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# 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

**Parthasarathi Mondal[1], Kaushik Mistry[1], Tapas Paul[2], Kallol Kumar Saha[1], Dipanjan Das[3], Snigdho Das[4]** ✉

[1] Dr. R. Ahmed Dental College and Hospital, Kolkata, West Bengal, India
[2] North Bengal Dental College and Hospital, Sushrutnagar, Darjeeling, West Bengal, India
[3] Haldia Institute of Dental Sciences and Research, Haldia, West Bengal, India
[4] Ramakrishna Sarada Mission Matri Bhavan Hospital, Kolkata, West Bengal, India
✉ snigdho1991@gmail.com

**Abstract**

INTRODUCTION. Developmental anomalies like dens invaginatus (DI) and palatogingival groove (PGG) increase susceptibility to pulpal and periradicular diseases, complicating root canal treatment. Advanced imaging modalities such as cone-beam computed tomography (CBCT) provide enhanced visualization, aiding in accurate diagnosis and treatment planning.

AIM. This study aimed to determine the prevalence and characteristics of DI and associated PGG in maxillary anterior teeth among an Indian population.

MATERIALS AND METHODS. A retrospective cross-sectional study was conducted on 586 CBCT scans recorded for clinical purposes, of which 228 met the inclusion criteria. CBCT images were analyzed for DI and associated PGG using Oehler's and Gu's classifications. Data were statistically analyzed, with significance set at $p \leqslant 0.05$.

RESULTS. DI was observed in 33 teeth (2.41%), predominantly in lateral incisors (6.14%). Oehler's Type I was the most common variant (78.8%). PGG was present in 8 teeth (24.24%), all of which classified as Gu's Type I in the teeth where DI was detected. Unilateral involvement of DI (56.5%) was more frequent than bilateral involvement (43.5%). No significant gender differences were noted for DI or PGG prevalence.

CONCLUSIONS. The prevalence of DI and associated PGG highlights the need for advanced diagnostic tools like CBCT to facilitate early detection and management. CBCT's three-dimensional imaging capabilities are indispensable for diagnosing these anomalies and improving treatment outcomes.

**Keywords:** dens invaginatus, palatogingival groove, cone-beam computed tomography, prevalence, indian population, Oehler's classification, Gu's classification

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# Распространенность и морфологическая оценка инвагинации десны с сопутствующей нёбно-десневой бороздкой на передних зубах верхней челюсти с помощью конусно-лучевой компьютерной томографии: ретроспективное исследование на выборке из Восточной Индии

**П. Мондал[1], К. Мистри[1] ✉, Т. Паул[2], К.К. Саха[1], Д. Дас[3], С. Дас[4]**

[1] Стоматологический колледж и больница доктора Р. Ахмеда, Калькутта, Западная Бенгалия, Индия
[2] Стоматологический колледж и больница Северной Бенгалии, Сушрутнагар, Дарджилинг, Западная Бенгалия, Индия
[3] Институт стоматологических наук и исследований в Халдии, Халдия, Западная Бенгалия, Индия
[4] Больница Рамакришны Сарады, Матхри Бхаван, Калькутта, Западная Бенгалия, Индия
✉ snigdho1991@gmail.com

**Резюме**

ВВЕДЕНИЕ. Аномалии развития, такие как инвагинатус (DI) и небно-дингивальная борозда (PGG), повышают восприимчивость к пульпозным и перирадикулярным заболеваниям, усложняя лечение корневых каналов. Передовые методы визуализации, такие как конусно-лучевая компьютерная томография (КЛКТ), обеспечивают улучшенную визуализацию, помогая в точной диагностике и планировании лечения.

ЦЕЛЬ. определить распространенность и характеристики DI и связанного с ним PGG на передних зубах верхней челюсти среди индийского населения.
МАТЕРИАЛЫ И МЕТОДЫ. Ретроспективное поперечное исследование было проведено на основе 586 снимков КЛКТ, сделанных в клинических целях, из которых 228 соответствовали критериям включения. Снимки КЛКТ были проанализированы на наличие ДИ и связанного с ним ПГГ с использованием классификаций Элера и Гу. Данные были подвергнуты статистическому анализу, значимость была установлена на уровне $p \leqslant 0{,}05$.
РЕЗУЛЬТАТЫ. ДИ был обнаружен в 33 зубах (2,41%), преимущественно в боковых резцах (6,14%). Тип I по Элеру был наиболее распространённым вариантом (78,8%). PGG присутствовал в 8 зубах (24,24%), и все они были классифицированы как тип I по Гу в зубах, в которых был выявлен DI. Одностороннее поражение DI (56,5%) встречалось чаще, чем двустороннее (43,5%). Значительных гендерных различий в распространённости DI или PGG отмечено не было.
ВЫВОДЫ. Распространённость диссеминированного инфильтрата и связанного с ним PGG подчёркивает необходимость в передовых диагностических инструментах, таких как КТ-перфузия, для облегчения раннего выявления и лечения. Возможности КТ-перфузии для получения трёхмерных изображений незаменимы для диагностики этих аномалий и улучшения результатов лечения.

**Ключевые слова:** вагинальный дентин, нёбно-десневая борозда, конусно-лучевая компьютерная томография, распространённость, индийское население, классификация Элера, классификация Гу

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## INTRODUCTION

Developmental anomalies increase susceptibility to pulpal and periradicular diseases, often complicating root canal treatment [1]. These anomalies can alter the thickness and mineralization of tooth hard tissues, reduce pulpal volume, create areas difficult to clean with routine oral hygiene, and provide an environment conducive to microbial colonization, ultimately affecting disease progression and treatment outcomes [2; 3]. Two commonly encountered developmental anomalies are dens invaginatus (DI) and palatogingival groove (PGG). These conditions disrupt the normal relationship between enamel, dentin, cementum, and the periodontal ligament, with a notable predilection for maxillary lateral incisors, making them significant considerations in endodontic and periodontal practice [3]. The developmental abnormality known as dens invaginatus (DI), or dens in dente, mostly affects the permanent teeth. Although its exact cause is unknown, enamel is generally believed to invade the nearby dental papilla during tooth growth [4]. The crown is, where DI typically appears, however, occasionally the root or both the crown and the root may be affected. Clinically, DI can vary from minor enamel invaginations that marginally decrease pulp chamber capacity to more extensive invaginations that extend into the root, giving the radiological image of a “tooth within a tooth” [5].

The reported prevalence of DI varies from 0.3% to 10%, with a notable tendency for symmetry – its presence on one side of the arch increases the likelihood of occurrence on the opposite side [6]. In the Indian population, the prevalence of DI in maxillary lateral incisors is approximately 2.4–13.5% [3; 7]. Another commonly disregarded dental abnormality that may be a factor in endodontic treatment failure is the PGG. On the palatal surface of maxillary incisors, PGG is a funnel-shaped depression first identified by Black in 1908 as a radicular groove (RG) [8]. It usually starts close to the cingulum and spreads apically toward the root surface and cementoenamel junction (CEJ).

Occasionally, the pulp chamber may extend into the periodontal space [1]. In some instances, the groove can be so extensive that it results in a bifurcation, along with a small additional proximal root. Earlier reports have indicated that the prevalence of PGGs ranges from 0.5% to 9.58% [3; 9–15]. Numerous investigations worldwide have explored the frequency of DI and PGG across varied populations and ethnic groups [7; 12; 16]. However, considering the influence of these conditions on treatment outcomes, there is a continual need to enhance existing knowledge by adopting advanced diagnostic tools and examining diverse population samples.

A non-invasive imaging modality, three-dimensional cone-beam computed tomography (CBCT), provides detailed anatomic visualization that simplifies diagnosis, classification, and treatment planning, ultimately leading to improved therapeutic outcomes. However, the use of CBCT to establish the prevalence of these two anomalies is not extensively documented in the literature. Notably, there is also scarcity of studies evaluating the association between PGGs and dens invaginatus, emphasizing the need for further research in this area. Hence, the present study was designed to determine the prevalence of DI and associated PGG in maxillary anterior teeth, and categorize them based on the degree of invagination, associated with these entities in an Indian population [3; 14; 15].

## MATERIALS AND METHODS

This retrospective cross-sectional study was carried out in the Endodontic Department of a tertiary dental college following approval from the Institutional Ethics Committee (RADCH/EC/59/2024). A previous study [3] reported a 13.5% prevalence of dens invaginatus in an Indian population. Using the Daniel's formula $N = 4PQ/d^2$ where $P$ is 0.135, $Q$ equals 100 – $P$, and d is minimum error precision which set at 5% of $P$, the minimum sample size required was calculated to be 189 CBCT scans (or screening approximately 1134 maxillary teeth) at a 95% confidence level.

A total of 586 CBCT scans of maxillary anterior teeth, recorded between September 2023 and July 2024, were retrieved from the department archives. These scans were originally obtained for various clinical reasons unrelated to this investigation, ensuring that no images were captured exclusively for research purposes. All scans were anonymized before evaluation, and the requirement for written informed consent had been fulfilled as part of the routine CBCT acquisition protocol in the institution.

CBCT imaging was performed using a MyRay (SkyView Imaging, Imola,Italy) machine operating at 90 kVp with a pulsed beam current of 1–10 mA, while exposure times were automatically adjusted according to the scanned region. An experienced maxillofacial radiologist performed the acquisitions according to the manufacturer's protocol, and the resulting datasets were viewed using the proprietary NNT viewer software. Only those scans displaying highquality images of fully formed permanent maxillary anterior teeth, with minimal motion artifacts and no metallic restorations or prosthetic components, were considered suitable. Any scans showing poor image resolution, incomplete root formation, or the presence of posts, implants, or large restorations were excluded from the analysis. Application of these inclusion and exclusion criteria yielded 228 eligible scans out of the initial 586.

Two calibrated examiners (MP and MK) examined all images independently, assessing axial, coronal, and sagittal sections for evidence of dens invaginatus and PGGs. In instances of disagreement, consensus was achieved through discussion or by consulting a third senior examiner (DS).

DI was classified according to Oehler's criteria [17], which distinguishes four main types based on how far the invagination extends and whether it communicates with the periodontal ligament (PDL). Type I remains confined to the crown, not crossing the CEJ or the pulp chamber. Type II crosses the CEJ and may involve the pulp but does not establish a pathway to the PDL. Type IIIa extends through the root to connect with the PDL, yet typically spares the pulp. Type IIIb also traverses the root but communicates with the PDL via the apical foramen, sometimes altering the tooth's anatomy even if it does not directly involve the pulp.

PGGs were categorized using Gu's classification [18], which evaluates groove depth and length relative to the coronal third of the root. Type I remains short and shallow, ending within the coronal third. Type II runs beyond the coronal third but is relatively shallow. Type III also extends past the coronal third but is characterized by a deeper groove that often reaches farther into the root.

### Statistical Analysis

Data were organized in Microsoft Excel 2021 and analyzed using IBM SPSS Statistics for Windows, Version 27.0 (Armonk, NY: IBM Corp). Descriptive statistics described categorical variables by frequencies and percentages and reported continuous variables using measures of central tendency (mean or median), dispersion (standard deviation or interquartile range), and minimum and maximum values. The chi-square test was applied to evaluate categorical data, with a significance level set at a five percent level.

## RESULTS

The mean age of all study subjects was 26.8 years, while for those with DI, it was slightly higher at 27.6 years. The median age for all subjects was 25 years (IQR: 19–33), and for those with DI, it was 27 years (IQR: 21.3–30.8). Among all study subjects, 124 (54.4%) were females and 104 (45.6%) were males. Among those with DI, 12 (54.5%) were males, and 10 (45.5%) were females.

Table 1 summarises the study findings. Out of the 1368 teeth examined in 228 CBCT scans, DI was observed in 33 (2.41%) teeth. Among these, 5 (1.09%) of 456 central incisors and 28 (6.14%) of 456 lateral incisors were affected, while no cases were found in 456 canines ($p < 0.0001$). Type I was more prevalent, observed in 26 (78.8%) cases, compared to Type II in 7 (21.2%) cases ($p < 0.0001$). Unilateral involvement was noted in 13 (56.5%) cases and Bilateral involvement in 10 (43.5%) cases ($p = 0.532$).

**Table 1.** Descriptive summary of the study findings

**Таблица 1.** Описательное резюме результатов исследования

| Parameter | Total number of teeth examined | Frequency (%age) |
|---|---|---|
| **Teeth-Wise Prevalence** | | |
| Central Incisor | 1368 | 5 (1.09%) |
| Lateral Incisor | | 28 (6.14%) |
| Canine | | 0 (0%) |
| **Type of Dens Invaginatus** | | |
| Type I (%) | 33 | 26 (78.8%) |
| Type II (%) | | 7 (21.2%) |
| **Laterality** | | |
| Unilateral (%) | 33 | 10 (43.5%) |
| Bilateral (%) | | 13 (56.5%) |
| Palatogingival Groove | 33 | 8 (24.24%) |

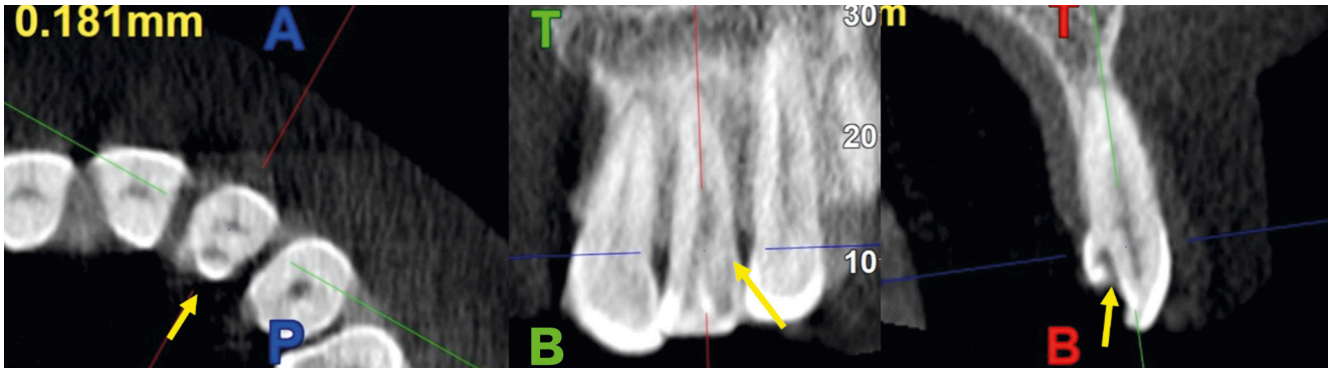


**Fig. 1.** Cone beam computed tomography images showing Oehler's Type I dens invaginatus with palatogingival groove in left maxillary lateral incisor in (*A*) axial, (*B*) coronal and (*C*) sagittal sections

**Рис. 1.** Изображения, полученные с помощью конусно-лучевой компьютерной томографии, демонстрирующие инвагинацию зубного ряда I типа Элера с нёбно-десневой бороздкой в левом боковом резце верхней челюсти на (*A*) аксиальном, (*B*) корональном и (*C*) сагиттальном срезах

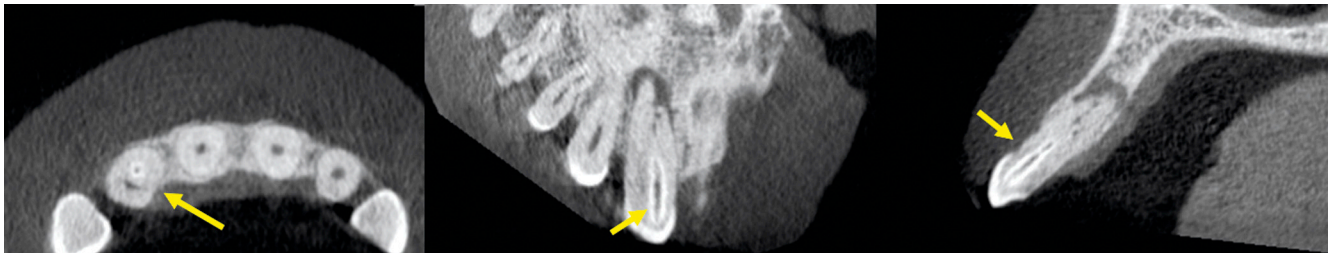


**Fig. 2.** Cone beam computed tomography images showing Oehler's Type II dens invaginatus with palatogingival groove in right maxillary lateral incisor in (*A*) axial, (*B*) coronal and (*C*) sagittal sections

**Рис. 2.** Изображения, полученные с помощью конусно-лучевой компьютерной томографии, демонстрирующие инвагинацию дентина II типа по Элеру с нёбно-десневой бороздкой в правом боковом резце верхней челюсти на (*A*) осевом, (*B*) корональном и (*C*) сагиттальном срезах

Among males, DI affected 5 (29.4%) central incisors and 12 (70.6%) lateral incisors. Among females, no central incisors were affected, while 16 (100%) lateral incisors were involved ($p$ = 0.02). Type I was observed in 14 (82.4%) teeth among males and in 12 (75.0%) among females, while Type II was found in 3 (17.6%) teeth among males and 4 (25.0%) among females ($p$ = 0.61). Among males, 4 (33.3%) cases showed unilateral involvement, while 8 (66.7%) were bilateral. Among females, 6 (60.0%) were unilateral, and 4 (40.0%) were bilateral ($p$ = 0.21). The PGG was present in 8 of 33 (33.33%) cases, all classified as Gu's Type I. Figure 1 illustrates a case of Type I DI with PGG and Figure 2 depicts a case of Type II DI with PGG.PGG was seen only in lateral incisors and had 1 bilateral presence. Figure 3 shows a case with bilateral occurrence of PGG.

The inter-rater reliability for DI was found to be 0.92 and for PGG, it was 1.

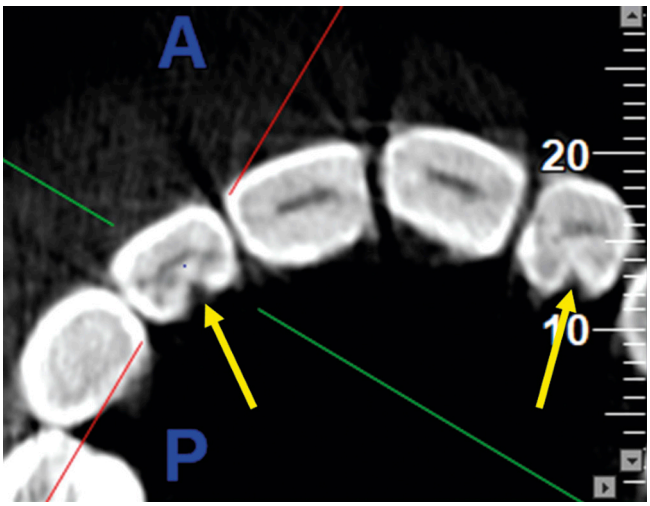


**Fig. 3.** Cone beam computed tomography images showing a case with bilateral presence of palatogingival groove in axial section

**Рис. 3.** Изображения конусно-лучевой компьютерной томографии, демонстрирующие случай двустороннего наличия нёбно-десневой борозды в аксиальном срезе

## DISCUSSION

Advancements in radiographic diagnostics have significantly enhanced the management of developmental dental anomalies, allowing patients to preserve their natural dentition for extended periods. Historically,

the etiology of DI was poorly understood, and extraction was often the only treatment option due to the lack of viable endodontic techniques. The introduction of cone-beam computed tomography (CBCT) has revolutionized this approach, enabled detailed visualization of tooth structures and facilitated successful endodontic interventions in complex cases [19]. Conventional radiographs, while useful for detecting the broad outline of anomalies, fail to provide the three-dimensional detail necessary for accurate diagnosis and treatment planning [20]. CBCT has become essential in such cases, allowing clinicians to visualize the intricate anatomy of affected teeth and tailor their interventions accordingly.

A thorough understanding of anatomical variations is critical for successful outcomes in managing conditions like DI and PGG. These anomalies pose significant challenges for both endodontic and restorative procedures and are relatively common [3]. Studies employing clinical examinations, microscopic analyses, and two-dimensional radiographs have provided valuable insights into their prevalence, yet these methods are limited in capturing their three-dimensional complexity.

In the present study, the prevalence of DI was 2.41%, with the highest occurrence in lateral incisors (6.14%), followed by central incisors (1.09%), and no cases observed in canines. This aligns with previous studies reporting variable prevalence rates due to differences in study populations. For instance, Capar et al. [21] found a prevalence of 10.7% using CBCT, while Varun et al. [3] reported 13.5% in an Indian cohort, both higher than the findings of this study. Conversely, earlier studies by Ardakani et al. [22] and Poyton and Morgan [23] reported much lower prevalence rates of 0.8% and 0.25%, respectively, further highlighting population differences.

Gender distribution in the present study revealed no significant differences, consistent with findings from Varun et al. [3], Kfir et al. [24], and Cakici et al. [25] However, it contrasts with studies by Gündüz et al. [26] and Haghanifar et al. [27], who reported a higher prevalence in women, and Chen et al. [28] and Colak et al. [29], who noted a higher prevalence in men. Additionally, unilateral DI was more common (56.5%) than bilateral cases (43.5%), which aligns with some studies but contrasts with others reporting bilateral prevalence rates ranging from 25% to 82% [16; 28–31]. Oehler's Type I DI was the most prevalent type (78.8%), consistent with studies by Varun et al. [3] and Cakici et al. [25], but contrasting with Mabrouk et al. [30], who found Type II to be more common. These discrepancies likely stem from differences in population demographics and study methodologies. Regarding PGG, the present study reported its presence in 33.3% (8 teeth) with associated DI, all classified as Gu's Type I. An isolated prevalence of 2.33% and 7.36% have been reported by Biswas et al. [15] and Varun et al. [3], respectively, and the 2.88% reported by Lekshmi et al. [14].

Treatment for DI should be guided by the complexity of its structure and clinical presentation. In cases where the root canal and invaginated area can be adequately prepared and filled, conventional root canal therapy can achieve favorable outcomes. If infection persists, endodontic surgery may be necessary to remove the infection and prevent recurrence. In cases where conventional treatment and surgery fail, extraction followed by intentional replantation may be considered [32]. Similarly, PGG management requires an interdisciplinary approach focused on eliminating the causative factor to achieve a favorable prognosis. While not all teeth with PGG develop periapical pathology, accessory foramina and lateral canals may act as pathways for secondary endodontic infections, necessitating close monitoring and tailored interventions [28; 33].

This study had several limitations. First, the retrospective design relied on archived CBCT scans, which may not represent the broader population. Second, the sample size was limited to scans meeting stringent inclusion criteria, potentially reducing the generalizability of the findings. Third, while inter-rater reliability was high, subtle variations in interpreting CBCT images could introduce bias. Nevertheless, the study provides valuable insights into the prevalence and types of DI and PGG in an Indian population, contributing to the limited body of literature on these anomalies.

## CONCLUSION

This study demonstrated a prevalence of 2.41% for DI, out of which 24.24% were detected with an associated PGG in maxillary anterior teeth within an Indian population. DI was most frequently observed in lateral incisors, with Oehler's Type I being the most common classification. PGG was exclusively classified as Gu's Type I and was present only in lateral incisors. No significant gender differences were observed in the prevalence of DI or PGG. The findings underscore the importance of CBCT in diagnosing and managing these anomalies due to its ability to provide detailed three-dimensional imaging. Future research with larger, more diverse populations is recommended to further understand the prevalence, etiology, and clinical implications of these developmental anomalies.

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## INFORMATION ABOUT THE AUTHORS

**Parthasarathi Mondal** – MDS Conservative Dentistry & Endodontics, Associate Professor, Department of Conservative Dentistry & Endodontics, Dr. R. Ahmed Dental College and Hospital, Kolkata, West Bengal, India; https://orcid.org/0009-0000-3334-5812

**Kaushik Mistry** – Postgraduate Student, Conservative Dentistry & Endodontics, Department of Conservative Dentistry & Endodontics, Dr. R. Ahmed Dental College and Hospital, Kolkata, West Bengal, India; https://orcid.org/0009-0000-4931-9096

**Tapas Paul** – MDS, Conservative Dentistry & Endodontics, Dental Surgeon cum Clinical Tutor, Department of Conservative Dentistry & Endodontics, North Bengal Dental College and Hospital, Sushrutnagar, Darjeeling, West Bengal, India; https://orcid.org/0009-0001-8450-928X

**Kallol Kumar Saha** – MDS, Conservative Dentistry & Endodontics, Professor and Head, Department of Conservative Dentistry & Endodontics, Dr. R. Ahmed Dental College and Hospital, Kolkata, West Bengal, India; https://orcid.org/0009-0009-8542-2096

**Dipanjan Das** – Assistant Professor, Department of Conservative Dentistry & Endodontics, Haldia Institute of Dental Sciences and Research, Haldia, West Bengal, India; https://orcid.org/0009-0006-7534-8556

**Snigdho Das** – MDS, Conservative Dentistry & Endodontics, Consultant Dental Surgeon, Department of Dentistry, Ramakrishna Sarada Mission Matri Bhavan Hospital, Kolkata, West Bengal, India; https://orcid.org/0000-0002-9061-748X

## ИНФОРМАЦИЯ ОБ АВТОРАХ

**Партасарати Мондал** – д.м.н., врач-стоматолог, специалист по консервативной стоматологии и эндодонтии, доцент кафедры консервативной стоматологии и эндодонтии, Стоматологический колледж и больница доктора Р. Ахмеда, Калькутта, Западная Бенгалия, Индия; https://orcid.org/0009-0000-3334-5812

**Каушик Мистри** – аспирант, врач-стоматолог, терапевтическая стоматология и эндодонтия, профессор и заведующий кафедрой терапевтической стоматологии и эндодонтии, Стоматологический колледж Северной Бенгалии П. О. Сушрутанагар; 734012, Индия, Западная Бенгалия, Дарджилинг, Силигури; https://orcid.org/0009-0009-6386-7916

**Тапас Паул** – д.м.н., консервативная стоматология и эндодонтия, хирург-стоматолог и клинический преподаватель, отделение консервативной стоматологии и эндодонтии, Стоматологический колледж и больница Северной Бенгалии, Сушрутнагар, Дарджилинг, Западная Бенгалия, Индия; https://orcid.org/0009-0001-8450-928X

**Каллол Кумар Саха** – д.м.н., консервативная стоматология и эндодонтия, профессор и заведующий кафедрой консервативной стоматологии и эндодонтии, Стоматологический колледж и больница доктора Р. Ахмеда, Калькутта, Западная Бенгалия, Индия; https://orcid.org/0009-0009-8542-2096

**Дипанджан Дас** – ассистент-профессор, кафедра терапевтической стоматологии и эндодонтии, Институт стоматологических наук и исследований в Халдии, Халдия, Западная Бенгалия, Индия; https://orcid.org/0009-0006-7534-8556

**Снигдхо Дас** – д.м.н., консервативная стоматология и эндодонтия, хирург-стоматолог-консультант, отделение стоматологии, больница Рамакришны Сарада Мишн Матри Бхаван, Калькутта, Западная Бенгалия, Индия; https://orcid.org/0000-0002-9061-748X

## AUTHOR'S CONTRIBUTION

Parthasarathi Mondal – Clinical studies, Experimental studies, Data analysis, Manuscript preparation, Guarantor.

Kaushik Mistry – Definition of intellectual content, Literature search, Data acquisition, Manuscript editing, Guarantor.

Tapas Paul – Definition of intellectual content, Design, Literature search, Manuscript review, Guarantor.

Kallol Kumar Saha – Literature search, Manuscript editing, Manuscript review, Guarantor.

Dipanjan Das – Literature search, Manuscript editing, Manuscript review, Guarantor.

Snigdho Das – Literature search, Data analysis, Statistical analysis, Manuscript preparation, Guarantor.

## ВКЛАД АВТОРОВ

П. Мондал – клинические исследования, экспериментальные исследования, анализ данных, подготовка рукописи.

К. Мистри – определение интеллектуального содержания, поиск литературы, сбор данных, редактирование рукописи.

Т. Паул – определение интеллектуального содержания, дизайн, поиск литературы, рецензирование рукописи.

К.К. Саха – поиск литературы, редактирование рукописи, рецензирование рукописи.

Д. Дас – поиск литературы, редактирование рукописи, рецензирование рукописи.

С. Дас – поиск литературы, анализ данных, статистический анализ, подготовка рукописи.