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TYPES AND CLASSIFICATION OF SECONDARY TOOTH DEFORMATION

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Abstract

Background. Secondary dental deformations (SDD) are acquired morphological changes in the dentofacial complex arising after primary dental disease, tooth loss, trauma, or functional disturbances. Their prevalence in adult patients with partial edentulism ranges from 40% to 65%, yet no universally adopted classification system exists, complicating standardized diagnosis and treatment planning.

Objectives. To systematically review and critically compare existing SDD classification systems; to characterize the principal clinical types with reference to morphological, radiological, and functional criteria; and to synthesize available epidemiological data on type distribution.

Methods. A systematic search of PubMed/MEDLINE, Scopus, Web of Science, and Cochrane Library (January 2000 – December 2024) was conducted according to PRISMA 2020 guidelines. Of 1,847 records identified, 78 publications met inclusion criteria and formed the evidence base. Study quality was assessed using the Newcastle-Ottawa Scale for observational studies and AMSTAR-2 for systematic reviews.

Results. Seven major classification systems were identified, analyzable along directional-geometric, functional-biomechanical, and etiological-pathogenetic axes. Pooled prevalence data from 11 multicenter studies (n = 6,843) showed that supraalveolar elongation was most prevalent (38.2%; 95% CI: 35.1–41.3%), followed by mesial drift (27.5%; 95% CI: 24.4–30.6%) and combined multidirectional type (18.9%; 95% CI: 16.3–21.4%). Female sex was associated with significantly higher rates of supraalveolar elongation in the 35–64 age group ($p < 0.05$). The Pozdnyakova vertical classification retains the highest prosthetic treatment-planning utility, with CBCT-derived thresholds enabling objective subtype differentiation.

Conclusions. Classification of SDD requires a multi-axial approach incorporating direction, vertical-alveolar subtype, functional decompensation

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stage, and deformation severity. Posterior arch segments account for 78.3% of clinically significant SDD, with maxillary molar elongation and mandibular molar mesial drift being the highest-frequency type-location combinations. Early prosthetic rehabilitation within six months of tooth extraction prevents the majority of supraalveolar deformations and should be regarded as a primary preventive goal.

Keywords

secondary dental deformations; dental classification; supraalveolar elongation; Pozdnyakova classification; mesial drift; dentoalveolar deformation; occlusal collapse; partial edentulism

1. INTRODUCTION

The dentofacial complex is a dynamically balanced biomechanical system in which each tooth is maintained in position by the equilibrium of physiological forces. When this equilibrium is disrupted — by tooth loss, periodontal disease, parafunctional habits, or systemic pathology — the architecture of the dentition undergoes progressive adaptive changes collectively described as secondary dental deformations (SDD). Unlike congenital or hereditary malocclusions classified as primary orthodontic disorders, secondary deformations arise in a previously normal or functional dentition and evolve over time in response to altered biomechanical conditions **[1, 2]**.

The clinical importance of SDD is substantial. According to pooled data from six multinational cross-sectional surveys, approximately 57.4% of adults presenting for prosthetic rehabilitation demonstrate at least one clinically significant form of secondary deformation. In patients over 55 years of age with long-standing partial edentulism (more than five years), prevalence increases to 74.8% when subclinical changes detected by cone-beam computed tomography (CBCT) are included **[3, 4]**. These deformations complicate prosthetic rehabilitation in multiple ways: they reduce prosthetic space, create unfavorable load angles, compromise esthetic outcomes, and — when combined with temporomandibular joint dysfunction — generate chronic pain conditions that significantly diminish patient quality of life **[5]**.

Despite this clinical burden, the classification of SDD remains fragmented across the literature. Eastern European dental schools have traditionally employed morphological classifications (Gavrilov, Pozdnyakova, Betelman), while Western academic frameworks tend toward functional-biomechanical models (Okeson, Dawson). Digital imaging technologies introduced in the 2000s have enabled volumetric analysis that revealed alveolar bone changes invisible on two-

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dimensional radiographs, necessitating updates to earlier classification schemes **[6, 7]**. To date, no consensus on a unified international classification system has been reached, constituting a recognized gap in dental evidence-based practice.

This systematic review aims: (1) to compile and critically compare all major SDD classification systems identified in the indexed literature; (2) to describe each principal clinical type with reference to morphological, radiological, and functional criteria; (3) to present available epidemiological and statistical data on type distribution; and (4) to propose a practical multi-axial framework for clinical use.

2. METHODS

2.1. Search Strategy

A systematic literature search was conducted in accordance with PRISMA 2020 guidelines. Electronic databases searched included PubMed/MEDLINE, Scopus, Web of Science Core Collection, Cochrane Library, and EMBASE. The search was limited to publications between January 1, 2000, and December 31, 2024. Search terms included: 'secondary dental deformation,' 'dentoalveolar elongation,' 'mesial drift,' 'Pozdnyakova classification,' 'Gavrilov classification,' 'occlusal deformation,' 'supraeruption,' 'tooth migration,' and related MeSH headings. Language restrictions were applied to English, Russian, German, and French full texts. Reference lists of eligible studies were hand-searched for additional sources.

2.2. Inclusion and Exclusion Criteria

Studies were included if they: (1) enrolled adult patients (≥18 years) with clinically or radiologically confirmed SDD; (2) reported classification, prevalence, or type-distribution data; and (3) used standardized clinical examination supplemented by radiological assessment. Studies were excluded if they addressed primary orthodontic malocclusion only, were published in languages other than those specified, had sample sizes below 30, or lacked radiological verification of SDD type.

2.3. Data Extraction and Quality Assessment

Two independent reviewers performed title/abstract screening and full-text eligibility assessment; discrepancies were resolved by a third reviewer. Data extracted included study design, sample size, patient demographics, classification system applied, prevalence by type, and treatment outcomes. Study quality was assessed using the Newcastle-Ottawa Scale (NOS) for cohort and cross-sectional studies (maximum 9 stars) and AMSTAR-2 for included systematic reviews.

Table 1. PRISMA-Compliant Study Selection Summary

Stage	Records (n)	Excluded (n)
Initial database records identified	1,847	—

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After duplicate removal	1,204	643
Title and abstract screening	312	892
Full-text eligibility assessment	112	200
Studies included in final synthesis	**78**	34
of which: observational/cross-sectional	41	—
of which: cohort/longitudinal	19	—
of which: systematic reviews/meta-analyses	11	—
of which: clinical trials/RCTs	7	—

Table 1. Study selection according to PRISMA 2020 guidelines. RCT = randomized controlled trial.

3. RESULTS

3.1. Historical Development and Overview of Classification Systems

Systematic classification of dental deformations dates to the early twentieth century. Angle's 1899 taxonomy of malocclusion established the conceptual vocabulary of dental position relative to a reference plane, a framework later adapted for secondary acquired changes **[8]**. Simon (1919) introduced gnathostatic models referenced to the Frankfort horizontal plane, enabling three-dimensional description of tooth displacement vectors **[9]**. The first explicit distinction between primary and secondary dental deformations was formalized by Doinikov (1938) based on clinical observations in war-injured patients **[10]**.

The period from 1950 to 2000 produced the major classification systems still in clinical use today. Betelman (1951) proposed a directional taxonomy distinguishing vertical, horizontal, and mixed displacement. Gavrilov (1968) expanded this by incorporating alveolar bone participation as a diagnostic variable. Pozdnyakova (1976) introduced the vertical two-type classification — supraalveolar and infraalveolar — with A and B subtypes based on alveolar hypertrophy, which remains the most widely used prosthetically oriented system in Eastern European dental practice **[11–13]**. Western literature developed independently along functional lines, culminating in Okeson's (1998, 2012) framework linking morphological deformation to neuromuscular and temporomandibular joint consequences **[14, 15]**.

Table 2. Comparative Overview of Major Classification Systems for Secondary Dental Deformations

Author	ear	Classification Axis	Key Contribution	Principal Limitation
Betelman A.I.	951	Directional: vertical /	First systematic directional SDD	No functional or radiological criteria

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		horizontal / mixed	taxonomy in Russian dental literature	
Gavrilov E.I.	1968	Directional + alveolar bone change	Incorporated alveolar hypertrophy into vertical subtypes	Limited applicability to posterior segments
Pozdnyakova A.I.	1976	Vertical: supraalveolar / infraalveolar, with A/B subtypes	Dual-axis system enabling direct prosthetic treatment planning	No imaging criteria; relies on clinical assessment only
Kopeikin V.N.	1988	Integrated directional + quantitative degree grading	Added clinically useful degree grading to directional taxonomy	Angular thresholds lack radiological validation
Okeson J.P.	1998	Functional-biomechanical: occlusal stability / decompensation stages	Linked morphological SDD to TMJ and neuromuscular sequelae	Does not describe individual tooth displacement types
Dawson P.E.	2006	Equilibrium theory / complete dentistry classification	Emphasized neuromuscular equilibrium as reference standard	Complex; limited practical utility in routine orthopedics
Misch C.E.	2015	Implant-oriented bone and arch deformity staging	Integrated SDD assessment into implant pre-surgical planning	Limited to implant candidates; not comprehensive

Table 2. Historical overview of major SDD classification systems. TMJ = temporomandibular joint.

3.2. Gavrilov–Kopeikin Directional Classification

The directional classification, foundational in Gavrilov (1968) and expanded by Kopeikin (1988), organizes SDD according to the vector of crown displacement relative to the tooth's anatomical long axis and the occlusal plane. It is the most widely used system in Eastern European and Central Asian dental practice because its categories correspond directly to prosthetic design requirements **[16, 17]**.

Table 3. Gavrilov–Kopeikin Directional Classification of Secondary Dental Deformations

Direction	Subtype	Clinical description	Radiological signs	Prosthetic implication

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Vertica	Supraalve ar (extrusion)	Crown ongates beyond cclusal plane; veolar bone may llow	Increased crown ngth; alveolar ridge ypertrophy on PG/CBCT	Loss of rosthetic space; may quire surgical veoloplasty
Vertica	Infraalve ar (intrusion)	Crown epressed below cclusal plane under cessive loading	Reduced crown eight; oblique PDL ber direction on BCT	Compensatory rosthetic build-up quired
Sagitta	Mesial pping	Crown inclines nteriorly; distal ony pocket forms	Tipping angle sible on periapical m; angular bone efect distally	Orthodontic prighting often quired before FPD
Sagitta	Distal pping	Crown inclines osteriorly; mesial ony pocket forms	Reversed tipping ttern on periapical m	Less common; sess antagonist ntacts carefully
Transv sal	Buccal eviation	Crown igrates toward heek; cross-bite ndency in pposing arch	Arch width nalysis; buccal bone inning on CBCT cial view	Monitor for ucosal trauma; nctional wax-up sential
Transv sal	Lingual/ alatal eviation	Crown igrates toward idline; lingual one thickening	Narrowed arch idth; increased inter- dicular distance on BCT	Assess tongue pace and phonetics
Rotati nal	Torsiversi n	Tooth rotates ound its long axis; own faces normal direction	Crown rotation sible on occlusal ew; altered contact orphology	Rotation rrection before rosthetics; crown ep angle altered
Combi ed	Mixed ectors	Two or more ncurrent splacement rections in the me tooth	Multi-planar BCT analysis quired; 3D landmark easurements	Multidisciplinar protocol: thodontics + surgery prosthetics

Table 3. OPG = orthopantomogram; CBCT = cone-beam computed tomography; PDL = periodontal ligament; FPD = fixed partial denture.

3.3. Pozdnyakova Vertical Classification

Pozdnyakova's classification (1976) provides direct, prosthetically actionable information by distinguishing cases in which alveolar bone participates in the deformation from those where only the crown has moved. This distinction determines whether preparatory interventions are required before prosthetic rehabilitation can proceed **[13, 18]**.

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Table 4. Pozdnyakova Classification of Vertical Secondary Dental Deformations with Clinical-Radiological Criteria

Type	Sub	Definition	Radiological Feature	Alveolar Bone	Treatment Path
I (Supraalveolar)	IA	Crown elongation without alveolar hypertrophy	Increased clinical crown length; normal alveolar crest height	No bone change; normal crest	Direct prosthetic restoration; no surgical preparation needed
I (Supraalveolar)	IB	Crown elongation with alveolar hypertrophy (bone follows tooth)	Elevated alveolar crest; crown-bone complex protrudes into prosthetic space	Alveolar crest 2–8 mm above reference plane	Surgical alveoloplasty OR orthodontic intrusion required before prosthetics
II (Infraalveolar)	IIA	Partial intrusion; crown 1–3 mm below occlusal plane	Reduced crown height; mild bone resorption at crest	Mild alveolar resorption or remodeling	Compensatory prosthetic build-up; monitor for periapical changes
II (Infraalveolar)	IIB	Severe intrusion; crown more than 3 mm below occlusal plane	Periapical changes; root exposure possible; angular defects on CBCT	Significant bone loss; angular defects	Endodontic evaluation; extraction decision; implant planning
III (Combined)	I+II	Simultaneous supra- and infraalveolar elements in the same quadrant	Mixed radiological signs; asymmetric bone levels	Variable and asymmetric; requires 3D CBCT for complete mapping	Multidisciplinary protocol; staged approach mandatory

Table 4. Pozdnyakova classification with expanded clinical and radiological criteria. CBCT = cone-beam computed tomography.

3.4. Functional Classification (Okeson Decompensation Stages)

Functional classifications describe SDD consequences on the neuromuscular system and temporomandibular joints rather than tooth morphology. Okeson's

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framework (1998, 2012) provides a staging system based on the degree to which deformations have disrupted functional occlusion and generated neuromuscular or articular sequelae. This system is indispensable for pre-treatment assessment and should be used in parallel with morphological classification **[14, 15]**.

Table 5. Okeson Functional Classification of Occlusal Deformation Consequences

Stage	Designation	Clinical Criteria	Neuromuscular / Status	Treatment Priority
0	Compensated	Morphological mation present; cts within tive range	No muscle ractivity; no TMJ ds; no pain	Monitoring; elective hetic restoration
I	Deflective ct	Premature or ctive contacts g l/protrusive sion; no VD ge	Occasional muscle ıe; no structural TMJ ges	Occlusal adjustment; prosthetic correction
II	Partial npensation	Multiple ature contacts; ed OVD; chewing ency reduced >25%	Chronic oral/masseter rness; clicking; initial displacement	Urgent OVD ration; splint therapy; hetic planning
III	Complete sal collapse	Loss of posterior ort; anterior ct only; catory efficiency	Structural TMJ ge; bruxism; myalgia; on jaw movement	Emergency ization; disciplinary pre- hetic treatment latory

Table 5. OVD = occlusal vertical dimension; VD = vertical dimension; TMJ = temporomandibular joint.

3.5. Clinical Types of Secondary Dental Deformations

3.5.1. Supraalveolar Elongation (Popov–Godon Phenomenon)

Supraalveolar elongation — described independently by Popov (1880) and Godon (1902) — is the most prevalent form of SDD and the one with the greatest impact on prosthetic rehabilitation. The condition arises when a tooth loses its occlusal antagonist, eliminating the counterforce that limits passive eruption. The tooth continues to erupt beyond the normal occlusal plane, carrying the surrounding alveolar bone in Type IB cases **[19, 20]**. The eruption rate is not constant. Longitudinal studies using digital occlusal analysis have documented rapid initial elongation (0.8–1.4 mm/year) in the first 12–24 months after antagonist loss, followed by deceleration as the tooth approaches opposing soft tissue **[21]**.

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Table 6. Degree Classification of Supraalveolar Elongation

Degree	Elongation (mm beyond OP)	Alveolar Changes	CBCT Findings	Treatment Approach	Frequency (%)
I — Mild	< 2	None; crown elongation only	Normal alveolar crest; PDL within normal limits	Direct prosthetic restoration	38
II — Moderate	2–4	Minimal alveolar hypertrophy; gingival enlargement	Alveolar crest 1–2 mm above reference	Selective grinding or composite build-up of opposing arch	31
III — Severe	4–6	Pronounced alveolar hypertrophy; gingival overgrowth into prosthetic space	Alveolar crest 3–5 mm above reference	Orthodontic intrusion (4–6 months) or surgical alveoloplasty	22
IV — Critical	**> 6**	Severe alveolar overgrowth; may contact opposing arch mucosa	Alveolar crest >5 mm above reference; >50% prosthetic space lost	Surgical resection + orthodontics; consider extraction and implant	9

Table 6. OP = occlusal plane; CBCT = cone-beam computed tomography; PDL = periodontal ligament. Frequency data pooled from [20, 21, 22].

3.5.2. Mesial Drift and Sagittal Deformations

Mesial drift is the physiological tendency for teeth to migrate anteriorly throughout life, normally restrained by interdental contacts and the pressure equilibrium of lips, cheeks, and tongue. Following posterior tooth loss, this tendency is unrestrained, leading to progressive anterior tipping and bodily movement. In the lower arch, first and second molars frequently drift mesially after first molar extraction, reducing restorative space by a mean of 3.2 mm (95% CI: 2.8–3.6 mm) within three years if the extraction site remains unrestored **[23, 24]**.

Table 7. Degree Classification of Mesial Tipping Deformation

Degree	Tipping	Clinical Signs	Periodontal	Prosthetic Limitation	Prevalence (%)

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	Angle		**Consequence**		
I — Mild	< 10°	Minimal contact changes; slight food impaction	Suprabony pockets ≤3 mm; normal bone level	Standard FPD achievable with minor preparation	43
II — Moderate	10°–20°	Premature contacts; persistent food impaction; gingival inflammation	Angular bone defect distally; probing depth 4–5 mm	FPD path requires tooth reduction or tipping correction	34
III — Severe	20°–35°	TMJ loading changes; mandibular shift; functional decompensation	Infrabony defect >4 mm distally; furcation involvement possible	Orthodontic uprighting mandatory (4–8 months)	17
IV — Critical	**> 35°**	Complete occlusal collapse; severe TMJ dysfunction; pain on opening	Extensive bone loss; poor tooth prognosis	Extraction + implant vs. surgical uprighting; specialist referral	6

Table 7. TMJ = temporomandibular joint; FPD = fixed partial denture. Prevalence data pooled from [23, 25, 26].

3.5.3. Transversal Deformations

Transversal deformations occur in the horizontal plane perpendicular to the sagittal axis. Buccal deviation of posterior teeth most commonly results from arch-length discrepancy following multiple extractions and arch collapse. Lingual and palatal deviations are frequently associated with loss of cross-bite equilibrium or tongue-pressure preponderance following orthodontic relapse. Both subtypes alter the buccolingual relationship of opposing arches, creating cross-bite tendencies or traumatic contacts that accelerate further deformation **[27]**.

3.5.4. Rotational Deformations (Torsiversion)

Torsiversion — rotation of a tooth around its own long axis — arises as a secondary deformation when a tooth migrates bodily into an adjacent edentulous space and rotates under unequal mesial and distal contact pressures during drift. Posterior torsiversion displaces the occlusal table, creating eccentric contacts generating lateral forces with each chewing stroke. Digital T-Scan occlusal analysis in patients with molar torsiversion has demonstrated lateral force components of 30–45° from the desired axial direction, a magnitude well within the range

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associated with periodontal ligament damage and progressive alveolar bone loss **[28]**.

3.6. Epidemiological Data and Prevalence of SDD Types

To establish a reliable epidemiological profile, we performed a pooled analysis of 11 multicenter studies meeting inclusion criteria (total n = 6,843 patients with confirmed SDD; age range 25–74 years; published 2005–2024). Study populations included patients attending university dental clinics in Uzbekistan, Russia, Turkey, Germany, South Korea, and Brazil. All studies used standardized clinical examination supplemented by OPG radiography; six of eleven also used CBCT for subsurface alveolar assessment.

Table 8. Pooled Prevalence of Secondary Dental Deformation Types (11 Studies, n = 6,843)

SDD Type / Subtype	n	Prev. (%)	95% CI	Male (%)	Female (%)
Supraalveolar elongation (total)	2,614	**38.2**	35.1–41.3	34.1	42.4
— Type IA (no alveolar hypertrophy)	1,371	20.0	17.6–22.5	18.3	21.7
— Type IB (with alveolar hypertrophy)	1,243	18.2	15.8–20.5	15.8	20.7
Mesial drift / Sagittal deformation	1,882	**27.5**	24.4–30.6	30.2	24.9
Combined type (multi-directional)	1,293	**18.9**	16.3–21.4	19.4	18.3
Transversal deformation	616	**9.0**	7.2–10.8	8.7	9.3
Rotational (torsiversion)	267	**3.9**	2.8–5.1	4.1	3.7
Infraalveolar (Type II — intrusion)	171	**2.5**	1.7–3.3	3.0	2.0
TOTAL	**6,843**	**100.0**	—	—	—

Table 8. Pooled prevalence data from 11 multicenter studies (2005–2024). CI = confidence interval.

SDD are not uniformly distributed across the dentition. Posterior segments of both arches account for 78.3% of all clinically significant deformations; anterior deformations represent only 21.7%. Within posterior segments, the mandibular molar region has the highest incidence of mesial drift (41.2% of all mesial drift cases), while the maxillary molar region has the highest rates of supraalveolar elongation (53.7%), likely because gravitational forces augment passive eruption in the upper arch **[29, 30]**.

Age-stratified analysis (n = 3,420; pooled from [31, 32]) showed prevalence rising steeply between 35 and 55 years (38.7% to 61.8%) and plateauing in patients over 65 years (58.4%), a pattern attributable to the fact that patients in the oldest

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cohort typically had already received prosthetic treatment or extraction that interrupted further SDD evolution. Female sex was associated with significantly higher rates of supraalveolar elongation in the 35–64 age group ($p < 0.05$), a finding discussed further below.

3.7. Diagnostic Criteria and Radiological Thresholds

Accurate diagnosis of SDD type and severity requires structured clinical examination combined with appropriate imaging. The clinical examination protocol includes: visual inspection with measurement of clinical crown length and gingival margin position; six-point periodontal probing per tooth; occlusal contact analysis using articulating paper (8 μm) supplemented by digital T-Scan III force mapping; standardized clinical photography; and study models obtained from alginate impressions or intraoral digital scanning **[33, 34]**.

Periapical radiographs and full-arch orthopantomogram are the minimum radiological requirement for SDD classification. CBCT (0.2 mm voxel resolution, full-arch or region-of-interest field of view) is the gold standard for differentiating Pozdnyakova subtypes IA and IB, as this distinction determines the necessity for surgical intervention. Quantitative CBCT criteria derived from validation studies against surgical findings **[35, 36]** are presented in Table 9.

Table 9. CBCT-Based Quantitative Criteria for Pozdnyakova Subtype Differentiation

CBCT Measurement	Normal Range	Type IA	Type IB	Clinical Action Threshold
Alveolar crest height above occlusal plane reference (mm)	0 ± 0.5	0–2 mm	**> 2 mm**	Surgical review if > 3 mm
Percentage of elongation attributable to bone overgrowth (%)	< 10	10–30	**> 30**	Alveoloplasty if > 40%
PDL space width at apex (mm)	0.15–0.38	0.15–0.38	0.20–0.50	Widening indicates active tooth movement
Crown-root ratio	≤ 1:1	1:1–3:2	**> 3:2**	Extraction risk if ratio exceeds 2:1
Buccal bone plate thickness (mm)	> 1.5	> 1.5	0.5–2.0	< 1 mm signals bone dehiscence risk

Table 9. CBCT = cone-beam computed tomography; PDL = periodontal ligament. Data from [35, 36].

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4. DISCUSSION

This systematic review of 78 peer-reviewed publications provides a comprehensive synthesis of SDD classification systems and type-specific epidemiological data. Several clinically important conclusions emerge.

First, the fragmentation of classification systems along geographic and disciplinary lines creates a situation where identical clinical presentations may receive different diagnoses depending on the treating clinician's training tradition. The Eastern European morphological school and the Western functional-biomechanical school each capture important but non-overlapping diagnostic dimensions. A multi-axial classification framework that integrates direction (Gavrilov–Kopeikin), vertical-alveolar subtype (Pozdnyakova), and functional decompensation stage (Okeson) is the most clinically complete approach currently available from the published literature. Its adoption as a standardized international framework would facilitate cross-institutional research, clinical audit, and evidence-based treatment guidelines.

Second, the epidemiological data presented in this review reinforce the importance of early prosthetic intervention. The mean interval from tooth extraction to clinically significant supraalveolar elongation is approximately 14.3 months (95% CI: 11.2–17.4 months), derived from three longitudinal cohort studies included in the analysis **[21, 37, 38]**. This timeline indicates that a restoration provided within six months of extraction — consistent with evidence-based implant and fixed partial denture timing protocols — would prevent the majority of Type IA supraalveolar deformations. For Type IB prevention, the threshold is even shorter: alveolar hypertrophy becomes radiologically detectable at a mean of 9.4 months after antagonist loss in patients with concurrent periodontal disease **[39]**. The public health cost of delayed rehabilitation is therefore measurable in terms of preventable surgical procedures.

Third, the gender differences in SDD distribution identified in this review — specifically the significantly higher prevalence of supraalveolar elongation in females across the 35–64 age group — have not previously been emphasized in classification literature. The most plausible biological mechanism is the well-documented association between estrogen decline, reduced osteoclast inhibition, alveolar bone resorption, and facilitated passive eruption in post-menopausal women **[40, 41]**. Post-menopausal patients with tooth loss should therefore be considered a high-priority risk group for early prosthetic rehabilitation, with systemic bone health optimization considered as part of a multidisciplinary management plan.

Fourth, the high proportion of combined-type SDD (18.9%) in the pooled data underscores that single-axis classification is insufficient for a substantial minority of patients. For nearly one in five SDD patients, morphological changes occur simultaneously in multiple directions and require multidisciplinary management that simple morphological or simple functional classification alone cannot guide.

The principal limitation of this review is the heterogeneity of included studies in terms of patient populations, classification systems applied, and radiological methods used for SDD verification. The pooled prevalence figures should therefore be interpreted as estimates with moderate rather than high certainty. Future research should prioritize prospective multicenter studies with standardized CBCT-based SDD classification and reporting to provide more precise epidemiological data.

5. CONCLUSIONS

Classification of secondary dental deformations should be multi-axial, combining direction, vertical-alveolar subtype, functional decompensation stage, and deformation severity. No single existing classification system captures all clinically necessary information; the Gavrilov–Kopeikin, Pozdnyakova, and Okeson frameworks complement each other and should be applied together in clinical practice.

Supraalveolar elongation is the most prevalent SDD type (38.2%), with Pozdnyakova Type IB constituting the most surgically demanding subtype. CBCT-based quantitative criteria — specifically, alveolar crest height exceeding 2 mm above the occlusal reference plane and bone overgrowth accounting for more than 30% of total elongation — provide objective thresholds for subtype differentiation and surgical decision-making.

Posterior arch segments account for 78.3% of clinically significant SDD, with maxillary molar elongation and mandibular molar mesial drift representing the highest-frequency type-location combinations. The 14.3-month mean interval from antagonist loss to clinically significant elongation underlines the urgency of timely prosthetic rehabilitation. Prevention of SDD should be regarded as a primary prosthetic care goal rather than a secondary complication to manage after deformation has occurred.

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