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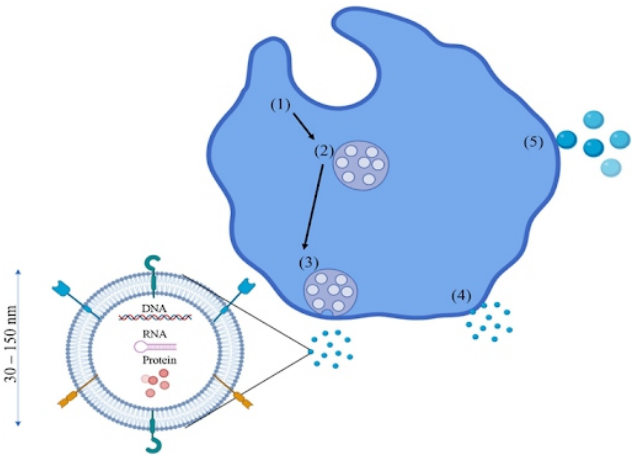

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CONTENTS

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Editorial

Navigating role of AI in Scientific Publishing

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The realm of scientific publishing has consistently progressed alongside technological advancements — transitioning from handwritten documents to online journals, and from traditional peer review via mail to immediate global access. At present, artificial intelligence (AI) signifies the next significant transformation. Its emergence goes beyond a simple technological improvement; it is altering the ways in which knowledge is generated, assessed, and shared. However, amidst this enthusiasm, one reality persists: science is, and must continue to be, an inherently human pursuit. The integration of artificial intelligence (AI) into scientific writing and publishing is not just an imaginative notion; it is an actual transformation that is altering the academic environment.

Language models help improve grammar, ensure clarity, and assist with formatting. Automated systems evaluate manuscripts for plagiarism, inconsistencies in statistics, and adherence to reporting standards. Editorial processes are becoming quicker and more efficient, easing the administrative load that previously hindered the speed of research publication. AI provides assistance in expressing ideas more effectively in multilingual settings, which may help make global scientific discussions more accessible.

A robust ethical framework is crucial for directing the incorporation of AI into scientific publishing. AI must be used to augment the work and not replace human and limit the creativity. Authors must disclose use of AI in scientific publishing. The authors needs to be accountable to use AI ethically, morally and legally.

The future of publishing depends on the thoughtful integration of technology, functioning not merely as a time-saving tool but as a means to enhance diligent, responsible, and impactful scholarly writing. Scientific progress is driven not by the speed of machines, but by the depth of human thought — and when utilized thoughtfully, AI can assist us in achieving just that.

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Editorial

Strengthening the foundation of oral health through clinical trial registration

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1. Introduction

Randomized controlled trial (RCT) remain the gold standard for clinical investigation in healthcare sciences, so it naturally applies to dentistry as well. RCTs provide the critical evidence necessary to advance patient care and ensure therapeutic safety. However, the integrity of this evidence depends heavily on transparency and the mitigation of bias. Historically, the dental field has seen a slower adoption of clinical trial registration compared to other medical disciplines, with some assessments indicating that less than 25% of dental RCTs were registered in public databases.[1] As we move further into an era of evidence-based practice, the mandatory *a priori* registration of all clinical trials is no longer a luxury—it is an ethical and scientific necessity.

2. The Scientific and Ethical Mandate

Registration serves as a safeguard against two of the most pervasive threats to research integrity: publication bias and selective outcome reporting. By declaring study protocols, primary endpoints, and methodologies before the first patient is recruited, researchers provide a transparent "audit trail" that prevents the post-hoc manipulation of data to favour statistically significant results.[2,3]

The ethical implications are equally profound. Participants in dental research volunteer under the assumption that their contribution will advance collective knowledge. Failing to register or publish trials, particularly those with null or negative results, violates this unspoken contract and leads to the unnecessary duplication of studies, effectively exposing future patients to redundant risks.[4]

3. Global Standards and Accountability

The International Committee of Medical Journal Editors (ICMJE) established the global benchmark over two decades ago, requiring trial registration as a condition for publication.[1,4] Major dental publications, such as the Journal of Dental Research (JDR) and Brazilian Oral Research, have followed suit, mandating registration prior to study initiation.[1,4] Furthermore, regional registries like the Clinical Trials Registry–India (CTRI) have become vital infrastructure for ensuring that dental research—ranging from public health initiatives to specialized orthodontic trials—is accessible and accountable.[2,3] Adherence to reporting standards, such as the CONSORT (Consolidated Standards of Reporting Trials) statement and the SPIRIT (Standard Protocol Items: Recommendations for Interventional Trials) guidelines, further reinforces this framework.[1,5] These tools ensure that the design, conduct, and analysis of a trial are described with enough clarity to allow for critical appraisal and replication.[5]

4. A Call to Action

While we have seen significant improvements in registration trends, we must strive for 100% compliance. It is the responsibility of investigators, academic mentors, and ethics committees to normalize registration as a standard first step in the research timeline. By ensuring every trial is registered, we protect the rights of our participants, enhance the credibility of our findings, and ultimately provide a more reliable foundation for the clinical decisions that impact our patients' lives.

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5. Conflict of Interest

None.

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Review Article

Orthodontic considerations in pediatric cancer survivors: An insight

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Abstract

Every year, around 50-200 million children (0-19 years) worldwide are diagnosed with cancer. Efficient and successful patient support and assistance systems and the deterrence of complications significantly improve survival rates and limit long-term relapses. Orthodontic treatment of children who have suffered or are currently enduring cancer treatment is challenging for the Orthodontist and the family members. There are various oncological therapies. These include radio and chemotherapy, bone transplants. These modalities have helped increase the number of paediatric cancer survivors exponentially. But there is an ardent necessity of long term follow up, both in terms of medical and dental. The treatment timing and the nature of cancer dictate Orthodontic management in children with cancer. The children undergoing chemotherapy or radiotherapy must be dealt with cautiously and with the utmost care during the Orthodontic treatment. Various features like gingivitis, mucositis, xerostomia are typically seen in cancer survivors. These conditions affect the duration of the orthodontic treatment and adversely pose a threat to oral hygiene maintenance. Here, in this article, we provide our perspective on different Orthodontic considerations while dealing with pediatric patients who have already overcome cancer. Cancer therapy critically affects oral and dental health and demands conventional Orthodontic care alterations. This article also provides specific recommendations based on the prevailing practice and existing literature to help Orthodontists modify their treatment modality for pediatric cancer survivors.

Keywords: Cancer survivors, Neoplasm, Therapy, Malocclusion.

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1. Introduction

Orthodontic treatment is an explicit specialty that deals with patients of all ages, mainly children, adolescents, and young adults. The Orthodontist may come across children and adolescents who are long-term cancer survivors. Cancer will be second if we consider various reasons for death in children following post-accident trauma and poisoning. Among the prevalent diagnosed cancers, cancer cases in children represent 2% of them. Pediatric cancer survivors seeking Orthodontic treatment increase with the decrease in the mortality rates due to the ongoing advancement in finding treatment solutions for such cancer-affected children.[1] Undesirable effects of Orthodontic treatment, like various dental developmental problems and disorders in the growth of the craniofacial skeleton, are expected in long-term pediatric cancer survivors. Thus, Orthodontists need to make changes and modifications in their treatments considering the health condition of such children.

2. Cancer Treatment Modalities and their Effects

Oncological patients consulting an Orthodontist can be divided into three groups:

1. Cancer survivors.
2. Patients undergoing supportive treatment.
3. Patients undergoing active oncological treatment (primary cancer, relapses).

The basis of most oncological treatment in children is chemotherapy (medication), but when accompanied by radiotherapy and surgery, it forms a combined cancer treatment modality for them.

Oncological patients getting chemotherapy and radiation therapy during their growing phase have consequences on the growth of craniofacial structures and dental development, such as arrested root development, microdontia, enamel disturbances, premature apical closure, and aplasia. The

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chances of carious teeth may also be increased due to reduced salivary function. Changes in taste perception are also evident.[2] In pediatrics, some cancer treatments can adversely affect the development of cranial bones, cervical vertebrae, and structures related to the oral cavity involving the teeth and jaws.[3,4] Common adverse effects of oncological treatment on dental development include arrested root development, microdontia, enamel disturbances, premature apical closure, and aplasia.[5,6] Kaste et al. documented that the patient's age during cancer treatment is a critical factor in the development and degree of these oral complications.[7-9]

3. Physiopathology of Cancer Therapy

Cells with an increased rate of cell division, like tumor cells, are targeted in Chemotherapy. Antineoplastic drugs do not differentiate between neoplastic cells and normal cells. The regular cells, such as the basal epithelial cells in the buccal mucosa possessing high mitotic activity, are also affected. Oral mucosal epithelium is thinning due to the continuous renewal of cells, leading to its increased susceptibility to microtrauma. Mucosal erosions or ulceration are often encountered during chemotherapy.[10]

A complete interpretation of the physiopathology of these tumor lesions is yet to be done. Mucositis is illustrated in five different biological phases (**Figure 1**).[11]

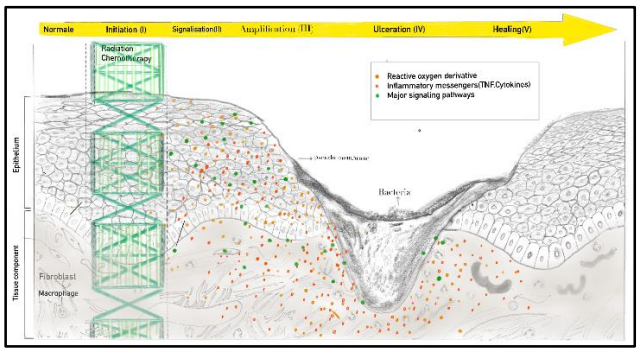

Figure 1: Stages of mucositis ("Reproduced from Boyer et al.[11]")

The regenerative function of the mucosa is often affected when chemotherapy and radiotherapy are combined, causing oral ulceration, signifying a significant risk factor for infections for the patients. Radio and chemotherapy negatively affect the salivary glands, leading to quantitative and qualitative alterations in salivary flow.

Secretions of a few drugs or metabolites (like methotrexate) are in saliva. The altered high viscosity of saliva, oral microflora, and plaque are affected by saliva's modified pH.[12] Corticosteroid administration during chemotherapy disrupts the metabolism of bone. It is found that there is a predominance of osteoclasts in patients under chemotherapy. The appointment duration and the number of visits to the Orthodontist should be minimal to reduce the chance of infection, as the patients are vulnerable to various infectious factors during dental visits.

4. The Role of an Orthodontist and the risks involved

Treatment planning done by Orthodontists for this group of patients includes simple mechanics that minimize the chance of root resorption, application of light force, terminating the treatment with the compromised outcome, and earlier than usual, excluding the mandibular arch. It is recommended that the commencement of orthodontic treatment be delayed for at least two years post-completion of cancer therapy.[13,14] According to the existing literature, it is estimated that delayed consequences of cancer therapy are seen in nearly 50% of all survivors. These delayed consequences may be caused by cancer or its treatment like chemotherapy, radiotherapy, surgery, or supportive care such as transfusions, antibiotics, immunosuppressive therapy, or a combination of these factors.

The after-effects depend on the extent, grade, intensity, and area the disease affects. The child's age and psychological and physical developmental status during the diagnosis and treatment are essential factors for the late adverse effects. Genetic or hereditary influence may play a role in aggravating the late effects.[15]

Late sequelae include organ failure, the secondary onset of malignancy, early mortality, decreased fertility, and adverse psychosocial problems. The following principles have to be taken care of by Orthodontists when treating oncological patients:[16]

1. Orthodontic treatment should commence after two years of completion of anticancer therapy. It is related to the chances of developing secondary malignancy in 2.6-12.1% of cases.
2. The treatment planning should be modified to consider the health condition of the patient and also should satisfy the patient's expectations.
3. The treatment mechanics should be simple and uncomplicated, with light force application that helps in reducing the chances of resorption of roots.
4. Esthetic brackets or clear aligners should be preferred instead of metal to avoid minor artifacts during imaging examinations.
5. The treatment duration should be reduced, and the appointments should be short.
6. Mostly, treatment will end without ideal finishing and detailing and a compromised outcome.
7. Treatment should only be restricted to the maxillary arch. As such, patients' growth period is limited due to decreased duration of pubertal growth. So, the mandibular growth becomes inhibited, making class II corrections difficult and growth modification nearly impossible.
8. Patients should always be motivated to maintain good oral hygiene. Due to salivary dysfunction, patients are more prone to caries. It is suggested that patients not use elastics, and they should be prescribed fluoride products and mouth moisturizers.[17,18]

Osteoradionecrosis increases in patients undergoing radiotherapy, mainly affecting the body of the mandible.[19]

Considering the risk factors, an undesirable effect was seen for advanced tumors, segmental resections of the mandible, and radiation therapy before or after the tooth extractions. Extraction of teeth needed for Orthodontic treatment was responsible for most of the osteoradionecrosis in patients. Healing post-extraction is also a problem in such children.[20] Extractions indicated for Orthodontic treatment should be deferred for two years post-cancer therapy when starting or resuming the Orthodontic treatment.

Patients undergoing anticancer therapy develop low resistance to microbial infections and degeneration of oral mucosa. Subsequently, they become at risk for complications associated with appliances that may irritate the oral mucosa. Thus, oral appliances for such patients should be chosen considering their risks. Patients should be advised to rinse their mouths frequently with artificial saliva and apply fluoride topically. Ulcerations may occur due to the decreased regenerative ability of the mucosa.

The appliances should be removed if the patient has to undergo supportive chemotherapy or radiotherapy during the active Orthodontic treatment to reduce the incidence of oral complications. Once the patient shows improvement and there is a diminution of the tumor with an improved prognosis, Orthodontic treatment can recommence. Though orthodontic treatment for such patients won't result in ideal finishing, it does not have harmful side effects.

Major risk factors to be considered before Orthodontic treatment

1. Age: Below eight years
2. Type: Solid tumor
3. Region: Craniofacial region, CNS
4. Therapy: Allogenic stem cell transplantation
5. Radiotherapy: Total body or head and neck area and more than 2400 cGy
6. Chemotherapy: Busulfan/ Cyclophosphamide
7. Years of disease-free: Less than two years
8. Sequalae: Hypothyroidism, Hypopituitarism, Prolonged Immunosuppression
9. Oral health- Agenesis of teeth, Microdontia, abnormal root development, decreased salivation

A study by Neill et al. mentions, though less in number, that pediatric cancer survivors do seek Orthodontic treatment. Most Orthodontists agreed to treat the cancer survivors, with expected complexity and complications. Thus, these cases should be managed with the knowledge of existing evidence and treatment modalities.

Most of the Orthodontists who participated in this study reported enquiring about the patient's medical history. A detailed medical history should be recorded for each patient, which becomes more significant in pediatric cancer patients.

There should be a proper follow-up of the patients, and verification of medical records should be done to ensure that the Orthodontic expectations are met without compromising the health and well-being of the patient. Seventy-two percent of the Orthodontists in this study came across dental complications in pediatric cancer survivors. Their treatment planning included a variety of Orthodontic treatment modifications. Commonly reported complications included malaligned teeth, microdontia, root stunting, and altered growth and development. Also frequently noted in this study was a need for longer treatment times and modifications to the treatment plan.

5. Long-Term Stability in Orthodontic Treatment for Cancer Survivors

Before resuming Orthodontic treatment, checking the completion date of cancer therapy and any ongoing supportive treatment is advisable. The risks of infection can be predicted if the patient is still on antibiotic prophylaxis and immunosuppressants. Two years post-HSCT (hematopoietic stem cell transplantation), Orthodontic treatment can commence or restart if stopped between cancer therapy. It is rare to find any acute complications as immunological efficiency is increased.[21] For chemotherapy without radiotherapy or surgery, Orthodontic treatment may commence after a few months of the treatment.

The long-term stability and retention of the results of Orthodontic treatment is challenging. Ten years post Orthodontic treatment showed stable results in only 30–50% of the patients.[22]

It must be noted that retention and stability are essential to Orthodontic treatment.[23] All other treatment goals, including ideal occlusal function and optimal aesthetics, may be disturbed without Orthodontic stability.[24,25]

In their study, Littlewood et al. and Woods et al. explored the causes of relapse post-Orthodontic treatment. Along with the gingival, periodontal, occlusal factors, and growth, the effect of mandibular muscles also has a role in maintaining occlusal stability. According to their research, the treatment stability worsened during the 3-year retention period in cancer survivors compared to healthy subjects.

6. Conclusion

Significant development is seen in pediatric cancers, allowing several children to survive into adulthood and often requiring Orthodontic treatment. According to the literature present, it is evident that pediatric cancer patients face the after-effects of cancer therapy, so Orthodontists need to modify their treatment. Strictly outlined Orthodontic protocols should be formed and evaluated by Orthodontists to treat these patients as effectively as possible. If required,

the guidelines and methods should be shared with cancer treatment centers to advise patients on elective treatment, such as orthodontics.

7. Ethics Approval

Not applicable

8. Author Contributions

Ananya Panda contributed to manuscript preparation, and Sumita Mishra and Shambhavi Jha contributed to data collection from various existing literature

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10. Conflict of Interest

None.

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Review Article

Nano Revolution in Modern Endodontics: A Narrative Review

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Abstract

Nanotechnology has become a groundbreaking advancement in endodontics, greatly improving the success of root canal therapy and supporting tissue regeneration. The incorporation of nanomaterials into endodontic procedures enhances disinfection, improves the mechanical performance of dental materials, and opens new possibilities for regenerative healing. Owing to their nanoscale size and high surface area, nanoparticles can penetrate deeply into dentinal tubules, delivering superior antimicrobial effects and lowering the likelihood of reinfection when compared with traditional techniques. Additionally, nanomaterials strengthen root canal sealers by improving their adhesion, fracture resistance, and overall durability, leading to more predictable clinical outcomes. Nanotechnology also holds significant potential in pulp tissue regeneration through targeted drug delivery systems and the promotion of stem cell differentiation, contributing to biologically based treatment approaches. Furthermore, these innovations may reduce treatment time, improve patient comfort, and support minimally invasive endodontic techniques. However, concerns related to nanoparticle safety, toxicity, and long-term biocompatibility persist, emphasizing the need for continued research. This review examines the current uses and future prospects of nanotechnology in endodontics, underscoring its transformative impact on root canal treatment outcomes and the advancement of dental care, while encouraging further clinical trials to validate efficacy, safety, and widespread application in routine dental practice.

Keywords: Nanotechnology, Nanoparticles, Endodontics, Nanomaterial, Drug delivery

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1. Introduction

Nanotechnology, which involves the manipulation of materials at the nanoscale range of 1–100 nm, has become a significant advancement across multiple scientific disciplines, including dentistry. Within endodontics, the integration of nanotechnology holds considerable promise by offering innovative solutions to many persistent limitations of conventional root canal treatment. Endodontic therapy focuses on managing diseases of the dental pulp and periapical tissues and relies heavily on thorough canal disinfection, effective obturation, and the potential for tissue regeneration to ensure long-term treatment success. However, conventional techniques frequently prove inadequate due to the complex morphology of the root canal system, making complete elimination of microorganisms from all anatomical irregularities a challenging task.[1]

Nanoparticles including silver, zinc oxide, and titanium dioxide have gained increasing attention in endodontic applications because of their potent antimicrobial activity. Owing to their nanoscale dimensions, these particles are capable of infiltrating dentinal tubules that remain inaccessible to conventional irrigant and disinfection techniques. The combination of reduced particle size and increased surface area allows nanoparticles to demonstrate superior antibacterial action against the diverse microbial populations commonly associated with root canal infections. As a result, their incorporation into endodontic procedures enhances microbial control and substantially lowers the

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likelihood of reinfection, thereby improving overall treatment success.[2]

Beyond their antimicrobial role, nanotechnology has demonstrated considerable potential in improving the physical and mechanical characteristics of materials employed in root canal therapy. The addition of silica-based nanoparticles to root canal sealers has been shown to enhance their mechanical strength, resistance to fracture, and long-term stability, resulting in superior canal sealing and reduced bacterial penetration.[3] In addition, the presence of nanoparticles improves the bonding ability of restorative materials to dental tissues, which contributes to greater durability and improved clinical outcomes of endodontic procedures.

Nanotechnology also offers promising advancements in the field of regenerative endodontics. Nanoparticles may function as delivery vehicles for bioactive substances and growth factors, thereby promoting pulp tissue regeneration and supporting the healing of periapical pathologies.[4] This regenerative strategy provides a viable alternative to tooth extraction and supports the preservation of natural dentition through biologically driven repair mechanisms. Furthermore, nanoparticles can be incorporated into targeted drug delivery platforms, enabling controlled and site-specific release of antimicrobial agents. This approach enhances therapeutic effectiveness while simultaneously reducing undesirable systemic effects.[5]

2. Mechanisim of Action of Nanoparticles

2.1. Electrostatic interaction and cell membrarne damage

Nanoparticles carrying a positive surface charge are attracted to the negatively charged bacterial cell envelope through electrostatic forces, leading to their accumulation on the microbial surface. This interaction compromises the structural integrity of the cell wall and increases membrane permeability, facilitating nanoparticle entry into the cytoplasm and subsequent leakage of intracellular components. Additionally, nanoparticles may associate with mesosomic structures, interfering with bacterial respiration, cell division, and genetic replication, ultimately resulting in cell death.[6]

2.2. Disruption of metal ion hemostasis

Microorganisms rely on tightly regulated metal ion concentrations for normal metabolic activity. The excessive presence of metal-based nanoparticles disturbs this equilibrium, impairing essential biochemical pathways. Such imbalance results in metabolic dysfunction, growth inhibition, and irreversible cellular damage, culminating in microbial death.[7]

2.3. Reactive oxygen species (Ros) production

Following penetration of the bacterial cell membrane, nanoparticles stimulate the generation of reactive oxygen species, inducing oxidative stress within the cell. This oxidative environment disrupts ATP synthesis and cellular respiration while causing structural damage to the cell membrane. The antimicrobial effect is further intensified through redox cycling reactions and pro-oxidant functional groups present at the metal oxide–nanoparticle interface.[8]

2.4. Protein and enzyme inactivation

Nanoparticles promote oxidative modification of amino acid residues, leading to the formation of carbonyl groups within proteins. This process accelerates protein degradation and enzyme inactivation, thereby impairing vital enzymatic functions and contributing to microbial cell death.[9]

2.5. Genotoxic effects and signal pathway interference

Due to their electrical and physicochemical properties, nanoparticles can interact directly with nucleic acids, adversely affecting the replication of both chromosomal and plasmid DNA. Such interactions disrupt cellular signaling pathways and genetic processes essential for microbial survival, ultimately leading to cell death.[10]

2.6. Enhanced penetration into root canal anatomy

The nanoscale size of nanoparticles allows improved penetration of irrigants into dentinal tubules and complex root canal irregularities, particularly in the apical third. This enhanced penetration optimizes fluid movement and facilitates more effective cleaning and debridement of the canal system.[11]

2.7. Antibiofilm properties

Nanoparticles such as silver and titanium dioxide possess the ability to infiltrate and disrupt biofilm structures. When used in conjunction with conventional disinfectants, they exhibit a synergistic effect that enhances biofilm breakdown and improves microbial elimination.[12]

2.8. Controlled delivery of therapeutic agents

Nanocarrier systems, including liposomes, micelles, and nanocapsules, enable sustained and site-specific release of therapeutic agents such as antibiotics and growth factors. This targeted delivery prolongs therapeutic action at the intended site while minimizing systemic exposure and adverse effects.[13]

2.9. Improvement in sealing and bonding

The incorporation of nanoparticles, such as nano-hydroxyapatite, into root canal sealers enhances adhesion to dentin, promotes remineralization, and reduces bacterial microleakage. Nanocomposite formulations improve flow characteristics and sealing efficiency, contributing to improved clinical outcomes.[14]

2.10. Dentin remineralization

Nano-hydroxyapatite particles can infiltrate microscopic defects within dentin, replenishing lost mineral content and restoring structural integrity. This process strengthens dentin and reduces susceptibility to further demineralization and fracture. [14]

2.11. Role in regenerative endodontics

Nanomaterials including nano scaffolds, bioactive nanoparticles, and nanogels support regenerative endodontic strategies by facilitating stem cell adhesion, proliferation, and differentiation into odontoblast-like cells. This promotes the formation of new dentin and pulp-like tissues, aiding in tissue repair and regeneration.[15]

2.12. Photocatalytic properties

Titanium dioxide nanoparticles, upon activation by ultraviolet light, generate reactive oxygen species capable of degrading organic debris and biofilms. This photocatalytic activity enhances disinfection during root canal therapy and may also contribute to tooth whitening effects.[16]

3. **Applications of Nanoparticles in Endodontics**

3.1. Nanomaterials as endodontic irrigants

Irrigation is a fundamental component of endodontic therapy, as it aids in the elimination of microorganisms, necrotic pulp remnants, and dentinal debris from the root canal system. Conventional irrigating solutions such as sodium hypochlorite and chlorhexidine are routinely employed; however, these agents possess certain drawbacks, including the inability of chlorhexidine to dissolve organic tissues and concerns related to cytotoxicity. In recent years, nanoparticles—particularly silver nanoparticles—have gained attention as potential irrigating agents owing to their large surface area and strong antimicrobial activity.[17]

Evidence suggests that silver nanoparticles are capable of penetrating the smear layer and forming a protective interface that limits bacterial penetration while preserving the structural integrity of dentin. Additionally, these nanoparticles can effectively reach the apical region of the root canal and demonstrate significant antibacterial activity against Enterococcus faecalis. The application of auxiliary techniques, such as low-intensity electric or magnetic fields, has been shown to further improve nanoparticle penetration within the intricate anatomy of the root canal system.

Recent advancements in endodontic irrigation involve the integration of nanoparticles with activation techniques such as passive ultrasonic irrigation and laser-based activation to improve their antibacterial performance. Research has shown that the use of silver nanoparticles in conjunction with ultrasonic or laser activation results in significantly greater microbial reduction when compared with conventional irrigation protocols.[18] In addition, chitosan-based nanoparticles have attracted increasing interest due to their capacity to effectively eliminate the smear layer and promote deeper sealer penetration while preserving the mechanical integrity of dentin. These observations underscore the promising role of nanoparticles in enhancing both the antimicrobial effectiveness and functional properties of root canal irrigating solutions.[18]

3.2. Nanomaterials as obturating materials

Nanomaterials as Obturating Materials Gutta-percha remains the most widely used obturating material in endodontics, however, its lack of antibacterial properties limits its effectiveness. Incorporating nanomaterials such as silver nanoparticles and nanodiamonds into gutta-percha is an emerging strategy to enhance its antibacterial properties and improve clinical outcomes. Silver nanoparticles provide sustained release of silver ions, which exhibit antimicrobial effects against pathogens like E. faecalis and C. albicans. Nanodiamonds, combined with amoxicillin, also show promise by enhancing antibacterial activity and improving the mechanical properties of gutta-percha Further innovations include bioceramic calcium silicate nanoparticles, which can be coated onto or incorporated into gutta-percha points. These modifications increase fracture resistance and enhance obturation quality by improving sealer penetration and push-out bond strength. These advancements in nanomaterial-based obturation materials highlight their potential to reduce the risk of reinfection and enhance the longevity and effectiveness of root canal treatments.[19]

3.3. Nanomaterials in endodontic sealers

Endodontic sealers are integral to the obturation process, as they occupy the interface between core filling materials, such as gutta-percha, and the dentinal walls, thereby achieving a three-dimensional seal that blocks lateral and accessory canals. For sustained clinical success, an ideal sealer should provide an effective hermetic seal, maintain dimensional stability over time, and possess antimicrobial activity while remaining biocompatible with periapical tissues. In addition, sealers are required to be insoluble in tissue fluids after setting yet retrievable when necessary.

A wide range of endodontic sealers has been developed, including zinc oxide–eugenol, calcium hydroxide, calcium phosphate, glass ionomer, calcium silicate, salicylate, methacrylate resin, silicone, and epoxy resin–based formulations. Despite these advances, none of the currently available sealers fully satisfy all the characteristics of an ideal material. As a result, nanotechnology has emerged as a promising approach to enhance sealer performance. The incorporation of nanoparticles offers multiple advantages, including prolonged antimicrobial activity that improves bactericidal efficacy. Nanoparticles may also function as delivery systems for therapeutic agents, enabling localized drug release, or act as surface modifiers that enhance

micromechanical bonding to dentin. Furthermore, nanomaterials can increase bioactivity by promoting mineral deposition, thereby improving adaptation and integration with dentinal walls.[20] Overall, the integration of nanomaterials into endodontic sealers represents a significant strategy for overcoming existing limitations and enhancing the quality and durability of root canal obturation.

3.4. Metal and metal oxide nanoparticles in endodontic sealers

The addition of metal and metal oxide nanoparticles to endodontic sealers has been shown to enhance their antimicrobial effectiveness and overall material performance. Among these, silver nanoparticles have demonstrated strong antimicrobial activity against a wide range of microorganisms, including Candida albicans and Enterococcus faecalis. Consequently, silver nanoparticles have been incorporated into several commercially available sealers, such as AH Plus, EndoSequence, MTA Fillapex, Sealapex, and TubliSeal. Silver nanoparticles within the size range of approximately 20–54 nm significantly improve antibacterial efficacy, particularly against E. faecalis. However, despite their antimicrobial benefits, silver-modified sealers may still permit bacterial leakage over extended periods. In addition, concerns regarding cytotoxicity persist, as silver nanoparticles are capable of generating reactive oxygen species, which may induce oxidative stress and adversely affect osteoblasts and fibroblasts.[21]

Zinc oxide nanoparticles exhibit superior antimicrobial properties when compared with other metal oxides such as magnesium oxide and titanium dioxide. These nanoparticles effectively inhibit E. faecalis growth without adversely affecting the physical characteristics of methacrylate resin–based sealers. Zinc oxide nanoparticles, typically around 40 nm in size, demonstrate lower cytotoxicity toward fibroblasts than silver nanoparticles and are associated with improved cellular proliferation. The combined use of silver and zinc oxide nanoparticles may provide an optimal balance between antimicrobial efficacy and biocompatibility. However, zinc oxide nanoparticles smaller than 50 nm may exhibit toxic effects on osteoblasts, emphasizing the critical role of nanoparticle size and morphology in determining biological response. In addition, zinc oxide nanoparticles have been shown to enhance sealer properties such as flowability and penetration into dentinal tubules.[21] Other metal oxide nanoparticles, including ferrimagnetic magnetite (Fe_3O_4) nanoparticles with sizes ranging from 50 to 100 nm, have also been investigated for their ability to improve dentinal tubule penetration, particularly when used in conjunction with an external magnetic field. Collectively, these findings indicate that metal and metal oxide nanoparticles can significantly improve both the antimicrobial performance and physical characteristics of endodontic sealers. Nevertheless, careful evaluation of cytotoxicity and long-term clinical behaviour remains essential before widespread clinical adoption.

3.5. Nanomaterials as Nanocarriers

Nanomaterials such as halloysite nanotubes and multi-walled carbon nanotubes have demonstrated significant potential as drug-delivery vehicles in endodontic sealers. Halloysite nanotubes loaded with antimicrobial agents have been shown to markedly suppress the growth of Enterococcus faecalis when compared with conventional sealer formulations. Similarly, multi-walled carbon nanotubes exhibit enhanced antibacterial activity when combined with agents such as chlorhexidine and silver nanoparticles.[22]

Mesoporous silica nanoparticles and mesoporous calcium-silicate nanoparticles possess a highly porous structure that allows effective penetration into dentinal tubules and enables sustained release of antimicrobial agents. This controlled release contributes to improved antimicrobial action and promotes periapical healing. In addition, poly (lactic-co-glycolic acid)–based nanoparticles have been utilized as carriers for propolis and other therapeutic agents, providing prolonged drug release and strong antibacterial effects against E. faecalis and other endodontic pathogens.

3.6. Nanomaterials in retro-filling and root-repair materials

Root-end filling materials are essential in periapical surgical procedures, with mineral trioxide aggregate widely regarded as the standard material of choice. Despite its advantages, MTA exhibits several shortcomings, including difficult handling characteristics, extended setting time, and limited antimicrobial activity. To address these limitations, nanoparticles have been incorporated into MTA and other bioactive endodontic repair materials. The addition of silver nanoparticles has been reported to enhance antimicrobial efficacy, biocompatibility, calcium ion release, and dimensional stability, while also reducing setting time and improving radiopacity.[23]

Other nanoparticle systems, including bismuth-based lipophilic nanoparticles, titanium dioxide nanoparticles, and zinc oxide nanoparticles, have been investigated for their ability to further improve antimicrobial properties, mechanical strength, and radiographic visibility. However, optimization is required to prevent adverse effects on compressive strength. Hydroxyapatite nanoparticles have been shown to enhance radiopacity and exhibit antibiofilm activity, although their incorporation may negatively influence compressive strength and solubility. Additionally, nanoparticles such as titanium dioxide and silver have been reported to improve the bond strength of MTA to dentin, whereas silicon dioxide nanoparticles appear to have minimal influence on bonding performance.[23,24]

3.7. Nanomaterials for pulpal repair and regeneration

Pulpal regeneration is a complex process that relies on the coordinated use of stem cells, scaffolding materials, and

bioactive molecules to restore the pulp–dentin complex. An ideal scaffold should closely resemble the native extracellular matrix (ECM). In this context, nanofibrous scaffolds have gained attention due to their ability to enhance cell–material interactions, provide structural support, and promote stem cell adhesion, proliferation, and differentiation. Nanofibers facilitate cellular attachment, protein adsorption, and integrin-mediated interactions, thereby influencing stem cell behaviour and activating intracellular signaling pathways involved in tissue regeneration.

Nanoparticle-based systems have emerged as promising scaffold materials for pulpal repair. Various nanoparticles, including magnetic nanoparticles, titanium dioxide (TiO_2) nanoparticles, and hydroxyapatite nanoparticles, have been shown to support stem cell attachment, growth, and lineage-specific differentiation. Additionally, mesoporous bioactive nanoparticles and zinc-based bioglass nanoparticles play a significant role in enhancing odontoblastic differentiation and angiogenesis, highlighting their potential applications in regenerative endodontics. Chitosan nanoparticles, commonly employed as drug delivery vehicles, can modulate stem cell differentiation depending on their encapsulation strategies. Furthermore, mesoporous bioglass nanospheres exhibit both antimicrobial properties and regenerative potential, making them valuable materials for pulpal tissue engineering.[25]

4. Conclusion

In summary, the application of nanoparticles in endodontics offers substantial potential to improve clinical treatment outcomes. Their distinctive physicochemical characteristics facilitate enhanced root canal disinfection, precise delivery of therapeutic agents, and support for tissue regenerative processes. The incorporation of nanoparticle-based antimicrobial systems and endodontic sealers has demonstrated superior effectiveness in biofilm management while improving sealing ability and biocompatibility. Although current findings are promising, continued research is essential to refine material formulations, confirm long-term safety, and develop standardized protocols for clinical use. With further advancement, nanotechnology is poised to significantly transform endodontic practice by increasing treatment predictability and improving overall patient care.

5. Authors' Contributions

1. Dr. Gaurav Jain: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review editing.
2. Dr. Swadhinta Raj: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft, Writing – review editing.
3. Dr. Sonali Verma: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review editing.
4. Dr. Pradyumna Misra: Conceptualization, Data curation, Formal analysis.
5. Dr. Manoj Hans: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft.
6. Dr. Lalit C. Boruah: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft.

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None.

7. Conflict of Interest

None.

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Review Article

AI (Artificial intelligence) use in dentistry: Overview, current situation, and prospects

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Abstract

Dentistry is being rapidly transformed by artificial intelligence (AI), which has progressed from experimental prototypes to reliable therapeutic tools. When it comes to using radiographic analysis to identify caries, periapical pathology, periodontal bone loss, and oral lesions, deep learning models are currently on par with or better than human specialists. Prosthodontic design workflows are accelerated by generative models, and orthodontic landmarking has become more accurate. By simplifying healthcare decision-making, documentation, and communication, large language models (LLMs) improve patient engagement. Personalized risk stratification is made possible by predictive analytics, which enhances treatment planning and preventive care.

There are still issues despite these developments. Biases in training data can jeopardize diagnostic equality, and AI systems frequently have trouble generalizing across diverse populations. Continued issues include data governance, regulatory compliance, and smooth integration into current dentistry workflows. The industry is adopting MLOps (machine learning operations) for scalable deployment, post-market surveillance to track actual performance, and human-in-the-loop validation to provide clinical oversight in order to address issues.

In 2024 and 2025, chairside decision support solutions that provide real-time insights during patient visits will become more important. In order to ensure safe data transmission across platforms, emerging AI ecosystems strive to be both interoperable and privacy-preserving. With the ability to interpret text, pictures, and 3D scans, multimodal foundation models hold the potential to unite therapeutic and diagnostic workflows and usher in a new era of intelligent, patient-centered dental care.

Keywords: AI in dentistry, Dental caries, Periapical diseases, Periodontal diseases, Mouth neoplasms.

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1. Introduction

Artificial intelligence (AI) in dentistry has evolved from discrete proof-of-concept models to integrated decision-support systems that enhance clinical procedures in diagnosis, planning, and manufacturing. Early applications were restricted to certain tasks, such as identifying cavities on bitewing and periapical radiographs or segmenting periodontal bone levels on panoramic and CBCT images. These tasks are currently successfully completed using transformer-based architectures and high-performing convolutional neural networks (CNNs), which offer greater diagnostic consistency and repeatability across many imaging modalities.[1]

Beyond image analysis, multimodal architectures and foundation models that can analyze text, 2D images, and 3D data allow for more comprehensive clinical reasoning and documentation support. These models streamline administrative and diagnostic procedures by facilitating tasks like automated charting, treatment planning, and integration of radiography data with clinical notes.[2]

Digital processes in prosthodontics and maxillofacial surgery have been revolutionized by generative AI. Dental

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prosthesis and surgical procedures can be precisely designed and simulated thanks to CAD/CAM (Computer aided design/Computer aided manufacturing) systems that are powered by generative models and NeRF-style (Neural Radiance fields; to create realistic visual effects, simulations) representations. These technologies assist both functional and aesthetic results by improving visualization, customisation, and production efficiency integrated with machines like CBCT (Cone beam computer tomography) and clinical scans.[3]

Robust generalization is still difficult despite these developments. The transferability of AI models across settings is limited by the heterogeneity of dental practice, which includes differences in imaging methods, equipment vendors, patient demographics, and clinical aims. This emphasizes the necessity of strict validation, domain adaption techniques, and governance structures that guarantee security, equity, and adherence to regulations.[4]

The review outlines validated use cases, summarizes current capabilities, and offers a practical implementation perspective. It highlights how crucial it is to match AI tools with clinical goals, incorporate them into current workflows, and set up supervision procedures to keep an eye on performance and direct responsible deployment. AI's use in dentistry will grow from task automation to full clinical augmentation as it develops.[5]

2. Methods

A strong framework consisting of peer-reviewed literature, systematic reviews from late 2024–2025, and reputable regulatory requirements is put together in this narrative review. Based on dataset features, external validation rigor, and integration challenges, the methodology prioritizes thematic arrangement by clinical domain. The review offers methodological openness and applicability to actual clinical workflows by harmonizing evidence from various sources. In order to contextualize compliance and deployment feasibility, regulatory insights are integrated. By emphasizing domain-specific subtleties and translational obstacles, the methodical approach makes it easier to critically evaluate AI applications in dentistry. A thorough, fact-based assessment of both established and new technologies is supported by this integrative approach.

3. Discussion

3.1. Artificial intelligence in dentistry: Current situation

Artificial intelligence (AI) is changing therapeutic planning, clinical procedures, and diagnostic accuracy in dentistry. AI systems are becoming more and more verified for clinical use, from generative models in prosthodontic design to convolutional neural networks (CNNs) in radiography interpretation. However, to guarantee safety, equity, and practical effectiveness, its implementation requires strict calibration, governance, and regulatory supervision.[6]

3.1.1. Diagnostics and imaging

AI has shown great potential in dental imaging, especially in lesion segmentation and caries detection:

1. Caries Detection on Radiographs: Expert-level performance in detecting carious lesions on bitewing and periapical radiographs has been demonstrated by CNN (Convolutional Neural Networks; a deep learning model) and transformer-based pipelines. Their diagnostic accuracy is confirmed by external validation tests, and some models are as sensitive and specific as human examiners. However, clinical supervision is required due to spectrum bias and image quality variability.[6]

2. CBCT-Based Lesion Segmentation: Deep learning models are being developed for the detection of endodontic and periapical lesions on cone beam computed tomography (CBCT). Although segmentation accuracy is increasing, anatomical complexity and imaging errors necessitate careful calibration of these models. For safe deployment, clinician-in-the-loop validation is still crucial.[7]

Periodontal Bone Level Estimation: The generalizability of AI models assessing alveolar bone levels on panoramic radiographs is improved by standardized labeling procedures and multicenter datasets. Particularly in population-based investigations, these instruments provide longitudinal monitoring and periodontal screening.[8]

Orthodontic Landmark Recognition: When it comes to cephalometric landmark recognition, deep learning models show excellent reproducibility both within and across examiners. Their application in growth assessment and treatment planning is supported by their robustness to small imaging variability, and their clinical acceptability is enhanced by transparent uncertainty estimates.[8-9]

Oral Cancer Screening: Leukoplakia and potentially malignant illnesses can be detected using image-based models. Equal performance across skin and mucosal tones is crucial, though. Fairness audits and a variety of training datasets are necessary to address spectrum bias.[10]

3.1.2. Digital dentistry and prosthodontics

AI is using generative modeling and automation to streamline prosthodontic workflows:

Design of Margin Detection and Restoration: Occlusal surface adjustment, crown and onlay design, and margin recognition are all automated by geometry-aware models. Particularly when combined with intraoral scanning and CAD/CAM workflows, these solutions decrease manual errors and enhance fit.

NeRF and Implicit Surface Modeling: High-fidelity 3D reconstructions for craniofacial rehabilitation are made possible by Neural Radiance Fields (NeRF) and implicit surface methods. In complicated prosthodontic and maxillofacial conditions, these models make planning and visualization easier.

Additive Manufacturing Quality Control: 3D printing workflows are rapidly integrating AI-driven evaluations of fit, printability, and structural integrity. These instruments decrease chairside modifications and improve fabrication accuracy.[11]

3.1.3. Growth assessment and orthodontics

AI technologies are improving orthodontic diagnosis and treatment planning:
Models of Tooth Segmentation and Cephalometry: Automated segmentation and landmarking regularly save time and increase accuracy. Clinical and regulatory acceptance depend on transparent uncertainty quantification and clinician validation.

Therapy Duration Predictive Modeling: New models predict the number of aligner refinements and the total length of therapy. However, before clinical application, strong external validation across a variety of malocclusion types and demographic groups is required.[12]

3.1.4. Pathology and oral medicine

In oral pathology, AI facilitates early diagnosis and organized reporting:

Image-Based Screening: Leukoplakia and oral cancer can be prioritized with the use of models trained on various datasets. Deployment requires adherence to ethical data governance and equitable performance across phenotypes. NLP (natural language processing for pathology reports): By organizing pathology narratives, NLP tools improve follow-up, readability, and triage. When these systems are in line with defined terminologies, they facilitate research utility and interoperability.[13]

3.1.5. Documentation and practice operations

Administrative and patient-facing duties are being transformed by large language models (LLMs):

Clinical Documentation and Coding: LLMs help with the creation of clinical notes, coding protocols, and encounter summaries. These technologies enhance factuality and lessen hallucinations when paired with retrieval-augmented generation and institution-specific protocols.[14]

Patient Education and Communication: AI-driven chatbots and educational resources tailor patient communications. To guarantee safety and compliance, role-based access restrictions, audit logs, and content guardrails are crucial.[15]

3.1.6. Evidence from regulation and the real world

To allow AI in dentistry practice, regulatory frameworks are changing:

FDA Clearance and 510(k) Pathway: The 510(k); Medical device safety clearance pathway has granted regulatory approval to a number of dental imaging AI tools e.g Pearl second opinion 3D imaging, with performance claims linked to certain demographics and indications.

Post-Market monitoring and ML Upgrades: Change-control techniques and post-market monitoring are essential as models change. These consist of clinician feedback loops, drift detection, and performance monitoring.

Real-World Evidence and Lifecycle Governance: To promote adaptive AI, regulators are placing a greater emphasis on real-world data. Frameworks for lifecycle governance make sure that changes preserve equity, safety, and effectiveness.

3.2. Difficulties and prospects for AI in dentistry

Artificial intelligence (AI) has the potential to revolutionize dentistry, but there are significant obstacles that must be overcome to guarantee its safe, efficient, and equitable application. Bias and generalizability continue to be the most important issues among them. When subjected to domain shifts—such as modifications in imaging technology, patient populations, or illness prevalence—AI models trained on data from particular scanners, suppliers, or demographic groupings may show performance loss. Strategies including thorough external validation, varied and representative training datasets, and ongoing performance monitoring are crucial to reducing these hazards. These strategies aid in ensuring that AI systems remain dependable in a variety of healthcare settings and patient populations.

When developing collaborative models, privacy and data governance are equally important. Institutions can collaboratively enhance AI models without sending sensitive medical data thanks to strategies like federated learning and differentiated privacy, which lowers the dangers related to data mobility and centralization. However, any data-sharing system must continue to be based on fundamental principles such strong de-identification, informed consent, and data reduction. These protections promote stakeholder trust while simultaneously upholding moral principles.

An additional level of complexity is presented by workflow integration. Human-centered design, which places an emphasis on usability, transparency, and physician monitoring, is essential for the successful implementation of AI in clinical dentistry. To prevent over-reliance or misunderstanding, systems need to have explicit fail-safes and ways to communicate uncertainty. MLOps (Machine Learning Operations) frameworks are essential in operational environments. These consist of rollback capabilities, drift

detection, and version control, which together enable safe, auditable, and adaptable AI deployment.

In 2024 and 2025, the environment is expected to undergo substantial change. Advanced chairside decision support and automated documentation workflows will be supported by multimodal foundation models that can integrate 2D radiographs, CBCT/3D imaging, intraoral photos, and textual data. These models promise to lessen administrative load, improve diagnosis accuracy, and simplify clinical documentation. Importantly, interoperable ecosystems that follow privacy-preserving guidelines and make use of protocols like DICOMweb and FHIR for smooth integration across vendors and care settings will enable their deployment.

It is anticipated that regulatory frameworks would also change. Given the dynamic nature of AI systems in clinical application, it is anticipated that the U.S. Food and Drug Administration (FDA) would provide advice that emphasizes adaptive learning mechanisms and real-world performance reporting. These rules will be essential in guaranteeing accountability, openness, and patient safety.

4. Conclusion

In conclusion, AI is already showing quantifiable advantages in a range of dental applications, including workflow optimization and radiographic interpretation. The next stage of development, however, will depend on resolving important issues, such as guaranteeing generalizability under domain shift, protecting data privacy, integrating AI into clinical procedures, and conforming to changing regulatory norms. AI may be safely and successfully developed to assist excellent, patient-centred dental treatment with strong validation, governance, and professional involvement.

5. Source of Funding

None.

6. Conflict of Interest

None.

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Original Research Article

A comparative evaluation of the anteroposterior position of maxillary central incisors in adult females of Gujarati Origin: A photographic study

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Abstract

Introduction: This study investigates the anteroposterior (AP) positioning of maxillary central incisors in Gujarati females, emphasizing the role of soft tissue in orthodontic treatment outcomes. While the goal of orthodontic treatment is to achieve structural balance and functional efficiency, patient satisfaction often hinges on esthetic harmony.
Materials and Methods: A cross-sectional study was conducted with 100 adult females exhibiting aesthetically pleasing profiles. Posed smile photographs were taken to capture key facial landmarks, including Trichion, Glabella, Superion, and the Facial Axis (FA) point. Measurements were recorded for the distances from the FA point to the Goal Anterior Limit Line (GALL), Forehead Anterior Limit Line (FALL), and Glabellar Vertical Line (GVL). Statistical analysis was performed to assess the significance of these distances.
Results: The mean distances measured were 7.6±13.3 mm for GALL, 6.7±3.5 mm for FALL, and 8.2±3 mm for GVL, with an average forehead inclination of 9±3 degrees. GALL and FALL were found to be clinically significant (p-value = 0.000), while GVL was less significant (p-value = 0.243).
Conclusion: GALL and FALL are more clinically relevant landmarks for assessing the AP position of maxillary central incisors in Gujarati females, underscoring the forehead's importance in evaluating facial aesthetics.

Keywords: Anteroposterior position, Maxillary central incisors, Forehead landmarks.

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1. Introduction

A successful orthodontic treatment outcome is perceived differently by the patient and the orthodontist. The goal of orthodontic treatment is primarily to achieve structural balance, functional efficiency, and esthetic harmony but, to the patient, esthetic outcome is the most appreciated. The shift to soft tissue paradigm has changed the perspective of the orthodontist. The treatment approach has evolved from being dentition-oriented to profile-oriented. With increasing awareness and preceding current trends, more adults especially females are inclined towards orthodontic treatment for achieving a pleasing smile. Geron et al. have also demonstrated that females are more concerned about their smile aesthetics as compared to males.[1,2]

Evaluating the facial profile is a crucial element of a comprehensive orthodontic diagnosis. Research on facial aesthetics within orthodontic literature has primarily focused on the profile view of the face, particularly on the profile outline derived from photographs or cephalometric radiographs. With advancements in orthodontic and surgical techniques, there has been a shift towards prioritizing the ideal positioning of the upper incisors as the foundationfor treatment planning.[3] This allows for the development of treatment strategies that aim to position the incisors optimally, subsequently aligning the other teeth around this ideal position.[4]

Andrews' six keys[5] of occlusion served as the foundation for orthodontic treatment planning from 1972 until 1991, when he changed his strategy to the six elements of orofacial harmony, which included lateral cephalograms and soft

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tissues.[6] In order to improve facial harmony, Andrews used the forehead as a stable marker in element II to assess the maxillary incisors' anteroposterior location.[7,8] This notion states that the goal anterior-limit line (GALL) and the FA point (which is the clinical midpoint facial axis of the clinical crown of the upper incisor and splits it into an occlusal half and gingival half), correspond to represent the optimal position of the maxilla. The glabellar vertical line (GVL)[9] and the forehead's anterior-limit line (FALL) are the points where the GALL, (a line parallel to the frontal plane of the head), crosses.

The frontal plane of the head is parallel to both the GVL and the FALL. The facial axis (FFA) point on the forehead is where the FALL passes through, and the GVL crosses the glabella. The FFA point is clinically determined according to the type of forehead: if the forehead is angular and round, it is located between the Superion (a point near the Trichion at the prominent upper region of the forehead) and the Glabella. If the forehead is straight, it is located between the Trichion and the Glabella.

As proposed by Sarver and Ackerman, to effectively address a patient's smile, orthodontists need to assess and quantify it in both static and dynamic conditions. They noted that while rigid rules for facial aesthetics are difficult to establish, general guidelines can be developed. They emphasized that the optimal positioning of the upper incisors, both antero-posteriorly and verticallyin relation to adjacent soft tissues, is crucial.[10,11] Their approach introduced the concept of using the positioning of the upper incisors as the initial step in the diagnostic process.[10]

Andrews shift from hard-tissue internal cephalometric landmarks to soft-tissue profile landmarks, suggested the placement of the upper incisors crucial for facial aesthetics from both frontal and lateral views. His study, conducted on the Caucasian population, highlighted that there are ethnic variations in the position of central incisors, which means the positioning of the GALL may differ across ethnic groups. Several studies have assessed the anteroposterior (AP) position of maxillary incisors in various populations. To enhance diagnostic value, this study aims to determine the standard for the AP position of maxillary incisors in Gujarati females.

2. Materials and Methods

A cross-sectional study was carried out in the Department of orthodontics and dentofacial orthopedics. Randomized sampling was done to select the subjects for this study. Informed consent was obtained from all participants. Adult females (N=100) with pleasing profiles and optimum smile esthetics were selected for the study and smile profile photographs were recorded. Subjects, who had undergone any orthodontic and/or prosthetic rehabilitation or any candidates with facial asymmetry and jaw deformities, were excluded.

Posed-smile photographs with adequately visible forehead structures and fully bared maxillary incisors were obtained from all the participants in natural head position (NHP) by the same clinician. A distance of 56.0 cm between the tripod stand of the camera and the patient was established by the use of a measuring tape and maintained while taking all the photographs. (**Figure 1**) After that, pictures were added to Microsoft Office 2010 and enlarged to around life size. The average vertical measurement from the trichion to the incisal border of the maxillary central incisors was used to determine life size image. This measurement was obtained from lateral cephalograms of ten randomly chosen adult female patients.) Thereafter, all the photographs were imported to Autocade 2018 designing software for the identification of landmarks and determination of distances among them.

The following landmarks were used in this study: (**Figure 2**)

1. Trichion: The central point of the forehead where the hairline meets the forehead.
2. Glabella (Mesophryon): The region between the eyebrows and above the nasion on the frontal bone.
3. Superion: On angular and rounded foreheads, this point indicates the superior boundary of the clinical forehead, or the area of the forehead that is more closely associated with the face than the scalp.
4. The forehead's FFA point, which is located halfway between the glabella and superion on the midsagittal plane,
5. Forehead inclination: This is the angle formed by the FFA line, which goes via the FFA point, and the clinical forehead.

After identifying all of the above landmarks on photograph, lines were constructed on the forehead & measured its inclination as mentioned in **Figure 3**.

1. FA point (facial axis point) – the clinical midpoint of the facial axis ofclinical crown of upper incisors
2. GVL line (Glabellar vertical line) - line parallel to FA point and thatpasses through the glabella.
3. FALL line (forehead’s anterior limit line) – a line that parallels the head’sfrontal plane and passes through the FFA point.
4. GALL line (Goal Anterior Limit Line) – A line representing optimal anterior border according to Andrew’s element I concept. When the cant of forehead is 7 degrees or less it passes through the FFA point. For everyincrease in the degree, it passes through a point on the forehead that is 0.6mm anterior to the FFA point.[6]

Once these landmark points were identified, three vertical lines were drawn asseen in **Figure 3**.

1. Line 1: Through glabella
2. Line 2: Through FFA point
3. Line 3: Through maxillary central incisor FA point

Following this the horizontal linear measurements were recorded from FA point of upper incisor to FALL, GALL and GVL line.(**Figure 3**)

3. Result

The graph in **Figure 4** shows that the descriptive analysis of the AP position of the maxillary incisor from GALL was found out 7.6±13.3mm, for FALL was 6.7±3.5 mm andGVL is 8.2±3 mm. The average forehead inclination for all the subjects was 9±3degree.

The results are highly significant. GALL and FALL are clinically more significant (p-value – 0.000) than GVL (0.243). (**Table 1**)

GALL & FALL are statistically significant (p-value – 0.000) when compared toGVL (p-value – 0.243) (**Table 2**)

Linear regression analysis derives a formula Y = 8.773 + 1.530*Gall line - 1.574*Fall line-0.140*GVL lineHere, Y was considered as forehead inclination.

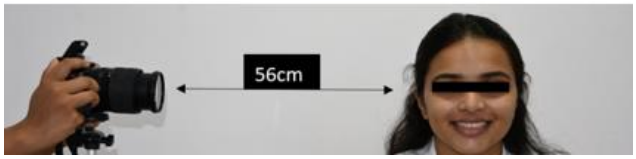

Figure 1: A distance of 56.0 cm between the camera's tripod stand and the patient was maintained using a measuring tape while capturing all photographs

Figure 2: Landmark identification on photographs

Figure 3: Measurement of GALL, FALL, GVL and Forehead inclination

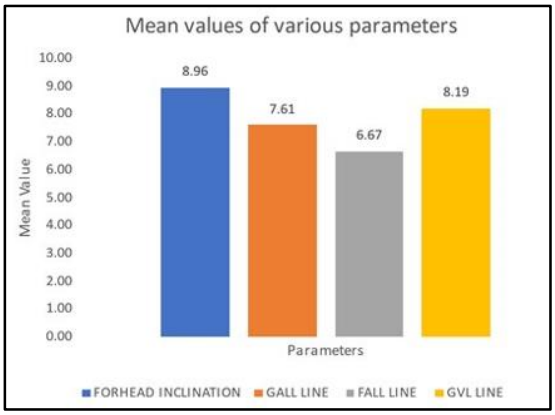

Figure 4: Descriptive analysis of the AP position of the maxillary incisor from GALL, FALL and GVL.

Table 1: Depicts that GALL and FALL are clinically more significant than GVL

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. The error in the estimate**
1	.947[a]	.897	.894	1.066

a. Predictors: (Constant), GVL LINE, FALL LINE, GALL LINE

Table 2: Depicts that GALL & FALL are statistically significant when compared to GVL.

Coefficients							
Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t-value**	**p-value (Sig.)**	**95% Confidence Interval for B**	
	B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
(Constant)	8.773	0.306	—	28.626	0.000	8.165	9.381
GALL LINE	1.530	0.092	1.539	16.657	0.000	1.348	1.713
FALL LINE	-1.547	0.071	-1.678	-21.767	0.000	-1.688	-1.406
GVL LINE	-0.140	0.119	-0.139	-1.174	0.243	-0.376	0.097

a. Dependent variable: Forehead inclination

4. Discussion

The Angle's paradigm,[5] considered that optimal oral occlusion and hard tissue interactions, served as the foundation for orthodontic diagnosis and treatment planning until now. The goal of orthodontic treatment was to achieve best possible occlusal and facial results for each patient, with aesthetic considerations often being prioritized from the patient's perspective.[12] The orthodontist must plan the treatment based on soft tissue adaptability of the patients since the soft tissues significantly dictate the boundaries of orthodontictreatment. The soft tissue paradigm emphasizes the function and aesthetics of soft tissue in both diagnosis and treatment planning.

The role of soft tissue is crucial, as changes in the anteroposterior position of the maxillary incisors, such as when anterior retraction is performed, typically result in the soft tissue conforming to the new position of the teeth. This resultsin the alteration of the facial profile and aesthetics of the patient. Moreover, thesoft tissue profile plays a vital role in defining the smile, as the lips and surrounding soft tissues are framed by the teeth, thereby affecting the overall balance and appeal of the smile.[13]

The smile arc, as defined by Frush and Fisher,[14] is the harmony between the curvature of the upper border of the lower lip and the curvature of the incisal edges of the maxillary front teeth. A harmonic curve of the maxillary anteriorincisal margins has been important for producing a youthful and attractive aesthetic look for more than 50 years, according to prosthodontists.[15] Even though orthodontists have always used the phrase "curved smile line," Sarver favours the word "smile arc."[10]

In addition to the importance of the smile arc, forehead inclination has a major role in determining the extraction and non-extraction treatment approach.[16] The theory that, in people with facial harmony, there is a correlation between the prominence and inclination of the forehead and the AP locations of the teeth and jaws serves as justification for using the forehead to define the target for the maxillary incisors. In this case, Dr. LF Andrews[17] also recommends utilizing the forehead as a suitable reference point. The forehead's inclination is generally the same among ethnic groups, despite differences in the hard and soft tissue architecture.[18,19]

In a smiling profile view, the labiolingual angle and the AP position of the maxillary incisors have a significant impact on facial appearance. The significance of the incisors' optimal AP location when viewed sagittally was verified by Cao et al.[20] The Andrews study, which has a strong correlation with this particular study, demonstrated that the forehead inclination was a crucial landmark in determining the maxillary incisors' AP position.

The maxillary central incisors should be positioned halfway between the glabella, which ranges from -8.5 mm to 9.0 mm, and the forehead's FA point, according to a study by Andrews[21] on adult white females.

Numerous investigations were conducted thereafter to evaluate the same in other ethnic groups. The nearly varied findings from each study indicate to various maxillary central incisor locations. According to Cho et al.,[22] the maxillary central incisors of most Korean female patients undergoing orthodontic treatment were positioned anteriorly to the glabella. In adult African American females, Gidaly et al.[23] investigated the ideal AP relationship between the maxillary central incisors and the forehead and glabellar vertical (GV). According to his findings, Andrews recommended optimal AP position for maxillary central incisors, which was meant for Caucasian females and not for African American females. Alternatively, African ladies have the best maxillary incisor position in front of the GV. Gidaly also suggested using the patient's forehead inclination to create an equation for the ideal AP upper incisor location in relation to GV. According to a study by Tomblyn et al.,[24] in the majority of Caucasian patients, the GV and GALL matched. In 95% of the population, the GALL is 1 mm behind the GV, and in 99.7% of the population, it is 1.5 mm behind the GV. These variances emphasize how crucial it is to take racial and cultural diversity into account when developing a treatment strategy.

This study provides important insights into the facial profiles of Gujarati females with aesthetically pleasing features. It was observed that the GALL and FALL are positioned at nearly identical distances from the FA line, suggesting that these two measurements are closely aligned in individuals with harmonious facial profiles. The research emphasizes that GALL and FALL hold greater clinical significance in evaluating facial balance and symmetry compared to theGVL making them crucial parameters in the assessment of facial aesthetics.

Building on these observations, the study derived a mathematical formula toestimate forehead inclination:

Forehead inclination =8.773 + 1.530*Gall line -1.574*Fall line-0.140*GVLline

This formula is particularly valuable in clinical practice, as it allows practitioners to calculate the GALL distance from the FA line when the FALL and GVL measurements are already known. By integrating these variables, the formula offers a practical method for assessing the spatial relationships between key facial landmarks, contributing to more precise evaluations of facial profiles and supporting the development of individualized aesthetic treatments.

The above study confirmed the optimal efficacy of the forehead in deciding the optimal AP position of incisors and GALL and FALL has more reliability in the Gujarati population rather than GVL. Therefore, it suggests that there

is a difference in the distance of the FA line from GALL, FALL, and GVL indifferent racial groups.

5. Conclusion

In comparison to the Glabellar vertical line, the Goal anterior limit line and the Forehead anterior limit line are clinically more significant landmarks for assessing the antero-posterior location of maxillary central incisors in Gujarati females.

When evaluating the facial profile of adult Gujarati females in relation to the AP maxillary central incisor location, the forehead can be an important marker.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Original Research Article

Assessment of dental students' knowledge, attitudes, and practices regarding the use of interdental aids: A questionnaire-based study

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Abstract

Background: The attitudes and behaviours of medical undergraduate & postgraduate students regarding their oral health reflect their understanding and perception of interdental cleaning aids in maintaining oral hygiene. Interdental aids are specially designed tools intended to clean the interproximal areas—spaces between the teeth—that are typically inaccessible to a regular toothbrush. These tools play a crucial role in achieving comprehensive oral hygiene and in preventing common dental conditions such as gingivitis, periodontitis, and dental caries.

Objective: To assess whether increasing dental education improves the Knowledge, Attitude and Practice of interdental aids among the dental students of Delhi-NCR.

Materials and Methods: A questionnaire-based cross-sectional study was conducted between January and March 2025 among dental students in the Delhi-NCR region. A total of 251 medical undergraduate students participated in the study. Data were collected using a self-designed questionnaire comprising 20 multiple-choice questions focused on knowledge, attitudes, and practices related to interdental aids.

The analysis aimed to assess the association between students' awareness of interdental cleaning and their oral hygiene practices across different academic years. Of the 251 participants, 153 were female and 98 were male, with an average age range of 20 to 25 years.

Approximately half of the students were aware that interproximal tooth surfaces are the most difficult to clean and cannot be effectively reached with a standard toothbrush. Statistically significant differences were observed across academic years in relation to tongue cleaning habits, the perceived importance of interdental aids, and the difficulties encountered during their use.

Conclusion: The findings indicate that the awareness and knowledge regarding interdental aids among the students were generally satisfactory. This survey highlights the crucial role of interdental aids in achieving and maintaining optimal oral hygiene. It underscores the responsibility of dental professionals to not only adhere to recommended oral self-care practices themselves but also to actively educate and encourage their patients about the proper use and benefits of interdental aids.

Keywords: Attitude, Interdental aids, Knowledge, Questionnaire, Students, Delhi-NCR, Gingivitis, Oral Health, Periodontitis, Plaque.

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1. Introduction

Maintaining good oral hygiene is essential for promoting overall dental and systemic health. Interdental aids—such as dental floss, interdental brushes, and water flossers—play a crucial role in preventing plaque accumulation and reducing the risk of gum-related diseases. While toothbrushing remains the most widely practiced method of oral hygiene, the knowledge, attitudes, and awareness of interdental aids among dental students are pivotal, as they can influence both their future clinical practices and the oral health guidance they provide to patients.[1-3]

Oral hygiene is a fundamental aspect of an individual's well-being, closely tied to the function and health of oral tissues. Good oral hygiene not only supports better daily functioning but also contributes significantly to overall health. Common issues such as periodontal disease and dental caries can severely impact oral health. These conditions often result from the accumulation of dental plaque—a biofilm that forms due to inadequate mechanical cleaning of the teeth, especially in interproximal areas.

The health of the periodontium can be compromised when there is an imbalance between localized microbial

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activity and the host's inflammatory response. Infections of the gingival and periodontal tissues typically arise from poor plaque control, highlighting the importance of effective self-care practices, including the use of interdental aids.[4]

Tooth cleaning remains the most effective mechanical method for removing bacterial plaque and maintaining plaque-free tooth surfaces. However, effective oral hygiene requires the thorough cleansing of all tooth surfaces, including the interdental areas, which are particularly susceptible to plaque accumulation and disease progression.[5]

While most individuals rely on non-professional means of plaque control, conventional toothbrushes often fail to adequately clean interdental spaces, where microorganisms can persist. Interdental aids such as dental floss, interdental brushes, and wooden sticks have been widely promoted as essential tools for cleaning these hard-to-reach areas. Their effectiveness, however, depends not only on the anatomical contour of the interproximal surfaces but also on the individual's manual dexterity, motivation, and behavior.[6]

Studies have consistently shown that proper use of interdental aids significantly reduces plaque accumulation and the incidence of gingivitis. Nevertheless, many individuals neglect interdental cleaning due to the time-consuming nature of the task and the precision it demands. This neglect is exacerbated by a general lack of awareness and education regarding interdental hygiene, despite the high prevalence of periodontal diseases worldwide.[7]

This issue becomes particularly concerning from a preventive health perspective. There is often insufficient emphasis on basic oral hygiene practices, and interdental cleaning remains underutilized even among populations with higher health literacy.

The present study is a quantitative cross-sectional survey designed to assess the Knowledge, Attitude, and Practice (KAP) of dental students regarding interdental aids. A KAP study is a well-established approach that helps in understanding what individuals know, how they feel, and how they behave in relation to a specific topic. In the context of oral health, especially interdental hygiene, this triad—Knowledge, Attitude, and Practice—serves as a critical framework for evaluating current awareness levels and identifying gaps that need to be addressed in both education and clinical practice (**Figure 1**).

Attitudes toward dental care are shaped by cognitive, affective, and behavioral factors. The cognitive component encompasses a person's beliefs and knowledge, while the affective component involves the emotional reinforcement of these beliefs. The behavioral component reflects an individual's readiness to take action in response to specific circumstances or stimuli. For example, one's self-assessment of dental health (cognitive) and willingness to attend regular dental check-ups (behavioral) collectively define their overall attitude toward dental care. To effectively design preventive and therapeutic oral health programs, as well as develop targeted training for dental professionals, it is essential to obtain accurate data from representative population studies.[8-10]

2. Materials and Methods

2.1. Study design and settings

This cross-sectional, questionnaire-based study targeted clinical-level dental students, including I-IV BDS students, interns, and MDS students, at dental colleges in the Delhi NCR region. Using convenience sampling, a total of 251 participants present during the study period were enrolled. The study was conducted from January 2025 to March 2025.

2.2. Questionnaire

The survey was administered online via Google Forms. A self-administered questionnaire was designed, beginning with an introductory paragraph that explained the study's objectives, assured participant anonymity, voluntary participation, and confidentiality of responses, which were accessible only to the research team. Students were informed that their participation was entirely voluntary and that choosing not to participate or withdrawing from the study at any point would have no impact on their academic standing. Consent to participate was obtained electronically before students could proceed with the questionnaire.

The questionnaire comprised 24 items: 4 demographic questions covering gender, age group, and year of study, and 20 questions focused on students' awareness, usage, benefits, key knowledge, and perceptions regarding interdental aids.

2.3. Data collection

The validated Google Forms questionnaire was distributed to the target sample via their official university email addresses. Participation was entirely voluntary, and no incentives were offered to encourage response. To enhance participation, reminder emails were sent three times at one-month intervals throughout the study period.

Data collection was conducted using Microsoft Excel (Version 2013), where responses were compiled and organized for analysis. The responses obtained from participants in the pilot study were included in the final dataset, as no modifications were made to the questionnaire following the pilot phase.

2.4. Statistical analysis

The data was tabulated and Collected using Google Docs. The analysis and comparison were also done by google docs software.

3. Result

In the present study, overall 251 students of Delhi-NCR responded to the questionnaire (**Figure 2**). Among them, 153 females and 98 males, with a mean age range of 20 - 25 years (**Figure 3**). Most of the students were interns, followed by students of 1st year, 3rd year, MDS students, 2nd year and 4th year as shown in (**Figure 4**).

3.1. Participants distribution according to gender and age

Among the 251 responses included in the study, 153 (60.9%) were females, and 98 (39.04%) were males. Of the 251 participants, 73 (29.08%) were aged 18–20, 38 (15.13%) were aged 21–23, 85 (33.86%) were aged 24–25, and 55 (21.91%) were aged 26–32.

3.2. Awareness, usage of interdental aids

The study revealed that dental students in the Delhi NCR region demonstrated a moderately high level of awareness regarding interdental aids. Key findings included:

1. A majority of students recognized the importance of mechanical plaque control as a supplement to routine toothbrushing.
2. Most participants were familiar with the different types of interdental aids, such as dental floss, interdental brushes, and oral irrigators.
3. Awareness levels were notably higher among senior students and those with greater clinical exposure, likely due to their curriculum and clinical postings.

These findings suggest that while foundational knowledge exists, integrating interdental aid education earlier in the curriculum and reinforcing it through clinical training may further enhance awareness and practical understanding.

However, a significant knowledge-practice gap was identified. Despite high levels of awareness, the actual usage of interdental aids was relatively low. Only a small proportion of students reported using these aids daily. Among the tools used, dental floss and interdental brushes were the most common. Reported barriers to consistent use included time constraints, inconvenience, difficulty in handling, and lack of established habits.

These insights highlight the need to incorporate structured oral hygiene modules within the dental curriculum that not only impart knowledge but also emphasize behavioral reinforcement. Encouraging personal use of interdental aids among dental students may also enhance their confidence and motivation to recommend these practices to future patients.

3.3. Comparison between knowledge based questions and year of study

As the academic year progressed, a statistically significant rise in knowledge scores was noted. When asked about the clinical application, technique, and relative benefits of different interdental aids, interns, final year BDS student and MDS students did the best. First and second-year BDS students frequently possessed theoretical knowledge but lacked depth in terms of clinical utility. Clinical exposure and curriculum design seem to be related to knowledge improvement.

Overall knowledge scores among the participants according to the year of study:

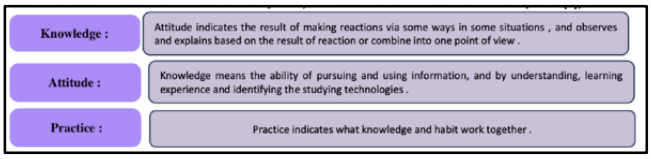

Figure 1: KAP model[5]

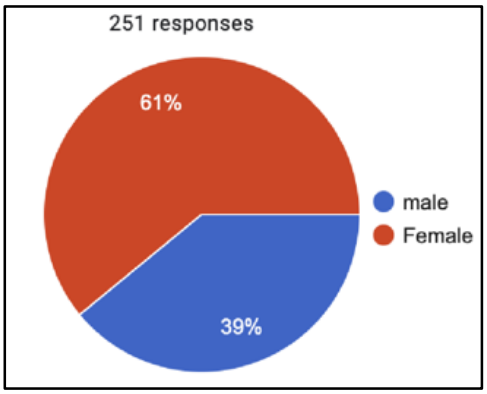

Figure 2: Gender

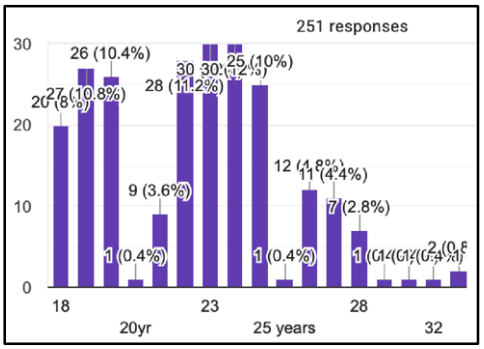

Figure 3: Age

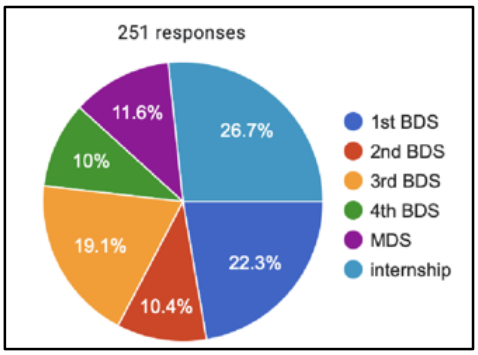

Figure 4: Year of study

Table 1: Mean Knowledge Score of students though different academic years

Year of study	Mean Knowledge Score [out of 10]	Interpretation
1st year BDS	4.1	Basic awareness only
2nd year BDS	5.0	Developing knowledge
3rd year BDS	6.2	Moderate knowledge
4th year BDS	6.8	Good theoretical knowledge
Interns	8.0	Strong clinical knowledge
MDS	8.7	Advanced clinical and academic knowledge

4. Discussion

Periodontal diseases and systemic health share a bidirectional relationship. Maintaining optimal oral hygiene is critical not only for oral health but also for overall well-being. This is primarily achieved through effective plaque control. Various oral hygiene modalities, a balanced diet, healthy lifestyle choices, and adherence to professional counseling and care are essential in promoting oral health.[11]

Dental plaque is the principal etiological factor in the development of both hard and soft tissue oral diseases. Its reduction significantly decreases the incidence of dental caries, gingivitis, and periodontal diseases. While toothbrushing is the cornerstone of daily oral hygiene, it is often insufficient in cleaning hard-to-reach interproximal areas. Adjunctive aids such as interdental floss, interdental brushes, and wooden picks play a crucial role in enhancing plaque removal and maintaining interdental cleanliness.

The present study aimed to assess and compare the Knowledge, Attitude, and Practice (KAP) regarding interdental aids among dental students at various stages of their academic training. It also examined whether the increase in knowledge was reflected in their personal oral hygiene behaviors.

Our findings revealed that with the progression in academic level, dental students demonstrated significant improvements in their knowledge, attitude, and practice regarding interdental aids. Postgraduate (MDS) students exhibited superior KAP scores compared to undergraduate students. Gender comparisons also indicated better awareness and utilization of interdental aids among MDS students.

Previous studies have reported varying outcomes on the influence of dental education on students' oral hygiene behaviors. Research by Cortes et al., Lang et al., Cavaillon et al., and Yildiz et al. indicated clear improvements in oral hygiene practices during dental education. Conversely, El-Mostehy et al. observed no significant improvement in hygiene practices among 100 Egyptian students, despite receiving adequate education and information.[6,10-13]

Despite these conflicting results, our study supports the notion that increased education level correlates with improved KAP regarding interdental hygiene. It is essential for all dental professionals to utilize this knowledge in both personal practice and patient care to prevent periodontal diseases and dental caries. Furthermore, departments dealing with orthodontics, prosthodontics, and other dental specialties must also emphasize the importance of interdental aids, given their role in long-term periodontal health.[14]

In conclusion, dental students must not only acquire knowledge about oral hygiene and interdental aids but also develop a positive attitude and implement proper practices. This is vital for maintaining the health of their own periodontium and for delivering effective care to their patients.[15]

5. Strengths

The study provides valuable insights into the current knowledge, attitudes, and practices (KAP) regarding interdental aids among the target population. A validated and structured questionnaire was used, enhancing the reliability and consistency of the data collection process. The findings help identify critical gaps in oral hygiene practices, offering direction for future oral health promotion strategies. If a diverse participant group was included, this increases the generalizability of findings within the population studied.

6. Limitations

The sample may not represent the broader population due to limited institutional or geographic scope. Reliance on self-reported data introduces potential recall bias and social desirability bias, which could affect the accuracy of responses. The cross-sectional design restricts the ability to assess changes in KAP over time. The study may not have accounted for all socioeconomic, cultural, or educational factors that influence oral hygiene behaviors.

7. Future scope

Conduct similar studies on a larger and more diverse sample across different geographic regions to enhance generalizability. Implement longitudinal studies to evaluate the impact of educational interventions on KAP over time. Incorporate qualitative research (e.g., interviews or focus groups) to explore barriers and motivators related to the use of interdental aids. Combine clinical evaluations with questionnaire responses for a more comprehensive assessment of oral hygiene practices.

8. Recommendations

Integrate educational programs about interdental aids into both academic curricula and community outreach efforts. Dental professionals should routinely recommend and reinforce the daily use of interdental aids as part of standard oral hygiene practices. Future research should aim to develop

tailored oral hygiene strategies informed by demographic and behavioral data from KAP studies. Policy makers and public health authorities should promote awareness through media campaigns, school programs, and primary healthcare services.

9. Conclusion

This KAP-based study offers significant insights into the awareness, attitudes, and behavioral patterns surrounding the use of interdental aids among dental students. While the majority demonstrated a basic understanding of the importance of interdental cleaning, discrepancies in attitude and actual practice were evident. The predominant reliance on toothbrushes, with limited use of adjunctive aids like floss, interdental brushes, and oral irrigators, highlights a gap between knowledge and practice.

These findings underscore the need for targeted educational initiatives and behaviour reinforcement strategies. Regular dental check-ups, along with public health programs, can play a crucial role in raising awareness, improving interdental hygiene practices, and ultimately contributing to the prevention of periodontal diseases.

10. Data Availability

The data supporting the findings of this study are available within the article.

11. Source of Funding

None.

12. Conflict of Interest

None.

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Original Research Article

Self-perceived oral health attitudes and behaviors among male and female patients suffering from chronic Periodontitis

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Abstract

Introduction: Chronic periodontitis is a severe inflammatory condition that damages the tissues supporting the teeth, leading to ligament destruction, bone loss, and potential tooth loss. It negatively affects overall quality of life, especially self-esteem and oral health-related quality of life (OHRQoL). The disease's visible symptoms can increase social stigma, causing shame and social withdrawal.

Objective: To explore the effect of chronic periodontitis on OHRQoL of men and women using the OHIP-49 (Oral health impact profile), self-formulated general questionnaires, and the Rosenberg Self-Esteem Scale.

Materials and Methods: The study involved 250 chronic periodontitis patients. Periodontal parameters, including oral hygiene, plaque levels, gingival inflammation, probing depth, and periodontal status, were assessed. Self-esteem was measured with the Rosenberg Self-Esteem Scale, while OHRQoL was evaluated using the OHIP-49 and self-formulated questionnaires.

Result: A survey of 250 patients (123 men, 127 women, and aged 21–65) showed gender differences in psychosocial impact of chronic periodontitis.78% of women vs. 48.8% of men reported social difficulties, and 68.3% of women vs. 44.9% of men reported lower tolerance towards partners. Women showed higher lack of self-confidence while also being more proactive in oral hygiene and early treatment-seeking. Men often ignored early signs, delayed dental visits, and underestimated their condition, worsening outcomes. Recognizing these differences is vital for tailored awareness, early detection, and improved periodontal care.

Conclusion: Both men and women with healthy periodontium also reported better OHRQoL. Individuals maintaining good oral hygiene had better self-esteem and OHRQoL. Chronic periodontitis has a significant negative impact on self-esteem and OHRQoL in both men and women.

Keywords: Chronic periodontitis (CP), Oral health-related quality of life (OHRQoL), Oral health impact profile (OHIP)-49.

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1. Introduction

Chronic periodontitis (CP) results from a chronic inflammatory reaction to subgingival biofilm and results in damage to tooth supporting structures such as the periodontal ligament, cementum, connective tissue and alveolar bone. Severe forms of the disease ultimately lead to tooth loss if left untreated.[1] Across the world, the prevalence of severe CP is known to range from 5 to 15% of the population.[2] Overall well-being, self-confidence, and quality of life is significantly influenced by oral health. The United States Surgeon General's Report defines oral health-related quality of life (OHRQoL) as 'a multidimensional construct that reflects (among other things) people's comfort when eating, sleeping and engaging in social interaction; their self-esteem; and their satisfaction with respect to their oral health'.[3] Studies have found an association between OHRQoL and the clinical characteristics of CP.[4-6]

Several instruments have been developed for measuring the multidimensional nature of OHRQoL. Among these instruments, one is the Oral Health Impact Profile (OHIP).[7]

How individuals evaluate their own oral cavity greatly influences health-related behaviours. Studies suggest that gender differences play a significant role in shaping oral health attitudes and behaviours, with women generally

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exhibiting better oral hygiene practices and more positive attitudes towards dental care than men.

Despite these findings, limited research explores gender-specific differences in self-perceived oral health attitudes and behaviours among patients with chronic periodontitis.[8] This study aims to addresses this gap in patients diagnosed with chronic Periodontitis by evaluating and comparing self-perceived oral health attitudes and behaviours among male and female.

Understanding these differences can help dental professionals to develop targeted interventions for improving oral health outcomes and quality of life for patients suffering with chronic periodontitis. By exploring the role of self-perception and gender in oral health, this study can inform more effective management strategies.

2. Materials and Methods

A cross-sectional epidemiological study was conducted in the Department of Periodontology at I.T.S. Dental college, Hospital and Research Centre, Greater Noida, over a period of 5 months. Based on the inclusion criteria, 250 Men and Women were included in the study reporting to outpatient section of periodontology department.

Inclusion criteria included patients of both the genders aged between 21 to 70 years of age, diagnosed with chronic periodontitis, had not undergone periodontal therapy in the past six months, and were willing to participate and give informed consent.

Exclusion criteria excluded patients with aggressive periodontitis, undergoing orthodontic treatment or taking medications affecting gingival health, pregnant or lactating women or individuals with cognitive impairments affecting questionnaire response.

A structured questionnaire was used to collect data, including questions of demographic details, OHIP – 49(self-perceived oral health status and oral health attitudes and behaviors)

A bilingual questionnaire was designed (English and Hindi) to ensure better understanding. Assistance was offered to patients who were illiterate or had difficulty in understanding.

3. Result

The survey was conducted on 250 patients, in which 123 were men while women were 127, aged between 21-65 years of age. The results revealed that 78% of females faced difficulty in social interactions whereas only 48.8% of men experienced social stigma due to their condition. While 68.3% of females reported less tolerance towards family partners, only 44.9% of men reported such an instance.(**Table 1-4**)

The results also showed the lack of self confidence in females were much higher in comparison to male reporting with the same condition.

Self-perceived oral health influences individuals' hygiene habits, treatment adherence, and willingness to seek care. Studies show that women generally prioritize oral health more than men, maintaining better hygiene practices and seeking early intervention for chronic periodontitis due to concerns about aesthetics and function.

Men, on the other hand, are often less proactive, tending to ignore early signs of gum disease and delaying dental visit. This may be linked to societal norms that de-emphasize self-care in men.

Additionally, men with chronic periodontitis may underestimate their condition, creating a gap between perception and clinical reality. This misperception often results in delayed treatment, worsening the disease over time. Addressing these differences is crucial for improving periodontal care, encouraging early detection, and promoting better oral health awareness in both men and women.

Table 1: Attitude: How much do you value your dental health?

Crosstab						
			How much do you value your dental health?			Total
			A little	A lot	not at all	
Gender	male	Count	60	30	33	123
		% within Gender	48.8%	24.4%	26.8%	100.0%
	female	Count	67	35	25	127
		% within Gender	52.8%	27.6%	19.7%	100.0%
Total		Count	127	65	58	250
		% within Gender	50.8%	26.0%	23.2%	100.0%

Chi-Square Tests			
	Value	df	P value
Pearson Chi-Square	1.810[a]	2	.404
Likelihood Ratio	1.814	2	.404
N of Valid Cases	250		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 28.54.

Table 2: Attitude: How often do you visit your dentist?

Crosstab						
			How often do you visit your dentist?			Total
			Once a year	twice a year	when I have a dental problem	
Gender	male	Count	25	5	93	123
		% within Gender	20.3%	4.1%	75.6%	100.0%
	female	Count	27	13	87	127
		% within Gender	21.3%	10.2%	68.5%	100.0%
Total		Count	52	18	180	250
		% within Gender	20.8%	7.2%	72.0%	100.0%

Chi-Square Tests			
	Value	df	P value
Pearson Chi-Square	3.769[a]	2	.152
Likelihood Ratio	3.896	2	.143
N of Valid Cases	250		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.86.

Table 3: Perception: According to you a regular dental checkup must be?

Crosstab							
			According to you a regular dental checkup must be?				Total
			Once a year	every 6 months	once a year	when necessary	
Gender	Male	Count	22	16	4	81	123
		% within Gender	17.9%	13.0%	3.3%	65.9%	100.0%
	Female	Count	28	23	4	72	127
		% within Gender	22.0%	18.1%	3.1%	56.7%	100.0%
Total		Count	50	39	8	153	250
		% within Gender	20.0%	15.6%	3.2%	61.2%	100.0%

Chi-Square Tests				
	Value	df	P value	
Pearson Chi-Square	2.442[a]	3	.486	Pearson Chi-Square
Likelihood Ratio	2.451	3	.484	Likelihood Ratio
N of Valid Cases	250			N of Valid Cases

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 3.94.

Table 4: Knowledge: What would you do if you come across initial caries in any of your tooth?

Crosstab						
			What would you do if you come across initial caries in any of your tooth?			Total
			take preventive measures	treat as soon as possible	wait and watch	
Gender	Female	Count	33	29	65	127
		% within Gender	25.2%	22.8%	52.0%	100.0%
	Male	Count	45	20	58	123
		% within Gender	37.0%	16.5%	46.5%	100.0%
Total		Count	78	49	123	250
		% within Gender	31.2%	19.6%	49.2%	100.0%

Chi-Square Tests			
	Value	df	P value
Pearson Chi-Square	4.422[a]	2	.110
Likelihood Ratio	4.448	2	.108
N of Valid Cases	250		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 24.11.

4. Discussion

The current research sought to assess and compare self-reported oral health attitudes and behaviors between male and female patients with chronic periodontitis. The results provide important information regarding how gender disparities affect not only individual oral health beliefs but also daily behavior that could affect disease development and control.[9-12]

Our findings indicated that female patients tended to have more favourable oral health attitudes and improved hygiene habits than their male equivalents. Women brushed more frequently, were most likely to use adjunct aids like mouthwash or dental floss, and attended dental clinics more frequently for preventative check-ups. These conclusions are consistent with earlier research, which has frequently found women to be more health-aware, active in the pursuit of care, and more adherent to oral hygiene advice than men. This may result from increased aesthetic concern, enhanced levels of health awareness, and perhaps a more favourable attitude towards health practitioners and preventive treatment in women.

Conversely, male respondents of this study demonstrated a relatively lower awareness and concern regarding their periodontal status. Most men underestimated the severity of symptoms such as bleeding gums, bad breath, and teeth mobility and were likely to postpone seeking professional advice. This gender-specific variation in self-conception may be responsible for delayed diagnosis and more progressed disease at the time of presentation in males. These trends place greater demands on gender-specific oral health awareness and education programs with particular emphasis on enhancing periodontal knowledge and self-care habits in men.[13-15]

Another important finding of the present study was the notable discrepancy between objective clinical periodontal status and patients' self-perceived oral health, with this gap being particularly evident among male participants. Despite presenting with moderate to severe periodontal involvement based on established clinical parameters—such as increased probing depth, clinical attachment loss, and gingival inflammation—a substantial proportion of men rated their oral health as satisfactory or even good. This discordance between perceived and actual disease status is clinically significant, as underestimation of periodontal severity can lead to reduced motivation for professional consultation, delayed treatment-seeking behavior, and poor adherence to recommended oral hygiene practices. Over time, such neglect may contribute to disease progression, increased risk of tooth loss, and potential systemic health implications associated with chronic periodontal inflammation.[16-17]

In contrast, female participants generally demonstrated a closer alignment between their self-assessment and clinical findings. Women who reported dissatisfaction with their oral condition were more likely to exhibit advanced periodontal destruction and more pronounced clinical signs, indicating greater awareness and accuracy in evaluating their gingival health. This gender-based variation in perception may be influenced by differences in health literacy, health-seeking behavior, esthetic concerns, and preventive attitudes toward oral care. Collectively, these observations underscore the importance of enhancing patient education and awareness—particularly among male patients—to bridge the gap between subjective perception and objective clinical reality, thereby promoting timely intervention, improved compliance, and better long-term periodontal outcomes.

Although socioeconomic status and educational attainment were not the primary focus of the present investigation, both factors appeared to exert a noticeable influence on oral health–related behaviors and perceptions. Participants with higher levels of education—irrespective of gender—demonstrated greater awareness of periodontal health, more consistent engagement in preventive oral hygiene practices, and a more realistic appraisal of their own oral condition when compared with less-educated counterparts. These individuals were more likely to recognize early signs of disease, appreciate the importance of regular dental visits, and adopt evidence-based self-care measures, suggesting that educational exposure may enhance both knowledge and personal responsibility toward oral health maintenance.[18-19]

The observed pattern highlights the broader role of health literacy as a key determinant in bridging the gap between objective disease status and subjective patient perception. Individuals with better health literacy are typically more capable of interpreting clinical symptoms, understanding professional advice, and making informed decisions regarding treatment and prevention. Conversely, limited educational exposure may contribute to misconceptions, underestimation of disease severity, and delayed healthcare utilization. Together, these insights underscore the need for targeted educational interventions and community-based awareness programs aimed at improving oral health literacy across diverse socioeconomic groups, thereby fostering early recognition, timely treatment-seeking behavior, and improved periodontal outcomes.

The results of this research underscore the need for integrating both the behavioral and perceptual factors into periodontal treatment protocols. While mechanical debridement and clinical treatment are still the mainstays of periodontal therapy, the achievement of long-term success with disease control is highly predicated on patient motivation, home oral hygiene measures, and symptom

responsiveness, all of which are driven by the patient's personal attitudes and perceptions.

5. Limitation

The study has certain limitations that should be considered while interpreting its findings. The cross-sectional design limits the ability to establish causal relationships between oral health perception, behavior, and periodontal status, as data were collected at a single time point. Therefore, temporal associations and disease progression patterns could not be evaluated. The reliance on self-reported questionnaires may have introduced recall bias and social desirability bias, potentially affecting the accuracy of responses related to oral hygiene practices and perceptions. Participants may have overreported positive behaviors or underestimated disease severity. Variations in individual understanding of questionnaire items could also have influenced response consistency. Additionally, the study was conducted at a single centre, which may limit the generalizability of the findings to broader populations. Sociocultural and regional differences in oral health awareness and access to care may affect outcomes in different settings. Larger multicentric studies with more diverse samples are needed to improve external validity. Longitudinal research designs are recommended to better understand causal pathways and behavioral changes over time.

6. Conclusion

This research highlights noteworthy differences based on gender in self-reported oral hygiene practices and awareness among individuals suffering from chronic periodontitis. Female participants generally demonstrated a more accurate understanding of their oral condition and reported higher engagement in daily preventive behaviors such as effective plaque control and regular dental visits. In contrast, many male participants tended to underestimate the severity of their periodontal disease, which may contribute to delayed diagnosis and reduced adherence to recommended treatment protocols. Moreover, the results emphasize that gender differences extend beyond clinical parameters and significantly influence attitudes toward oral health maintenance. The observed disparities underscore the necessity for targeted and gender-sensitive oral health education strategies. Tailored awareness campaigns could help bridge gaps in disease perception and encourage proactive self-management among male patients. Additionally, customized training programs focusing on practical oral hygiene skills and risk awareness may enhance treatment compliance. Overall, such targeted interventions could contribute to improved preventive practices and better periodontal health outcomes across diverse patient populations.

7. Source of Funding

None.

8. Conflict of Interest

None.

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Original Research Article

Assessing the psychological impact on periodontal health in a cohort of dental students in varying levels of academic sessions - A questionnaire based study

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Abstract

Background: Psychosocial variables like stress, depression, loneliness and anxiety act as a confounding factor in increasing the severity of Chronic Periodontitis which are common among college students for a variety of Reasons. It is a condition of physiological or psychological strain brought on by unfavorable internal or external physical, mental, or emotional stimuli.
Aim: Assessing the psychological impact on periodontal health in a cohort of dental students in varying levels of academic sessions.
Objective: A dichotomous self-structured questionnaire with Kappa testing with 10 explicit statements and questions were given to the subjects in which UCLA loneliness scale (Russell et al. 1980), the Spielberger et al. (1970) state-trait anxiety inventory (STAI) and DASS score was applied.
Materials and Methods: The questionnaire was pertinent to Stress, Anxiety, Depression and Loneliness in the two groups of students- Students appearing for exams (Test group) and Regular going students (Control group) subjects between 18-30 years to the students of ITS Dental College, Hospital and Research Centre, Greater Noida.
Result: 80.8% of the exam going students showed a positive co-relation between psychological state and their periodontal status.
Conclusion: This questionnaire-based study highlights a significant correlation between psychological stress and periodontal health among dental students at different academic levels. Elevated stress, anxiety, and emotional distress—especially during exams—were associated with poorer periodontal conditions. The findings emphasize that psychological well-being is not just a supplementary concern but a critical factor in maintaining oral health. These results reinforce the importance of a holistic approach to health in academic settings, advocating for strategies that prioritize both mental and periodontal well-being.

Keywords: Stress, Anxiety, Depression, Loneliness, Periodontitis, Students, Delhi-NCR, Oral Health

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1. Introduction

Periodontitis is one of the most prevalent non-communicable diseases globally and presents a major public health challenge due to its impact on oral and overall health. As a multifactorial inflammatory condition, periodontitis not only affects the tooth-supporting tissues but is also strongly linked with a variety of systemic conditions.[1] Increasing evidence indicates that aggressive periodontitis may be a significant risk factor for conditions such as cardiovascular disease, diabetes mellitus, chronic obstructive pulmonary disease, hypertension, and certain cancers.[2] Basically, periodontitis is an inflammatory infectious disease that occurs chronically due to the host's immune response against dental plaque microbial flora.[3,4]

Chronic inflammation of the periodontal tissues is elicited by persistent pathogens. This inflammation, mediated by the immune system, results in destruction of the tooth-supporting structures, clinically manifesting as loss of attachment, formation of periodontal pockets, and alveolar bone resorption. In advanced stages, patients present with mobility of teeth, gingival recession, and tooth loss.[5,6] In an effort to standardize the diagnosis and grading of the severity and progression of periodontitis, Tonetti et al. suggested a classification system in 2018 that was developed jointly by the European Federation of Periodontology and the American Academy of Periodontology.[7] This staging system classifies periodontitis based on clinical presentation and extent of periodontal support destruction, using clinical loss of

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attachment, radiographic evidence of bone loss, and tooth loss secondary to the disease as major criteria for staging.

Psychosocial factors like stress, depression, social isolation, and anxiety have been reported to be important confounding variables in the etiology and progression of Chronic Periodontitis, particularly in college students. These mental states can impair the immune system, rendering people more vulnerable to inflammation and compromising the body's capacity to resist periodontal infection.

Chronic periodontitis is an inflammatory condition of the tooth supporting tissues caused primarily by bacterial plaque. Psychosocial stressors, though, worsen the severity of the condition by affecting health habits like poor oral hygiene, smoking, inappropriate nutrition, and irregular dental check-ups.

Among university students, academic pressures, lifestyle alterations, financial stresses, and social adaptation lead to higher levels of psychological and emotional distress. Stress, more specifically, is a condition of mental or physical tension that occurs in response to undesirable internal or external stimuli. Its prolongation brings about physiological alterations like an elevated level of cortisol, which compromises the immune function and encourages periodontal tissue destruction.

As such, psychosocial health should be addressed in preventing and managing chronic periodontitis. The inclusion of stress management techniques, mental health assistance, and oral hygiene practice education can minimize the susceptibility and effect of periodontal diseases in this high-risk group.

2. Objective

A dichotomous self-structured questionnaire with Kappa testing with 10 explicit statements and questions were given to the subjects in which UCLA loneliness scale (Russell et al. 1980),[23] the Spielberger et ai. (1970)[24] state-trait anxiety inventory (STAI) and DASS score was applied.

3. Materials and Methods

A questionnaire consisting of 10 explicit statements and questions to assess Stress, Anxiety, Depression and Loneliness was prepared. The cohort consisted of students of ITS Dental College, Hospital and Research Centre, Greater Noida, belonging to the age group of 18-25 years. Students were divided into two groups- Exam-going (Test group) and Non- exam going (Control group). The questionnaire was filled 3 days prior to the first examination. This dichotomous self-structured questionnaire was given to 200 students using online Google forms out of which 193 responses were received, which underwent Kappa testing. Parameters assessed were UCLA loneliness scale (Russell et al. 1980),[23] STAI- State-Trait Anxiety Inventory (Spielberger et al. 1970) [24] and DASS score.(**Figure 1**,**2**)

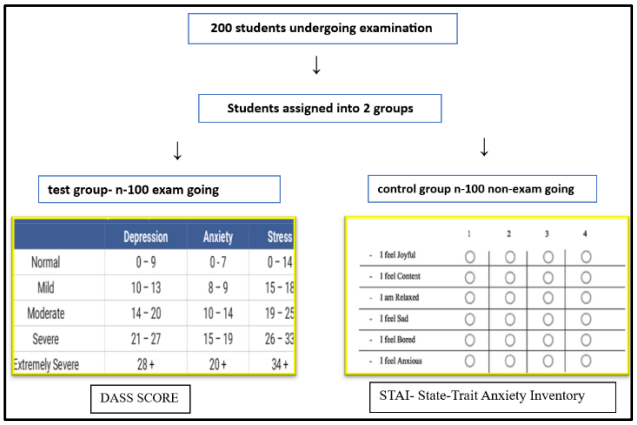

Figure 1: Study design flow diagram showing 200 students assigned into two groups: a test group (n = 100) undergoing examination assessed using the DASS (Depression, Anxiety, and Stress Scale), and a control group (n = 100) not undergoing examination assessed using the STAI (State–Trait Anxiety Inventory).

	M	SD	Corrected item-total correlations
1. I lack companionship	2.25	0.91	0.56
2. I feel part of a group of friends[a]	1.77	0.82	0.45
3. I feel left out	1.68	0.85	0.63
4. I feel isolated from others	1.89	0.95	0.69
5. I am unhappy being so withdrawn	2.20	0.85	0.62
6. People are around me but not with me	2.20	0.85	0.54

[a] Item should be reversed before scoring

Figure 2: Ucla loneliness scale

3.1. Questionaire

A self-structured questionnaire consisting of 10 questions was developed to assess the physical and psychological changes experienced by students during examination and non-examination phases. The items focused on identifying variations in bodily sensations, perceived stress levels, sleep patterns, appetite, and other relevant changes reported by students in both academic contexts.

3.2. Data collection

The questionnaires were distributed to the students via Google Forms through their respective university email addresses.

3.3. Statistical analysis

The data was tabulated and collected using Google Docs. The analysis and comparison were also done by google docs software.

4. Result

The results showed 80.8% of the exam going students showed a positive co-relation between psychological state and their periodontal status. Thereby implying that

psychological state impacts the periodontal health, and the overall quality of life of an individual.(**Figure 3**)

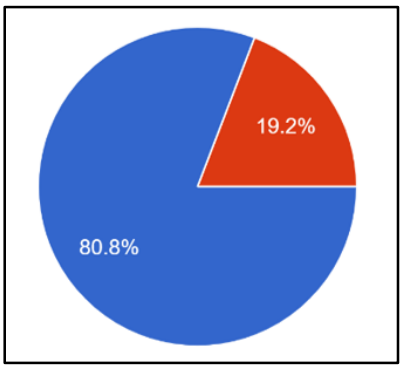

Figure 3: Exam going Students showed a positive under pie chart Co-relation between psychological state and their periodontal status

5. Discussion

The current study attempted to assess psychological burden among dental students during academic exams and its relationship with periodontal status. The results support the postulation that increased psychological stress can significantly influence oral health, especially periodontal status. More than 60% of the exam-attending students presented with high psychological distress, which was matched by worse periodontal health parameters compared with their non-exam peers.[8-12]

This correlation of psychological measures and periodontal status is in line with the literature, where stress, anxiety, and depression have been identified as major modifiers of host immune responses. Psychological stress has the potential to affect behavior, endocrine balance, and immune response. Increased levels of cortisol and catecholamines upon stress have been demonstrated to change immune regulation, inhibit antimicrobial action, and increase production of inflammatory cytokines, all of which could play a role in periodontal tissue destruction. Furthermore, neuroendocrine mechanisms may directly impact the vasculature and connective tissue that sustains the periodontium and compromise tissue integrity.[13-16]

Our research also identifies the behavioral effects of psychological stress. Stress resulting from exams is known to affect cognitive and executive abilities, compelling students to compromise on personal health habits such as oral hygiene routines. Irregular brushing, enhanced intake of comfort foods, poor sleep hygiene, and decreased motivation for regular checks are frequently seen under exam-related stress. These kinds of behavioral aspects are feasible causative factors for the enhanced intensity and prevalence of periodontal symptoms noted in the exam-seeking group.

Notably, the employment of established psychometric measures like the DASS-21, STAI (State-Trait Anxiety Inventory), and UCLA Loneliness Scale contributes to the legitimacy of students' psychological profiling in our cohort. These measures provide a multifaceted view of every psychological domain, enabling more precise correlation with outcomes of oral health. Our dichotomous approach—contrasting students receiving examinations and those not being actively involved in exams—brings further distinction by separating examination-associated psychological stress as a pivotal influencing variable.[17,18]

The novelty of the current study is in its thorough psychological evaluation through combined administration of the UCLA Loneliness Scale, State-Trait Anxiety Inventory (STAI), and Depression Anxiety Stress Scales (DASS-21)—a combination of instruments seldom used in tandem in periodontal investigations. Although DASS-21 has been used more frequently in clinical and educational environments to measure emotional distress, there has been little published literature regarding the use of the UCLA and STAI scales in assessing psychological effects on periodontal health. The UCLA scale alone assesses perceived social isolation, a variable that is frequently not addressed despite its established connection to mental and systemic health. Likewise, the STAI differentiates between transient state anxiety and more stable trait anxiety, providing a subtle understanding of an individual's stress profile. Integrating these indices, our study allows us to have a multi-dimensional perspective of psychological well-being, going beyond overall stress evaluation. This methodological strategy deepens the assessment of psychosocial influences and their effects on periodontal condition, distinguishing our research from what has been done before and opening the door to more integrative mental health screening in the field of oral health research. Interestingly, though earlier research such as that of Khalil et al. (2020) has shown the occurrence of psychosomatic oral symptoms under chronic stress, our research is different in methodology with its focus on an acute, academically triggered period of stress and its particular effect on periodontal health. This difference introduces a new aspect to previous studies and denotes the temporal effect of stress on the oral environment.[9]

Another research by Kaur[10] investigated the epidemiological prevalence of stress-related oral manifestations among the general population of Ludhiana and revealed a significant relation between psychological stress and the occurrence of aphthous ulcers, burning mouth syndrome, and periodontal disease. The findings indicated that people with higher levels of stress were highly susceptible to oral disorders, especially the inflammatory diseases of gums and mucosa. These results are consonant with the findings of our research, and this further supports the evidence that psychological stress is a causative factor for worsening periodontal health.[9] Kandagal et al. (2012) investigated the effect of psychological stress on the oral mucosa and discovered a direct relationship between increased levels of stress and the occurrence of oral lesions like recurrent aphthous ulcers, lichen planus, and burning mouth syndrome.[11]

The seminal exploratory research by Minneman et al.[12] (1995) examined the interplay among personality factors, stress levels, and gingival or soft tissue oral health. According to their findings, individuals with greater stress levels and particular personality types—greater neuroticism, for example—had increased likelihoods of poor gingival health and stress-induced oral pathologies.[11] These findings concur with our research's outcomes, verifying the connection between psychological stress and periodontal deterioration, especially in groups that are exposed to extreme mental strain, like dental students. The results of this study also raise more general questions about the responsibility of academic institutions to protect not only the intellectual development of students, but their well-being in general. Dental students, because of the rigorous nature of their curriculum and clinical roles, are potentially at greater risk for psychological stress, which itself puts them at risk for systemic and oral diseases.[19-22]

6. Strengths

This research uniquely examines the interface of psychological stress and periodontal status in dental students, a somewhat neglected but important group. A standardized, validated questionnaire was used, allowing for standardization of data collection and increased internal validity. Having students from different years allowed comparison between different levels of stress and educational experience, making the data and interpretation richer. The research responds to a significant matter of public health by delineating psychological stress as a modifiable risk factor in periodontal health.

7. Limitations

The cross-sectional study design restricts the potential to conclude causal associations between psychological stress and periodontal outcomes. Self-reported information can be vulnerable to response and recall bias, particularly with regard to psychological evaluations and oral hygiene habits. The sample was restricted to one geographic area/institutional setting, limiting generalizability of the results to larger student populations. The sample size is small and further studies are required.

8. Future Scope

Future studies should take a longitudinal design to monitor alterations in psychological stress and periodontal status longitudinally, particularly through key academic milestones. Clinical assessment of periodontal health with indices like GI, PI, and PPD, as well as saliva biomarkers of stress (e.g., cortisol), would be more complete and objective. Comparative research involving students from other disciplinary or different institutions of study may be utilized to examine whether dental education singularly contributes to psychological stress and oral health. Interventional research examining the effectiveness of stress management interventions upon periodontal health outcomes in students may be investigated.

9. Recommendations

Include routine mental health screenings and counseling sessions for dental students, particularly during high-stress academic periods like exams and clinical postings. Curricula in education programs should include modules on stress management skills, time management, study habits, and mental health in addition to clinical competencies. Urge institutions to implement holistic student wellness programs to enhance positive mental and oral health results. They must be taught about the two-way association between periodontal disease and stress, encouraging self-care and early treatment.

10. Conclusion

This research offers strong evidence that psychological distress during academic examination periods has a significant impact on periodontal health in dental students. The evident co-relation of high stress levels, anxiety, depression, and loneliness with poor periodontal status indicates that psychosocial health is not merely an ancillary consideration in dental education but is a key factor that determines the quality of life and overall health of students.

Considering the excessive occurrence of stress disorders in health professions students, the study emphasizes the immediate necessity for integrative health models in schools. Stress management treatments, availability of psychological counseling, mindfulness-based relaxation training, and college policies that enhance mental health consciousness could significantly help prevent stress-related periodontal deterioration.

In addition, regular screening for oral health and mental well-being at academic milestones might make possible the early detection of at-risk individuals, enabling interventions in a timely fashion. Peer-support groups and faculty mentorship programs could also serve as a buffer against academic stress, promoting resilience and healthy coping strategies.

Finally, the relationship between psychologic health and periodontal status determined in this study not only adds to the expanding literature on mind-body interactions for health but also inspires a change in policy at the educational level—a one that respects mental health as a fundamental pillar of academic and professional achievement. Subsequent studies with greater sample sizes and longitudinal follow-up would offer greater insights into the extended influence of psychosocial tension on both oral and systemic health outcomes.

11. Data Availability

The data supporting the findings of this study are available within the article.

12. Conflict of Interest

None.

13. Conflict of Interest

None.

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Case Report

Corpus alienum in maxillofacial region: A wooden foreign body masquerading as infection

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Abstract

Penetrating foreign bodies in the maxillofacial region are uncommon and often overlooked due to their varied presentation and limitations in clinical accessibility. Foreign materials such as wood, metal, plastic, or glass may remain inert for years; however, when irritation occurs, they can trigger significant inflammatory responses requiring prompt diagnosis and management. This report describes a 32-year-old male who presented with pain, swelling, trismus, and purulent discharge over the right frontozygomatic region one week after a road traffic accident. Initial radiography failed to detect the foreign body, but ultrasonography revealed a hypoechoic mass consistent with an embedded wooden fragment. Surgical exploration through the existing laceration enabled successful retrieval of multiple wooden pieces. The infected wound was managed with thorough debridement using hydrogen peroxide, saline, and super-oxidized solution, followed by a course of oral antibiotics, resulting in uneventful healing. This case highlights the importance of detailed history, appropriate imaging selection, and timely intervention for effective foreign body management in maxillofacial trauma.

Keywords: Corpus Alienum, Foreign body, Hydrogen peroxide, Superoxide.

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1. Introduction

Penetrating foreign bodies in the maxillofacial region are relatively uncommon and usually missed in diagnosis.[1] A foreign body (*corpus alienum*) is defined as any microscopic or macroscopic external object introduced into the human body, either through accidental injury or iatrogenic procedures.[2,3] These objects—commonly metal, wood, plastic, or glass—may be inert or irritating.[4] Foreign bodies often remain inert for years without causing harm, but if irritation occurs, they may trigger inflammatory reactions and damage surrounding tissues.[5]

Impaction of foreign bodies in the Oral and Maxillofacial region is uncommon[1] and may present diagnostic challenges due to factors such as object size, type, limited access, and proximity to vital structures[2,3]. Reported cases include traumatic impaction of toothbrushes,[4] vegetative materials,[5] and metallic objects[6] in both children and adults. While some foreign bodies may remain dormant for years without damaging adjacent structures,[7] others may produce chronic inflammatory reactions and lead to infection[8]. Therefore, accurate identification, localization, and timely removal are essential.

2. Case Report

A male patient aged 32yr reported to emergency department with complaints of pain, swelling on right frontozygomatic region and pus discharge from the laceration present of the same region for 4 days accompanied with reduced mouth opening. Patient gave history of trauma due to road traffic accident 1 week ago, which wasn't addressed according to its severity, though patient got regular dressing done, the pain and pus discharge continued and increased eventually. Hence patient was referred to our tertiary hospital for further management.

Palpation revealed a tender swelling over right zygomatic arch , accompanied by pus discharge from existing

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laceration, trismus and interincisal opening of 25mm. CT was done to rule out fracture of maxillofacial skeleton, a USG (**Figure 1**) then revealed heterogeneously hypoechoic area of size 1.4x0.5x1.3cm in right frontozygomatic region, respective region was explored under local anaesthesia through the existing laceration (**Figure 3**), debridement was done and multiple dark wooden stick measuring 1.4x0.5x1.3 cm was retrieved (**Figure 2**). Since there was active infection noticed on site, the wound was thoroughly debrided with hydrogen peroxide followed by saline followed by application of super oxidized solution for 5-6 consecutive days. Patient was given oral antibiotics for 7 days. Pt was kept on regular follow-up and wound was to be closed secondarily.

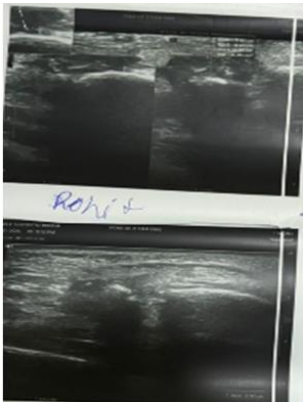

Figure 1: USG revealing heterogeneously hypoechoic areas size 1.4×1.3cm

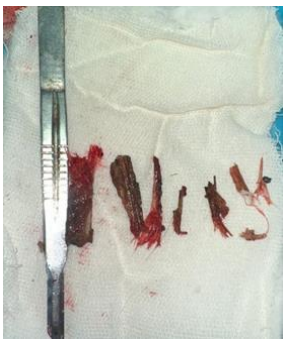

Figure 2: Shows multiple wooden sticks retrieved from right frontozygomatic area

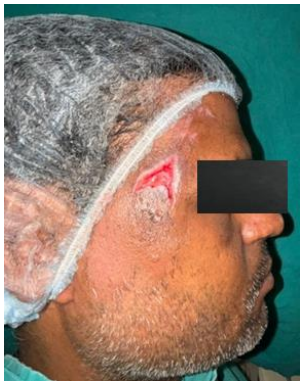

Figure 3: Post-op day 6 shows healthy margin of tissue

3. Discussion

Foreign bodies may be ingested, inserted into a body cavity, especially by children or impacted into the body tissue following a traumatic or iatrogenic injury. The diagnosis and early detection of foreign bodies are usually based on the patient's history, clinical examination and the various radiological imaging methods such as ultrasound, plain radiographs, Computed Tomography, Magnetic Resonance Imaging.[9] The effect of foreign body may differ as per its content and age[1] some can produce chronic inflammatory reaction and need to be removed. Patient presented to us after seeking primary treatment which did not give symptomatic relief, the active infection, tenderness over right frontozygomatic region associated with trismus helped narrow down to infection due to foreign body.

The mode of injury precedes the diagnostic aid. The visibility of materials on plain radiograph depends upon their ability to absorb x-rays.[9] Most foreign bodies are detectable by plain radiographs therefore it is the first diagnostic tool ordered to rule out associated fractures as well as entrapment. In our case, wood being an organic material with low density and not associated with radio-opaque substance, was not visible on plain x-ray therefore USG was done and it revealed the location and size of the foreign body.[9]

Through the existing laceration, accessibility was made and surgical exploration was done under local anaesthesia and pieces of wood were retrieved from right frontozygomatic region as shown in **Figure 2** and none of the important anatomical structures were injured following which thorough debridement was done with 3% hydrogen peroxide and saline consecutively and continued with superoxide. 3% hydrogen peroxide acts as an oxidizing antiseptic, releasing reactive oxygen species that disrupt microbial cell walls and proteins.[11] The effervescence helps mechanically debride contaminated wounds, aiding initial wound cleansing. It provides mild hemostasis in minor bleeding but may delay healing if used repeatedly due to cytotoxicity. After using hydrogen peroxide, saline is applied to flush out residual H_2O_2, stopping further oxidative damage to healthy tissue. It also removes foam and debris, restoring a gentle, physiologic environment. This helps prevent cytotoxicity and supports proper wound healing.[10]

Super oxidized spray releases reactive oxygen species that injures microbial membranes, proteins, and DNA, providing broad-spectrum antimicrobial activity. Its non-cytotoxic, pH-balanced formulation allows safe, repeated use without harming viable tissue. By reducing inflammation and bioburden, it supports granulation and epithelialization which can be remarkably seen in (**Figure 3**), making it effective for ongoing wound irrigation and infection control.[11] With oral antibiotics and regular debridement and no sign of pus, wound healed and was closed primarily.

4. Conclusion

The take home message here is, a detailed case history, the mode of injury lays the path for selection of diagnostic tool aiding retrieval of foreign body without further complications. Presentation time primary or secondary helps decide the line of treatment; secondary presentation often associated with active infection requires thorough debridement and regular follow-up unlike primary which can be accessed and closure can be done with sutures. The diagnostic tool used for localizing foreign body depends upon the nature of foreign body which circles back to the location and mode of injury. Therefore, a full circle of case history, diagnostic tool and surgical skills aids in uncomplicated recovery.

5. Source of Funding

None.

6. Conflict of Interest

None.

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Short Communication

Auto transplantation of impacted tooth aided by 3D printing: A review

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Abstract

Advancements in the field of CBCT imaging and 3D printing have opened up new avenues with respect to auto transplantation treatment of impacted tooth especially in the anterior region where esthetics is of paramount importance. This article aims to illustrate the steps involved in this process.

Keywords: Rapid prototyping, CBCT, 3D printing, Impacted teeth.

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1. Introduction

Any reduction in the duration of orthodontic treatment is desirable by the orthodontists as well as the patients. Various factors can affect the duration of orthodontic treatment. The type of malocclusion as well as choice of treatment mechanics are one of the major factors in determining how much time the treatment will take.[1] In this article, an outline has been etched, which can be followed with appropriate modifications, as individual case of impacted tooth in anterior (aesthetic) zone requires.[2] It illustrates the use of 3D printing as an aid to auto transplantation.

2. Discussion

A case with impacted canine in maxillary left quadrant has been illustrated. (**Figure 1**) After the initial strap-up (**Figure 2**), space is created for the impacted canine (**Figure 3**). A CBCT scan of the maxilla is done to ensure that the canine is not causing any resorption in adjacent lateral incisor or premolar and can be extracted without causing damage to any vital structure (**Figure 4**). The same CBCT scan is then used for creating a prototype by 3D printing (**Figure 5**). Using the prototype, a socket is created for the canine (**Figure 6**). After a satisfactory amount of bone has been drilled in and recipient site prepared in the required shape and size, the impacted canine is exposed attempting minimal damage (**Figure 7**). It is then placed in the prepared socket and splinted with adjacent lateral and premolar. The tooth is positioned slightly higher than occlusal plane (**Figure 8**).The splint is then left in place for about 8 weeks. Root Canal Treatment is carried out during this duration. Normal orthodontic treatment is resumed. When the tooth is orthodontically extruded, it gives a good emergence profile and gingival contour.

Figure 1: Pre-treatment cast with impacted canine and retained deciduous canine

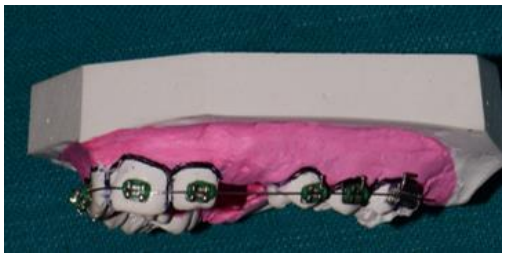

Figure 2: Strap- Up

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Figure 3: Creating space for canine

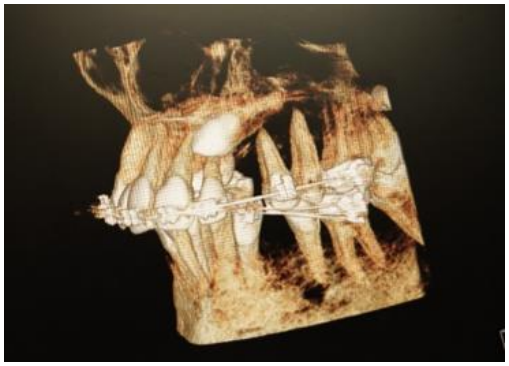

Figure 4: CBCT scan showing impacted canine. It is not causing damage to adjacent lateral or premolar.

Figure 5: Prototype prepared by 3D printing

Figure 6: Recipient site prepared using prototype as guide

Figure 7: Impacted canine exposed and extracted with care

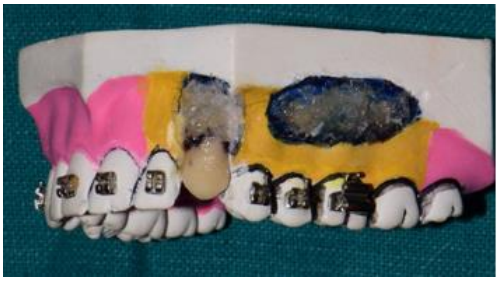

Figure 8: Canine placed at a level higher than occlusal plane and splinted to adjacent teeth.

2.1. Advantages

1. The CBCT scan assisted 3D printed prototype aids in accurate preparation of anatomic site.[3]
2. Auto transplantation avoids the need of complex traction mechanics and minimizes the risk to damage to adjacent teeth4.
3. Can be used in cases where the position of tooth is not favourable thus avoiding possible need for extraction and / or need of prosthetic tooth.[4]
4. The intact periodontal ligament makes orthodontic tooth movement possible.[6]
5. It gives an esthetic outcome because:
   a. The patient's own tooth is used in its anatomical site.
   b. The gingival contour matches that of naturally erupted tooth.[2]
   c. The tooth retains proprioceptive and functional capacity.[6]

2.2. Disadvantages

1. Case selection is very important.
   a. Feasibility of extraction of impacted tooth without damaging adjacent structures has to be gauged judiciously.
   b. Impacted tooth should have intact periodontal ligament.
2. Creates a large bony defect at extraction site that needs to be filled with bone graft.
3. Patient's acceptance to surgery is required.
4. A 10% risk of failure of auto transplantation persists.

3. Conclusion

Rapid prototyping of impacted tooth by 3D printing using CBCT scan ensures that the recipient site it prepared with

considerable accuracy before the impacted tooth is extracted. Hence, the impacted tooth spends minimal amount of outside the oral cavity during surgery. This considerably increases the success rate of the auto transplantation procedure. This auto transplantation procedure allows the patient's own tooth to be brought into its anatomical location with reduced treatment time and increased esthetic outcome.

4. Source of Funding

None.

5. Conflict of Interest

None.

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Short Communication

Mesenchymal stem cell exosomes in periodontal regenerations

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Abstract

Periodontal diseases are chronic inflammatory conditions affecting the tooth-supporting structures and represent a significant global health burden due to their high prevalence, complex etiology, and the need for long-term treatment and maintenance. While conventional periodontal therapy effectively halts disease progression through mechanotherapy and chemotherapeutic approaches, predictable regeneration of the lost periodontal apparatus remains a major clinical challenge. Various graft materials such as autografts, allografts, and xenografts have been employed with varying degrees of clinical success; however, consistent histological evidence of true periodontal regeneration remains elusive.

Recent advances in regenerative medicine have shifted focus toward biologically driven strategies involving signaling molecules, cells, and scaffolds to promote periodontal regeneration. Among these, mesenchymal stem/stromal cell (MSC)–derived exosomes have emerged as a promising cell-free therapeutic modality. Exosomes are nano-sized extracellular vesicles that mediate intercellular communication and possess potent immunomodulatory, anti-inflammatory, angiogenic, and regenerative properties. MSC-derived exosomes have demonstrated the ability to suppress inflammatory responses and enhance tissue repair through the delivery of bioactive molecules.

Preclinical evidence suggests that MSC exosome–based therapies can enhance periodontal ligament cell function and promote periodontal regeneration. Experimental studies using exosome-loaded collagen scaffolds have shown significant improvements in alveolar bone formation, functional periodontal ligament regeneration, and inhibition of epithelial down-growth in animal models. These findings indicate that transient exposure to MSC-derived exosomes may initiate sustained endogenous regenerative processes.

Although clinical application of MSC exosomes in periodontology is still in its early stages, ongoing clinical trials highlight their translational potential. MSC-derived exosomes represent a novel and promising approach for achieving predictable periodontal regeneration and may overcome the limitations associated with conventional grafting and cell-based therapies.

Keywords: Alveolar bone, Tissue engineering, Cell-free therapy.

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1. Introduction

Periodontal diseases are chronic inflammatory disorders that affect the tooth-supporting structures, including the gingiva, periodontal ligament (PDL), cementum, and alveolar bone. They are among the most prevalent oral diseases worldwide and constitute a major cause of tooth loss in adults. Epidemiological studies indicate that severe periodontitis affects a substantial proportion of the global population, contributing significantly to oral dysfunction, aesthetic compromise, and diminished quality of life. In addition to local effects, periodontal diseases have been associated with several systemic conditions, including diabetes mellitus, cardiovascular diseases, and adverse pregnancy outcomes, further amplifying their public health importance.[1]

The global burden of periodontal disease remains high due to its multifactorial etiology, chronic progressive nature, and the need for lifelong maintenance therapy. Conventional periodontal therapy aims to control the microbial biofilm and suppress inflammation primarily through mechanical debridement, surgical intervention, and adjunctive chemotherapeutic agents. These approaches are effective in halting disease progression and maintaining periodontal stability; however, they fall short of predictably regenerating the lost periodontal tissues.

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The ultimate goal of periodontal therapy is the regeneration of the periodontal attachment apparatus, defined histologically by the formation of new cementum with inserting collagen fibers, a functionally oriented periodontal ligament, and newly formed alveolar bone. Over the decades, various regenerative techniques such as guided tissue regeneration (GTR), bone grafting, and the use of biologics have been explored to achieve this objective. Autografts, allografts, xenografts, and synthetic bone substitutes have been extensively used with variable clinical outcomes. Despite measurable clinical improvements in probing depth reduction and clinical attachment gain, true periodontal regeneration as evidenced by histological studies remains unpredictable and inconsistent.

In recent years, advances in regenerative medicine and tissue engineering have introduced novel biologically driven strategies that aim to enhance the intrinsic regenerative capacity of periodontal tissues. These approaches involve the coordinated use of signaling molecules, cells, and scaffolds to stimulate endogenous healing processes. Cell-based therapies utilizing mesenchymal stem/stromal cells (MSCs) and adult fibroblasts have demonstrated encouraging results in experimental studies; however, their clinical application is limited by concerns related to immune rejection, tumorigenicity, ethical issues, cost, and regulatory complexities.

Emerging evidence suggests that the regenerative effects of MSCs are primarily mediated through their paracrine activity rather than direct cell differentiation. This paracrine signaling is largely facilitated by extracellular vesicles, particularly exosomes. MSC-derived exosomes have gained increasing attention as a cell-free regenerative therapy due to their ability to modulate inflammation, promote angiogenesis, and enhance tissue regeneration. Consequently, exosome-based therapies, often combined with suitable scaffold systems including nano-scaffolds, represent a promising and innovative approach in periodontal regeneration.

This article reviews the role of mesenchymal stem cell–derived exosomes in periodontal regeneration, focusing on their biological characteristics, mechanisms of action, experimental evidence, and translational potential.

2. MSCs-Exosomes

Stem cells, just like every other cell in the human body, release exosomes to communicate with each other. Exosomes are membrane-bound vesicles with a diameter of about 40–160 nm, which are released from cells by an endosomal pathway.

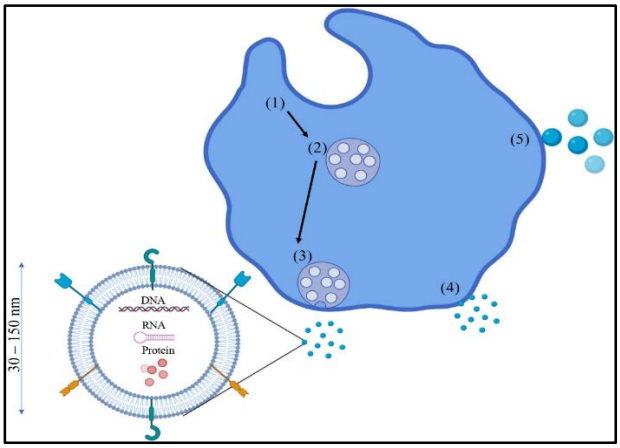

Figure 1: Exosomes: Exosome formation typically begins as endosomes (1) begin to bud inward and form multi-vesicular bodies (MVBs) (2). These MVBs then fuse with the plasma membrane (3) and release the exosomes into the intracellular space. Plasma membrane can also bleb off small extracellular vesicles 30–150 nm in diameter which fall in the same size classification as exosomes, so differentiating the two can be difficult (4). If these plasma membrane blebs are > 150 nm in diameter, they are classified as microvesicles or microparticles (5). Exosomes can contain a number of different molecules as cargo such as proteins/cytokines (free floating and membrane bound), DNA, RNA, and other nucleic acids.

Cholesterol, sphingomyelin, ceramide, and various lipid molecules are found in large quantities on the exosomal membrane (Mashouri et al., 2019).[2] Once the exosomes are released into the intercellular space, they can be taken up by recipient cells by endocytosis, receptor–ligand binding, or through direct binding (Kahroba et al., 2019).[3]

2.1. Potential mechanisms of action

Mesenchymal stem/stromal cells have been shown to suppress inflammation through direct cell-to-cell contact in inflamed tissues and through production of numerous anti-inflammatory molecules such as indoleamine 2,3 dioxygenase (IDO) (Su et al., 2014),[4] nitric oxide (NO) (Su et al., 2014),[4] prostaglandin E2 (PGE2) (Hsu et al., 2013),[5] transforming growth factor (TGF)-β, heme oxygenase 1 (HO1) and hepatocyte growth factor (HGF) among others. These molecules suppress the effect of immune cells such as macrophages Eslani et al., 2018),[6] monocytes, dendritic cells. B-cells, NK cells and T-cells.

In addition to soluble factors, MSCs influence target cells through the secretion of exosomes, which encapsulate and deliver bioactive molecules directly to recipient cells. MSC-derived exosomes have been shown to modulate macrophage polarization, reduce pro-inflammatory cytokine production, and promote a regenerative microenvironment. These properties are particularly relevant in periodontal disease, where chronic inflammation plays a central role in tissue destruction.

Preclinical studies have demonstrated the therapeutic potential of MSC-derived exosomes in a variety of pathological conditions, including wound healing (Fang et al., 2016; Samaeekia et al., 2018),[7] angiogenesis (Huang et al., 2017),[8] ischemic injury, and inflammatory diseases. By delivering microRNAs and proteins that regulate cell proliferation, differentiation, and survival, exosomes can orchestrate complex regenerative processes without the risks associated with live cell transplantation

2.2. Mesenchymal stem cell exosomes enhance periodontal ligament cell functions and promote periodontal regeneration

The application of MSC-derived exosomes in periodontal regeneration has gained increasing attention due to their ability to enhance periodontal ligament cell function and promote tissue repair. One of the most significant studies in this field was conducted by Jacob Ren Jie Chew et al. in 2019,[9] who investigated the regenerative potential of MSC exosome-loaded collagen sponges in an immunocompetent rat periodontal defect model.

In this study, human MSC-derived exosomes were incorporated into collagen sponges and implanted into surgically created periodontal defects. The authors demonstrated that exosome-loaded collagen scaffolds significantly enhanced periodontal regeneration without eliciting any adverse immune reactions. Periodontal regeneration was evaluated using standard parameters, including alveolar bone formation, functional periodontal ligament length, and inhibition of epithelial down-growth.

Collagen sponges were selected as the scaffold material due to their widespread clinical use, biocompatibility, radiolucency, resorbability, and relative inertness compared to bone substitutes such as deproteinized bovine bone mineral. These characteristics made collagen an ideal scaffold for evaluating the regenerative effects of MSC-derived exosomes on periodontal tissues.

The study revealed that a single application of exosome-loaded collagen sponge resulted in significantly enhanced bone regeneration and increased functional periodontal ligament length at four weeks post-implantation. Notably, although exosomes were rapidly released and degraded within the first 48 hours, their regenerative effects persisted for at least four weeks. This finding suggests that transient exposure to MSC-derived exosomes may be sufficient to initiate a sustained regenerative cascade by restoring tissue homeostasis and activating endogenous repair mechanisms.

These observations support the hypothesis that MSC-derived exosomes act as biological triggers that modulate the local microenvironment, reduce inflammation, and promote coordinated tissue regeneration rather than serving as long-term structural components.

3. Clinical Translation and Current Status

Despite promising preclinical evidence, the clinical application of MSC-derived exosomes in periodontology remains in its early stages. To date, no completed human clinical trials specifically evaluating MSC exosome therapy for periodontal regeneration have been published. However, ongoing clinical trials indicate growing interest in translating this technology into clinical practice.

One such study titled “Effect of Adipose-Derived Stem Cell Exosomes as an Adjunctive Therapy to Scaling and Root Planing in the Treatment of Periodontitis” is currently underway. This trial aims to evaluate the safety and efficacy of exosome-based therapy as an adjunct to conventional periodontal treatment. The outcomes of such studies are expected to provide valuable insights into the feasibility, optimal dosage, delivery methods, and long-term effects of MSC-derived exosomes in periodontal therapy.

4. Conclusions

Periodontal regeneration remains one of the most challenging objectives in periodontal therapy due to the complex architecture and functional requirements of the periodontal tissues. While conventional grafting materials and regenerative techniques have demonstrated clinical benefits, predictable and complete regeneration of the periodontal attachment apparatus remains elusive.

Mesenchymal stem/stromal cell–derived exosomes represent a novel and promising cell-free therapeutic approach for periodontal regeneration. Their potent immunomodulatory, anti-inflammatory, and regenerative properties, combined with reduced safety concerns compared to cell-based therapies, make them attractive candidates for future clinical applications. Emerging preclinical evidence suggests that MSC-derived exosomes can enhance periodontal regeneration by modulating the local microenvironment and activating endogenous repair mechanisms.

Although clinical translation is still in its early phases, ongoing research and clinical trials highlight the potential of MSC exosome–based therapies to revolutionize periodontal regeneration. With further investigation into optimal delivery systems, dosage, and long-term outcomes, MSC-derived exosomes may offer a predictable and biologically driven solution for achieving true periodontal regeneration in the future.

5. Source of Funding

None.

6. Conflict of Interest

None.

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