttar Pradesh	School screening and paediatric OPD	5,000	5–15 years	2,661 M/2,339 F	2.56% (128/5,000)
	Mantri et al.,	Retrospective radiographic	Chennai, Tamil	Dental college	342	13–72		Dilaceration-specific

29	2025 [46]	cross-sectional	Nadu	archive; Tamil population	participants; 10,089 teeth	years; mean 33.75 years	172 M/170 F	study: 29.24%
30	Mondal et al., 2025 [47]	Retrospective cross-sectional	Kolkata, West Bengal	Archived CBCT scans from a dental college	228 participants; 1,368 teeth	Mean 26.8 years	104 M/124 F	DI-specific study: 2.41% of teeth; participant-level estimate NR
31	Narain et al., 2025 [48,49]	Cross-sectional; two potentially overlapping reports collated	Jaipur, Rajasthan	Five schools	5,000	6–16 years	NR	NR; anomaly-specific study
32	Shan et al., 2025 [50]	Comparative cross-sectional	Chennai, Tamil Nadu	Special-needs schools and paediatric OPD	673; 337 cases and 336 controls	3–13 years	Cases: 233 M/104 F; controls: 161 M/175 F	Cases: 51.6%; controls: 22.6%

TABLE 3: Characteristics of the studies included in the systematic review

Abbreviations: CBCT, cone-beam computed tomography; DI, dens invaginatus; F, female; IOPA, intraoral periapical radiograph; M, male; N, sample size; NR, not reported or not reliably extractable; OPG, orthopantomogram; OPD, outpatient department.

Overall percentages reflect each source study's anomaly list and are not directly comparable. The two reports by Narain et al. were treated as one potentially overlapping cohort for participant totals [48,49].

Prevalence of the Developmental Anomalies

Talon cusp was the most frequently investigated outcome and was assessed in 24 studies. Its reported participant-level prevalence ranged from 0% to 15.6%, with the upper estimate obtained from an institution-based sample from Greater Noida [38]. Fourteen studies provided separable numerical estimates for fusion, ranging from 0% to 1.2%, while 10 studies provided separable estimates for gemination or twinning, ranging from 0% to 1.41%. These ranges included separately reported case and control subgroup estimates when each subgroup had its own numerator and denominator. The upper fusion estimate of 1.2% was obtained from the control subgroup of the comparative paediatric study rather than from a whole-study estimate [50]. The highest gemination estimate was reported in a panoramic radiographic study [35]. Three studies reported unclassified double teeth, with estimates ranging from 0.18% to 3.0%. These combined estimates were not assigned separately to fusion and gemination (Table *4*).

No.	Author, year	N	Gemination/ twinning	Fusion	Concrescence	Dilaceration	Talon cusp	Dens invaginatus	Dens evaginatus	Taurodontism	Enamel pearl	Double teeth, unclassified
1	Guttal et al., 2010 [18]	20,182	0.005%	0.084%	0.02%	0.39%	0.074%	0.02%	0.05%	0.31%	NA	NA
2	Gupta et al., 2011 [19]	1,123	NA	0.27%	NA	NA	0.97%	NA	2.40%	2.49%	NA	NA
3	Nayak and Nayak, 2011 [20]	500	NA	NA	NA	NA	0.2%	NA	NA	NA	NA	NA
4	Prabhu et al., 2012 [21]	2,740	NA	NA	NA	NA	0.58% (16/2,740)	NA	NA	NA	NA	NA
5	Kathariya et al., 2013 [22]	600	NR	NR	NA	NA	6.3%	NA	NA	5.5%	NA	3.0% (18/600)
6	Patil and Doni, 2013 [23]	3,320	NA	NA	NA	NA	NA	2.41%	NA	NA	NA	NA
7	Patil, Doni, Kaswan and Rahman, 2013 [24]	4,133	0%	0%	NA	0.5%	NA	0.4%	NA	0.4%	NA	NA
8	Vibhute et al., 2013 [25]	220	0%	0.9%	NA	4.1%	1.4%	NA	NA	NA	NA	NA
9	Solanki et al., 2014 [26]	6,000	NA	NA	NA	NA	3.07%	NA	NA	NA	NA	NA
10	Javali and Meti, 2015 [27]	3,000	0.10%	0.17%	0.03%	1.00%	1.80%	0.40%	0.13%	0.30%	NA	NA
11	Shah et al., 2015 [28]	525	NA	NA	NA	NA	NA	NA	NA	11.8%	NA	NA
12	Yamunadevi et al., 2015 [29]	244	NA	NA	NA	NA	14.34%	NA	0.4%	NA	NA	NA

13	Goutham et al., 2017 [30]	1,080	NA	NA	0.09%	16.48%	0.37%	NA	NA	0.28%	NA	NA
14	Shilpa et al., 2017 [31]	4,180	NR	NR	NA	NA	0.04%	NA	NA	NA	NA	0.95%
15	Chandrika et al., 2018 [32]	600	NA	NA	NA	3.0%	NA	0%	0.67%	NA	NA	NA
16	Das et al., 2018 [33]	156	NA	NA	NA	NA	NA	NA	7%	NA	NA	NA
17	Bandaru et al., 2019 [34]	5,000	NA	0.04%	NA	NA	0.02%	NA	NA	NA	NA	NA
18	Khan et al., 2019 [35]	2,062	1.41%	0.82%	NA	6.74%	0.82%	1.21%	NA	NA	NA	NA
19	Kishore and Kumar, 2019 [36]	6,182	NA	NA	NA	NA	0.016%	NA	NA	NA	NA	NA
20	Sharma et al., 2019 [37]	3,000	0.1%	0%	0%	0.03%	0.5%	0.17% (5/3,000)	0.13%	0.4%	NA	NA
21	Khurana et al., 2021 [38]	2,250	NA	NA	NA	NA	15.6%	NA	NA	NA	NA	NA
22	Mohan et al., 2021 [39]	2,385	NA	0.126%	NA	NA	0.25%	NA	0.25%	NR	NA	NA
23	Jain et al., 2022 [40]	3,000	0.03%	0.06%	NA	9.2%	2.23%	0.03%	1.26%	3.7%	NA	NA
24	Varun et al., 2022 [41]	163	NA	NA	NA	NA	NA	13.5%	NA	NA	NA	NA
25	Kadtan and Kalla, 2023 [42]	7,966	0.06%	0.05%	0%	0%	0.62%	0.19%	0.43%	0%	0%	NA
26	Panwar et al., 2023 [43]	5,140	0.08%	0%	0%	21.5%	0%	0%	0%	0.23%	NA	NA
27	Varalakshmi et al., 2024 [44]	1,116	NA	NA	NA	NA	0.27%	0.81%	NA	NA	NA	NA
28	Batra et al., 2025 [45]	5,000	NA	0.24%	NA	NA	0.26%	NA	NA	NA	NA	NA
29	Mantri et al., 2025 [46]	342	NA	NA	NA	29.24%	NA	NA	NA	NA	NA	NA
30	Mondal et al., 2025 [47]	228	NA	NA	NA	NA	NA	Participant: NR; tooth: 2.41% (33/1,368)	NA	NA	NA	NA
31	Narain et al., 2025 [48,49]	5,000	NR	NR	NA	NA	0.26%	NA	0.02%	NR	NA	0.18% (9/5,000)
32	Shan et al., 2025 [50]	673	Cases: 0.9%; controls: 0%	Cases: 0.9%; controls: 1.2%	NA	NA	Cases: 3.6%; controls: 0.6%	NA	NA	0% in both groups	NA	NA

TABLE 4: Reported prevalence of the nine eligible developmental tooth-shape anomalies among included studies

Abbreviations: N, number of participants screened; NA, not assessed or not reported; NR, no usable separate participant-level estimate.

Percentages are participant-level unless explicitly identified as tooth-level. Separately reported case and control estimates were retained as descriptive subgroup estimates and were not recombined. Double-tooth estimates were not assigned simultaneously to fusion and gemination. Prabhu et al. contributed only the screened-population estimate for talon cusp because radiographs for associated anomalies were restricted to affected teeth [21].

Taurodontism was assessed in 14 studies; 12 provided a numerical estimate, and two did not provide usable counts. Quantified prevalence ranged from 0% to 11.8%, with the highest value reported in a retrospective orthopantomogram study [28]. Dilaceration was reported in 12 studies and showed the widest reported range, from 0% to 29.24%. The upper value was participant-level prevalence in a Tamil radiographic cohort; the corresponding tooth-level prevalence was 1.49%, illustrating the importance of retaining the original unit of analysis [46].

Dens invaginatus was assessed in 13 studies, of which 12 provided a usable participant-level estimate; reported prevalence ranged from 0% to 13.5%. The upper estimate came from a CBCT study [41]. A further CBCT study reported 33 affected teeth among 1,368 examined (2.41%); conflicting participant counts prevented a reliable participant-level estimate [47]. Dens evaginatus was reported in 12 studies and ranged from 0% to 7%, with the upper estimate obtained in a clinically examined tribal sample [33]. Concrescence was evaluated in six studies and ranged from 0% to 0.09%, with the upper value reported in a panoramic radiographic investigation [30]. Enamel pearl was assessed in a single study, which reported no cases. Clinically reported absence of a root-surface or internal anomaly should be interpreted cautiously when systematic radiographic assessment was not performed. A representative image of the developmental anomalies related to the shape of the teeth from the review team's institutional department is collectively presented in Figure *2*.

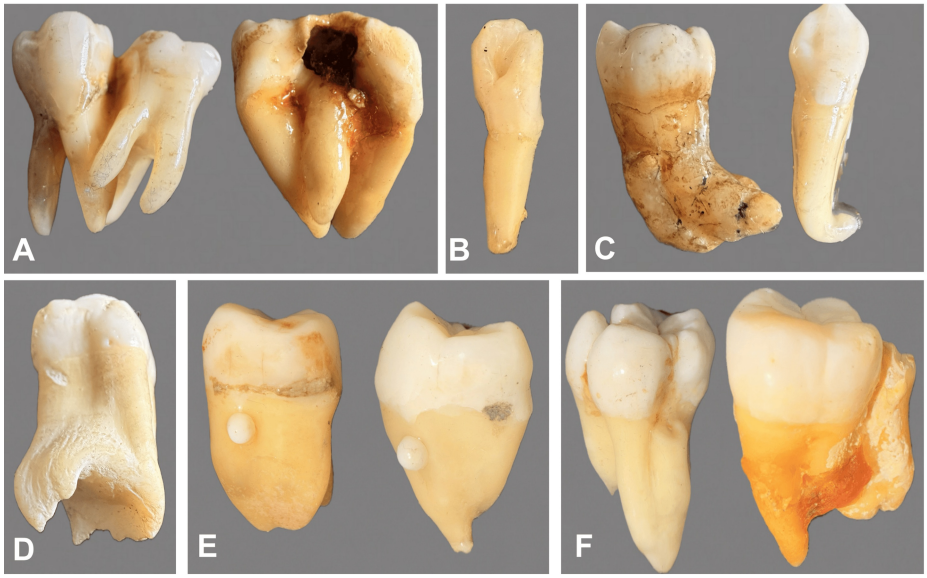

FIGURE 2: Representative samples of the developmental anomalies: A) concrescence; B) talon cusp; C) dilaceration; D) taurodontism; E) enamel pearl; F) fusion

Picture Courtesy: Dr. Treville Pereira

The teeth were retrieved from the routinely extracted teeth in the departmental archives and do not contain patient-identifying information in any form. Therefore, patient consent was obtained according to protocol at the time of their extraction but is not required for their use for publication purposes.

Findings by Diagnostic Method, Population, Age, and Unit of Analysis

Diagnostic method: Clinical surveys contributed most of the evidence for externally visible crown anomalies, particularly talon cusp, fusion, and gemination. Radiographic studies provided greater diagnostic coverage for dilaceration, taurodontism, and dens invaginatus, while CBCT allowed more detailed assessment of internal and root morphology. Direct comparisons between diagnostic methods were not possible because the underlying populations, age groups, and anomaly checklists differed. A reported absence of an internal or root-surface anomaly in a clinically examined population was therefore interpreted cautiously.

Population and setting: Community- and school-based studies primarily represented children or geographically defined populations, whereas institution-based studies included dental outpatients, orthodontic patients, and archived radiographic records. Referral-based imaging cohorts and the condition-specific study by Shan et al. were treated as selected populations and interpreted separately from broadly sampled school or community populations. Their estimates were retained because they described prevalence within clearly defined groups but were not interpreted as representative of the general Indian population. In the comparative study by Shan et al., case and control estimates were presented separately and were not combined [50].

Age and dentition: Paediatric studies generally involved school-based clinical examinations of primary or mixed dentition, whereas adult and broad-age studies were more frequently institution-based and used archived radiographs. Age categories and dentition stages were reported inconsistently, and most studies did not provide directly comparable age-stratified estimates. Consequently, formal comparisons between children and adults or between primary, mixed, and permanent dentitions were not undertaken.

Unit of analysis: Participant-level and tooth-level prevalence estimates were not combined. This distinction was particularly important for dilaceration: Mantri et al. reported a participant-level prevalence of 29.24%, whereas the corresponding tooth-level prevalence was 1.49% [46]. Similarly, Mondal et al. reported 33 affected teeth among 1,368 examined teeth, corresponding to a tooth-level dens invaginatus prevalence of 2.41% [47]. Inconsistent participant counts prevented reconstruction of a reliable participant-level estimate for that study. Tooth-level findings were therefore described separately and excluded from participant-level prevalence ranges.

Risk of Bias in Included Studies

Seventeen of the 32 studies (53.1%) were judged to have low risk of bias, and 15 (46.9%) had moderate risk. None was rated high risk (Table 5). Application of the prespecified decision rules showed that moderate-risk judgments were generally attributable to one important concern involving representativeness, diagnostic coverage, measurement reliability, or internal reporting consistency. No study demonstrated multiple major limitations affecting both sampling and ascertainment to the extent required for a high-risk classification. Common strengths were identifiable sample denominators, description of study settings, and use of recognized clinical or radiographic assessment. Important uncertainties concerned representativeness, recruitment, examiner calibration, diagnostic coverage, and inconsistent source reporting. Overall study ratings did not remove the outcome-specific limitations of prevalence estimates based on selected clinical samples. Moderate-risk judgments reflected referral-based or restricted sampling frames, uncertain representativeness, incomplete reporting of recruitment, limited examiner-calibration details, or material discrepancies in participant counts and statistical reporting. For anomalies requiring radiographic confirmation, purely clinical ascertainment also limited confidence in a reported absence. These concerns could influence both the magnitude and generalisability of the prevalence estimates.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Overall judgment
Guttal et al., 2010 [18]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Gupta et al., 2011 [19]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Nayak and Nayak, 2011 [20]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Prabhu et al., 2012 [21]	U	U	Y	Y	Y	Y	U	Y	U	Moderate
Kathariya et al., 2013 [22]	Y	Y	Y	U	Y	Y	U	U	Y	Moderate
Patil and Doni, 2013 [23]	U	U	Y	Y	Y	Y	Y	Y	Y	Low
Patil et al., 2013 [24]	U	U	Y	Y	Y	Y	Y	Y	Y	Low
Vibhute et al., 2013 [25]	N	U	U	Y	Y	Y	U	Y	Y	Moderate
Solanki et al., 2014 [26]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Javali and Meti, 2015 [27]	U	Y	Y	Y	Y	Y	U	Y	Y	Low
Shah et al., 2015 [28]	U	U	Y	Y	N	Y	Y	Y	U	Moderate
Yamunadevi et al., 2015 [29]	N	U	U	Y	Y	Y	U	Y	Y	Moderate
Goutham et al., 2017 [30]	U	U	Y	Y	Y	Y	Y	Y	Y	Low
Shilpa et al., 2017 [31]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Chandrika et al., 2018 [32]	N	U	Y	Y	U	Y	U	Y	Y	Moderate
Das et al., 2018 [33]	Y	Y	U	Y	U	Y	U	Y	U	Moderate
Bandaru et al., 2019 [34]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Khan et al., 2019 [35]	U	U	Y	Y	Y	Y	Y	Y	Y	Low
Kishore and Kumar, 2019 [36]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Sharma et al., 2019 [37]	U	Y	Y	Y	Y	Y	U	Y	Y	Low
Khurana et al., 2021 [38]	U	U	Y	U	Y	Y	U	U	Y	Moderate
Mohan et al., 2021 [39]	U	Y	Y	Y	Y	Y	Y	N	Y	Moderate
Jain et al., 2022 [40]	U	Y	Y	Y	Y	Y	Y	Y	Y	Low
Varun et al., 2022 [41]	N	U	U	Y	U	Y	Y	Y	U	Moderate
Kadtan and Kalla, 2023 [42]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Panwar et al., 2023 [43]	U	Y	Y	Y	Y	Y	Y	Y	Y	Low
Varalakshmi et al., 2024 [44]	U	U	Y	Y	Y	Y	U	Y	Y	Moderate
Batra et al., 2025 [45]	Y	Y	Y	Y	Y	Y	U	Y	Y	Low
Mantri et al., 2025 [46]	U	U	U	Y	U	Y	Y	Y	U	Moderate

Mondal et al., 2025 [47]	N	U	U	Y	U	Y	Y	U	U	Moderate
Narain et al., 2025 [48,49]	Y	U	Y	U	Y	U	U	Y	Y	Moderate
Shan et al., 2025 [50]	U	U	Y	Y	Y	Y	U	Y	Y	Moderate

TABLE 5: Risk of bias assessment using the Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data

Domains: Q1, appropriateness of the sample frame; Q2, appropriateness of participant sampling; Q3, adequacy of sample size; Q4, adequate description of participants and setting; Q5, sufficient coverage of the identified sample in the analysis; Q6, validity of the method used to identify developmental anomalies; Q7, standard and reliable measurement of the condition; Q8, appropriateness of statistical analysis; Q9, adequacy of response rate or appropriate management of a low response rate.

Abbreviations: JBI, Joanna Briggs Institute; N, no; U, unclear; Y, yes

Overall judgments emphasized Q1, Q2, Q6, and Q7. Low risk indicated no major limitation expected to materially alter prevalence; moderate risk indicated one important concern that could influence the estimate; and high risk required multiple major concerns affecting both sampling and ascertainment. An unclear domain judgment did not automatically determine the overall category.

Certainty of Evidence

Certainty was low for the prevalence of gemination/twinning, fusion, dilaceration, talon cusp, dens invaginatus, dens evaginatus and taurodontism. Each was downgraded for sampling or reporting limitations and marked inconsistency across settings and diagnostic methods. Certainty was very low for concrescence and enamel pearl because selection limitations were compounded by incomplete diagnostic coverage and sparse or absent events (Table *6*). The body of evidence was directly relevant to Indian clinical and community settings, but the underlying samples did not support nationally representative estimates. For concrescence and enamel pearl, the absence of systematic radiographic assessment in some contributing evidence introduced additional indirectness. Publication bias could not be assessed reliably. No outcome achieved high certainty.

Outcome	Contributing studies	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty
Gemination/twinning	10 quantified; 3 combined-only	Serious	Serious	Not serious	Not serious	Not assessable	Low
Fusion	14 quantified; 3 combined-only	Serious	Serious	Not serious	Not serious	Not assessable	Low
Concrescence	6	Serious	Not serious	Serious	Serious	Not assessable	Very low
Dilaceration	12	Serious	Serious	Not serious	Not serious	Not assessable	Low
Talon cusp	24	Serious	Serious	Not serious	Not serious	Not assessable	Low
Dens invaginatus	13 assessed; 12 participant-level	Serious	Serious	Not serious	Not serious	Not assessable	Low
Dens evaginatus	12	Serious	Serious	Not serious	Not serious	Not assessable	Low
Taurodontism	14 assessed; 12 quantified	Serious	Serious	Not serious	Not serious	Not assessable	Low
Enamel pearl	1	Serious	Not assessable	Serious	Serious	Not assessable	Very low

TABLE 6: GRADE assessment of the certainty of evidence for the prevalence of developmental tooth-shape anomalies

Abbreviations: GRADE, Grading of Recommendations Assessment, Development and Evaluation.

Note: Cross-sectional evidence initially entered the assessment at high certainty because this design was appropriate for estimating prevalence. Risk of bias was considered serious when selected sampling frames or important reporting or measurement concerns affected the evidence. Inconsistency reflected marked variation across populations, settings, diagnostic criteria, or assessment methods. For concrescence and enamel pearl, indirectness reflected incomplete detection of clinically occult root surface anomalies, while imprecision reflected sparse evidence and few or no detected events. Publication bias could not be assessed reliably and was not downgraded solely because formal assessment was impossible. Unclassified double-tooth reports did not contribute separate fusion or gemination estimates.

Discussion

The present systematic review consolidated evidence from 32 studies conducted across 14 Indian states and demonstrated considerable variation in the reported prevalence of developmental tooth-shape anomalies. Talon cusp was the most frequently investigated anomaly, whereas dilaceration showed the widest prevalence range. Fusion, gemination, taurodontism, dens invaginatus and dens evaginatus were documented across several populations, while evidence for concrescence and enamel pearl remained sparse. Although 17 studies had low overall risk of bias, the absence of nationally representative sampling and the marked methodological heterogeneity limited the certainty and generalisability of the estimates.

The wide prevalence ranges should not be interpreted entirely as biological differences between Indian populations. The included studies varied in age, dentition, clinical setting, anomaly definition, imaging method, denominator, and population selection. Similar variation has been reported internationally across orthodontic, general dental, and paediatric populations [51-53]. In the present review, school and community samples were considered separately from referral-based imaging cohorts and condition-specific groups. Institution-based and orthodontic populations may contain a greater proportion of complex cases, whereas school-based clinical surveys may fail to identify anomalies that require radiographic confirmation. Accordingly, estimates from selected populations were interpreted only within their sampling context. A single pooled national estimate would have obscured these clinically and methodologically important differences.

Talon cusp was the most extensively reported anomaly, probably because it is generally visible during routine clinical examination. Nevertheless, small accessory cusps may be overlooked or classified differently, particularly when diagnostic thresholds are not stated. Fusion and gemination also present a diagnostic challenge because distinction often depends on tooth count, crown morphology and radiographic appearance [5]. Reports using the undifferentiated term double teeth therefore cannot provide independent prevalence estimates for both conditions. Similarly, differences in the criteria used to identify taurodontism may influence prevalence because the anomaly can be defined subjectively or through different radiographic indices [11]. These factors may partly explain the inconsistency observed for otherwise well-represented outcomes.

Dilaceration produced the widest prevalence range, extending to 29.24%. This upper value represented participant-level prevalence, whereas tooth-level prevalence in the same study was substantially lower. Hamasha et al. reported dilaceration in 3.78% of examined teeth, illustrating how estimates change according to whether persons or teeth form the denominator [54]. Radiographic modality also influences detection. CBCT provides three-dimensional visualisation and may identify subtle root bends, invaginations and complex morphology that are obscured on panoramic images. However, its use should remain justified by clinical need rather than routine epidemiological screening because of radiation-exposure considerations [55].

The limited evidence for concrescence and enamel pearl warrants particular caution. Both anomalies are usually located on root surfaces and may remain undetected during clinical examination. Their apparent rarity may therefore reflect limited radiographic assessment rather than true absence. Moreover, an unreported anomaly cannot be interpreted as having zero prevalence unless the study explicitly included it within the diagnostic checklist. This distinction explains why certainty was very low for these outcomes, particularly when root-surface abnormalities were assessed without systematic imaging.

The findings have practical relevance because developmental shape anomalies may complicate diagnosis, plaque control, orthodontic movement, extraction and endodontic treatment [4]. Routine clinical examination should therefore include careful assessment of unusual crown morphology, while existing radiographs should be evaluated systematically for root and pulpal variations. Advanced imaging may be considered when conventional findings are inconclusive, and the result is likely to alter management [55]. Nevertheless, the present estimates should guide clinical awareness rather than population screening recommendations.

The review was strengthened by explicit eligibility criteria, separation of missing data from confirmed zero prevalence, collation of complementary reports, structured consideration of selected populations, study-level JBI appraisal, and outcome-specific GRADE assessment. Nevertheless, the search strategy required named anomaly terms and prevalence-related wording and may have missed reports described only using broader dental-anomaly terminology. Google Scholar screening was restricted to the first 200 relevance-ranked results according to a prespecified limit, although no additional eligible report was identified among the later-ranked records within that set. Supplementary reference checking partly addressed these search limitations.

Other limitations included the predominance of institution-based or otherwise selected samples, uneven geographical coverage, inconsistent diagnostic definitions, and the absence of sufficiently comparable data for meta-analysis. In addition, some participant-level ranges included separately reported case and control subgroup estimates, while participant- and tooth-level estimates were not directly comparable. Prevalence reviews are especially vulnerable to misleading summary estimates when sampling frames, denominators and case definitions differ substantially [56,57]. These limitations reduced certainty and prevented

nationally representative inference.

Future studies should employ multicentre population-based sampling, standardised diagnostic criteria, calibrated examiners and clear participant- and tooth-level numerators and denominators. Greater representation of underserved regions and dedicated assessment of concrescence and enamel pearl would improve the precision and national applicability of future evidence.

Conclusions

Developmental tooth-shape anomalies occur across Indian populations, although their reported prevalence varies considerably according to the population, diagnostic method, and denominator used. Certainty was low for most anomalies and very low for concrescence and enamel pearl. Clinicians should remain attentive to these variations during clinical and radiographic assessment, while future multicentre population-based studies using standardised definitions are required to obtain more reliable national estimates.

Appendices

S. no.	Report	Bibliographic details	Reason for exclusion or removal
1	Nazzal et al., 2025	Nazzal H, et al. Prevalence of hypodontia and other developmental dental anomalies in children with or without molar incisor hypomineralisation. J Dent. 2025;155:105598. doi:10.1016/j.jdent.2025.105598.	No separable Indian data: Participants from India were combined with those from Singapore in a regional South-East Asian estimate; anomaly-specific prevalence data for India could not be extracted separately.
2	Liñares et al., 2024	Liñares A, Dopico J, Blanco C, Pico A, Sobrino T, Blanco J, et al. The systemic impact of non-surgical treatment of peri-implantitis with or without adjunctive systemic metronidazole: secondary analysis of a randomized clinical trial. Clin Oral Implants Res. 2024;35(12):1519–1530. doi:10.1111/clr.14339.	Ineligible topic and outcomes: The study evaluated the systemic effects of peri-implantitis treatment and did not report the prevalence of eligible developmental tooth shape anomalies.
3	Gupta et al., 2014	Gupta S, Garg KN, Tripathi A, Gupta OP. Distribution of various developmental dental anomalies in Uttar Pradesh: a hospital-based study. Res Rev J Dent Sci. 2014;2(3):1–6.	No usable population denominator: The report described 130 individuals with dental anomalies but did not provide the total number of patients examined. Therefore, prevalence estimates could not be calculated.
4	Hatipoğlu et al., 2025	Hatipoğlu FP, Magat G, Karobari MI, et al. Multinational cross-sectional study and meta-analysis on radicular grooves, C-shaped canals, and taurodontism in mandibular first premolars across 20 countries. Sci Rep. 2025;15:17974. doi:10.1038/s41598-025-02666-9.	No separable Indian data: Findings from India were pooled within the overall Asian estimate, and an India-specific prevalence estimate for taurodontism could not be extracted.

TABLE 7: Full-text reports excluded from the review, with reasons for exclusion

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

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References

1. Balic A, Thesleff I: Tissue interactions regulating tooth development and renewal . Curr Top Dev Biol. 2015, 115:157-86. 10.1016/bs.ctdb.2015.07.006
2. Brook AH, Jernvall J, Smith RN, Hughes TE, Townsend GC: The dentition: the outcomes of morphogenesis leading to variations of tooth number, size and shape. Aust Dent J. 2014, 59 Suppl 1:131-42. 10.1111/adj.12160
3. Kurosaka H, Itoh S, Morita C, Tsujimoto T, Murata Y, Inubushi T, Yamashiro T: Development of dentition: from initiation to occlusion and related diseases. J Oral Biosci. 2022, 64:159-64. 10.1016/j.job.2022.02.005
4. Ahmed HM, Dummer PM: A new system for classifying tooth, root and canal anomalies . Int Endod J. 2018, 51:389-404. 10.1111/iej.12867
5. Ben Salem M, Chouchene F, Masmoudi F, Baaziz A, Maatouk F, Ghedira H: Fusion or gemination? Diagnosis and management in primary teeth: a report of two cases. Case Rep Dent. 2021, 2021:6661776. 10.1155/2021/6661776
6. Syed AZ, Alluri LC, Mallela D, Frazee T: Concrescence: cone-beam computed tomography imaging perspective. Case Rep Dent. 2016, 2016:8597872. 10.1155/2016/8597872
7. Jin C, Skilbeck M, Low A, Lin W, Au C, Mei L: Root dilaceration: a case report and literature review . Australas Orthod J. 2023, 39:109-19. 10.2478/aoj-2023-0013
8. Decaup PH, Garot E, Rouas P: Prevalence of talon cusp: systematic literature review, meta-analysis and new scoring system. Arch Oral Biol. 2021, 125:105112. 10.1016/j.archoralbio.2021.105112
9. González-Mancilla S, Montero-Miralles P, Saúco-Márquez JJ, Areal-Quecuty V, Cabanillas-Balsera D, Segura-Egea JJ: Prevalence of dens invaginatus assessed by CBCT: systematic review and meta-analysis . J Clin Exp Dent. 2022, 14:e959-66. 10.4317/jced.59849
10. Chen JW, Huang GT, Bakland LK: Dens evaginatus: current treatment options . J Am Dent Assoc. 2020, 151:358-67. 10.1016/j.adaj.2020.01.015
11. Chetty M, Roomaney IA, Beighton P: Taurodontism in dental genetics . BDJ Open. 2021, 7:25. 10.1038/s41405-021-00081-6
12. Grine FE, Holt S, Brink JS, du Plessis A: Enamel pearls: their occurrence in recent human populations and earliest manifestation in the modern human lineage. Arch Oral Biol. 2019, 101:147-55. 10.1016/j.archoralbio.2019.03.004
13. Aljohani K, Shanab H, Alqarni A, Merdad K: Dental anomalies in Saudi Arabia: a systematic review . Healthcare (Basel). 2024, 12:2323. 10.3390/healthcare12232323
14. Goswami M, Bhardwaj S, Grewal N: Prevalence of shape-related developmental dental anomalies in India: a retrospective study. Int J Clin Pediatr Dent. 2020, 13:407-11. 10.5005/jp-journals-10005-1785
15. Page MJ, McKenzie JE, Bossuyt PM, et al.: The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021, 372:n71. 10.1136/bmj.n71
16. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C: Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. Int J Evid Based Healthc. 2015, 13:147-53. 10.1097/XEB.0000000000000054
17. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ: GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008, 336:924-6. 10.1136/bmj.39489.470347.AD
18. Guttal KS, Naikmasur VG, Bhargava P, Bathi RJ: Frequency of developmental dental anomalies in the Indian population. Eur J Dent. 2010, 4:263-9. 10.1055/s-0039-1697838
19. Gupta SK, Saxena P, Jain S, Jain D: Prevalence and distribution of selected developmental dental anomalies in an Indian population. J Oral Sci. 2011, 53:231-8. 10.2334/josnusd.53.231
20. Nayak P, Nayak S: Prevalence and distribution of dental anomalies in 500 Indian school children . Bangladesh J Med Sci. 2011, 10:41-4. 10.3329/bjms.v10i1.7318
21. Prabhu RV, Rao PK, Veena K, Shetty P, Chatra L, Shenai P: Prevalence of talon cusp in Indian population . J Clin Exp Dent. 2012, 4:e23-7. 10.4317/jced.50650
22. Kathariya MD, Nikam AP, Chopra K, Patil NN, Raheja H, Kathariya R: Prevalence of dental anomalies among school-going children in India. J Int Oral Health. 2013, 5:10-4.
23. Patil S, Doni B: Prevalence of dens invaginatus in North Indian population . Oral Maxillofac Pathol J. 2013, 4:282-8.
24. Patil S, Doni B, Kaswan S, Rahman F: Prevalence of dental anomalies in Indian population . J Clin Exp Dent. 2013, 5:e183-6. 10.4317/jced.51119
25. Vibhute AH, Vibhute NA, Daule RP: Prevalence of dental anomalies in pretreatment orthodontic patients in Western Maharashtra, India: an epidemiological study. J Orthod Res. 2013, 1:66-9.
26. Solanki J, Gupta S, Singh R, Vyas R, Khetan J: Developmental dental disorders and tongue lesions in pediatrics of Western India: a prevelance study. Occup Med Health Aff. 2014, 2:183. 10.4172/2329-6879.1000183
27. Javali R, Meti M: Prevalence of developmental anomalies of teeth in a group of North Karnataka population,

India. Int J Dent Res. 2015, 3:5-9. 10.14419/ijdr.v3i1.4363
28. Shah D, Garcha V, Garde J, Ekhande D: Prevalence of taurodontism among patients visiting a dental teaching hospital in Pune, India: a retrospective orthopantomogram study. J Indian Assoc Public Health Dent. 2015, 13:83-6. 10.4103/2319-5932.153601
29. Yamunadevi A, Selvamani M, Vinitha V, Srivandhana R, Balakrithiga M, Prabhu S, Ganapathy N: Clinical evaluation of nonsyndromic dental anomalies in Dravidian population: a cluster sample analysis. J Pharm Bioallied Sci. 2015, 7:S499-503. 10.4103/0975-7406.163517
30. Goutham B, Bhuyan L, Chinnannavar SN, Kundu M, Jha K, Behura SS: Prevalence of dental anomalies in Odisha population: a panoramic radiographic study. J Contemp Dent Pract. 2017, 18:549-53. 10.5005/jp-journals-10024-2082
31. Shilpa G, Gokhale N, Mallineni SK, Nuvvula S: Prevalence of dental anomalies in deciduous dentition and its association with succedaneous dentition: a cross-sectional study of 4180 South Indian children. J Indian Soc Pedod Prev Dent. 2017, 35:56-62. 10.4103/0970-4388.199228
32. Chandrika V, Madhuri C, Sahu SC, Yagnesh M, Yelchuru SH: Prevalence of dental anomalies in South Indian population attending orthodontic treatment. IP Indian J Orthod Dentofacial Res. 2018, 4:80-2. 10.18231/2455-6785.2018.0016
33. Lima D, Bhuyan AC, Rubi K, Chandana K: Dental morphological anomalies in the Adi tribe of Pasighat in Arunachal Pradesh. Int J Health Res Med Leg Pract. 2018, 4:37-40.
34. Bandaru BK, Thankappan P, Kumar Nandan SR, Amudala R, Annem SK, Rajendra Santosh AB: The prevalence of developmental anomalies among school children in Southern district of Andhra Pradesh, India. J Oral Maxillofac Pathol. 2019, 23:160. 10.4103/jomfp.JOMFP_119_18
35. Khan A, Pranav, Singh RK, Imran M, Kalita K, Jha JK: Prevalence of dental anomalies in Garhwa population: a radiograph based study. Int J Sci Res. 2019, 8:41-2.
36. Kishore J, Kumar A: Prevalence of dental anomalies in school children of Muzaffarpur district (age 5 to 12 years). Int J Contemp Med Res. 2019, 6:1-3. 10.21276/ijcmr.2019.6.11.4
37. Sharma S, Chandra S, Singh RNP, Shahi AK, Kumar S, Singh B: Prevalence of developmental anomalies of teeth in a group of Indian children a cross sectional. Int J Contemp Med Res. 2019, 6:1-3. 10.21276/ijcmr.2019.6.10.12
38. Khurana A, Gupta N, Chauhan U, Dewan R: Prevalence of dental morphology anomalies in Greater Noida population. Int J Sci Healthc Res. 2021, 6:148-56.
39. Mohan S, Viswanath B, Thakur J, Tekriwal S, Singh A, Jaiswal R: Prevalence and distribution of selected dental anomalies in the patients reporting to Dental Institute, RIMS, Ranchi. J Pharm Bioallied Sci. 2021, 13:S993-6. 10.4103/jpbs.jpbs_148_21
40. Jain A, Sisodia S, Rana KS, Gupta C, Ansari I, Dholakia PP: The study of prevalence and distribution of shape anomalies of teeth in Indian population on the basis of age and gender. Cureus. 2022, 14:e28532. 10.7759/cureus.28532
41. Varun K, Arora M, Pubreja L, Juneja R, Middha M: Prevalence of dens invaginatus and palatogingival groove in North India: a cone-beam computed tomography-based study. J Conserv Dent. 2022, 25:306-310.
42. Kadtan A, Kalla K: Exploring developmental dental anomalies: unveiling their prevalence and distribution in the population of Hyderabad. Int J Appl Dent Sci. 2023, 9:235-9. 10.22271/oral.2023.v9.i4d.1877
43. Panwar A, Kamarthi N, Sharma S, et al.: Prevalence, distribution, and clinical relevance of nonsyndromic dental anomalies in the general population of Uttar Pradesh, India: a radiographic study. J Global Oral Health. 2023, 6:30-4. 10.25259/JGOH_31_2022
44. Varalakshmi C, Rairam S, Ratnakar P, Patil V, Kanimilli S, Neema KV: Prevalence of dental anomalies in maxillary lateral incisors: an institutional cross-sectional study from Karnataka. J Clin Diagn Res. 2024, 18:50-3. 10.7860/JCDR/2024/66233.18951
45. Batra M, Gupta A, Singh S, F S, Tomar RK, Prasad S, Yatharth Y: Prevalence of developmental anomalies in teeth among Indian school children: an epidemiological study. Bioinformation. 2025, 21:1135-8. 10.6026/973206300211135
46. Mantri A, Pandiar D, Krishnan RP, Maheswari TN, Evanjelin JP: Prevalence and morphometric evaluation of dilaceration in Indian Tamils: an analysis of 10,089 permanent teeth. Oral Radiol. 2025, 41:190-6. 10.1007/s11282-024-00789-9
47. Mondal P, Mistry K, Paul T, Saha KK, Das D, Das S: Prevalence and morphological evaluation of dens invaginatus with associated palatogingival groove in maxillary anterior teeth using cone-beam computed tomography: a retrospective study on an Eastern Indian cohort. Endodontics Today. 2025, 23:175-81. 10.36377/ET-0083
48. Narain P, Kulkarni RS, Rao AS: Prevalence of microdontia, talon cusp and double teeth in children of Jaipur district: an observational study. Int J Sci Res. 2025, 14:842-3. 10.21275/SR25318214817
49. Narain P, Kulkarni RKS, Arora M, Rao AS: Prevalence of hypodontia, supernumerary teeth and dens evaginatus in children of Jaipur district: an observational study. Int J Sci Res. 2025, 14:588-9. 10.21275/SR25312113826
50. Shan S, Swaminathan K, Vivek K, Haridoss S: Developmental disturbances of teeth in children with autism spectrum disorder and attention-deficit hyperactivity disorder: a cross-sectional study. Int J Clin Pediatr Dent. 2025, 18:S80-5. 10.5005/jp-journals-10005-3326
51. Uslu O, Akcam MO, Evirgen S, Cebeci I: Prevalence of dental anomalies in various malocclusions . Am J Orthod Dentofacial Orthop. 2009, 135:328-35. 10.1016/j.ajodo.2007.03.030
52. Aren G, Guven Y, Guney Tolgay C, et al.: The prevalence of dental anomalies in a Turkish population . J Istanb Univ Fac Dent. 2015, 49:23-8. 10.17096/jiufd.86392
53. Bäckman B, Wahlin YB: Variations in number and morphology of permanent teeth in 7-year-old Swedish children. Int J Paediatr Dent. 2001, 11:11-7. 10.1046/j.1365-263x.2001.00205.x
54. Hamasha AA, Al-Khateeb T, Darwazeh A: Prevalence of dilaceration in Jordanian adults . Int Endod J. 2002, 35:910-2. 10.1046/j.1365-2591.2002.00593.x
55. Patel S, Brown J, Semper M, Abella F, Mannocci F: European Society of Endodontology position statement: use of cone beam computed tomography in Endodontics: European Society of Endodontology (ESE)

developed by. Int Endod J. 2019, 52:1675-8. 10.1111/iej.13187

56. Borges Migliavaca C, Stein C, Colpani V, Barker TH, Munn Z, Falavigna M: How are systematic reviews of prevalence conducted? A methodological study. BMC Med Res Methodol. 2020, 20:96. 10.1186/s12874-020-00975-3

57. Barendregt JJ, Doi SA, Lee YY, Norman RE, Vos T: Meta-analysis of prevalence. J Epidemiol Community Health. 2013, 67:974-8. 10.1136/jech-2013-203104