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Anatomical prevalence of the cervical enamel projection

A narrative review

UPDATE

Prevalencia anatómica de la proyección del esmalte cervical

Una revisión narrativa

Prevalência anatômica da projeção cervical do esmalte

Uma revisão narrativa

Abstract

Atypical dental anatomy or, more precisely, certain morphological defects in dental structure should be considered predisposing factors for the onset and progression of periodontal disease, as they favor biofilm accumulation and may be associated with its development and progression.

This study aims to provide a narrative review of the literature on the prevalence of an anatomical alteration classified as cervical enamel projection (CEP).

Articles related to cervical enamel projections published in Portuguese, English, or Spanish were analyzed without restriction on year of publication, using databases such as EMBASE, Google Scholar, Scopus, PubMed, and Web of Science, and the MeSH descriptors “anatomy” and “cervical enamel projection.”

A total of 134 studies were identified; however, only 37 met all inclusion criteria and were included in the qualitative analysis. The publications ranged from 1964 to 2019, comprising in vitro studies (20), literature reviews (10), and clinical cases (7).

Cervical enamel projection, in both upper and lower molars, is a frequent finding in anatomical studies, with a prevalence reported in the literature ranging from 5.86% to 85% in molar teeth.

Keywords: Dental anatomy. Developmental defects of enamel. Review.

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Resumen

La anatomía dental atípica o, más precisamente, algunos defectos morfológicos en la estructura dental deben considerarse factores predisponentes para la aparición y progresión de la enfermedad periodontal, ya que favorecen la acumulación de biofilm y pueden estar relacionados con la aparición y progresión de la enfermedad periodontal.

El objetivo del presente estudio es revisar narrativamente la literatura sobre la prevalencia de una alteración anatómica clasificada como proyección cervical del esmalte (PCE).

Se analizaron estudios relacionados con las proyecciones del esmalte cervical publicados en portugués, inglés o español sin restricción de año de publicación en bases de datos como EMBASE, Google Scholar, Scopus, PubMed y Web of Science utilizando los descriptores MESH "anatomía" y "proyección cervical del esmalte".

Se encontraron 134 estudios; sin embargo, solo 37 cumplieron con todos los criterios de inclusión y se incorporaron al análisis cualitativo completo. Las publicaciones se realizaron entre 1964 y 2019 y se identificaron estudios in vitro (20), revisiones bibliográficas (10) y casos clínicos (7).

La presencia de proyección cervical del esmalte, tanto en molares superiores como inferiores, es un hallazgo frecuente en todos los estudios anatómicos presentando una prevalencia observada en la literatura de 5,86 al 85% en dientes molares.

Palabras clave: Anatomía dental. Defectos del desarrollo del esmalte. Revisión.

Resumo

Anatomia dentária atípica, ou mais precisamente, certos defeitos morfológicos na estrutura dentária, devem ser considerados fatores predisponentes para o surgimento e progressão da doença periodontal, pois promovem o acúmulo de biofilme e podem estar relacionados ao surgimento e progressão da doença periodontal.

O objetivo deste estudo é revisar narrativamente a literatura sobre a prevalência de uma alteração anatômica classificada como projeção cervical do esmalte (PCE).

Estudos relacionados às projeções cervicais do esmalte publicados em português, inglês ou espanhol foram analisados sem restrição quanto ao ano de publicação em bases de dados como EMBASE, Google Acadêmico, Scopus, PubMed e Web of Science, utilizando os descritores MESH "anatomia" e "projeção cervical do esmalte".

Foram encontrados 134 estudos; no entanto, apenas 37 preencheram todos os critérios de inclusão e foram incorporados à análise qualitativa completa. As publicações foram publicadas entre 1964 e 2019, e incluíram estudos in vitro (20), revisões de literatura (10) e casos clínicos (7).

A presença de projeção cervical do esmalte, tanto em molares superiores quanto inferiores, é um achado frequente em todos os estudos anatômicos, com prevalência observada na literatura de 5,86 a 85% em dentes molares.

Palavras-chave: Anatomia dentária. Defeitos de desenvolvimento do esmalte. Revisão.

Introduction and background

Cervical enamel projection (CEP) can be regarded as a developmental anomaly in which enamel extends cervically toward the furcation area of molars, altering the contour of the cementoenamel junction.[1]

Based on a critical analysis of the relevant literature, some researchers have identified that this significant anatomical anomaly may occur primarily in molars, with occasional presence in other teeth.[2] The etiopathogenesis of CEP is related to prolonged and focal activity of ameloblasts in the cervical loop or Hertwig's epithelial sheath after complete formation of the dental crown; these cells retain the ability to produce and deposit enamel proteins, such as amelogenin, on the root surface.[2–4] Although these findings may explain the ectopic presence of enamel on the root, the exact mechanism underlying CEP formation remains unclear.[2]

Cervical enamel projection, both in upper and lower molars, is frequently observed in anatomical studies, with a prevalence ranging from 8.6% to 85% (Hou and Tsai, 1997).[5] Masters and Hoskins[6] established a classification system based on the extent of cervical enamel projection toward the furcation. In a Class I projection, a slight extension of the cementoenamel junction toward the furcation is observed; in a Class II projection, the enamel projection approaches the furcation without entering it; and in a Class III projection, the enamel extends to the furcation (**Figure 1**).

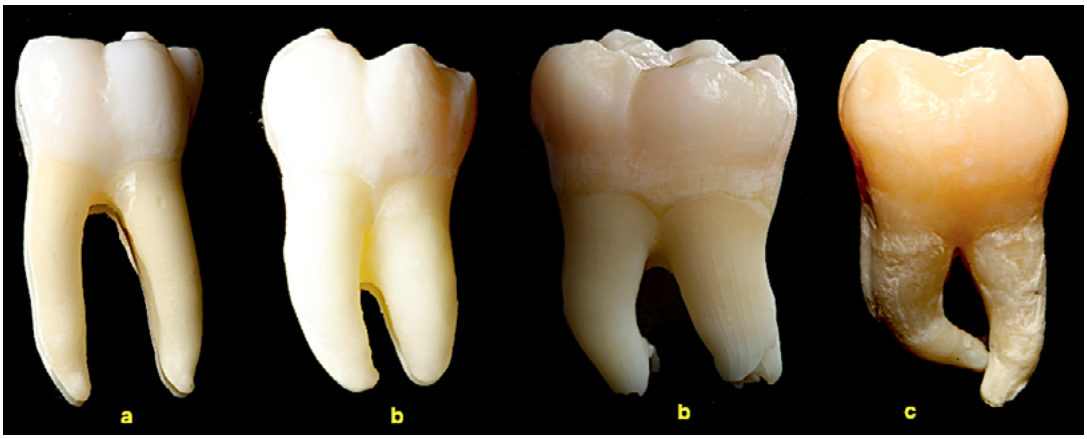


Figure 1. Examples of the different projection categories according to the classification by Masters and Hoskins.[6] **A.** Grade I projection: a slight extension of the cementoenamel junction toward the furcation. **B.** Grade II: the enamel projection approaches the furcation without penetrating it. **C.** Grade III: an enamel projection extends to the furcation itself.

Thus, this study aims to provide a narrative review of the literature on an anatomical abnormality classified as cervical enamel projection, affecting root anatomy.

Materials and methods

This study is a comprehensive narrative review focused on the anatomical condition defined as cervical enamel projection. It was conducted in accordance with the Synthesis Without Meta-analysis (SwiM) guidelines,[7] developed to guide reviews of interventions in which a meta-analysis of effect estimates is not feasible.

An exploratory literature search was conducted in the Medline (PubMed), Scopus, EMBASE, Web of Science, and Google Scholar databases to identify studies published in Portuguese, English, and Spanish, with no restriction on year of publication. The search was performed by two independent reviewers (RCM and GFC). The following MeSH (Medical Subject Headings) terms were used: (Anatomy) AND (Cervical Enamel Projection) OR "Cervical Enamel Projection" [All Fields].

Inclusion criteria comprised full-text articles, including in vitro (experimental) studies, literature reviews (narrative and systematic), and clinical case studies, with no time restrictions.

Studies or articles with abstracts in languages other than those specified, as well as those whose content did not demonstrate the proposed relationship with the research objective, were excluded. Animal studies and letters to the editor were also excluded. The search period spanned from September 2023 to September 2024.

The titles and abstracts of studies identified through the search strategy were screened by the reviewers and selected according to the research objectives. Data on authorship, year and country of publication, and primary outcomes were extracted. Data collection and extraction were performed independently by two reviewers (GFC and RCM). Discrepancies were resolved by consensus or, when necessary, by consultation with a third reviewer (JM) to ensure data integrity. Inter-reviewer agreement was assessed using the Kappa statistic (k = 0.90). At the end of this phase, the final number of included studies was determined. The search results are presented in a flow diagram adapted and translated from the PRISMA statement for systematic reviews, showing the stages of identification, screening, eligibility, and inclusion of the studies related to the anatomical entity analyzed (**Figure 2**).

Following the selection process, a systematic, selective, and analytical review of the studies meeting the eligibility criteria was conducted. Data were evaluated using content analysis and are presented in the corresponding flow diagram.

The database search conducted in the electronic databases specified in the methodological description identified 134 records, as detailed in the study flow diagram (**Figure 2**). Of these, 37 articles met all inclusion criteria and were included in the full qualitative analysis. The studies were published between 1964 and 2019 and comprised in vitro studies (20), literature reviews (10), and clinical cases (7).

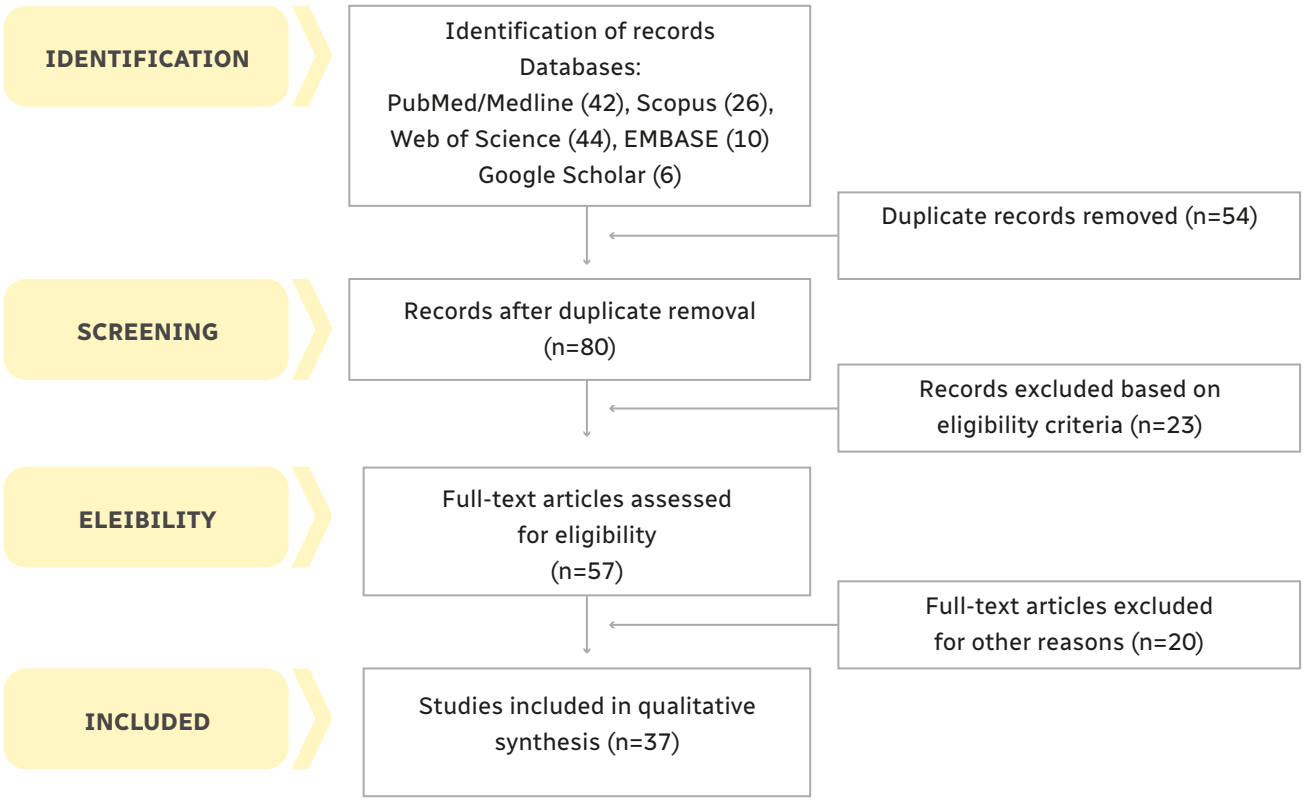


Figure 2. Study selection process presented in a flow diagram of the studies included in the qualitative analysis. Adapted from the PRISMA flow diagram.

Results and discussion

The prevalence of CEP in studies evaluating extracted teeth shows considerable variability, ranging from 5.86% to 59% in maxillary molars and from 10.3% to 85% in mandibular molars.[5,6,8–16] The reported prevalence of Grade III cervical enamel projection in mandibular molars ranged from 4.3% to 46% across studies, and from 4.8% to 27.6% in maxillary molars (**Table 1**).[6,8,10,12,13,17] Class III projections are the most clinically significant due to their morphological characteristics and their relationship with tissues in the furcation region, which hinders access for cleaning.[2]

Regarding prevalence, the study by Masters and Hoskins,[6] which evaluated 474 maxillary and mandibular molars, reported the presence of cervical enamel projection in 28.6% of mandibular molars and 17% of maxillary molars, classified into three categories (**Figure 1**). Similarly, Leib *et al.* (1967),[10] who evaluated 301 molars, reported a prevalence of 25% and 22% in mandibular and maxillary molars, respectively.[10] A study conducted on 1,608 molars showed that both maxillary and

mandibular molars presented enamel projections, with an incidence ranging from 24.4% in maxillary molars to 34.8% in mandibular molars.[11] Risnes *et al.* (1974)[18] assessed 8,854 extracted molars from a Norwegian population for the presence of cervical enamel projection. The authors concluded that mandibular molars showed a higher prevalence than maxillary molars. Similarly, Zee *et al.* (1991)[13] identified, in a Chinese population of 194 maxillary molars and 168 mandibular molars, a prevalence of cervical enamel projection of 59% in maxillary teeth and 79% in mandibular teeth. Leite *et al.* (1995)[19] investigated cervical enamel projection in 1,903 extracted permanent molars and found that its incidence is higher on the buccal and lingual surfaces, occurring most frequently in mandibular first molars (27.7%) and maxillary first molars (19.6%). Hou and Tsai (1997)[5] evaluated cervical enamel projection in 87 molars—56 first and 31 second molars—and reported that 63.2% exhibited cervical enamel projection, with a higher prevalence in first molars (67.9%).

The association of anatomical developmental abnormalities was also observed in a microscopic and radiographic study of molars, in which a long enamel projection was found associated with another anatomical anomaly known as an enamel pearl.[20] Gaspersic *et al.* (1992)[4] compared the structure and composition of 12 enamel projections and 12 enamel pearls in permanent human molars and suggested that these two forms of ectopic enamel differ in their histogenesis. Their findings suggest that amelogenesis in enamel projections represents a continuation of amelogenesis in the cervical region. In contrast, amelogenesis in enamel pearls follows the same pattern as that of the dental crown, extending from the occlusal region to the cervical margin of the enamel. Melo and Consolaro (2000)[2] analyzed the morphology of cervical enamel projection in 1000 human teeth using macro- and stereomicroscopy and concluded that these projections are typically found in molars, with occasional occurrence in other teeth. They affect the buccal surface and are more frequent in Class I (57.5%) and Class III (33.2%) teeth. In an anatomical study, de Souza *et al.* (2014)[16] evaluated the prevalence of cervical enamel projection in 234 human maxillary and mandibular molars and concluded that it occurs more frequently in mandibular molars.

Swerts *et al.* (2008)[14] evaluated the incidence and degree of cervical enamel projection in 406 permanent molars. They reported that 52.67% of the molars exhibited cervical enamel projection of any degree, with Grade I showing the highest incidence (32.99%). Mandibular molars were slightly more affected than maxillary molars (50.48% vs. 49.52%), and 28.71% of mandibular molars exhibited Grades II and III. In comparison, maxillary molars showed 11.37%. The second maxillary molar was the most affected (61.01%), followed by the first mandibular molar (59.025%), the second mandibular molar (50.87%), and the first maxillary molar (34.40%).

Table 1. Prevalence of cervical enamel projections in maxillary and mandibular molars.

	Maxillary			Mandibular		
Investigator	Number of molars	Prevalence of CEPs	% with CEP	Number of molars	Prevalence of CEPs	% with CEP
Masters and Hoskins (1964)	170	87	28.6%	304	28	17%
Grewe (1965)	3.438	543	15.8%	1.802	454	25.2%
Leib *et al.* (1967)	301	66	22%	301	75	25%
Bissada and Abdelmalek (1973)	444	26	5.86%	694	72	10.37%
Tsatsas *et al.* (1973)	752	80	10.6%	856	402	47%
Swan and Hurt (1976)	980	307	31.4%	1020	344	33.7%
Zee *et al.* (1991)	194	114	59%	168	132	79%
Lee *et al.* (1995)	639	155	24%	1264	544	43%
Hou and Tsai (1997)	-	-	-	87	74	85%
Melo and Consolaro (2000)	366	199 (CEP I)	54.37% (CEP I)	634	376 (CEP I)	59.30% (CEP I)
		46 (CEP II)	12.56% (CEP II)		47 (CEP II)	7.4% (CEP II)
		121 (CEP III)	33% (CEP III)		211 (CEP III)	33.3% (CEP III)
Swerts *et al.* (2008)	211	104	49.52%	195	98	50.48%
Bhusari *et al.* (2013)	224	24	10.7%	720	88	12.2%
Souza *et al.* (2014)	124	15	12.1%	110	25	22.7%

Bissada and Abdelmalek (1973)[9] re-evaluated the incidence and distribution of cervical enamel projections and attempted to correlate their possible association with furcation involvement in Egyptian dry skulls. They assessed the incidence and location in 1138 maxillary and mandibular molars and found a lower incidence of cervical enamel projections (8.6%) compared with previous studies. However, mandibular second molars remained the most affected. Furthermore, they emphasized that routine periapical radiographic examination is not practical for detecting these defects. (9) In contrast, a study using dental computed tomography identified a high prevalence of cervical enamel projections in mandibular molars.[21]

Cervical enamel projection in 944 molars from dry skulls in India was evaluated by Bhusari *et al.* (2013).[15] The authors assessed its relationship with the development of furcation lesions in both the maxilla and the mandible. They concluded that the association between cervical enamel projection and furcation lesions was statistically significant, reinforcing the hypothesis of a possible role of these anomalies in the progression of periodontal disease. This interesting finding supports a correlation between cervical enamel projection and furcation lesions, with incidence varying among molars.

Many molars present cervical enamel projection, primarily of limited extent, with incidence varying across different studies, as illustrated in **Table 1**. There is also a strong relationship between cervical enamel projection and periodontal disease involving the furcation area in molars. Anatomical anomalies, particularly in posterior teeth, may not always be modifiable. However, awareness of possible anatomical variations and their early detection can help prevent future tooth loss.[2]

This morphological characteristic directly influences the insertion of periodontal ligament fibers into the cementum. The more apically the enamel extends, the more apical the insertion of periodontal connective tissue fibers, which in turn extends the junctional epithelium toward the furcation.[22]

The difficulty in early diagnosis of cervical enamel projection underscores the importance of understanding this anatomical peculiarity.[2] Diagnosis requires careful examination of the cementoenamel junction, where the projection can be detected. Diagnostic procedures for CEPs include thorough exploratory or periodontal probing, gingival retraction or flap surgery, and visual inspection. [9] The presence of edematous gingiva or a localized periodontal abscess may indicate cervical enamel projection in molars. Anatomically, the greater the extent of the projection (e.g., Grade III), the deeper and more localized the resulting periodontal pocket may be. Diagnosis using conventional radiography is ineffective, as it does not allow visualization of cervical enamel projection.[9,23]

Mechanical control of dental biofilm may be negatively affected in the presence of anatomical abnormalities such as cervical enamel projection, due to the potential formation of niches for bacterial retention or hindering periodontal root instrumentation.[8,9,24-28] Therefore, anatomical knowledge is essential when developing a periodontal diagnosis and treatment plan to avoid errors or difficulties in its implementation.[26] Identifying even subtle anatomical variations, carefully observing them, and complementing them with auxiliary resources can facilitate and improve periodontal treatment.

The findings of this study help highlight this anatomical feature, which is sometimes overlooked due to its unusual nature but may have significant consequences in both periodontics and restorative specialties due to inaccurate diagnosis and challenging treatment. A better understanding of these anatomical details allows for improved patient care, ensuring accurate diagnosis and more precise treatments.

Conclusions

Based on the anatomical findings, it is concluded that cervical enamel projection in upper and lower molars is a frequent finding in all anatomical studies analyzed, with a prevalence ranging from 5.86% to 85% in molar teeth.

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Data Availability

The complete dataset supporting the results of this study is available within the article.

Conflict of interest statement

The authors declare no conflict of interest.

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Authors Contributions and collaboration statement

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Gabrielle Ferreira Cardoso			x	x	x	x	x	x	x	x	x		x	x
Josiane Dias Pinz			x	x	x	x	x	x	x	x	x		x	x
Laura Lourenço Morel	x		x	x	x	x	x	x	x	x		x	x	x
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