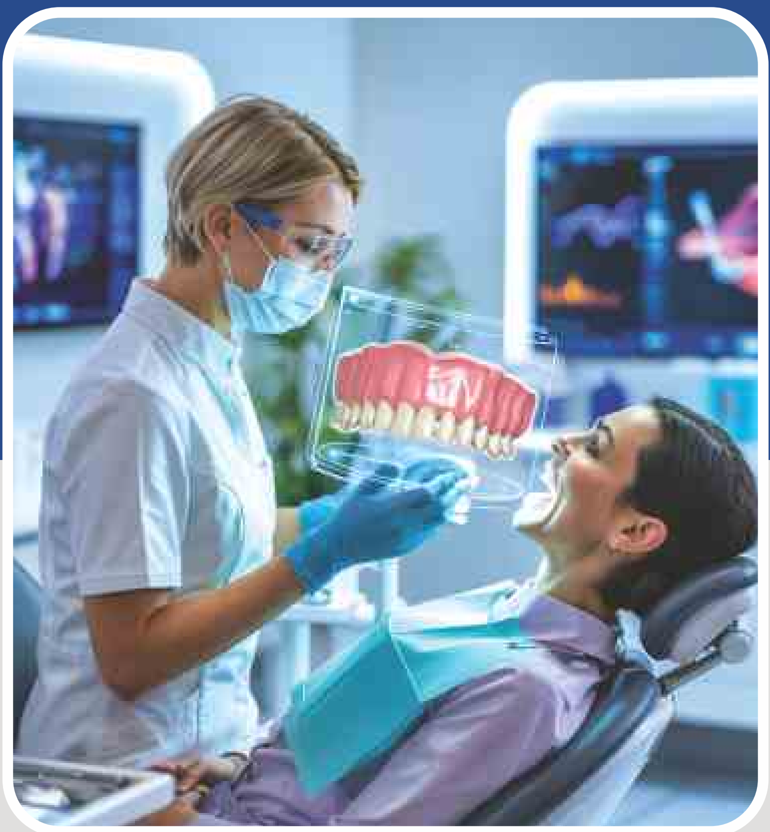
JIDAK

JOURNAL OF INDIAN DENTAL ASSOCIATION - KOCHI



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Journal of Indian Association of Kochi Branch (JIDAK) is the official scientific publication of Indian Dental Association, Kochi Branch. It is a peer-reviewed journal published triannually in e-format as well as print format.

The journal invites manuscripts from dental and other allied health sciences. It publishes manuscripts under categories of Original Research, Review and Case Reports.

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Editorial Board

PRESIDENT'S MESSAGE

Dear Members,

As we bring to you the final issue of the Journal of Indian Dental Association, Kochi Branch (JIDAK) for the year 2025, I take this opportunity to reflect with pride and gratitude on a year filled with academic achievements, professional camaraderie, and community service.

Throughout the year, JIDAK has continued to serve as a platform for scientific expression and professional growth, showcasing the talent, research, and clinical insights of our members.

As we step into a new year, let us continue to embrace innovation and lifelong learning while upholding the values of ethics and service that define our profession.

I extend my heartfelt appreciation to the Chief Editor Dr. Pooja Latti and her editorial team for their dedication in bringing out each issue with such quality and consistency in a time-bound frame, and to all contributors who enriched the journal with their valuable work.

May the coming year bring renewed enthusiasm, new ideas, and greater collaboration among us all. Together, let us continue to strengthen our association and inspire the next generation of dental professionals.

Wishing all our members and readers a wonderful year ahead filled with health, happiness, and success.

Warm regards,

Dr. Harigovind B
President, IDA Kochi Branch

SECRETARY'S MESSAGE

Dear Members,

It's a proud moment to witness the release of the third volume of the Journal this year— a true reflection of our branch's academic spirit and professional dedication. Academic writing is more than documentation; it is how we learn, share, and grow as a community. Each article or case report represents a spark of curiosity and a contribution to the collective wisdom of our profession. I encourage every member, especially our young colleagues, to engage in this process — to write, publish, and be part of this intellectual journey.

My heartfelt appreciation goes to the Editorial Team for their commitment, creativity, and perseverance in maintaining the journal's quality and continuity. Their work keeps our academic flame burning bright.

Dr. Vivek Narayan
Hon. Secretary, IDA Kochi Branch

Dear Readers,

As we step into the vibrant season of festivals - from Onam's spirit of togetherness to the joy of Diwali's lights - it is a time that reminds us of renewal, reflection, and gratitude. Much like these celebrations that bring people closer, our journal too serves as a bridge connecting clinicians, academicians, and students through shared knowledge and scientific curiosity.

The months of August to October also mark several important health observances - National Oral Hygiene Day (August 1), World Suicide Prevention Day (September 10), and World Mental Health Day (October 10) - all of which highlight the holistic nature of health, reminding us that oral well-being is deeply intertwined with overall wellness and emotional resilience.

In keeping with our mandate to foster academic excellence, this issue features a selection of articles that push the boundaries of contemporary dental practice, offering clinically relevant insights and exploring innovative concepts. Our feature on Omnichrome, a universal composite - single shade, provides a meticulous guide on this material for achieving biomimetic results. The Gut-Mouth Axis: we delve into the rapidly evolving field of Probiotics in Oral Health, examining the evidence for modulating the role of oral microbiome in oral diseases. Beyond the Usual Suspects: A critical article explores Non-Tobacco Reasons for Oral Cancer which sheds light on less-commonly discussed etiological factors. Finally, the future of materials science is discussed in our piece on Smart Dental Materials.

Together, these contributions reflect our collective commitment to advancing knowledge and improving patient care through science, innovation, and collaboration. We encourage all readers to engage deeply with the scientific articles presented.

Warm regards,

Dr. Pooja Latti
Chief Editor, JIDAK

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CASE REPORT

OMNICHROMA – "ONE SHADE TO MATCH THEM ALL": A CLINICAL PERSPECTIVE

ABSTRACT

Shade selection in restorative dentistry often involves a frustrating trial-and-error process. Clinicians juggle multiple composite shades, yet still struggle with mismatches due to metamerism, translucency, and aging effects. This article briefly discusses a product Omnichroma (Tokuyama Dental) which proposes a radical shift using a single shade of composite for all teeth by leveraging structural colour, rather than traditional pigments. Single-shade composite offers a practical, time-saving solution that could be especially beneficial for general practitioners.

Key words: Single shade composite, Structural colour, Shade matching, Chameleon effect, Adaptive light matching, Opalescence, Fluorescence.

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BACKGROUND

Traditionally, composite systems have relied on an array of pre-shaded materials based on guides like the VITA classical shade system. With increasing patient expectations for life-like restorations, the ability of composite resins to mimic the colour, translucency, and optical behavior of natural dentition has become a cornerstone of modern restorative practice. Clinicians must select the closest match from multiple options and may need to layer different shades and opacities to achieve a realistic result. This process is time-consuming, technique-sensitive, and inherently subjective, often leading to inconsistencies in outcomes. The challenge lies in the complex interplay of factors that determine tooth colour such as dentin shade, enamel translucency, and light reflection and how these are perceived under different lighting conditions. Moreover, variations in age, ethnicity, and lighting conditions further complicate shade selection[1].

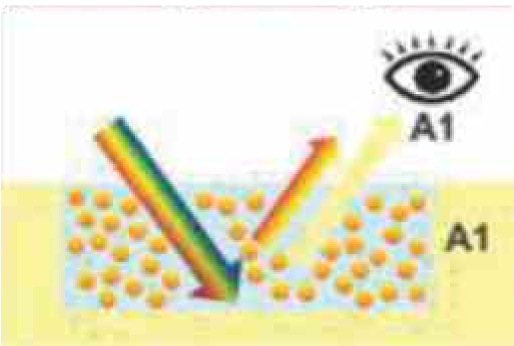
Current approaches include the following[2]:

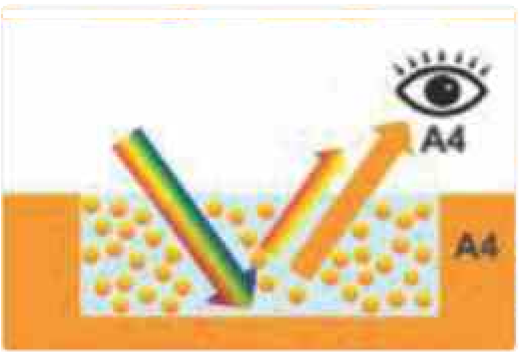
Technology/Technique	How it Works	Examples (& Availability In India)
Chemical Colour (Pigmented)	Traditional method: adds red/yellow dyes and pigments to match specific shades.	3M Filtek Universal Restorative (available); Ivoclar Tetric Prime, GC G-ænial A'Chord (all available)
Simplified colourimetric envelopes ("Cloud-Shade")	Packs limited shades (light, medium, dark) calibrated to Vita value; simpler than multi-shade layering.	GC G-ænial A'Chord, Ivoclar Tetric Prime, Dentsply TPH Spectra LT, 3M Filtek Universal, Kerr SimplyShade (all available)
Smart-Chameleon / Adaptive light matching	Highly translucent composites that "borrow" light from surrounding tooth to blend dynamically. Relies on filler-pigment mix.	3M Filtek Universal Restorative (USA); Activa SimpliShade (USA) [not yet common in India.]
Structural colour[1] / "Smart Chromatic"	Uses uniform ~260 nm spherical fillers to create interference-based red-yellow structural colour no pigments.	Omnichroma (Tokuyama) – available; Vittra APS Unique (FGM, Brazil) – not available; Venus Pearl One (Kulzer), Zen Chroma, Beautifil UniShade, Clearfil Majesty ES-2 U, Ecosite One, ONE Shade – availability: mostly not in India, some imported only
Opalescence / Fluorescence-enhanced composites	Mimics enamel optical behavior scattering blue in reflected light and orange-red in transmitted light, aiding blend.	Many nanohybrids with opalescent effects: GC Essentia Universal, Estelite S Quick, Gradia Direct, Charisma Diamond; most available in India
Pigment + translucency hybrid	Combines standard pigments with increased translucency to enhance chameleon/blending effect.	3M Filtek Universal Restorative (available)

Effective shade matching is not merely a cosmetic concern it influences patient satisfaction, clinical confidence, and restoration longevity. As aesthetic demands rise, mastering shade selection remains both a clinical art and a scientific challenge.

The Science Behind Omnichroma

Through the utilization of Tokuyama's spherical fillers and Smart Chromatic Technology, OMNICHROMA is the first use of structural colour in composite dentistry. Omnichroma's ability to match a wide shade range arises from structural colour technology. Unlike conventional composites that rely on added pigments, Omnichroma uses uniformly sized spherical fillers (260 nm) to scatter and reflect light in a way that mimics surrounding tooth structure[3,4]. When cured, the material appears to "blend in" with A1–D4 VITA shades[4].





OMNICHROMA Fillers generate red-to yellow structural colour as ambient light passes through the composite, without the need of added pigments and dyes. The red-to-yellow colour combines with the reflected colour of the patient's surrounding dentition, creating the perfect match from A1 to D4 and beyond.

Shade Matching: How Well Does It Work?

Clinical and in-vitro studies show that Omnichroma performs acceptably across most common shades, especially in class III, V, and small class I/II restorations[4]. In cases with strong ambient lighting or optimal isolation, esthetic integration is often impressive.

Prior to restoration

Post-operative image restored with OMNICHROMA

However, deep shades (A4/C4) or high-translucency anterior restorations may expose its limitations[5]. The broader challenge is that shade perception varies among clinicians, and conventional shade guides can be subjective[6]. In this context, Omnichroma simplifies clinical workflow by removing shade selection altogether, with comparable outcomes to multi-shade systems in many scenarios[5].

That being said, traditional pigment-based composites are still widely used. This can probably be attributed to the fact that they allow precise shade matching and customization, especially for complex anterior restorations where multi-shade layering meets esthetic demands better than single-shade composites. Familiarity and clinical confidence among practitioners in using these systems support their persistence. Cost-wise, single-shade composites may be priced higher per unit, while pigment-based variants remain economical and versatile in handling properties. Additionally, supply availability favors traditional composites globally. Finally, single-shade composites rely on optical effects that can be less effective in deep or highly discolored cavities, limiting their universal applicability at present.

Clinical workflow

Fig 1.
Clinical workflow for most clinical cases[7]

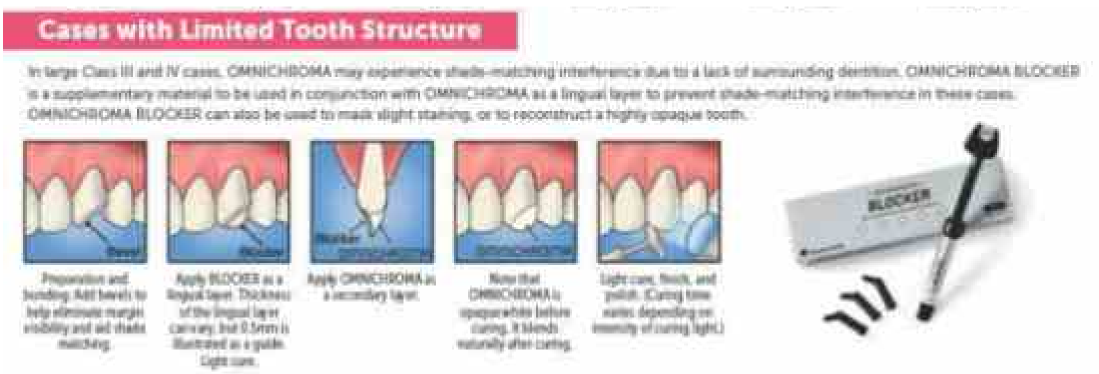


Fig 2.
Clinical workflow for cases with limited tooth structure[8]

Fig 3.
Clinical case done using Omnichroma[9]

Clinical Handling, Polishing & Workflow Impact

Omnichroma's creamy consistency allows smooth adaptation and sculpting, especially with warmed instruments[10]. Surface finish is best achieved with multi-step polishing protocols that enhance gloss and longevity[11]. The absence of multiple shade tubes significantly reduces inventory burden, particularly in busy general practices[12].

Limitations: Opacity, Fluorescence, and Masking Ability

Despite its strengths, Omnichroma is not a universal solution for all cases. Reports note insufficient fluorescence, which may affect lifelike appearance under UV or operatory lighting . Its relatively high opacity can sometimes lead to a visible halo or mismatch in large anterior restorations8. In cases involving dark dentin, masking ability may be inadequate without a blocker or opaque liner[12,13].

Alternatives: Other Universal Shade Composites

Other manufacturers offer single-shade composites with improved masking or handling. Products like Essentia Universal (GC), Zenchroma (Prevest), and Tetric EvoCeram® Universal (Ivoclar) combine multiple pigment technologies to extend shade compatibility[10,11]. These materials sometimes outperform Omnichroma in posterior restorations where opacity and wear resistance matter more.

Conclusion

Omnichroma marks a notable advancement in composite resin science by applying structural colour for esthetic dentistry. It offers genuine advantages in simplicity and shade blending, especially in small to moderate restorations (12). However, clinicians should remain discerning: in deep, anterior, or discoloured lesions, alternative materials may still besuperior. A practical approach involves keeping Omnichroma for general cases while reserving layered esthetic materials for more demanding work. Universal composites represent a promising direction, but not a one-size-fits-all solution at least not yet.

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REVIEW ARTICLE

INTELLIGENT INNOVATIONS: THE RISE OF SMART MATERIALS IN MODERN DENTISTRY

ABSTRACT

Smart materials in dentistry represent a significant advancement in dental science, enabling materials to sense and respond dynamically to environmental changes within the oral cavity. These materials possess adaptive properties such as shape memory, bioactivity, pH sensitivity, and temperature responsiveness, enhancing their performance and longevity. Common examples include shape memory alloys for orthodontic applications, pH-sensitive glass ionomer cements for caries prevention, and bioactive composites that promote remineralization, Silver nanoparticles that release antibacterial ions. Smart polymers and hydrogels further contribute to targeted drug delivery, controlled fluoride release, and improved tissue regeneration. Their ability to interact intelligently with oral conditions leads to improved patient comfort, reduced treatment time, and enhanced clinical outcomes. Despite their numerous advantages, challenges remain in terms of cost, long-term biocompatibility, limited long-term durability, regulatory and clinical barriers. Continuous research and technological integration are essential to overcome these limitations and expand their applications. Applications in biomedical field include smart pressure bandages that undergoes shrinkage when exposed to blood. The future of smart materials in dentistry lies in the development of multifunctional, biocompatible systems that seamlessly combine mechanical strength with biological intelligence to achieve personalized, preventive, and minimally invasive dental care.

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INTRODUCTION

Traditionally, materials designed for long-term use in the mouth are thought to survive longer if they are 'passive' and have no interaction with their environment. Materials such as amalgams, composites and cements are often judged on their ability to survive without interacting with the oral environment. Perhaps the first inclination that an 'active' rather than 'passive' material could be attractive was the realization of the benefit of fluoride release from materials[1]. Situation in hand is altered; the smart biomaterials react in the presence of saliva and other environmental factors. Various recent materials in materials science are in working order, meaning they must achieve their tasks and should go through intentional modification. Smart materials change one or more of their characteristics in response to inputs. They actively contribute to the functionality of the structure or apparatus[2].

The capacity to revert to the initial state following the removal of the stimulus is a crucial component of intelligent behavior. The first smart dental material to be used in dentistry were the nickel-titanium alloys, used as orthodontic wires.[3]

Smart materials are being created in search of ideal materials, which may result in smart dentistry. Modern dental tools have been enhanced to become more sophisticated and knowledgeable. Moreover in recent years, dentistry has improved because of these innovative materials[4].

Recent advances in technology and manufacturing tools e.g., additive manufacturing are enabling the development of "smart" dental materials that offer multiple functionalities for different therapies. In general, "smart" biomaterials change one or more of their properties in response to a stimulus. The definition of smart biomaterials is very broad, often misinterpreted, and non-inclusive hampering the identification and classification of biomaterials with different magnitudes of "smart" functions. To solve this dichotomy, Montoya et al. (2021) purposely classified smart biomaterials according to their level of smartness, which was determined by the degree of interaction between the biomaterial and the surroundings, and the precision to deliver a therapy. Four levels of smart biomaterials were defined, including bioinert, bioactive, bioresponsive, and autonomous.[5]

Dentistry's use of smart materials dates back to inventions in the early 20th century. During World War I, nickel was used in sonar systems due to its magnetostrictive properties, marking one of the earliest uses of stimulus-responsive materials. In 1938, the shape memory effect was first observed in copper-zinc and copper-tin alloys by Greniger and Mooradian, laying the groundwork for later smart material applications. This was further advanced in 1962 when Nickel-Titanium (NiTi) alloys were discovered to exhibit shape memory behavior an innovation that became foundational in orthodontics and endodontics, particularly for archwires and root canal instruments. The term "smart materials" was officially coined in the 1980s in the United States, originally for aerospace and military uses, but it was later adapted for biomedical and dental applications. A major milestone came in 1995 when researchers at ETH Zurich developed the Cercon Smart Ceramics System, which introduced machinable zirconia blocks for use in CAD/CAM dental crowns and bridges, significantly advancing smart ceramic technology in restorative dentistry.

Definition

Smart materials: materials that have properties which can be altered in a controlled manner when exposed to different stimuli like stress, moisture, temperature, Ph, magnetic and electric field.

McCabe Zrinyi defined smart materials as "materials that are able to be altered different stimuli and can transform back into its original state after removal of stimulus"[6].

Classification

Classification Of Smart Materials Smart materials are of two types passive and active materials.

I) **Passive Smart Materials:** They sense the external change and react to it without external control. They also possess self - repairing property.

Examples

1. GIC (Glass Ionomer Cement) – used for filling cavities in baby teeth.
2. Resin Modified GIC – used as a liner under composite fillings.
3. Compomer – used for restorations in children's teeth.
4. Dental Composites – used for aesthetic fillings in front teeth.
5. Giomer – used for restorations that release fluoride and look natural.[3]

II) Active Smart Materials: Active materials sense change in the environment and respond to them. Utilize a feedback loop to enable them to functions as a cognitive response through a controlled mechanism or system.[3]

Examples

1. Silver nanoparticles (Ag NPs) – release antibacterial ions.
2. Calcium phosphate / nano-hydroxyapatite – release minerals to remineralize teeth.
3. PAMAM dendrimers - fight bacteria and help tooth repair.
4. Liposome-based carriers - stick to teeth and release agents slowly.
5. Bioceramics / calcium silicate cements - help dentin healing and sealing.[7]

TABLE 1.0 SMART MATERIALS USED IN DENTISTRY

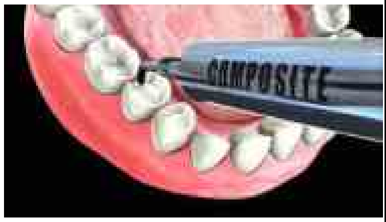
RESTORATIVE MATERIALS	TYPES
Restorative Dentistry[4,8]	1.Smart GIC. 2.Smart composites. 3.Smart Prep Burs. 4.Smart bonding system.
Prosthetic Dentistry[9]	1.Smart ceramics. 2.Smart impression materials.
Orthodontics[3,4]	1.Shape memory alloys.
	2.Smart orthodontic adhesive.
Pediatric and Preventive Dentistry[6]	1.Fluoride releasing pit and fissure sealants. 2.ACP releasing pits and fissure sealants. 3.Smart varnish.
Endodontics[9,10]	1.Niti Rotary Instruments. 2.Smartseal obturation system. 3.Smart Fiber posts.
Laser Dentistry[6]	1.Smart Fibers. 2.Periodontics 3.Smart antimicrobial peptide.
Implant Dentistry[9]	1.Smart coatings on implant.
Oral Surgery[9]	1.Smart sutures. 2.Bioactive glass

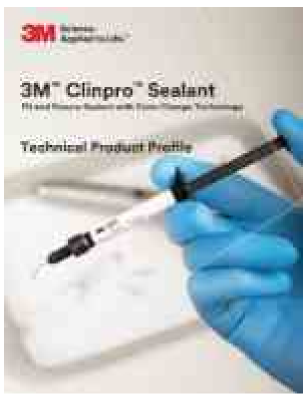
Characteristics of Smart Material in Dentistry

- React to changes like pH, temperature, or pressure.
- Work only when needed, such as releasing fluoride or medicine.
- Help teeth heal by promoting remineralization.
- Can return to shape after being bent or stretched (shape memory).
- Strong and flexible – combine strength with adaptability.
- Last longer than traditional materials in the mouth.
- Help protect teeth by fixing problems as they happen.
- Improve treatments and give better results for patients.

Properties and Description of Various Smart Materials used in Dentistry

PROPERTIES	DESCRIPTION	IMAGE	APPLICATION
Piezoelectric Material[5]	These are the materials which produce voltage when stress is applied and vice versa... In dentistry, this property is seen in , (PIEZO soft), smart ceramics and smart burs		**SMART BUR** the bur removes the soft, decayed tissues only.
Magneto strictive materials[6]	Similar to piezoelectric, respond to only magnetic fields rather than electric. One example used in dentistry is magnetostrictive ultrasonic scaler.		**PIEZO SCALER** Remove calculus and stains around implants
Magnetorheo logical materials[6]	Magnetorheological materials: These fluids contain either ferromagnetic or ferromagnetic particles that are dispersed or suspended, and a magnetic field is used as a stimulus.		**BIOACTIVE MAGNETIC COMPOSITE** -antimicrobial action -secondary dentin formation

Thermoresponsive material[3]	The presence of a glass transition temperature distinguishes amorphous and semi crystalline thermoplastic polymers.		**SHAPE-MEMORY POLYMERS (SMPS)** -Self-sealing at 37 °C root-canals
Light sensitive materials[6]	There are several material families that exhibit different types of behaviour to light stimulus. Electro-chromism is a change in colour as a function of an electric field.		**LIGHT CURED COMPOSITE RESIN** -INLAYS -ONLAYS -VENEER
Smart polymer[6]	Smart polymers or stimuli-responsive polymers are high-performance polymers that change according to the environment they are in.		**PH SENSTIVE POLYMER** -ANTICARIES RESTORATIVE COMPOSITE
Smart gels[10]	The concept of smart gels combines the basic concept of solvent-swollen polymer networks with the ability of the materials to respond to a variety of stimuli. Some gels can expand to hundreds of times their original volume or could collapse to expel upto 90% of their fluid content with a stimulus of temperature		**SMART ETCH** -PREVENT OVER ETCHING -REDUCE POST OPERATIVE SENSITIVITY

Smart Catalysts[9]	Unlike traditional one, these catalyst functions in an opposite way. With rise in temperature, they becomes less soluble, thus precipitates out of solution and becomes inactive. In the similar way, with decrease in temperature of the solution, this catalyst redissolves itself and becomes active a gain.		**<u>LIGHT CURED SELF HEALING COMPOSITE</u>** -MITIGITING SECONDARY CARIES
Shape Memory[6]	Some materials have the potential of changing their shape under pressure and once it is released they regain their original shape for e.g. NiTi. Rotary instruments. They are unique in a way that they can recover permanent strains when heated above a certain degree of temperature		**<u>NI TI ROTARY</u>** -RCT
Photochromic[10]	These materials change color in response to changes in light conditions. eg: - Clinpro™ Sealant (3M)		**<u>CLINPRO SEALENT</u>** AESTHETIC DENTISTRY

Requirements

According to Williams "smart" materials can respond to an external stimulus in a specific, controlled way. Conventional restorative materials can fail for a variety of causes, such as wear, marginal differences, secondary caries, and repair and tooth fractures. By introducing specific chemicals, smart materials tend to decrease these failures.

Smart materials respond by:

- Preventing secondary caries
- Preventing fracture of restoration
- Preventing fracture of tooth
- Providing a good marginal integrity
- Reducing wear
- Preventing marginal discrepancies
- Preventing wear[9]

Criteria for a Smart Material

- Asymmetrical nature
- Receiving and responding to stimuli
- Include at least one material with a smart structure[9]

Mechanism of Smart Materials

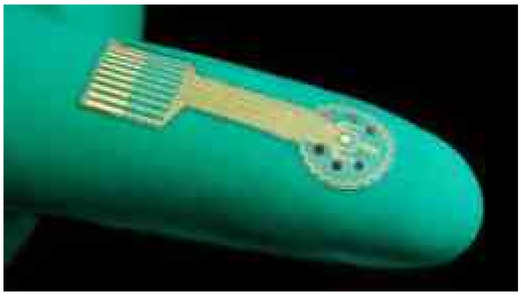
Bio-smart materials work by two mechanisms:

- Firstly, Promoting tissue repair and regeneration. They have inductive and instructional effects on body cells and tissues in presence of external and internal stimuli such as temperature, pH, magnetic and ionic strength.
- They can smartly and intelligently alter individuals' properties and controlled functions to engage actively in tissue regeneration.[9]

Applications in Biomedical Field

Smart Pressure Bandages

Polyethylene glycols bonded to different fibrous materials, such as cotton and polyester, exhibit intelligent properties like thermal adaptability and reversible shrinkage. Reversible shrinkage involves imparting a dimensional memory to the material such that when the material is exposed to a liquid it shrinks in the area. Such materials could be used for pressure bandages that contract when exposed to blood[9].



Hydrogel

They demonstrate plastic contraction in response to variations in temperature, pH, or magnetic and electrical fields. These materials have a wide range of applications, such as serving as soft actuators in the biomedical field or enabling controlled drug release.[10]

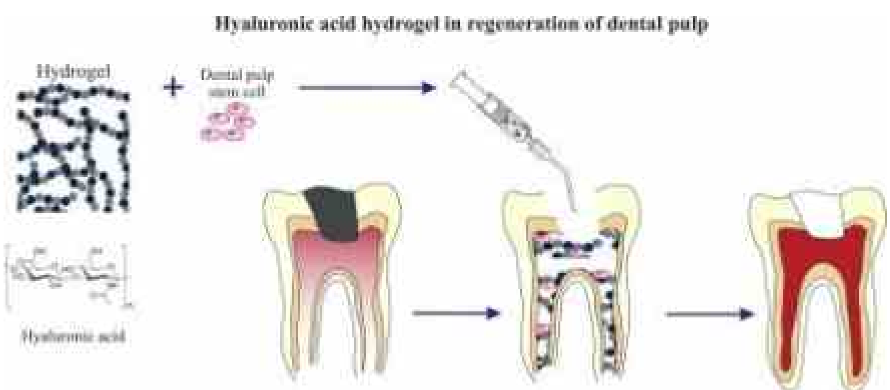


Figure 1: Effect of Hydrogel on dental pulp[12]

Future Scope of Smart Material in Dentistry[5]

Area	What Smart Materials Can Do	Current / Potential Examples
Antimicrobial / Infection Control	Respond to pH, enzymes, or light to kill or suppress bacteria; release antimicrobial agents only when needed.	pH-sensitive polymers; light-activated antibacterial coatings.
Stimuli-Responsive Restoratives	Change properties with temperature, moisture, etc. (e.g., expand, self-repair, remineralize).	Smart composites; calcium phosphate releasing sealants; resin-modified glass ionomers.
Shape-Memory Materials / Actuators	Return to original shape or respond to heat/stimuli to change position useful in orthodontics.	NiTi shape memory alloy wires in braces.
Bioactive / Biomimetic Materials	Mimic natural tooth/bone; promote tissue repair and remineralization.	Bioactive glass; nanomaterials resembling enamel/dentin.
Multifunctional Smart Materials	Combine multiple smart features like antimicrobial + self-repair + bioactivity.	Nanocomposites with combined responsiveness and antibacterial effects.
Clinical Translation & Implementation	Use in real-world dentistry easy to apply, effective in long-term dental care.	Smart coatings and restorative materials in clinical trials.

Limitations[4]:

- Stimulus-specific response - Most smart materials respond to only one type of trigger (e.g., pH, light), limiting their effectiveness in complex oral environments.
- Limited long-term durability - Some materials degrade or lose function over time due to moisture, temperature changes, or mechanical stress in the mouth.
- Biocompatibility concerns - Certain smart materials may cause irritation or toxicity when in prolonged contact with tissues or when releasing active agents.
- High production costs - Manufacturing smart materials can be expensive, making them less accessible for routine clinical use.
- Regulatory and clinical barriers - Many smart materials lack sufficient clinical trial data or regulatory approval, delaying their integration into standard dental practice.

Future Perspectives of Smart Material in Dentistry[12]

SL. No.	Future Direction	Description
1	Advanced Stimuli - Responsive Systems	Materials that respond precisely to triggers like pH, enzymes, light, or stress.
2	Autonomous Functionality	Materials that act automatically without external control, e.g., releasing agents on demand.
3	Multi-Stimuli Integration	Integration of multiple triggers for better accuracy and control.
4	Improved Biocompatibility	Designing materials that are safe and non-toxic to oral tissues.
5	Enhanced Durability	Smart materials that resist moisture, acids, wear, and temperature changes.
6	Clinical Translation	Focus on real-world use: scaling up production, clinical testing, and approval.
7	Minimizing Unwanted Effects	Preventing microbial resistance or harm to beneficial oral bacteria.
8	Combination with Regenerative Therapies	Using smart materials with healing or remineralizing agents for dual benefits.

Conclusion

In recent years, the development and application of smart materials have advanced significantly, opening up exciting new possibilities within both biomedicine and dentistry. These innovations mark the emergence of a new era-biosmart dentistry, where materials are no longer passive but actively interact with the oral environment to enhance clinical outcomes. This evolution reflects a paradigm shift in dental science, where the integration of intelligent materials is no longer optional but essential. As we move toward more personalized, adaptive, and preventive dental care, the strategic application of smart materials will play a critical role in transforming routine clinical procedures into more efficient, responsive, and biologically supportive treatments. The future of dentistry, therefore, lies in embracing these smart technologies to not only restore but also preserve and enhance oral health in a dynamic, patient-centered manner.

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REVIEW ARTICLE

NON-TOBACCO-RELATED ORAL CANCER - INSIGHTS INTO ETIOLOGICAL FACTORS

ABSTRACT

Oral cancer is a major global health concern, with approximately 300,000 new cases diagnosed every year. Oral cavity cancer (OCC) is traditionally associated with smoking, but there is a growing trend of non-smokers developing the disease. Non-tobacco-related oral cancer is an emerging subset of oral malignancies occurring in individuals without a history of tobacco or alcohol use, highlighting the multifactorial nature of oral carcinogenesis. Increasing evidence points to alternative risk factors such as human papillomavirus (HPV) infection, genetic susceptibility, chronic irritation, poor oral hygiene, nutritional deficiencies, and environmental carcinogens. These cancers often exhibit distinct molecular and clinical profiles compared to tobacco-associated cases, including differences in p16 expression, TP53 mutations, and tumor behavior. Non-tobacco-related oral cancers tend to occur in younger patients and may present at advanced stages due to delayed recognition. Understanding these alternative etiological pathways is crucial for improving early detection, prevention strategies, and personalized treatment approaches in this growing patient population. In Asia, habitual use of betel quid (with or without tobacco) significantly increases the risk of oral cancer. Dentists should be also aware of emerging risk factors such as the role of Human Papilloma virus (HPV) in oropharyngeal cancer. Studies have shown that the incidence of oral cancer is increasing more rapidly in women than men and also in younger patients under 45 years old. The objective of this article is to provide an insight of examining the incidence, demographics, subsite involvement, possible etiologies, prognosis, and treatment implications of oral cancer.

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INTRODUCTION

Oral cancer, affects the lips, anterior two-thirds of the tongue, gums, buccal cavity, and other areas of the oral cavity, is now a significant global health issue. It is the 16th most common cancer worldwide, accounting for over 389,485 new cases and 188,230 deaths annually, particularly in low-and middle-income countries. India has a high prevalence of oral cancer due to various cultural practices, lifestyle choices, and socioeconomic factors. The nation accounts for approximately one-third of the global oral cancer cases as a proportion of its adult population[1].

Traditionally, tobacco and alcohol consumption have been the primary risk factors for the development of head and neck squamous cell carcinoma (HNSCC). However, there is a growing trend of younger, non-smoking and non-drinking (NSND) oral squamous cell carcinoma (OSCC) patients without identifiable risk factors. Studies have shown that the incidence of oral cancer is increasing more rapidly in women than men (in 11 of the 22 registries studied) and in younger patients under 45 years old (14 of the 22 registries). The typical profile of OSCC patient has changed over the years.[2]

Etiology

Oral cancer is commonly linked to tobacco use, but not all cases are caused by smoking or chewing tobacco. These include infections like the human papillomavirus (HPV), poor nutrition, genetic mutations, long-term irritation in the mouth, and even environmental exposures.

Understanding these non-tobacco-related causes is important because they help explain why oral cancer can develop in healthy individuals without the traditional risk factors[2].

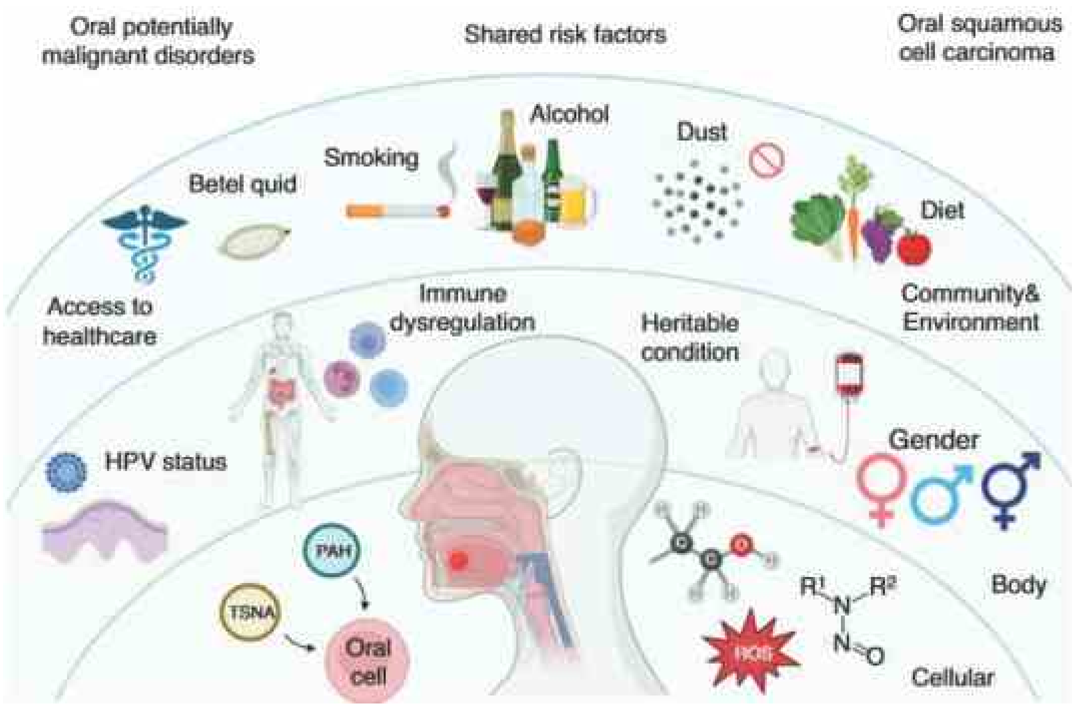

Figure 1: Risk factors of OPMDs and OSCC. The initiation and development of OPMDs and OSCC share similar risk factors, including smoking, alcohol abuse, betel quid (BQ) chewing, human papillomavirus (HPV) infection, nutritional insufficiency, immune deficiency, and hereditary conditions. OPMDs oral potentially malignant disorders, OSCC oral squamous cell carcinoma, PAH polycyclic aromatic hydrocarbons, ROS reactive oxygen species, TSNA tobacco-specific nitrosamines[3].

1. Dental Trauma

In case of oral cancer, chronic dental trauma (CDT) may play a role in the development of tumours, particularly in areas prone to trauma like the lateral tongue. This shows that CDT could be a potential contributing factor to oral cancer in individuals who don't have traditional risk factors like smoking or drinking. Various factors leading to Chronic dental trauma (CDT) including ill-fitting dentures, broken or sharp teeth, faulty dental restorations, or dental implants. In particular, ill-fitting dentures can cause trauma to the gingivobuccal area, which may contribute to the development of gingivobuccal cancer in older non-smoking and non-drinking oral cancer patients.[2]

Additionally, habits that cause repeated stress to the oral cavity, such as biting the oral mucosa, may also increase the risk of oral malignancy. When the oral mucosa is subjected to chronic mechanical irritation, it can lead to various changes, including redness, atrophy, ulcers, keratosis, hyperplasia, indentation, or scarring. The constant contact between the oral mucosa and teeth or dentures during normal movements or at rest can contribute to these changes. Research suggests that chronic trauma may play a role in the development of cancer by disrupting the normal architecture of tissues, promoting the expression of oncogenes, creating a favorable environment for inflammation, and increasing exposure to carcinogens.[4]

2. Genomics

Multiple risk factors that have been identified as being capable of inducing genomic alterations, which are commonly observed in both OSCC and OPMDs. Genetic mutations contribute to aberrant activation of oncogenic signalling and inactivation of suppressor signalling, promoting the transformation and uncontrolled proliferation of OSCC cells[3].

One study identified five distinct subtypes of OSCC that differed based on methylation patterns, including two atypical subtypes that don't fit the typical smoking-related profile.

These include: one HPV positive subtype, two smoking-related subtypes, and two atypical subtypes. Out of which: one of the atypical subtypes was genomically stable with widespread DNA hypermethylation-related gene silencing, and hence called 'CpG island methylator phenotype' (CIMP)-atypical subtype. An increased incidence of CIMP-atypical tumours were found on analysis of mutations in the gene encoding caspase 8 (CASP8). CASP8 notably also plays a crucial role in programmed cell death, and mutations in this gene may contribute to cancer development.TP53 mutations in non-smoking OSCC patients tend to have more aggressive tumours, poorer differentiation, and worse survival rates. Genomic analysis of OSCC tumours from non-smokers on analysis showed evidence of a more robust IFN-γ response and activation of immune checkpoint ligands, pointing to the possibility of viruses as the pathogenic cause of OSCC[2].

In human oral cancer, over 63 karyotypes have been described. Among them recurrent loss of chromosome 9, 13, 18 and Y deletions are more frequently reported than others. Nearly two-third of all head and neck cancer cells contain a deleted region on chromosome 9p21-22 which is seen in dysplastic and carcinoma-in-situ lesions, thereby indicating that gene in this region is knocked out early in carcinogenesis. Chromosomal region located in 3p and 13q are also often deleted and may yield new TSGs or oral carcinogenesis.[5] Aberrant expression of the proto-oncogene such as epidermal growth factor receptor (EGFRI c-erb 1) members of the ras family, as well as c-myc, int-2, hst-1, PRAD-l and bel, contribute to development oral cancer development. Simultaneous expression of growth factors such as TGF-alpha and EGFR may indicate more aggressive tumours than those over expressing EGFR alone. The intercellular messengers of the ras gene family (H-ras, K-ras and N-ras) have been examined in human oral cancer. A report from India study revealed that 35% of oral squamous cell carcinoma contains H-ras mutations[5].

3. Biologic Carcinogens

Viruses, including Epstein–Barr Virus (EBV) and Human Papilloma Virus (HPV) and oral microbiome including Fusobacterium, Mogi bacterium, Tannerella and Campylobacter species have a well-established associate on with head and neck cancer[2].

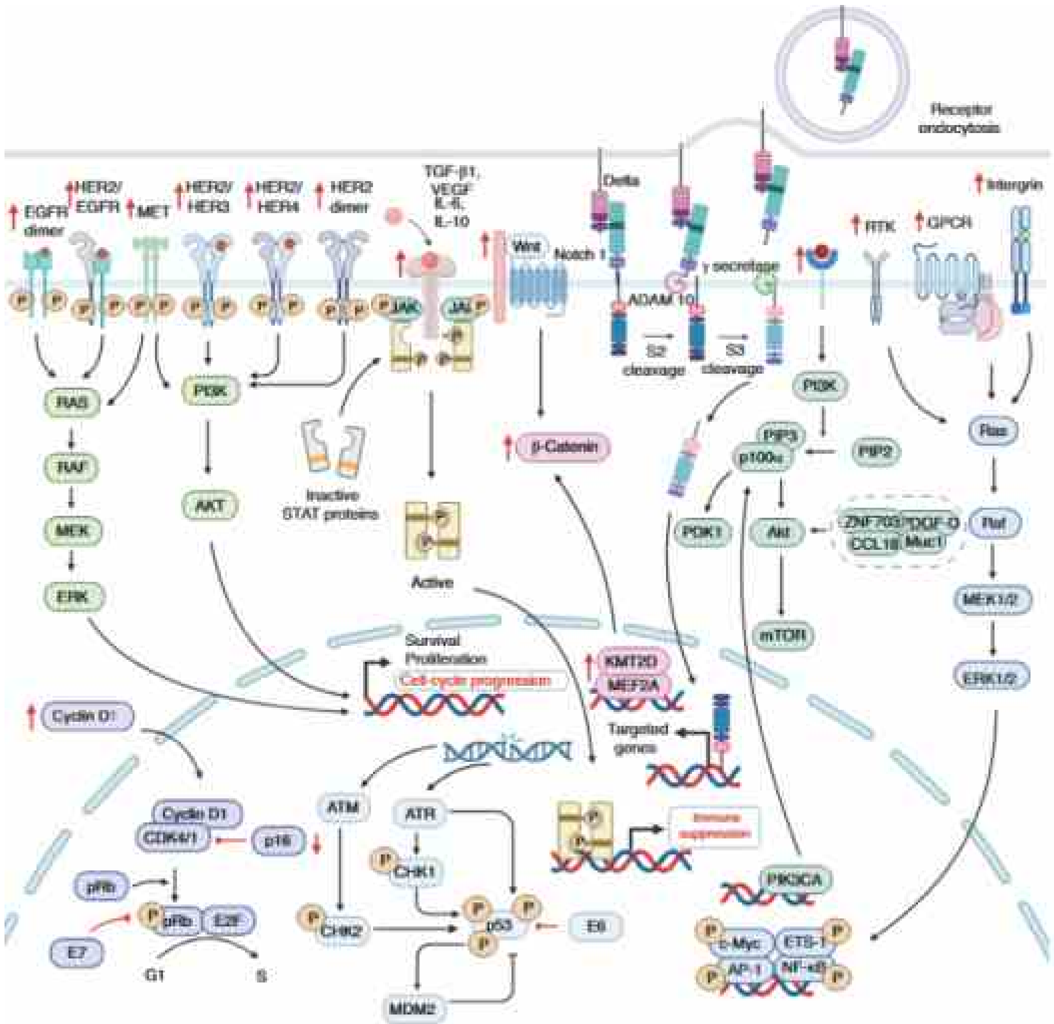

Figure 2: Genetic alterations in OSCC. Genetic alteration in the TP53/RB, p16/Cyclin D1/Rb, EGFR, Wnt/β-catenin, JAK/STAT, NOTCH, PI3K/AKT/ mTOR, MET, RAS/RAF/MASK signaling pathways contribute to OSCC progression. EGFR epidermal growth factor receptors, JAK Janus-activated kinase, MAPK mitogen-activated protein kinase, OSCC oral squamous cell carcinoma, RB retinoblastoma, Rb retinoblastoma tumor suppressor protein, STAT signal transducer and activator of the transcription, TP53 tumor protein p53[3].

Human Papilloma Virus (HPV) has been implicated in number of malignancies in humans, such as in the head and neck, vulvar, vaginal, penile, and cervical regions. The prevalence of OSCC associated with HPV infection has risen from less than 20% to more than 70% globally[4]. Low-risk HPVs, like HPV6 and HPV11, lead to benign warts, while high-risk HPVs, such as HPV16 and HPV18, result in premalignant squamous intraepithelial neoplasia that can progress to malignant lesions. It is uncertain how OSCC related to HPV behaves clinically. For men under 50, the occurrence of HPV-associated OSCC has increased. Patients with oral cancer caused by HPV are less often smokers or alcohol consumers, and their prognosis is usually favorable[4]. The floor of the mouth (9-42%) and the tongue (8-25%) appear to be the most common site of HPV infection, despite frequency variations across research[4].

Epstein-Barr virus (EBV), member of the herpesvirus family, is also linked to the development of certain malignancies, including lymphomas and nasopharyngeal carcinoma. It may contribute to oral malignancy by inducing genetic instability or affecting immune responses. The malignancy of EBV is associated with a number of proteins found in the viruses that regulate immune activity, cell apoptosis, and cell proliferation. Latent membrane proteins contribute to activating the signaling pathway, whereas the nuclear antigens of EBV help in gene expression.[4]

A. Microbiome

The microbiome has been an important topic in the field of cancer biology, and the oral microbiome is particularly relevant to OSCC development.[2] Smoking is thought to make the oral microbiome more pro-inflammatory while simultaneously diminishing commensal bacteria. Cancers including oral cancers are linked to microorganisms such as HPV (cervical cancer, oropharyngeal cancer), EBV (head and neck cancer), hepatitis B and C virus (hepatocellular carcinoma), Helicobacter pylori (gastroduo denal cancer), and Porphyromonas gingivalis (Oro digestive cancer).[6]

Notably, an increase in Fusobacterium, Mogi bacterium, and Tannerella has been reported, with a loss of Neisseria, which are commensal bacteria that can have protective effects on oral mucosa. Alcohol consumption increases OSCC-associated bacteria, such as the Campylobacter species. Smoking in conjunction with alcohol use lead to increased level of acetaldehyde in saliva, which is associated with carcinogenesis. Other factors that can alter the oral microbiota and possibly facilitating OSCC formation include viral (eg, HPV) infections and certain sexual behaviors.[2]

4. Substance Abuse

Substance abuse plays a major role in the development of oral cancer. Understanding these risks is key to preventing non-tobacco related oral cancers.

A. Marijuana

Marijuana is another contributing factor of HNSCC, that has been under investigation. The cigarette-adjusted risk for developing HNSCC for marijuana users was 2.6, with an observed dose-response relation. In a cross-sectional study of 530 patients with oral cavity and oropharyngeal SCC, 13.2% were marijuana users, and 2.3% of patients were exclusively marijuana and not tobacco smokers. The oral microbiome may also play role in effect of marijuana's on OSCC formation, and in tongue SCC samples from marijuana users (not adjusting for cigarette smoking or alcohol usage), a decline in Capnocytophaga, Fusobacterium, and Porphyromonas and elevation of Rothia was observed.[2]

B. Betel Quid

Betel quid, also known as "paan", is a mixture of substances including areca nut with or without tobacco wrapped in a betel leaf and placed in the mouth. It is common in south and southeast Asia and among people of south Asian origin in communities across the world[7]. Betel nut or quid is a prevalent recreational substance globally, especially in South and Southeast Asian countries, that has been linked to OSCC carcinogenesis. Betel nut chewing without tobacco additives is a well-established risk factor for OSCC. Yet, it is prudent to note its importance as a risk factor for OSCC in NSND patients, especially in Southeast Asia. A meta-analysis of Southeast Asian studies of OSCC risk factors found that betel quid chewing in non-smoking and non-drinking patients, had a pooled odds ratio of 7.90 (95% CI 6.1-9.30). These data suggest that betel quid chewing, especially in regions of high prevalence, can partially explain the etiology of NSND OSCC.[2]

5. Immunosupression

Immunocompromised patients, such as HIV+ patients and organ transplant recipients, are more likely to develop oral malignancies, suggesting that immune response plays a crucial role in OSCC development[3].

Tumor cells have the ability to create a set of immunosuppressive chemicals, such as regulatory T cells, tumor-associated macrophages, tumor-associated neutrophils, and cancer-associated fibroblasts. These substances can obstruct the immune cells' natural ability to fight cancer. Tumor cells can evade immune surveillance and tumor immunity through immunosuppressive mechanisms by their contact with immune cells. This finally advances the cancerous process. There was a significant correlation observed between the prognosis of OSCC in immunosuppressed patients and 11 immunosuppressive genes: CXCL8, TLR3, IL22, ORMDL3, FGFR3, CTLA4, HPRT1, BGLAP, CALCA, SPHK1, and INHBB. Two survival subtypes, one with a lower chance of survival and the other with a higher probability of survival, were distinguished between OSCC patients using a deep learning-based model in many studies.[4]

6. Diet and Nutrition

Tobacco and alcohol are primary causes of oral cancer, but diet plays a significant role. Certain nutrients can protect against or increase cancer risk.[8] There are plenty of evidence showing a positive correlation between low intake of fresh vegetables and fruits and a rise in risk of oral cancer[9].

Direct causative agent of cancer is through foods, carcinogens they contain, or indirectly through the metabolism's production of carcinogens. A majority individuals eat a wide range of foods that provide a variety of nutrients, and their dietary habits frequently changes throughout time in response to cultural and socioeconomic factors.

An eating pattern of animals includes foods, fats, sugars, processed foods, and a little complex carbs and fiber has replaced "traditional" eating patterns depend upon consumption of grains and cereals due to the so-called "nutri-

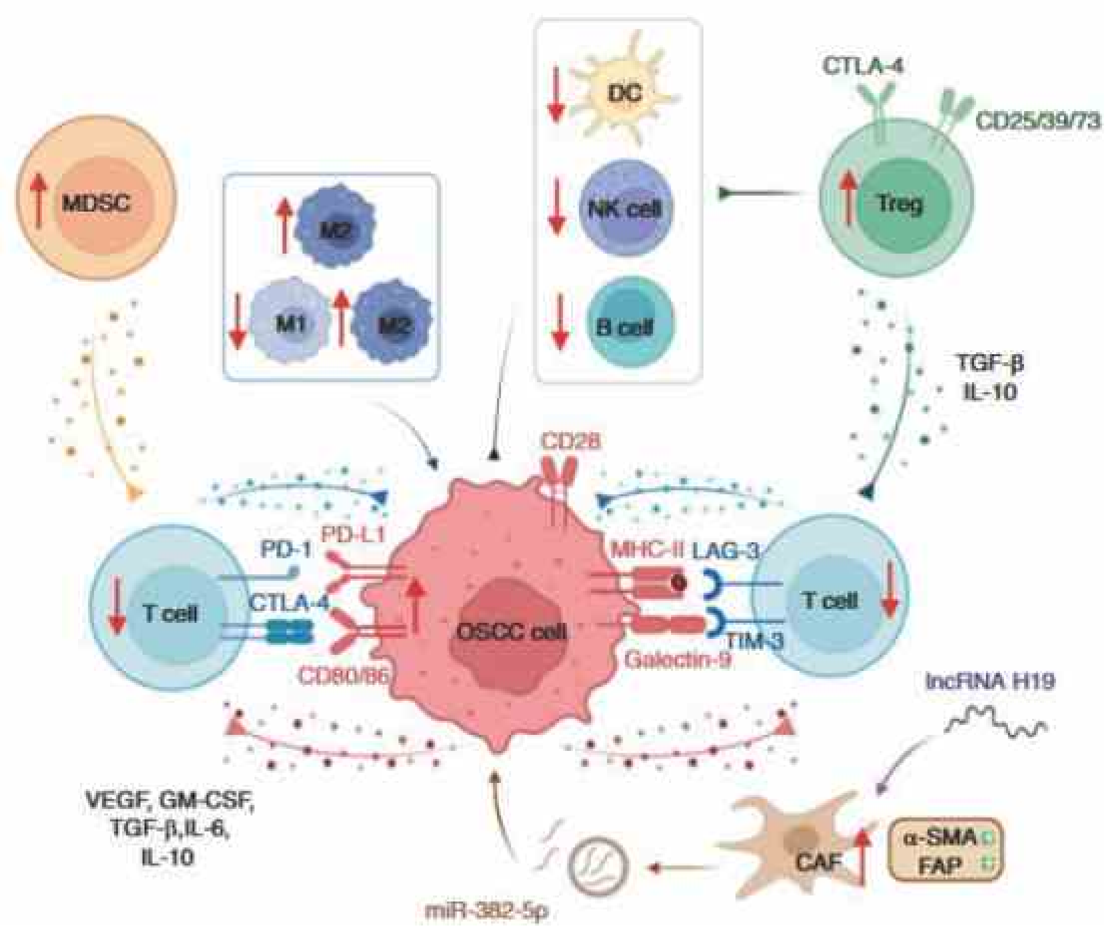

Figure 3: The immunosuppressive TME in OSCC comprises immunomodulatory cells such as CAFs, Tregs, TAMs, and MDSCs. PD-1/PD-L1 and CTLA-4/CD80/86 interactions, along with checkpoints like LAG-3 and TIM-3, suppress T-cell activity. OSCC cells, Tregs, and CAFs secrete VEGF, GM-CSF, TGF-β, IL-6, IL-10, and miR-385-5p, while M2 TAMs promote tumor growth and immune evasion.[3]

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tional transition". Such eating habits are potentially beneficial for the development of oropharyngeal cancer. Consuming animal fat-rich foods and high-fat sauces has been associated with an elevated risk of OSCC. Low fruit and vegetable diet has been linked to increased mouth cancer risk. vitamin E, have been associated with decreased cancerous risk because they include substances like tocopherol, which has anti-inflammatory and antioxidant properties. There are no evidences about vitamins B1, B5, B6, and K can control oral cancer[3].

Peppers, chilies, or capsicum are highly adaptable crops that form a staple component of many cuisines around the world, particularly in regions such as China, Mexico, Turkey, and Indonesia.

Chili is among the most commonly used spices, valued for its strong flavour and colouring properties. It also serves as a significant dietary source of pro-vitamin A (carotenoids), vitamin E (α-tocopherol), and vitamin C (ascorbic acid).

The compound capsaicin (trans-8-methyl-N-vanillyl-6-nonenamide) is the principal capsinoid present in chili peppers.[10] The higher consumption of spicy and hot foods with more quantity of chillies, as well as very hot temperatures, has been linked to a greater frequency of OSCC. These should be considered based on their ability to cause mechanical and chemical sensitivity of the local mucosa. [11]

7. Socio-Economic Status

Socioeconomic inequalities in oral health mainly refer to the differences in how common or severe oral health problems among people of varying socioeconomic statuses (SES).

Key Findings from the Indian Study

Dental Caries: (DMFT - Decayed, Missing, Filled Teeth)

Periodontal Disease: Prevalence was 12% (upper SES), 28% (middle SES), and 60% (lower SES), indicating a higher burden in lower SES groups.

Inverse Relationship: Mainly, people of lower socioeconomic status was likely to have higher prevalence of oral diseases.

The study notes minor variations in DMFT that might be due to a lack of large-scale studies assessing SES and dental caries. The factors Influencing are Access to care, oral hygiene behaviors, income, education, and cultural aspects play main roles. Water fluoridation could help reduce oral health disparities.[12]

8. Ethnicity and Race

Nutritional differences, smoking patterns (eg: bidi smoking in Asians), difference in amounts smoked or alcohol drunk and the two-way and three-way interaction of betel quid chewing with smoking and alcohol, rather than genetic factors, may play a role in these observed variations in populations and high incidence in some ethnic and racial groups.[9]

Evidence indicates that individuals from Asian or Asian British backgrounds, as well as those from lower socioeconomic groups, face the highest risk of developing oral cavity cancer (OCC). The incidence among Asian/Asian British populations is around 6.27 per 100,000, slightly higher than 5.96 per 100,000 seen in White individuals.

Recent studies have also shown that South Asian patients including those identifying as Indian, Pakistani, or Bangladeshi tend to experience poorer treatment outcomes when receiving radiotherapy for oral cavity cancers, particularly in healthcare settings that serve highly diverse populations.

The habitual use of smokeless tobacco and betel nut plays a major role in the differing rates and mortality patterns of oral cavity cancers worldwide, with the highest prevalence observed in South and South-East Asian communities.

Additionally, unequal access to healthcare services often influenced by location and migration status may impact both the incidence and survival outcomes. This inequity can also restrict the spread of public health education.

Differences in health-seeking behaviour among ethnic groups are another significant factor. Using the COM-B model (Capability, Opportunity, and Motivation – Behaviour) can help identify these behavioural influences and guide the creation of targeted, culturally appropriate interventions.

In some communities, limited awareness of available dental or health services, compounded by language barriers, can hinder understanding of oral health information provided by professionals or local authorities. To overcome these challenges, community-based outreach efforts and co-designed educational initiatives are essential.[13]

9. Oral Hygiene and Dentition

Oral health is strongly linked to systemic diseases like cardiovascular disease, diabetes, and Alzheimer's. Poor oral hygiene increases the risk and worsens the prognosis of head and neck cancers (HNC). The INHANCE consortium showed that regular dental visits and daily brushing lower HNC risk. Periodontal disease is associated with cancers of the digestive tract, breast, pancreas, prostate, uterus, and lungs. Harmful bacteria such as Porphyromonas gingivalis and Prevotella intermedia worsen cancer survival outcomes. Radiotherapy alters the oral microbiome, increasing harmful bacteria and post-treatment complications. Maintaining good oral hygiene before, during, and after cancer therapy improves recovery and survivorship.

Routine dental visits are linked to reduced cancer and overall mortality. Loss of teeth correlates with higher mortality risk. Southeast Asia lacks sufficient data on oral health and cancer associations. Affordable point-of-care tests like aMMP-8 can help detect early periodontal disease. School-based supervised toothbrushing programmes can effectively improve oral health and reduce inequalities.[14]

10. Physical Carcinogens

UV exposure to sunlight is a potent etiological and predisposing factor for OSCC in a non-habitual patient. Jobs that include working outside and prolonged sun exposure more likely to cause OSCC on the lips. The incidence of OSCC is estimated to be 3.33 or 3.94 per 100,000 individuals worldwide due to UV Radiation. Effective defense mechanism have been developed to shield epidermal keratinocytes from UV-induced tumor development and that cause apoptosis to be induced. UV light inhibits apoptosis process, that result in apoptosis deficit that seems more important than increased proliferation overall. The main etiology of inhibition of apoptosis may be COX-2 activation, reactive oxygen species production, and p53 inactivation[3].

Ionizing radiation including X-rays, beta, alpha, and gamma radiation and radioactive isotopes cause mutagenesis. studies indicate X-rays exposure increased chance of developing oral cancer. Ionizing radiation is strong enough to break free electrons from atoms that are firmly bonded, damaging DNA and p causing mutations that lead to the development of cancer. Dental X-rays are a common source for ionizing radiation exposure in the oral cavity. Frequent or high-dose exposure to ionizing radiation increase oral cancer risk, in medical settings, even though doses from routine dental X-rays are generally low and the risk is minimal. The diagnostic benefits of X-rays, including the detection of dental issues and oral or other medical conditions, outweigh the potential risks that can cause radiation exposure. Healthcare professionals follow standard protocol to ensure that radiation exposure is maintained as low as reasonably attainable in order to reduce the risk of radiation-induced mouth cancer. This require employing thyroid collars and lead aprons to protect non-imageable regions and using the lowest feasible radiation dosage for medical evaluations.[3]

11. Oral Lichen Planus (olp)

OLP is a chronic inflammatory T cell-mediated disease that affects the tongue and buccal mucosa. OLP is an inflammatory mucocutaneous disorder affecting 1% - 2% of the general population, of which 0.07% to 5.8% undergo malignant transformation. There are three clinical subtypes of OLP: erythematous or atrophic, reticular, and erosive. Among these, Erosive OLP is the most prevalent clinical subtype associated with malignant transformation[3].

Etiology of the disease is unknown, but progression of OLP is mainly through T lymphocyte auto reaction. Other cause factors include stress, systemic medications such as beta-blockers, nonsteroidal anti-inflammatory drugs, antimalarials, diuretics, oral hypoglycemics, and penicillamine, oral retroviral medications, hypersensitivity to dental materials, chronic liver disease and hepatitis C virus, and graft-versus-host disease. This illness is mainly initiated by immune system. T lymphocytes and macrophages, and also the degeneration of basal cells plays the major role in the histopatholgic features of subepithelial infiltration and is known as liquefaction degeneration. Clinical symptoms mainly include Red and White elements, together with different textures and reticular, papular, plaque-like, bullous, erythematous, and ulcerative are the clinical types.[4]

The prime incidence of OLP malignant transformation was reported in the year 1910. A recent meta-analysis reported that 1.1% of lesions of OLP turned out into OSCC globally, where Hepatitis C virus-positive individuals was at higher frequency. Erosive and Erythematous OLP are the ones that appears to change into OSCC most frequently. It is mainly due to the lack of protective mechanisms in the mucosa in erosive and erythematous OLP. Major site for Malignant transformation occurance is in the localized tongue lesions. According to Andabak-Rogulj et al., OLP lesions need an average of five and a half years to convert into an established OSCC.[4]

Summary on Etiological Factors of Non-tobacco related Oral Cancer

1. Chronic Dental Trauma (CDT): Repeated irritation from dentures or sharp teeth causes mucosal damage and inflammation, triggering oncogene activation and cancer even in non-smokers.

2. Genomics: Mutations in TP53, CASP8, EGFR, and others drive uncontrolled growth; TP53 mutations in non-smokers cause aggressive OSCC with poor prognosis.

3. Biologic Carcinogens: HPV (16,18) increases OSCC in young non-smokers with better outcomes; EBV disrupts apoptosis and immune control, promoting malignancy. Loss of protective bacteria and rise of pathogens like Fusobacterium cause inflammation and cancer; smoking and alcohol worsen dysbiosis.

4. Substance Abuse: Marijuana raises HNSCC risk (2.6×) and alters oral flora, promoting cancer pathways even without tobacco. Betel quid causes DNA damage and fibrosis, increasing OSCC risk in non-smokers, especially in South/Southeast Asia.

5. Immunosuppression: HIV, transplants, and tumor cells suppress immunity via PD-1/PD-L1 and CTLA-4, worsening OSCC survival.

6. Diet and Nutrition: Low fruit intake and high-fat diets raise cancer risk; antioxidants and capsaicin show protective effects.

7. Socio-economic Status: Low SES leads to poor oral health, limited care, and higher oral cancer due to health inequalities.

8. Ethnicity and Race: Asian groups face higher OSCC from betel and bidi use; delayed care and barriers worsen outcomes.

9. Oral Hygiene and Dentition: Poor hygiene and periodontal disease raise cancer risk; good hygiene improves prognosis and survival.

10. Physical Carcinogens: UV and radiation cause DNA damage and lip OSCC; dental X-rays safe with protection.

11. Oral Lichen Planus: Chronic autoimmune lesions (especially erosive types) may turn malignant over years, mainly on the tongue.

CONCLUSION

To understand the multifaceted nature of non-habit-induced OSCC, it requires a holistic approach that considers genetic, viral, immunological, environmental, hormonal, and psychosocial factors. OSCC is most common among certain people with occupations which have long-span exposure to sunlight and chronic irritation from traumatizing objects such as ill-fitting dentures, impinging dental restorations, pointed cusps, and root fragments can cause damage leading to OSCC. This unveils the challenging aspect of oral cancer that requires ongoing investigation and a multidisciplinary approach. Combined efforts between clinicians, researchers, and public health initiatives are essential. The medical community can be enhanced to a more comprehensive understanding of non-habit-induced OSCC and ultimately improve the outcome by continued research and partnership.

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REVIEW ARTICLE

THE ROLE OF PROBIOTICS IN ORAL HEALTH: A COMPREHENSIVE REVIEW

ABSTRACT

Oral health is intricately linked to the balance of microorganisms residing within the oral cavity. Disruption of this equilibrium contributes to the onset of several oral diseases, including dental caries, periodontitis, halitosis, and oral mucosal infections. With the rising challenge of antibiotic resistance and the limitations of conventional antimicrobial therapies, probiotics have emerged as a promising, natural, and sustainable alternative for the prevention and management of oral diseases. Probiotics are live microorganisms that, when administered in adequate amounts, confer health benefits by restoring microbial homeostasis and inhibiting pathogenic species.

Recent studies have demonstrated the efficacy of specific probiotic strains such as Lactobacillus, Bifidobacterium, and Streptococcus salivarius in reducing cariogenic and periodontopathogenic bacteria, alleviating halitosis, and suppressing fungal infections such as candidiasis. Their mechanisms of action include competitive exclusion of pathogens, secretion of antimicrobial substances like bacteriocins, modulation of host immune responses, and reinforcement of mucosal barrier functions. Additionally, innovations in probiotic delivery systems such as lozenges, chewing gums, and dairy-based formulations have enhanced bacterial viability and local efficacy in the oral cavity.

Despite promising findings, key challenges persist regarding strain selection, delivery methods, dosage optimization, and long-term safety. Further large-scale, randomized clinical trials are required to standardize probiotic use in dental care. This review consolidates recent evidence to highlight the benefits, mechanisms, challenges, and future prospects of probiotics as a preventive and therapeutic tool in maintaining oral health and combating microbial imbalance.

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INTRODUCTION

“Globally, oral conditions such as caries and periodontitis remain major health challenges. Conventional therapies often rely on antibiotics, which can disrupt beneficial microbiota and foster resistance. The concept of probiotics microorganisms beneficial to host health has therefore become central to exploring biological alternatives[1–3].

The term 'probiotic' is derived from the Greek word meaning 'for life,' and the concept of bacteriotherapy was first introduced in the beginning of the 20th century[4,5]. Probiotics are live cultures that are constituents of the natural microflora of the human body and are constituents of the natural microflora of the human body[3]. The growing global demand for less harmful, chemical-free alternatives to traditional disease management has positioned probiotic therapy as a promising solution in various fields, including dentistry[3,6]. Given that the oral cavity is an extension of the human gastrointestinal tract, the successful application of probiotics in gut health has naturally led researchers to explore their anti-pathogenic and immune-modulating effects within the mouth[2,4]. Recent studies, including clinical trials, strongly suggest an active role for probiotics in the prevention and treatment of oral infections[7].

Mechanisms of Action of Probiotics:

The therapeutic efficacy of probiotics in the oral cavity is attributed to several interconnected mechanisms, which allow them to create a protective biofilm in the oral cavity[8]:

- Competitive Exclusion: Probiotic strains can compete with pathogenic microorganisms for essential nutrients and adhesion sites on oral surfaces, thereby preventing the establishment and colonization of harmful bacteria[2,5,7].
- Antagonism: Probiotics can directly inhibit pathogens by producing antimicrobial compounds, such as bacteriocins (e.g., salivaricin), short-chain fatty acids, and other organic acids, which create an unfavorable environment for disease-causing microbes[5,7,9].
- Immune Modulation: Probiotics can interact with the host’s immune system, modulating local and systemic immune responses to strengthen mucosal barriers and decrease inflammation[2,5]. They can improve intestinal comfort and boost the immune response[2].

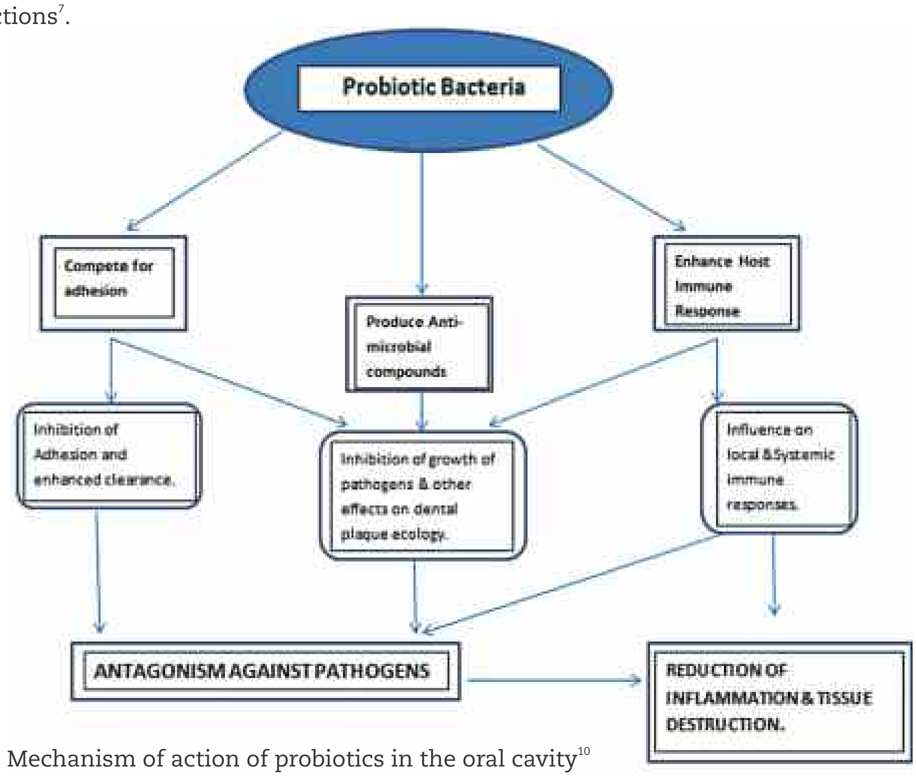

Figure 1- Mechanism of action of probiotics in the oral cavity[10]

Clinical Applications in Oral Health

1. Dental Caries

Dental caries is a multifactorial disease strongly associated with the composition of the oral microbiota, particularly high counts of acid-producing bacteria like Streptococcus mutans and Lactobacilli[7].

Efficacy: The first randomized controlled trials have shown that probiotics may help control dental caries, particularly in children, due to their inhibitory action against cariogenic streptococci[4]. Clinical studies strongly suggest an active role for probiotics in the prevention and treatment of dental caries[8,11]. Probiotic milk consumption, for instance, has been investigated for its effect on salivary S. mutans counts[8].

Safety Consideration: A crucial safety concern for oral probiotics is ensuring that the selected strains do not possess a high fermentation capacity, as acid production from sugar is detrimental to teeth[4]. The selection of non-acidogenic strains is therefore critical[4].

2. Periodontal Disease and Gingivitis

Periodontal diseases, including gingivitis and periodontitis, are caused by specific bacterial activity combined with the patient's immune response[10]. Probiotics may be a useful treatment to support periodontal health by modulating the local microbial community [10].

Efficacy: Several studies have explored the efficacy of probiotics in managing periodontal diseases[8,10,11]. Clinical evidence suggests that probiotics can reduce both plaque and gingival scores[10]. They are effective as an adjunct to traditional mechanical therapy, working by shifting the microbial balance away from known periodontitis-associated pathogens[10].

Mechanism: Probiotics help to reduce inflammation by modulating the inflammatory pathways implicated in tissue destruction[10]. They decrease the number of pathogens and alter the microbial balance to a healthy state[7].

3. Halitosis (Bad Breath)

Halitosis is often caused by volatile sulfur compounds (VSCs) produced by bacteria on the tongue dorsum and in the subgingival plaque[2].

Efficacy: Research suggests that probiotics, specifically strains of Streptococcus salivarius (like K12), can be useful in the management of halitosis[4]. Probiotic strains work by colonizing the oral surfaces and reducing the population of VSC-producing bacteria[2].

4. Oral Yeast Infections (Candidiasis)

Probiotics, particularly certain Lactobacillus strains, have shown inhibitory effects against fungal species like Candida[3,4]. The consumption of probiotic lozenges and cheese has been shown to reduce the count of Candida species in the oral cavity[3,4].

Delivery Vehicles

The success of probiotic therapy is linked to the vehicle used for delivery, which must ensure the viability and retention of the bacteria in the mouth [4,9].

Vehicles Investigated: While most initial studies investigated dairy products like milk and yogurt, other means such as lozenges, chewing gums, and probiotic tablets are now successfully studied, offering better local delivery and longer retention times in the oral cavity[4,7].

5.Oral Cancer

Probiotics play an important clinical role in the prevention and management of oral cancer due to their ability to modulate the oral microbiome, suppress carcinogenic activity, and enhance host immunity. Several probiotic strains particularly Lactobacillus and Bifidobacterium species exhibit anti-cancer effects by binding and neutralizing mutagenic compounds such as tobacco-specific nitrosamines and acetaldehyde, reducing inflammation, and inducing apoptosis in oral squamous cell carcinoma (OSCC) cells. Mechanistically, they lower local pH through short-chain fatty acid (SCFA) production (notably butyrate), which inhibits tumor cell proliferation and supports epithelial health. Clinically, probiotics have shown promise as adjuncts to conventional therapies by mitigating treatment-related complications such as

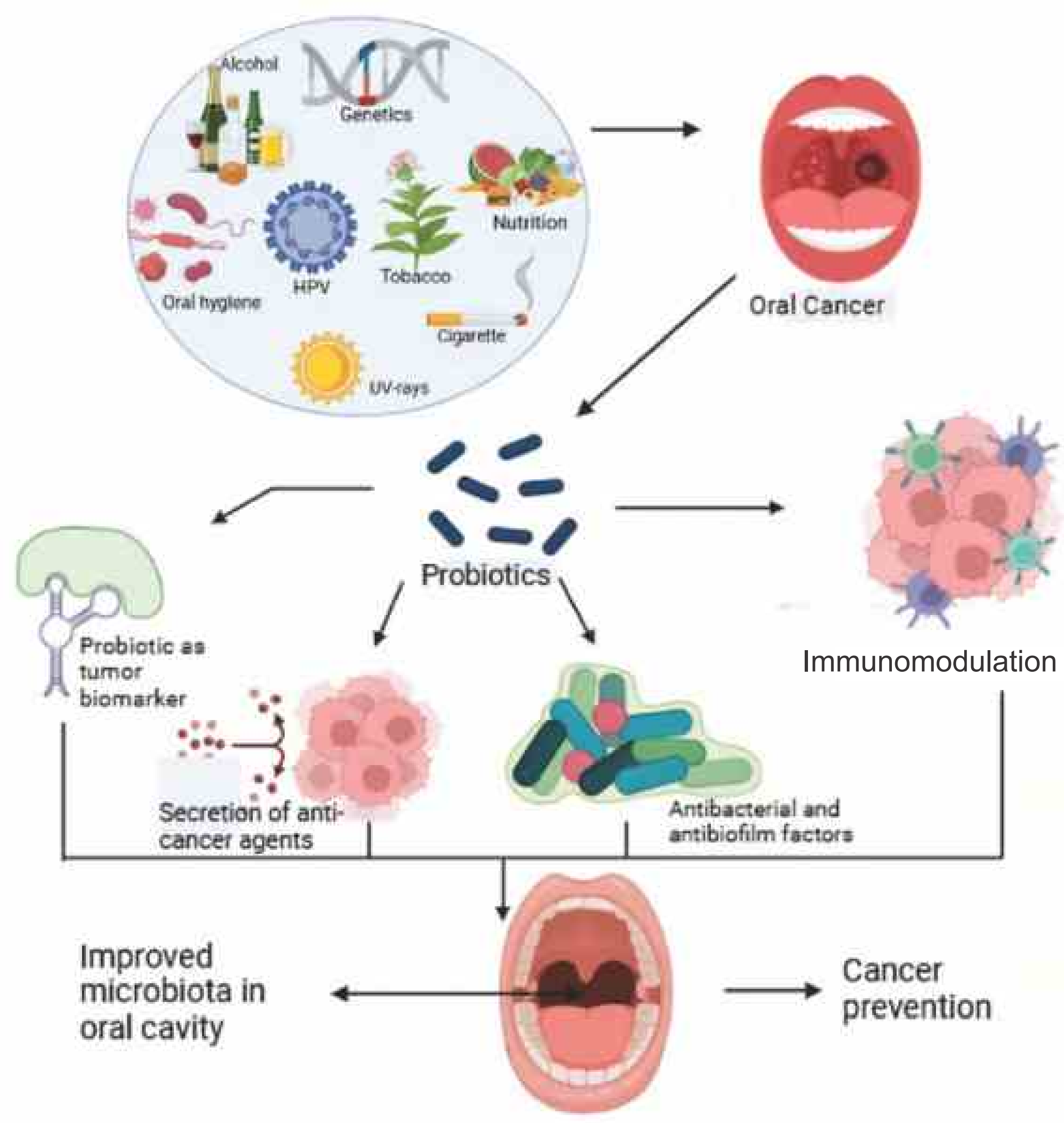

Figure 2- The potential role of probiotics in oral cancer prevention and management through various mechanisms. The arrows in the image depict the relationships and interactions between probiotics and their effects. The upward arrows toward "Oral Cancer" represent environmental and lifestyle risk factors contributing to its development. Arrows emanating from "Probiotics" illustrate the mechanisms through which probiotics influence cancer prevention and treatment, including immunomodulation, secretion of anti-cancer agents, and antibacterial effects. Additionally, arrows connecting various effects highlight the interconnected pathways through which probiotics enhance oral health and prevent cancer, such as improved microbiota leading to cancer prevention[12].

oral mucositis and enhancing patient quality of life. For example, Lactiplantibacillus plantarum Y33 and related strains have demonstrated dose- and time-dependent inhibition of OSCC cell growth while sparing normal cells, highlighting their therapeutic potential in oral cancer prevention and treatment.[12,13]

Summary

This review highlights the growing importance of probiotics in maintaining oral health by restoring microbial balance within the oral cavity. Oral diseases such as dental caries, periodontitis, halitosis, candidiasis, and oral cancer are closely linked to dysbiosis of oral microbiota. Conventional antibiotic-based therapies can disrupt beneficial bacteria and promote resistance, whereas probiotics offer a safe, natural alternative. Specific strains like Lactobacillus, Bifidobacterium, and Streptococcus salivarius exhibit beneficial effects through competitive exclusion of pathogens, production of antimicrobial substances, immune modulation, and mucosal protection. Clinical studies demonstrate their potential to reduce cariogenic and periodonto-pathogenic bacteria, suppress Candida species, alleviate halitosis, and even inhibit oral cancer cell growth. Advances in delivery vehicles such as lozenges, gums, and dairy-based products enhance their oral retention and effectiveness. Although further standardized clinical trials are needed, probiotics represent a promising adjunctive approach for sustainable oral disease prevention and health promotion.

Conclusion

Probiotics have emerged as a promising and biologically sustainable alternative in the prevention and management of oral diseases, offering a paradigm shift from conventional antimicrobial strategies to a microbiome-centered approach. By restoring microbial homeostasis, inhibiting pathogenic species, and modulating immune responses, probiotics contribute significantly to maintaining oral health and preventing dysbiosis-related conditions such as dental caries, periodontitis, halitosis, candidiasis, and even oral cancer. Their diverse mechanisms ranging from competitive exclusion and antimicrobial compound production to immune modulation and mucosal reinforcement underscore their therapeutic potential as natural adjuncts to conventional dental care.

Furthermore, advancements in probiotic delivery systems, including lozenges, chewing gums, and dairy-based formulations, have enhanced bacterial viability and local efficacy, paving the way for patient-friendly clinical applications. However, the full integration of probiotics into routine dental practice requires standardization of strains, optimal dosages, delivery vehicles, and long-term safety evaluations through large-scale, randomized controlled clinical trials.

In conclusion, probiotics represent a forward-looking, patient-centered approach to oral health care, aligning with the global movement toward preventive, minimally invasive, and biologically balanced therapies. With continued research and clinical validation, probiotic therapy holds the potential to become an integral component of evidence-based dental practice, transforming the future of oral disease prevention and management.

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CASE REPORT

WHEN METAL FAILS: A CASE REPORT ON ZIRCONIA CAST POST RESTORATION FOR OPTIMAL ESTHETICS

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ABSTRACT

Restoring endodontically treated teeth with extensive coronal destruction presents a considerable clinical challenge, particularly when esthetics are a priority. Conventional metal cast posts, though effective in retention and strength, often compromise esthetics and may lead to corrosion-related issues. This case report presents the restoration of a severely damaged maxillary left central incisor in a 25-year-old female patient using a custom-made zirconia cast post and core fabricated with CAD/CAM technology. The post and core were cemented with a self-adhesive resin cement and restored with an all-ceramic crown. Follow-up evaluations at one week, one month, and six months revealed excellent esthetic integration, functional stability, and patient satisfaction. Zirconia cast posts provide an ideal alternative in cases demanding superior esthetics and biocompatibility, although their rigidity and retreatment difficulty necessitate careful case selection and precise technique. This case demonstrates the clinical feasibility of zirconia cast posts as a durable and highly esthetic metal-free restorative option for anterior teeth.

Keywords: Zirconia cast post, esthetic dentistry, post and core, endodontically treated teeth, metal-free restoration, CAD/CAM.

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INTRODUCTION

The restoration of endodontically treated teeth with significant loss of coronal tooth structure is a common challenge in restorative dentistry. When there is insufficient residual dentin to support a final crown, the use of a post and core system is essential to provide adequate retention and stability. [1-4]

The rehabilitation of endodontically treated teeth with extensive loss of coronal tooth structure remains a challenge in restorative dentistry. When residual dentin is insufficient to support a definitive restoration, a post and core is often indicated to provide retention and stability for the final crown[5]. While metal posts such as titanium and stainless steel have traditionally been used, their inherent limitations including possible corrosion, adverse tissue reactions, and poor esthetic outcomes in the anterior region have driven the search for more esthetic and biocompatible alternatives.

Zirconia, a high-strength, tooth-colored ceramic, has emerged as a viable option for custom post and core restorations, offering excellent biocompatibility, favorable mechanical properties, and superior esthetics compared to conventional metal posts. Despite these advantages, zirconia posts have limitations, including a high elastic modulus which may concentrate stress and increase the risk of root fracture, as well as significant challenges with post removal in case of failure or retreatment. [6]

The main indication for using this type of post and core is to achieve superior esthetics, especially in cases with a thin gingival margin where a metal post could cause shine-through or gingival discoloration. It is also suitable for wide canals that require a custom fit.[6,7]

This case report describes restoring a severely damaged maxillary anterior tooth with a custom zirconia cast post and core, highlighting key clinical steps and considerations for a functional, esthetic result.

CASE REPORT

A 25-year-old female patient reported to the Department of Prosthodontics, Malabar Dental College And Research Centre, Manoor, with the chief complaint of a discolored and dislodged crown on maxillary left central incisor (Fig:1). The patient had a history of trauma 10 years prior, followed by root canal treatment done elsewhere and undergone orthodontic treatment 5 years prior. Clinical examination revealed that tooth #21 was endodontically treated but had extensive coronal structure loss, leaving only minimal sound dentin above the gingival margin. The periapical radiograph confirmed a satisfactory root canal obturation and an intact periapical region (Fig:2).

Given the patient's high esthetic demands and the location of the tooth in the smile zone, a metal post and core were deemed unsuitable due to the risk of shadowing through the all-ceramic crown. After discussing various treatment options, a custom-made zirconia cast post and core was planned to achieve optimal esthetics and functional stability.

Post-space preparation was performed by

Fig:1

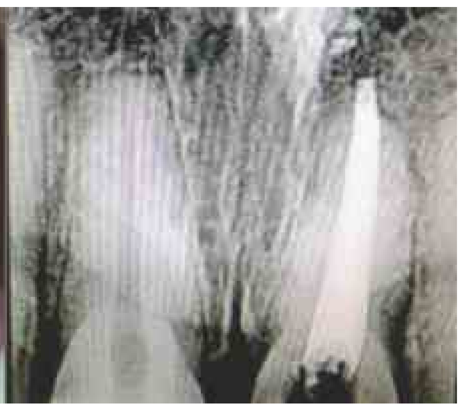

Fig:2

Fig:3

Fig:4

removing as much gutta-percha as possible using a hot endodontic plugger, followed by canal preparation with the largest Peeso reamer that fit the canal, ensuring at least 5 mm of apical gutta-percha was retained to preserve the apical seal. Radiographs were taken to make necessary adjustments in the reamer length (Fig:3). A keyway was cut to the depth of nearly 1mm in the orifice of the canal to provide anti -rotational stability to the post.

A direct technique was followed for the custom post and core by fabricating inlay wax pattern in the prepared post space in the patient's mouth (Fig:4). The pattern can also be made with a plastic roll, a bur, a metal pin, a paper clip or ortho ligature wire, in this case we used a customized wooden toothpick.

Impression of the maxillary arch was made

Fig:5

using poly vinyl siloxane impression material and alginate impression for the mandibular arch. Once the cast was poured, (Fig:5) the cast was then subjected for CAD/CAM milling of the zirconia post and core unit.

At the subsequent appointment, the milled zirconia post and core (Fig:6-9) was tried in for passive fit and checked for adaptation and occlusion. After verifying fit, the canal was cleaned using 37% phosphoric acid for 20

Fig:6

Fig:6

Fig:8

Fig:9

Fig:10

Fig:11

Fig:12

Fig:13

seconds (Fig:10) followed by rinsing with 5.2% NaOCl for 30 seconds. The Canals were rinsed with water and dried with paper points. To enhance retention, the surface of the zirconia post was micro roughened with 50 microns aluminium oxide and a micro air abrasive unit. Followed by application of 9.6% hydrofluoric acid etchant gel (Fig:12), then conditioned with silane coupling agent(fig16).

Zirconia post and core was luted using a self-adhesive resin cement (Fig:13) following the manufacturer's protocol. After the cement was set the excess was removed by grinding and tooth preparation was finalized with finishing diamonds (Fig:11). A final all-ceramic crown was then fabricated and cemented to complete the restoration.(Fig:14)

The patient was recalled after one week, one month, and six months to evaluate (Fig:15) the esthetic result and functional performance. At each follow-up, the restoration remained intact, with excellent gingival health and satisfactory patient acceptance.

Fig:14

Fig:15

Fig:16

DISCUSSION

Restoring endodontically treated teeth with extensive coronal loss demands a balance of strength, retention, and esthetics, remains a challenging aspect of prosthodontic practice. While custom metal cast posts have long been used for their durability and fit, they can compromise esthetics in the anterior region and may cause corrosion or allergic reactions. Zirconia posts offer a strong, biocompatible, tooth-colored alternative that avoids metal shine-through under all-ceramic crowns. However, their high rigidity can increase the risk of root fractures, and removal for retreatment is difficult. Careful case selection, precise preparation, and reliable bonding are essential for successful outcomes.

The present case demonstrates how a custom-milled zirconia cast post and core can successfully address these limitations, achieving optimal esthetics while providing satisfactory retention and support for an all-ceramic crown. This aligns with the findings of Meyenberg et al., 1995[8], who first highlighted the favourable optical properties and comparable flexural strength of zirconia posts to cast gold or titanium. Recent in vitro and clinical research continues to support these benefits. For example, Yesilyurt N G et al. 2020[9], found that zirconia posts maintained superior esthetic results when combined with all-ceramic restorations, especially in patients with thin biotypes or high smile lines.

However, despite these advantages, zirconia posts are not without drawbacks. Studies by Akkayan and Gülmez 2002[10], emphasize that zirconia's high elastic modulus can lead to unfavorable stress distribution within the root dentin, increasing the risk of vertical root fractures a risk that must be considered in patients with parafunctional habits such as bruxism. This risk was mitigated in this case through careful case selection, confirmation of the patient's low occlusal stress risk, and accurate post space preparation.

A key factor in the success of zirconia posts is their retention, which depends heavily on the choice of luting cement and surface pretreatment. Recent studies by Moqbel N M et al., 2022[11] confirm that resin cements, particularly phosphate monomer-based dual-cure systems like Panavia, achieve significantly stronger bonds with zirconia compared to conventional glass ionomer cements. This is enhanced further when the zirconia surface is conditioned using airborne-particle abrasion and silanization a protocol that was strictly followed in this case to ensure reliable retention.

Despite encouraging short-term outcomes, long-term evidence for zirconia posts remains limited. Only a few prospective clinical studies with 2–5-year follow-ups have been published (Sailer et al., 2007[12]; Casucci A et al., 2021[13]. This case contributes to the growing body of evidence that custom zirconia posts can perform well in demanding esthetic cases, but it also reinforces the need for more long-term clinical trials to validate their performance under functional stress.

This case shows that with proper patient selection, technique, and bonding, zirconia cast posts can achieve excellent esthetic and functional results where metal posts might compromise the outcome.

Conclusion

Custom-made zirconia cast posts and cores are a valuable option for restoring severely damaged anterior teeth when high esthetics are required. They offer excellent optical properties and biocompatibility compared to metal posts but demand careful patient selection due to their rigidity and the difficulty of removal if retreatment is needed. This case demonstrates how, with precise technique, surface treatment, and proper cementation, zirconia posts can deliver outstanding esthetic results without compromising strength.

Zirconia cast posts provide an excellent metal-free option for esthetic restoration of endodontically treated teeth in the anterior region. However, clinicians must balance their advantages with their limitations and apply careful case selection, precise technique, and appropriate bonding to ensure long-term success.

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