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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 Colleagues,

It is with great honor and a deep sense of responsibility that I pen this message for the scientific journal of the IDA Kochi Branch. As President, I take immense pride in leading a branch that has consistently championed excellence in dental science, clinical care, and community engagement.

Scientific progress is the cornerstone of our profession, and the publication of this journal is a testament to our collective commitment to academic growth and evidence-based practice. Our branch has always fostered an environment that encourages inquiry, innovation, and the dissemination of knowledge, values that are reflected in every page of this publication.

This year, our focus is on strengthening the scientific spirit within our fraternity through continuous learning, collaborative platforms, and active participation in research and publication. Amidst a dynamic professional landscape, staying updated and contributing to the body of dental knowledge is essential not only for personal development but also for the advancement of our field.

I congratulate the editorial team for their dedicated efforts in curating a journal that upholds high academic standards and serves as a valuable resource for our members and the wider dental community. Let this publication inspire all of us to explore new frontiers in clinical research and to share our insights with confidence and clarity.

I encourage all members to contribute actively to future editions, and to continue engaging in scientific endeavors that uplift the profession as a whole. Together, let us uphold the legacy of IDA Kochi and move forward with purpose, passion, and professional pride.

With best wishes

Dr. Harigovind B
President, IDA Kochi Branch

SECRETARY'S MESSAGE

Dear Members,

Bringing out a high-quality journal issue in today's times is indeed an arduous task. A journal serves as a vital platform for professionals to stay abreast of current trends in the field, while also offering clinicians and researchers a space to share their academic endeavors.

The editorial team of IDA Kochi, led by Dr. Pooja Latti and Dr. Sudheerkumar R. Prabhu, has done a commendable job in publishing the inaugural issue of the Journal of IDA Kochi (JIDAK) for this IDA year. Their dedication and hard work are truly worthy of appreciation.

The best way we can support this initiative is by encouraging our friends and colleagues to contribute manuscripts to the journal. I sincerely urge all readers to actively seek out and submit quality articles for publication in JIDAK, helping it grow into a thriving academic resource for the dental community.

Regards

Dr. Vivek Narayan
Hon. Secretary, IDA Kochi Branch

CHIEF EDITOR'S MESSAGE

Dear Readers,

As we step into the vibrant month of April, we find ourselves surrounded by the spirit of renewal, reflection, and rejuvenation. Festivals such as Holi, the festival of colors, Vishu, the traditional New Year of Kerala, and Easter, symbolizing hope, rebirth, and new beginnings, fill the season with light, meaning, and positivity. These occasions remind us of the importance of harmony, balance, and well-being values that align beautifully with our profession's commitment to holistic health.

April also marks World Health Day on April 7th, championed by the World Health Organization. This year's focus on "My Health, My Right" is especially relevant in today's context, where access to quality oral healthcare remains a fundamental right. It is our responsibility as dental professionals to ensure inclusivity, affordability, and awareness in dental care delivery.

On the scientific front, the field of dentistry continues to evolve at an impressive pace. From the integration of AI-driven diagnostics and 3D printing technologies in prosthodontics and orthodontics, to the growing promise of regenerative dentistry, smart dental materials and stem cell research, we are witnessing a transformation in how we diagnose, plan, and deliver treatment. With each patient we treat and each new advancement we adopt, we move a step closer to a healthier, brighter future. Together, let us continue to inspire change, spread awareness, and uphold excellence in dentistry.

Warm regards

Dr. Pooja Latti
Chief Editor, JIDAK

CONTENTS

ORIGINAL RESEARCH

ASSESSMENT OF PERIODONTAL HEALTH STATUS IN SMOKERS AND SMOKELESS TOBACCO USERS: A CROSS-SECTIONAL STUDY

ABSTRACT

Introduction: Periodontal disease is one of the most commonly occurring dental diseases affecting mankind. Tobacco usage is now known as the major risk factors for periodontal disease. Tobacco is addictive in all its forms and nicotine is considered the most pharmacologically active component in tobacco.

Objectives: The study aimed to compare periodontal status between tobacco users and non-users, measure nicotine levels in their blood and urine, and explore the relationship between their periodontal health and nicotine levels.

Methods: The present study was conducted on 150 male subjects, aged 35-44 years. Subjects with a history of tobacco consumption were divided into 4 groups based on type of tobacco use) and non-tobacco users (n=30) were in comparison group (group 1). Periodontal disease status was recorded with CPI (Community Periodontal Index) and Nicotine concentration in blood and urine samples was determined by spectrophotometric method.

Results: There were statistically significant differences in CPI scores in subjects with and without tobacco use ($p < 0.0005$). There was no statistically significant association between periodontal disease status and levels of nicotine in blood and urine.

Conclusions: Prevalence of periodontal disease was high among tobacco users when compared with non-users. Nicotine levels in blood and urine may be measured as an excellent indicator to evaluate type of tobacco usage, but not for periodontal disease.

Key words: Nicotine, Periodontal, Tobacco, Smokers, Chewers, Blood, Urine.

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INTRODUCTION

Tobacco usage is a menace that has grabbed millions of people all over the world, cutting across the nation and social barriers. Smoking, chewing and inhaling are the three ways in which tobacco is used. Dental Caries and Periodontal disease is the most commonly occurring dental diseases affecting mankind. Periodontal disease, ever since the days of Hippocrates, has crippled the survival of human dentition. Destruction of periodontal attachments is the effect of interaction between genetic, environmental and host factors.[1] For the last few decades, dentists and dental researches have become more aware of the critical role of tobacco usage to the prevalence of periodontal disease. Tobacco usage is now known as one of the major risk factors for periodontal disease.[2]

Tobacco is addictive in all its forms. Nicotine is considered the most pharmacologically active component in tobacco. Estimation of nicotine in biological fluids like saliva, blood and urine has been used as a method for monitoring exposure to tobacco. 35-44 years is the standard monitoring age group for adults since all the effects observed as periodontal and/or other oral lesions are observable in this age group.[3]

Very few studies have been reported on biochemical analysis of blood and urine among tobacco users and their association with periodontal status. Hence, the research was undertaken to assess and correlate the periodontal status of tobacco users with their nicotine concentration in blood and urine.

METHODOLOGY

A cross-sectional institution-based study was conducted to evaluate the periodontal status of different tobacco users and the nicotine concentration in their blood and urine. The study population consisted of male patients attending the outpatient Department of Community Dentistry, Yenepoya Dental College in 35-44 year age group. The study was approved by the Institutional Review Board.

Inclusion Criteria:

- Male subjects in the 35-44 year age group.
- Beedi smokers : Subjects smoking more than 5 beedis per day for a period of more than a year.
- Cigarette smokers : Subjects smoking more than 5 cigarettes per day for more than a year.
- Tobacco chewers: Subjects consuming tobacco in any chewable method daily for more than a year.
- Smokers who are also tobacco chewers: Subjects using more than 5 beedis / cigarettes per day for more than a year and also chewing tobacco.
- Non-Smokers (Controls): Subjects who had never smoked in their life time.
- Subjects who consented to be a part of the study.

Exclusion criteria: Subjects with systemic diseases, those on long term medication or drugs which may modify the periodontal status and who have undergone periodontal therapy in the past six months were excluded from study.

The study instrument consisted of a questionnaire with three parts.

The first part was for recording information on tobacco usage.

The second half was for recording clinical data. The periodontal disease was recorded using CPI.

The third part was to record the nicotine concentration in blood and urine. 3-5 subjects were examined in a day. The examinations were carried out by a trained investigator.

Sample collection for nicotine assessment:

Blood samples were withdrawn by standard venipuncture technique and collected in tubes containing EDTA. The precipitate obtained was separated at 4^0C by centrifugation (2000*g) for 10 minutes and then analyzed.

Urine sample was collected in a sterile glass bottle. Blood and Urine samples were placed in a ice box with temperature maintained at -4^0C and transferred to Yenepoya Research Centre for estimation of nicotine concentration in the samples. The biochemical analysis was started within 45 minutes of collection of samples. The method of Asthana (2004) for assessing nicotine concentration in blood and urine samples by spectrophotometric method.[4]

Statistical Analysis:

The data obtained was coded and entered in to the Microsoft Excel sheets. The data was then fed into the SPSS (Statistical Package for Social

Studies) software-20 for analysis. Chi-square test was used in analysis as the data were in frequencies of more than one categories and also it was able to find the significance (p value) if any in the same data. Pearson Correlation tests were also performed to see if there was any significant correlation between the CPI and LOA (Loss of Attachment) scores and nicotine levels in blood and urine samples in various groups.

RESULTS:

Periodontal status was assessed using Community Periodontal Index (CPI). Comparison of different forms of tobacco and non-tobacco users with the related CPI scores based on highest of all the 6 scores in an individual showed non-tobacco users with the highest percentage of healthy sextants (13.3%) and sextants with bleeding on probing (46.7%). Calculus was found to be elevated among tobacco chewers (50%) with other users. Periodontal pockets with 4 to 5 mm found to be higher among beedi chewers (36.7%). Periodontal pockets with 6 mm or more was higher among users of both forms of tobacco (30%). When the community periodontal index scores of various tobacco users and non-tobacco users were compared it was found to be statistically significant ($p<0.0005$). When attachment scores were compared with different forms of tobacco users, cigarette smokers had highest attachment loss with 0-3 mm (62.9%). Attachment loss with 4-5 mm (29.9%) was higher among beedi smokers. When loss of attachment score of various forms of tobacco and non-tobacco users were compared it was found to be statistically significant ($p<0.0005$).

Group	n	Nicotine levels (Mean)	Standard Deviation	Minimum level detected (ng/ml)	Maximum level detected (ng/ml)
NON-TOBACCO USER	30	30.91	9.84	0.0	43.5
CIGARETTE SMOKER	30	284.88	73.31	182.3	436.2
BEEDI SMOKER	30	504.38	208.25	158.4	797.6
TOBACCO CHEWER	30	311.94	91.86	151.7	487.9
SMOKER + CHEWER	30	505.58	205.79	166.8	786.1
TOTAL	**150**	**378.52**	**202.52**	**0.0**	**797.6**

Table 1: Comparison of nicotine levels in blood among tobacco and non-tobacco users

Group	n	Nicotine levels (Mean)	Standard Deviation	Minimum level detected (ng/ml)	Maximum level detected (ng/ml)
NON-TOBACCO USER	30	58.24	26.95	0.0	100.8
CIGARETTE SMOKER	30	618.52	245.05	261.4	1391.6
BEEDI SMOKER	30	2030.88	645.51	898.9	3461.8
TOBACCO CHEWER	30	678.86	278.72	266.6	1856.1
SMOKER + CHEWER	30	2018.28	634.46	898.9	3271.4
TOTAL	**150**	**1146.24**	**901.68**	**0.0**	**3461.8**

Table 2: Comparison of nicotine levels in urine among tobacco and non-tobacco users

Nicotine levels in blood were associated with various forms of tobacco use; the levels detected were highest in beedi smokers (797.6 ng/ml) and least in cigarette smokers (261.4 ng/ml). Among non-tobacco users maximum blood nicotine levels observed was (43.5 ng/ml) and minimum (0.0 ng/ml). The difference in blood nicotine levels among the various tobacco and non-tobacco users was found to be significant ($p<0.0005$). (Table -1).

When nicotine levels in urine with various forms of tobacco users was compared, it was found to be highest in beedi smokers (3461.8 ng/ml) and minimum in cigarette smokers (261.4 ng/ml). Among non-tobacco users, maximum urine nicotine levels observed was (100.8 ng/ml) and minimum (0.0 ng/ml). The difference in nicotine levels in urine among various tobacco and non-tobacco users was found to be significant ($p<0.0005$) (Table - 2).

When Community Periodontal Index scores were associated with nicotine levels of non-tobacco users it decreased with increase in CPI scores and was not significant ($R = -0.086$, $P>0.05$). Though the Nicotine levels in blood was found to increase with increase in CPI, the result was not statistically significant ($R = 0.136$, $P>0.05$). Correlation of loss of attachment scores with levels of nicotine in blood and urine of non-tobacco users showed a negative correlation, not significant. ($R= -0.37$, $p> 0.05$ & $R = -0.23$, $p > 0.05$).

When community periodontal index scores were associated with levels of nicotine in blood and urine of cigarette smokers, urine nicotine levels was found to decrease with increase in CPI scores, not statistically significant ($R = -.031$, $p>0.05$. Nicotine levels in blood showed an increase in levels with increase in CPI scores ($R = 0.023$) not statistically significant ($p>0.05$) .Loss of attachment scores with nicotine levels in blood and urine of cigarette smokers showed a positive correlation, which was not statistically significant ($r = 0.031$, $p>0.05$ and $r = 0.131$, $p>0.05$).

In subjects who smoked beedi when community periodontal index scores were associated with levels of nicotine in blood and urine of beedi smokers, it was found to decrease with increase in CPI scores in blood, which was not statistically significant ($R = -0.025$, $p>0.05$). Nicotine levels in urine was found to increase with increase in CPI scores in beedi smokers, which was not statistically significant ($R = 0.100$, $p>0.05$). Correlation of attachment loss with levels of nicotine in blood and urine, of beedi smokers showed positive correlation, which was not statistically significant ($R = 0.146$, $p>0.05$, $R = 0.256$, $p>0.05$). Loss of attachment scores with nicotine levels in urine of tobacco chewers was found to increase with loss of attachment scores, which was not statistically significant.($R = 0.030$, $p>0.05$).

Nicotine levels with blood was found to increase with attachment score, which was not statistically significant ($R = -0.087$, $p>0.05$). Mean urine concentration of nicotine was found to be the highest in beedi smokers, (2030.88±645.51) followed by users of both forms of tobacco (2018.28±634.46). Non smokers also showed mean concentration of 58.24±26.95.

Correlation of community periodontal Index scores with nicotine levels in urine of users of both forms of tobacco showed a positive correlation ($R = 0.106$, $r = 0.126$) which was not statistically significant ($p>0.05$). Nicotine levels in blood showed a negative correlation ($R = -0.024$) which was not statistically significant ($p>0.05$) .In the present study when attachment loss was correlated with nicotine levels in blood and urine was found to increase with increase in attachment scores ($R = 0.147$, $r = 0.251$) which was not statistically significant ($p>0.05$).

DISCUSSION

Tobacco consumption is the leading preventable cause of death in the developed world.[5] Tobacco use is directly related to a variety of medical problems including low birth weight, pulmonary and cardiovascular diseases.[35] Results of the study showed significant differences in the periodontal status with respect to CPI scores and LOA scores in tobacco and non-tobacco users. This is in agreement with most of the previous studies Haber et al 1993[7]; Linden and Mullaly1994[8]; Martinez Canut et al 1995[9]; Machuca et al 2000[10]; Hashim et al 2001[11] and Alwahadni and Linden 2003.[12]

High prevalence of bleeding, calculus and periodontal pockets were observed among beedi smokers and cigarette smokers. Loss of attachment was found to be highest among beedi users. This could be explained by the presence of more toxic irritants, high amount of tobacco in beedies and absence of filter in beedies.[4]

Sites with calculus detected were observed more in tobacco users than non-tobacco users.

This was in line with research conducted by Muller et al 2002.[2]

Sites with periodontal pockets 4-5 mm were found to be higher in tobacco smokers in comparison with non-tobacco users in whom it was considerably low. This is in agreement with the studies conducted by Linden and Mullaly 1994[8]; Martinez Canutet al 19959; Axelsson et al 1998[14]; Machuca et al 2000[10]; Haffajee et al 2001[17]; Calcina etal 2002[16] and Tanner et al 2005.[17]

Tobacco chewers had high prevalence of calculus when compared to tobacco smokers and users of both forms of tobacco. This is due to the cumulative effect of placement of tobacco for longer duration in the mouth and also more irritants seen in smokeless tobacco products.[18]

Nicotine is metabolized in the body into two major pharmacologically inactive metabolites: cotinine and nicotine-N-oxide. Half-life of nicotine following inhalation or parenteral administration is approximately 2 hours and the half-life of its metabolite cotinine, is about 19 hours. Nicotine and/or cotinine have been isolated in plasma, urine, saliva and GCF of cigarette smokers.[19]

The results demonstrated the presence of higher amount of nicotine in blood and urine of tobacco users compared to non-tobacco users.

Mean urine concentration of nicotine was found to be the highest in beedi smokers followed by users of both forms of tobacco and non smokers. Oral intake of tobacco in chewable form also increases its excretion, as nicotine can be absorbed from oral mucosa. This was in tune with the studies conducted by Behera etal 2003[20], Heinrich et al 2005[21] and Asthana et al 2004.[4]

Mean nicotine levels in blood in various tobacco users showed highest concentration in users of both forms of tobacco 505.58±205.79 followed by beedi smokers 504.38±208.25. Non smokers also showed nicotine levels in blood. This was in agreement with Asthana et al 2004[4] and Hengen and Hengen 1978.[22]

In our study nicotine levels in blood and urine showed no positive correlation with periodontal status. There are no previous studies in this regard and hence no comparison could be made.

The vasoactive properties of nicotine may possibly affect the pathogenesis of periodontal disease. Further studies are needed to accurately quantitate nicotine in blood and urine, perhaps with more specific and sensitive techniques such as radioimmunoassay and High performance liquid chromatography. Also, further research should be aimed at examining the effect of nicotine on periodontium by means of longitudinal studies with extended follow up of the subjects in order to better understand its possible role in the periodontal disease process.

SUMMARY AND CONCLUSION

The study was conducted to evaluate and correlate the periodontal status of 35-44 year male tobacco and non-tobacco users with their nicotine concentration in blood and urine. The findings suggested a marked association between tobacco use and periodontitis. The study showed statistically significant difference in the periodontal status with respect to CPI scores among tobacco and non-tobacco users.

In the study, when the loss of attachment scores of tobacco and non-tobacco users were compared, the difference was found to be statistically significant. The study showed non-tobacco users had significantly better periodontal status compared to various tobacco users. Increased attachment loss was observed in tobacco users with non-tobacco users.

The study showed that nicotine levels in blood and urine nicotine is higher in various tobacco users compared to non-tobacco users. Our results indicate that nicotine level in blood and urine may be considered as an excellent indicator to assess the exposure to tobacco.

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REVIEW ARTICLE

BAGHDADITE AND ITS EMERGING APPLICATIONS IN MODERN DENTISTRY: A NARRATIVE REVIEW

ABSTRACT

Background: Baghdadite is a Calcium Silicate ceramic with significant potential in clinical applications. It is potentially one of the most versatile and revolutionary materials of this century in dentistry. Recognized for its exceptional properties like bioactivity, biocompatibility, biodegradability and cell adhesion making it appropriate for a broad spectrum of dental applications including endodontics, bone regeneration, grafts, implantology, periodontal therapy, orthodontics, maxillofacial reconstruction and orthopaedics.

Materials & methods: An extensive electronic scientific literature search was carried out across multiple databases such as Scopus, Web of Science, Medline (PUBMED), and Cochrane central employing the search terms Bioceramics, Baghdadite, Bioactive ceramics, Calcium Silicate bioceramics. The selection criteria included brief communications, randomised clinical trials (RCTs), invitro analysis and animal investigations published in English were considered. Editorial reviews, Case reports, and opinion letters were eliminated in the initial scrutinization stage.

Results: Totally, 234 articles were identified through the database scout. Following a rigorous screening process, 47 articles fulfilled all the selection criteria, focussing on the applications of Baghdadite.

Conclusion: This review provides a comprehensive analysis of the existing scientific literature on Baghdadite, discussing its composition, structure, properties and clinical relevance.

Keywords: Bioceramics, Baghdadite, Bioactive ceramics, Calcium Silicate Bioceramics.

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INTRODUCTION

Bioceramics like MTA and Biodentin are extensively used in endodontics, bone regeneration, grafts, implantology, periodontal therapy, orthodontics, maxillofacial reconstruction and orthopaedics[1,2]. They are classified into three types: bioactive, bioinert and bioresorbable.[3,4] Calcium Phosphate and silicate ceramics like hydroxyapatite, calcium phosphate and bioglass ceramics are classified as bioactive. Alumina, Zirconia and Titanium based ceramics are bioinert, while calcium sulphate ceramics are bioresorbable.

Baghdadite (BAG) is a Zirconium based Calcium Silicate ceramic discovered from the Qandil metamorphic rocks from Dupezeh mountain, Iraq, which are of cretaceous calcareous origin. It belongs to the Wöhlerite group of minerals, characterised by the general formula- $X3_4[Si_20_7](O,OH,F)_2$ - as defined by Aarden and Gittins (1974) where X represents the metallic cations. The simplest member of this group is cuspidine $Ca_4[Si_20_7](O,OH,F)_2$. Baghdadite [$Ca_3Zr(Si_20_7)O_2$ or $Ca_3ZrSi_2O_9$] slightly deviates from the Wöhlerite group as it lacks fluoride and hydroxyl ions[5] The classification of Baghdadite within the bioceramic categories remains unclear, although it displays high bioactivity according to various studies.[6,7] Baghdadite also displays excellent chemical stability across various pH conditions, along with notable corrosion resistance, compressive strength, elastic moduli and other favourable biological characteristics. Several animal models have successfully demonstrated its potential for application in orthopaedics and dental implantology.[8-10]

This review aims to explore the properties and applications of this novel biomaterial and compare it with clinically established alternatives and explore the prospects in biomedical research and clinical practice.

COMPOSITION & STRUCTURE

Baghdadite has a monoclinic crystal structure having bulk density of 3.34g/cc. It consists of two distinct structural modules: One featuring disilicate groups and the other consisting of interconnected octahedral walls arranged in four columns. The ionic distribution within the polyhedron is characteristically patterned[11].

SYNTHESIS OF BAGHDADITE SCAFFOLDS

Baghdadite scaffolds are synthesised using several techniques, including the conventional sol gel technique, where Ca, Si, and Zr precursors are processed at high temperatures (1350°C)[8]. A modified sol gel technique halts untimely gelling by dissolving Zr independently in ethanol[6], the direct solid-state method necessitates sintering at 1350-1450°C, with research achieving Baghdadite coatings on Ti-6Al-4V implants[12,13]. Other techniques include electrospinning Polycaprolactone - Baghdadite (PCL-BAG) scaffolds[14], the polyurethane sponge method intensifying bone like apatite formation[15,16] and physical vapour and electrophoretic accumulation upgrading corrosion resistance and antibacterial properties[17]. 3D printing techniques, such as stereolithography and freeze drying, warrant custom scaffold fabrication with added bioactive coatings[18,19]. Plasma spray techniques are employed for implant coatings[7,20,21]. Ion assisted plasma polymerization (IAPP) on Mg-BAG scaffolds intensifies osteoinductivity by modulating BMP-2 and Si ion release[22]. These approaches contribute to the development of BAG scaffolds for bone regeneration and implantology

PROPERTIES:

Till 2014, practically no specifics have been recorded on the mechanical properties of Baghdadite in literature.[6]

Physical properties: Baghdadite exhibits a more consistent microstructure compared to Hydroxyapatite. Its crystallinity is a crucial factor that can be enhanced through heat treatment during the atmospheric plasma spraying process.[21,22]

Surface roughness: Research has shown that increasing in the Baghdadite concentration (3wt% and 5wt%) leads to an increased surface roughness in the PCL-BAG scaffolds, which in turn enhances cell adhesion and promotes cell proliferation.[23] Homogenous surface roughness seen in Baghdadite coating (9.9 ± 0.6µm) than Hap (10.1 ± 0.9µm).[7]

Solubility: Porosity- Baghdadite scaffolds demonstrate high interconnected porosities (74.8 ± 2.3% for unmodified Baghdadite and 76.7 ± 1.6% for modified one) that enhance vascularization[9,23]. Atmospheric plasma

sprayed Baghdadite coating exhibit a lamellar structure with porosity like Hydroxyapatite, though marginally lower on Ti-6Al-4V implants[13,46]. Hap-BAG composite scaffolds attain porosities >40% due to BAG addition, boosting osteoblastic proliferation (6,19,24). PCL-BAG scaffolds exhibit 70-83% porosity, while BAG-diopside scaffolds with PCL reach 73±1%[11,16]. In N6-BAG nanocomposites, porosity drops from 90±2% to 70±1% as BAG content increases[25].

Radiopacity: Baghdadite has demonstrated excellent radiopacity when incorporated into bone defect filling cements such as brushite. This represents a significant advancement in material identification on radiographs, as Ca-P cements like brushite and bone possess indistinguishable X ray mass attenuation coefficient.[26] Bismuth-doped Baghdadite exhibited 33% greater radiopacity than pure Baghdadite and 155% higher radiopacity compared to biphasic calcium phosphate. This enhanced radiopacity is attributed the presence of Zirconium present in Baghdadite.[27]

Mechanical properties of Baghdadite:

The mechanical properties of Baghdadite scaffolds, including the fracture toughness, porosity, bending strength, hardness depends on the fabrication method used. The direct solid-state technique at 1400°C, promotes a homogenous microstructure but limits optimal mechanical properties. Higher sintering temperatures reduces porosity, enhancing mechanical strength[12].

Baghdadite exhibits approximately 30% higher fracture toughness and 13% greater hardness than Hap, with comparable bending strength. Biomimetic nylon 6-BAG nanocomposites, fabricated using cuttlefish bone (CB) as a 'sacrificial template', showed improved compressive strength and compressive modulus.[25] Electrospun PCL-BAG nanocomposites achieved maximum tensile strength and uniform fibre thickness.[7] PCL-BAG scaffolds showed a compressive strength of 0.41 MPa[16]. Meanwhile, a Bag-diopside composite scaffold coated with 6%PCL exhibited a compressive modulus and compressive strength was 189.1 ± 1 MPa and 1.63 ± 0.2 MPa respectively, making it suitable for low load-bearing sites.[11]

Elastic moduli (4.09±0.01 MPa) and fracture strength (8.30±0.16 MPa) increased for PCL-1Gr-3Bag scaffold. compressive strength turned out to be like that of spongy bone and with chitosan and bag being hydrophilic it leads to a stronger bond and thus better mechanical properties. The compressive strength of spongy bone is reported to be 0.2-4 MPa. (Gibson and Ashby) But adding 5wt% decreased the overall mechanical properties of the scaffold which was due to the agglomeration of the nanoparticles and inhomogeneous phase distribution.[23]

Bag in composite scaffolds: degradation rate matched that of the gradual transfer of loads from implants to the new bone. Highest compressive strength compared to any other bag composite scaffolds from other studies. boron-doped Hydroxyapatite showed good mechanical strength that is suited for treating cancellous bone defects.[6]

Zinc incorporated Baghdadite composite: increased compressive strength with addition of ZnO.[28]

Baghdadite as an additive to other bone defect filling cements: The substitution of Baghdadite for Beta-Tri Calcium Phosphate in Brushite-based bone defect filling cement demonstrated significant enhancements in both mechanical and biological properties. A 10 wt% incorporation of BAG resulted in an increase in compressive strength from 12+/- 3.1 MPa to 21.2 +/- 4.1 MPa. Furthermore, at a 20 wt% BAG concentration, the cement maintained a physiological Ph of 7.2 in the culture medium, promoting environment conductive osteoblast proliferation in vitro.[16] The use of Baghdadite as a defect filling material resulted in an ultimate torsional strength equivalent to 5-10% of that of intact sheep tibia.[9]

Baghdadite implants: Schumacher et al[12] suggested that Baghdadite is suitable for use in non-load-bearing applications, such as coatings or bone defect filling.

Baghdadite Coatings: Crystallinity plays a crucial role in implant coatings, directly influencing mechanical strength and solubility. Higher crystallinity enhances mechanical properties butreduces solubility, thereby limiting bone formation. A uniform phase distribution of Ca, Si and Zr in Baghdadite coating ensures homogenous mechanical properties, such as elastic modulus and microhardness, as confirmed by

EDX analysis. The Vickers hardness test revealed a hardness of 325.5 ± 55.2 HV for the Baghdadite coating, compared to 118.3 ± 21.2HV300 for the Hap coating, which can be attributed to the presence of Zr in Baghdadite. Using the atmospheric plasma spray technique, Baghdadite coatings on Ti-6Al-4V implants demonstrated excellent chemical stability and enhanced apatite formation compared to the traditional Hydroxyapatite coatings, making them suitable for orthopedic and dental applications. Additionally, Pham et al employed a hybrid water-stabilized technique to coat Ti-6Al-4V implant with Baghdadite, resulting in coatings with superior hardness, elastic modulus and wear resistance compared to HA coatings[21]. Furthermore, doping Baghdadite with Sr slightly increased the compressive strength, hardness and fracture toughness[16].

Biological properties of BAG:

Osteoblasts, osteoclastic activity: Baghdadite enhances osteoblastic differentiation, maturation and apatite layer formation due to its increased surface roughness compared to casil ceramics. HOBs exhibited spreading with filapodia- like processes, forming a confluent sheet like layer with excessive proliferation. Cathepsin K mRNA expression was higher in $CaSiO_3$ indicating Baghdadite's bone resorption property.[7] ZnO-BAG composites[29] and diopside /BAG scaffolds with PCLF coating[11] showed good MG63 cell spreading, attributed to surface silanol groups. Similar results were observed with chitosan-Baghdadite nanoparticles on SS316L implants[29] and Ti-6Al-4V implants coated with Baghdadite, which promoted better HOB proliferation and gene expression than HAP coatings[21] Cell viability improved with 3 wt% BAG in a PCL matrix (14) PCL-Gr scaffolds with 3-5 wt% Baghdadite further enhanced cell viability and proliferation, confirmed by Hoechst staining. These fibrous scaffolds generated were morphologically like the natural ECM.[23]

In vivo, Luo et al demonstrated that Baghdadite ceramic spheres implanted in Wistar rat femur defects led to higher new bone formation rate, osteopontin and collagen type 1 expression than beta-TCP and Mg-doped diopside.[10]

Bioactivity: Multiple studies have demonstrated the apatite forming ability of Baghdadite[15,17,25,29]. This is likely due to the increased presence of Si^{4+} ions on the surface, leading to the formation of a silanol group (-Si-OH). These negatively charged groups facilitate the adsorption of Ca^{2+} and Phosphate ions, promoting the formation of Ca-P apatite layer.

Biodegradability: The slow biodegradation of Baghdadite scaffolds is favourable as it preserves the mechanical strength during the initial healing phase, allowing a gradual load transfer from the implant to the new forming bone.[27] Additionally, ZnOx-doped Baghdadite scaffolds exhibit an even lower biodegradation rate than pure Baghdadite.[28,29]

Anti-bacterial activity: The incorporation of Vancomycin to Baghdadite significantly enhanced its antibacterial potency compared to pure Baghdadite. As the concentration of Vancomycin was increased, the zone of inhibition against Staphylococcus aureus also expanded. This improved antibacterial property of Baghdadite-Vancomycin scaffold promoted the spreading and proliferation of MG63 cells. However, at a very high concentration of Vancomycin (5%), cell spreading was adversely affected. Thus, an ideal vancomycin concentration of approximately 1-3% is recommended. Additionally, the compressive strength of Baghdadite, both with and without Vancomycin is 0.86 MPa which is comparable to that of the spongy bone.[30]

Incorporation of ZnO to Baghdadite: Yadav et al (2021) reported that ZnO incorporated Baghdadite exhibited strong antibacterial efficacy against Ecoli.[28]

Stimulation of differentiation of PDLSCs: Baghdadite supports the adhesion and proliferation of hPDLSCs while promoting the expression of cementogenic and osteogenic markers. Its ionic products further enhance cementogenic / osteogenic differentiation via Wnt/β-catenin signalling pathway, likely due to the higher concentrations of Ca, Si and Zr, though lower than β-TCP. Baghdadite supported the differentiation of HOBs more effectively than the Hap coating on Ti-6Al-4V implants.[21]

BAG/PCL nanocomposite scaffolds promoted invitro proliferation of SAOS-2 human osteoblast-like cells without cytotoxicity[16]. Similar results were observed in PCL-Diopside scaffolds prepared via electrospinning.[31]

APPLICATIONS:

Bone defect repair: Baghdadite's enhanced bioactivity, due to Zr content, makes it's a promising material for bone defect repair. Roohani and Esfahani et al[8] were the first to use Baghdadite scaffolds for radial bone defect repair in rabbits, comparing modified (nBGs and PCL coated) and unmodified scaffolds. Both showed new bone formation, but modified scaffolds exhibited improved mechanical strength, as demonstrated by stress-strain curve analysis. The absence of additional stem cells or growth factors suggests Baghdadite's osteoinductive potential, making it viable for load bearing defect repair.

A similar study on large sheep tibiae defects showed that surface modified Baghdadite scaffolds-maintained bioactivity while enhancing mechanical properties, making them suitable for load bearing applications. Modified scaffolds showed slightly higher bone volume, though plate bending and fracture occurred post-surgery. However, after re-treatment, healing continued without complications.[9]

Orthopaedic bone defect: PMMA is widely used in orthopaedic surgeries, but adding graphene-coated Baghdadite improved its compressive strength by 33.6% and elastic modulus by 70.9% over Simplex-P bone cement. Enhanced radiopacity, apatite forming ability and angiogenesis were also observed. Additionally, incorporating 2 wt% vancomycin improved antibacterial activity. In vitro, MG63 cell proliferation and osteogenic differentiation of human adipose derived mesenchymal stem cells were confirmed. In vivo, osseointegration was evident within weeks of implantation in rats.[32]

Orthopaedic Implants: Baghdadite's composition (Zr, Ca and Si) enhances bone regeneration and corrosion resistance, particularly when treated with laser surface modifications[29]. Coating stainless steel implants with Chitosan-Baghdadite nanoparticles, has shown improved anti-bacterial properties, corrosion resistance, and bioactivity making it a viable orthopedic implant material.

Hip Arthroplasty: An invitro study examined Baghdadite's biocompatibility in large defect filling, such as in revision total hip arthroplasty (RTHA). Baghdadite induced TNF-alpha proliferation and IL-6 upregulation in THP-1 derived cell lines, indicating potential proinflammatory activity. However, whether this leads to bone resorption rather than formation remains unclear.[33]

Compared to diopside and akermanite, Baghdadite has lower porosity (11% vs 22% and 39% respectively) and a higher density, leading to superior mechanical properties. Baghdadite exhibited the highest compressive strength among the three.[34]

BAG as Endodontic Filling Materials: for Baghdadite to be effective as an endodontic filler, injectability is critical. Studies indicate that injectability improves with a lower powder to liquid ratio, but this compromises compressive strength. MaBAG cement shows promise, providing an alkaline environment conducive to tissue repair and mineralisation. However, Baghdadite in brushite, due to its high porosity and biodegradability, is unsuitable as an endodontic filler. A higher PLR improves compressive strength, but negatively affects injectability, necessitating further research. MaBAG demonstrated a radiopacity value (2.05 ± 0.07 mm Al) like that of biodentine, though the standard for root sealers is a min of 3mm Al. Additionally, MaBAG showed reduced activity against Staphylococcus aureus and Streptococcus mutans compared to Proroot MTA.[35]

FUTURE PERSPECTIVES:

The superior bioactivity of Baghdadite has positioned it at the forefront of in vivo studies, yielding successful results. Doping with elements like Sr and Mg enhances its porosity without compromising compressive strength. Extensive research on Baghdadite scaffolds has focussed on improving their properties, particularly through polymer composites like PCL-BAG and N6-BAG Nanocomposites, which have shown enhanced mechanical strength[25]. Chitosan has conferred antibacterial properties to Baghdadite scaffolds, with Vancomycin and ZnOx also being viable options. These doped Baghdadite scaffolds demonstrate near optimal properties for bone regeneration, showing promising results in rabbit tibia and sheep bone defect models. The ability to create personalised scaffolds offers surgeons new opportunities for reconstructive procedures, such as

following major cyst enucleations and tumour resections. Baghdadite also exhibited potential orthopaedic and dental implantology, with both in-vitro and in-vivo success.

In endodontics, Baghdadite demonstrated good injectability, radiopacity and antimicrobial properties - surpassing ProRoot MTA in a study- suggesting potential use in root canal fillings and apicoectomy. While MTA and Biodentin are widely used bioceramics, Baghdadite shows promise for pulpotomy and apexogenesis due to its ability to induce cellular differentiation. Additionally, Baghdadite could play a role in guided bone regeneration (GBR) by promoting PDLSC differentiation. The importance of macrophage activation in Baghdadite scaffold applications for bone tissue engineering has been highlighted, emphasizing the need for further research on host cell responses. Clinical trials are necessary to validate Baghdadite as an implant coating, given its impressive in vitro and in vivo results.

CONCLUSION

Baghdadite is an emerging and highly promising biomaterial for bone regeneration, orthopedic, and dental applications due to its superior bioactivity, mechanical strength, and biocompatibility. Its ability to support osteogenesis, cementogenesis, and guided bone regeneration, along with the successful invitro and in vivo results, underscores its potential for clinical translation. Doping strategies have further enhanced its properties, while polymer composites and antibacterial modifications expand its versatility. However, further research, particularly on macrophage interactions and long-term clinical performance, is essential. With continued advancements, Baghdadite could play a transformative role in regenerative medicine and implantology.

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REVIEW ARTICLE

DENTAL UNDERGRADUATE CURRICULUM IN INDIA: A SWOC ANALYSIS

ABSTRACT

The dental curriculum in India, governed by the Dental Council of India (DCI), plays a pivotal role in shaping future dental professionals. This review article provides a detailed SWOC (Strengths, Weaknesses, Opportunities, and Challenges) analysis of the current Bachelor of Dental Surgery (BDS) curriculum in India. Strengths include its comprehensive structure, significant clinical exposure, increasing alignment with global standards, emphasis on ethics, and a growing research focus. However, weaknesses such as inconsistent training quality across institutions, an urban-centric distribution of colleges, outdated teaching methodologies, limited integration of modern technologies, inadequate faculty development, an assessment-driven framework, and the high cost of education persist. Opportunities lie in embracing digital dentistry, expanding specialization programs, fostering interdisciplinary collaboration, promoting community-based education, leveraging dental tourism, enhancing continuing professional development, and bolstering research and innovation. Challenges include the rising number of graduates and limited job opportunities, the migration of dentists, the potential erosion of professional values, low public awareness of oral health, regulatory complexities, and the impact of the COVID-19 pandemic. The establishment of the National Dental Commission (NDC), suggest potential transformative changes in dental education. Addressing these weaknesses and threats while capitalizing on the identified strengths and opportunities, in alignment with evolving national healthcare education paradigms, is crucial for ensuring the Indian dental education system produces competent, ethical, and socially responsible dental professionals capable of meeting the nation's oral healthcare needs.

Key words: Dental curriculum, competency based education, education, reforms.

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INTRODUCTION

The healthcare landscape has undergone a significant transformation in the past two decades, influencing public health perspectives, and dental healthcare is no different. To meet these evolving societal demands, dental healthcare providers need to be adequately prepared. The current dental curriculum in India has historically prioritized the development of surgical skills, sometimes at the expense of a more holistic understanding of overall health and primary prevention. However, given the substantial population of the country, primary oral healthcare remains a crucial focus in national health planning, underscoring the vital role of the dental education system in equipping graduates to effectively address this fundamental need.[1]

Dental education plays a crucial role in producing competent dental professionals who can cater to the diverse needs of patients.[2] The Bachelor of Dental Surgery (BDS) curriculum in India serves as the cornerstone for training future dental professionals. Governed and regularly updated by the Dental Council of India (DCI), this curriculum aims to produce graduates equipped with the necessary knowledge, skills, and attitudes to address the oral health needs of the nation.

The adoption of the Choice Based Credit System (CBCS) in Indian undergraduate education, driven by recommendations from the National Knowledge Commission (2008-2009) and the Yashpal Committee (2009) and implemented by the University Grants Commission (UGC 2015), marks a significant step towards enhancing educational quality and providing students with greater flexibility and a student-centered learning environment tailored to individual interests and career aspirations.[2] This reform, in dental education, aligns with the overarching philosophy of the National Education Policy (NEP) 2020, which emphasizes recognizing and nurturing the unique abilities of each student.[3] Consequently, future perspectives for the Indian dental curriculum, especially with the establishment of the National Dental Commission (NDC), are likely to be significantly influenced by the principles underpinning CBCS and NEP 2020.[4] This suggests a continued movement towards student-centric learning, flexibility in course selection, and a focus on developing the holistic potential of dental graduates, mirroring the broader educational reforms aimed at creating a more advantageous and customized learning experience across all disciplines.[2]

Dental education in India has a long history, with evidence of dental practices dating back to ancient times. The first modern dental college was established in Calcutta in 1920. Since then, dental education has grown significantly, and India now has about 323 dental colleges offering undergraduate (BDS) and 281 colleges offering postgraduate (MDS) degrees. The Dental Council of India (DCI), established in 1949, is the statutory body that regulates dental education and the profession of dentistry throughout India.[5] The National Dental Commission (NDC) Bill, 2023 has been passed and aims to replace the DCI with the NDC to further improve the quality of dental education and align it with international standards.

SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is one of the oldest and most widely adopted strategy tools worldwide.[6] In response to the limitations of SWOT analysis, organizations have started to shift towards a more comprehensive approach, namely SWOC analysis, which stands for Strengths, Weaknesses, Opportunities, and Challenges. SWOC analysis is a more dynamic approach to strategic planning, which not only considers the internal and external factors but also focuses on the challenges arising from the organization's internal context, such as culture, processes, and systems.[7]

This review delves deeper into the strengths, weaknesses, opportunities, and challenges (SWOC) inherent in the current Indian dental education system, providing a more granular analysis of each aspect.

Strengths

1. **Comprehensive Curriculum:** The curriculum's strength lies in its extensive coverage of foundational medical sciences and all the major clinical disciplines within dentistry. This includes a robust preclinical phase focussing on basic sciences relevant to oral health, followed by clinical training across various specialties[8]. The detailed syllabi for each subject aim to provide a

strong theoretical base before clinical application.

2. **Clinical Exposure:** A significant advantage of the Indian dental curriculum is the mandatory clinical training integrated throughout the course, culminating in a compulsory one-year rotatory internship.[5] This hands-on experience in dental colleges and affiliated hospitals allows students to apply their theoretical knowledge under supervision, develop essential psychomotor skills, and gain confidence in managing diverse clinical scenarios. The internship is crucial for transitioning from a student to a practicing dentist, exposing them to real-world challenges and patient management protocols.
3. **Alignment with Global Standards:** Recognizing the importance of international comparability, the DCI has been actively working towards aligning the Indian dental education system with global benchmarks[9,10]. The introduction of the Choice Based Credit System (CBCBS) is a significant step in this direction. CBCS promotes flexibility in learning, allowing students to choose elective subjects, facilitating interdisciplinary learning, and potentially enabling credit transfer between institutions, both within and outside India. This learner-centric approach encourages self-directed learning and continuous evaluation.[1]
4. **Emphasis on Ethics and Professionalism:** Contemporary dental practice demands not only clinical competence but also adherence to ethical principles and professional conduct. The curriculum increasingly integrates modules and discussions on dental ethics, patient rights, communication skills, and professional responsibilities. This focus aims to cultivate graduates who are not only skilled clinicians but also empathetic, ethical, and responsible members of the healthcare community, capable of building trust with patients and collaborating effectively with colleagues.
5. **Increasing Research Focus:** Undergraduate research in health sciences is gaining importance and has demonstrated enhance performance of health-care professions. Recognizing the importance of evidence-based practice and innovation, there is a growing emphasis on introducing research methodologies to undergraduate dental students. This includes training in formulating research questions, designing studies, collecting and analyzing data, and critically appraising scientific literature.[12] Encouraging research at the undergraduate level aims to foster a spirit of inquiry, critical thinking, and a commitment to lifelong learning, potentially leading to future contributions in dental research.

Weaknesses

1. **Inconsistent Quality of Training:** A major concern within the Indian dental education landscape is the significant variation in the quality of training imparted by different dental colleges[13]. This disparity can stem from inadequate infrastructure, including well-equipped clinics and laboratories, a shortage of experienced and qualified faculty, and limited patient flow for clinical training. Colleges in urban areas may have an advantage over those in rural or remote regions in terms of resources and exposure. This inconsistency can lead to graduates with varying levels of preparedness for independent practice.
2. **Urban-Centric Distribution of Colleges:** The geographical distribution of dental colleges in India is skewed towards urban and suburban centers, often neglecting the oral health needs of rural and underserved populations[8]. This concentration contributes to a shortage of dental professionals in areas where access to care is most critical. Graduates may be less inclined to practice in these regions due to a lack of infrastructure, opportunities, and incentives, exacerbating the urban-rural divide in healthcare access.
3. **Outdated Teaching Methodologies:** While some institutions are adopting innovative teaching methods, many still rely heavily on traditional lecture-based instruction[2,10,14]. This passive learning approach may not effectively engage students, promote critical thinking, or cater to diverse learning styles. The lack of integration of active learning strategies, such as case-based learning, problem-based learning, and simulation-based training, can hinder the

development of clinical reasoning and decision-making skills.

4. **Limited Integration of Modern Technologies:** The rapid advancements in dental technology, including digital imaging, CAD/CAM systems, 3D printing, and teledentistry, are not consistently integrated into the curriculum across all institutions[11,13]. This lack of exposure can leave graduates ill-equipped to utilize these modern tools and techniques in their future practice, potentially hindering their efficiency and the quality of care they provide.[15]

5. **Inadequate Faculty Training and Development:** The quality of dental education is directly linked to the competence of the faculty. However, there may be a lack of structured and continuous professional development programs for dental educators to update their pedagogical skills, clinical knowledge, and research expertise. This can result in outdated teaching practices and a lag in incorporating the latest advancements into the curriculum.[13,16]

6. **Assessment-Driven Framework:** The emphasis on high-stakes examinations can sometimes overshadow the focus on deep learning and the development of practical skills[1]. Teaching and learning may become geared towards scoring well in exams rather than fostering a comprehensive understanding and the ability to apply knowledge effectively in clinical situations. This assessment-driven approach might not accurately reflect a student's overall competence and preparedness for practice.

7. **High Cost of Dental Education:** The escalating costs associated with dental education, including tuition fees, accommodation, and other expenses, can be a significant deterrent for many meritorious students from lower socioeconomic backgrounds[9]. This can lead to a less diverse student body and potentially impact the accessibility of dental care in the long run.

8. **Lack of uniformity in syllabus across the globe:** There exists a lack of uniformity and standardisation in dental curriculum across the globe. This variation in dental education metrics and practice regulations makes it difficult to develop a set of globally acceptable standards for curriculum structure and outcomes.[17]

9. **Focus on Knowledge domain:** The fact that the present syllabus is packed with a lot of knowledge components in the cognitive domain with reserved emphasis on the psychomotor domain (clinical skills), and almost no emphasis on the affective domain (attitude), is one of the key concerns.[1]

Opportunities

1. **Integration of Digital Dentistry:** The increasing accessibility and affordability of digital dental technologies present a significant opportunity to revolutionize dental education in India. Incorporating digital workflows into the curriculum can enhance diagnostic accuracy, treatment planning precision, and the efficiency of various dental procedures. Training students in digital imaging, CAD/CAM restorations, guided surgery, and other digital tools will equip them with the skills needed for contemporary practice.[13]

2. **Expansion of Specialization Programs:** With the growing demand for specialized dental care, there is a need and an opportunity to expand and enhance postgraduate programs in various dental specialties. Strengthening the infrastructure and faculty in postgraduate institutions and introducing new specialized areas can cater to the evolving healthcare needs of the population and provide more career avenues for dental graduates. Suggested courses to be introduced includes dental anaesthesiology, orofacial pain, forensic odontology etc.[18]

3. **Focus on Interdisciplinary Collaboration:** Promoting interprofessional education (IPE) and collaborative learning between dental and medical students can foster a more holistic understanding of patient care. Integrating topics related to systemic health and the interplay between oral and general health can lead to better patient management and improved communication between healthcare

professionals. Modern dentistry is moving away from strictly defined specialties towards a more unified and collaborative model. This integration is fuelled by the understanding that complex oral health issues often necessitate the combined knowledge of various dental experts to ensure the best possible patient results. Therefore, teamwork among specialists, general dentists, and other healthcare providers is now essential for delivering thorough and patient-focused care.[19]

4. **Community-Based Dental Education:** Increasing the emphasis on community-based dental education and outreach programs can provide students with valuable exposure to the oral health needs of diverse and underserved populations. This can instil a sense of social responsibility, improve their understanding of public health principles, and potentially encourage them to serve in areas with limited access to care. Community education programs offer students invaluable real-world learning experiences that can lead to significant shifts in their perspectives. These programs foster a deeper understanding and appreciation of the broader cultural, economic, and social factors influencing health and healthcare delivery. By applying their professional and clinical skills in community settings, students gain a more holistic and nuanced understanding of their patients within diverse social contexts, surpassing what traditional clinical training can offer. This ultimately equips them to better anticipate and address the diverse needs of their future patients across all healthcare settings.[20-22]

5. **Dental Tourism:** India has the potential to become a major hub for dental tourism due to its relatively affordable and high-quality dental services. By maintaining high educational standards and clinical expertise, the Indian dental education system can contribute to this growth, attracting international patients and providing students with exposure to global best practices and diverse patient demographics. Dental tourism in India is presently at a blossoming stage, but has enormous potential for future growth and development, which would improve the economic and social status of the society. India offers world-class treatment at highly affordable prices in comparison to Western countries.[23]

6. **Continuing Professional Development:** Continuing Professional Development (CPD) refers to skills and knowledge attained for both personal development and career advancement. Emphasizing and expanding continuing dental education (CDE) programs are crucial for ensuring that practicing dentists stay abreast of the latest advancements in the field. Developing accessible and high-quality CDE opportunities will contribute to improving the overall standards of dental care across the country.[24]

7. **Research and Innovation:** Fostering a research-oriented culture in dental institutions through dedicated research facilities, funding opportunities, and mentorship programs can lead to significant advancements in dental science and clinical practices relevant to the Indian context. Encouraging student and faculty participation in research projects and publications will contribute to the growth of evidence-based dentistry in India. The prevailing clinic-centric dental curriculum in India largely neglects research exposure for undergraduate students. Consequently, new dental graduates often struggle to comprehend and analyze scientific literature relevant to their profession. While the UG curriculum includes basic research methodology, covering study designs and elementary statistics, this limited exposure is inadequate for independently conducting research.[25] With various schemes introduced by organizations like the Indian Council of Medical Research and other intra- and extra mural grants introduced by various Universities, dental undergraduates in India have resulted in enhances scope for research.

8. **Student exchange and faculty exchange programs:** By incorporating student and faculty exchange programs within and outside the country, students and faculty can gain insights into various approaches to health education and professional environments. These collaborative experiences offer significant benefits to

students and, in turn, to the communities they will later serve. Furthermore, our educational plan should regularly incorporate the latest professional knowledge and scientific discussions. This can lead to a greater understanding and use of globally accepted standard clinical methods.[17]

9. **Simulation based learning:** To improve dental student learning, modern teaching tools like dental simulators should be more widely adopted alongside updated teaching methods. Currently, these simulation techniques are not a common feature of distance education. Looking ahead, understanding how traditional teaching and emerging technologies like distance simulation and virtual environments intersect is crucial for shaping the future of dental education.[17]
10. **Introduction of soft skills, practice management and other practice oriented interprofessional courses:** Although the topics are briefly covered in the speciality of Public Health Dentistry, the current curriculum does not deal with all the competencies required for practice management sufficiently. A more robust and comprehensive coverage of topics pertaining to practice management is the need of the hour in shaping competent dental professionals.[26]
11. **AI in dentistry**: The fourth industrial revolution is opening a new era, one of the most important contributions of which is Artificial Intelligence (AI). Many studies on AI applications in dentistry are underway or even have been put into practise in the aspects such as diagnosis, decision-making, treatment planning, prediction of treatment outcome, and disease prognosis.[27]

Challenges

1. **Increasing Number of Graduates and Limited Job Opportunities:** The proliferation of dental colleges in India has led to a significant increase in the number of dental graduates entering the job market.[8] However, the availability of commensurate job opportunities, particularly in urban areas, may not have kept pace. This can lead to unemployment, underemployment, and dissatisfaction among graduates, potentially impacting the attractiveness of the profession.
2. **Migration of Dentists:** The lack of adequate opportunities, infrastructure, and research facilities in certain regions of India may incentivize qualified dentists to seek better prospects in developed countries.[1,26] This "brain drain" can negatively impact the availability of skilled dental professionals within the country, particularly in underserved areas.
3. **Erosion of Professional Values:** In an increasingly competitive environment, there is a concern about a potential decline in ethical and professional values, with a greater emphasis on financial gains over patient welfare. The current Indian dental curriculum, heavily emphasizing clinical skills and knowledge assessment, faces a growing concern regarding lapses in academic integrity and unethical professional conduct. This lack of integrity during training poses a significant threat to the health and safety of future patients and the wider community. Furthermore, the increasing adoption of a business model in dentistry, driven by consumerism, is eroding the traditional trust patients held in their dentists. The curriculum and professional bodies need to actively reinforce ethical principles and promote a patient-centric approach to dental practice.[28]
4. **Public Perception and Awareness:** Despite the importance of oral health, public awareness and prioritization of dental care may still be low in many parts of India. The perception of dental treatments as expensive and non-essential can affect patient footfall and the growth of dental practices, potentially impacting the career prospects of new graduates.[8]
5. **Regulatory Challenges:** Ensuring uniform implementation of DCI guidelines and maintaining consistent standards across a large number of diverse dental institutions poses a significant regulatory challenge. Effective monitoring, accreditation, and quality assurance mechanisms are crucial to address this threat.
6. **Impact of COVID-19 Pandemic:** The COVID-19 pandemic has exposed vulnerabilities in

traditional clinical training methods and patient care delivery. The need for social distancing and infection control measures has significantly impacted the availability of clinical postings and hands-on training. Adapting the curriculum to incorporate innovative teaching methods, such as virtual simulations and teledentistry, while ensuring patient safety, remains a critical challenge.[29,30]

Future Perspectives and Potential Changes[31,32]

The landscape of healthcare education in India is evolving, with the National Medical Commission (NMC) implementing significant revisions to the MBBS undergraduate curriculum. These changes, centered, around competency-based learning, integrated teaching (horizontal and vertical), a longitudinal program on ethics and communication (AETCOM), early clinical exposure, outcome-based education, and enhanced skill acquisition through simulation and the DOAP method, offer valuable lessons for dental education

Furthermore, the anticipated establishment of the National Dental Commission (NDC), as outlined in the National Dental Commission Bill, 2023, signals a potential paradigm shift in the governance and regulation of dental education and practice in. It is expected that the NDC, once operational, will bring about reforms in dental education, potentially aligning it with the progressive changes observed in medical education under the NMC.

Drawing parallels from the NMC's approach, future revisions in the dental curriculum under the purview of the DCI or the anticipated NDC could focus on:

- Explicitly defining and implementing a competency-based dental education (CBDE) framework to ensure graduates possess the necessary skills and attitudes for effective dental practice.
- Enhancing the integration of basic sciences with clinical subjects and fostering interdisciplinary learning across different dental specialties to promote a more holistic understanding of oral health and disease.
- Introducing a structured and longitudinal program on ethics, professionalism, and communication tailored to the specific needs of dental practice, potentially inspired by the NMC's AETCOM module.
- Strategically increasing early and meaningful clinical exposure for dental students to provide context to their preclinical learning and enhance their understanding of clinical relevance.
- Adopting a more robust outcome-based education approach with clearly defined learning objectives and assessments aligned with the competencies required of an "Indian Dental Graduate".
- Increasing the utilization of simulation laboratories and structured skill acquisition methods like DOAP to ensure practical competence before direct patient interaction.
- Ensuring a stronger alignment of the dental curriculum with national oral health programs and public health priorities to prepare graduates to contribute effectively to community oral health initiatives.

These potential future directions, driven by the evolving landscape of medical education in India and the establishment of the NDC, present significant opportunities to address the existing weaknesses in the dental curriculum and further strengthen the quality and relevance of dental education in the country.

Conclusion

The Indian dental curriculum possesses inherent strengths in its comprehensive structure, emphasis on clinical exposure, and ongoing efforts towards global alignment. However, significant weaknesses, including inconsistencies in training quality, urban-centric distribution, and the need for pedagogical and technological modernization, need to be addressed to ensure the production of competent and well-rounded dental professionals. The opportunities presented by digital dentistry, specialization, interdisciplinary collaboration, and community engagement offer pathways for enhancing the curriculum's relevance and impact. Nevertheless, the threats posed by

increasing graduate numbers, potential migration, eroding professional values, and regulatory challenges demand proactive and strategic interventions. Looking towards the future, the transformative changes underway in medical education under the NMC and the establishment of the NDC signal a potential for significant reforms in dental education. Embracing competency-based learning, integrated teaching, enhanced focus on ethics and communication, early clinical exposure, outcome-based education, and modern pedagogical approaches will be crucial for developing a dynamic and relevant dental curriculum that produces ethical, skilled, and socially responsible dental professionals capable of meeting the evolving oral healthcare needs of the Indian population and contributing to global oral health.

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LOCAL DRUG DELIVERY SYSTEMS IN PERIODONTAL DISEASE MANAGEMENT: AN UPDATE

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ABSTRACT

Periodontitis is the sixth ubiquitous chronic disease affecting more than 743 million people worldwide, having undesirable impact on oral functions, self-confidence, systemic health and overall well-being of an individual. The treatment of periodontitis requires removal of the etiology by maintaining oral hygiene, performing non-surgical periodontal therapy like scaling, root debridement, and risk factor modifications. Localized therapy has gained significant attention because of its site-specific nature and adverse effects of systemic antibiotics. The different types of Local Drug delivery systems (LDDS) are available as Fibers, Strips and films, Microparticles, Nanosystems, Gels, Membranes, and Scaffolds. LDDS can be used in localized periodontal pockets with probing pocket depth >5mm, after completion of successful phase I therapy, in medically compromised patients where surgical therapy is contraindicated or not suggested, as an adjunct to mechanical debridement and in patients suffering from recurrent or refractory periodontitis. Antimicrobial agents like tetracycline, minocycline, chlorhexidine, doxycycline, metronidazole; nanoparticles; host modulation, gene therapy, photodynamic therapy and phytotherapy are the recent types of LDDS used for the treatment of periodontics.

Key words: Local, drug delivery, periodontal disease.

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INTRODUCTION

Periodontitis, which is a common cause of tooth loss in adult populations, is an inflammatory response to the over-growth of anaerobic organisms such as Bacteroides and aerobic organisms such as spirochaetes in the subgingival plaque[1] and an abnormal immune response of the host. It can get worse in the presence of other factors, such as systemic diseases, such as diabetes, or bad habits, such as smoking.[2]

Periodontitis is the sixth ubiquitous chronic disease affecting more than 743 million people worldwide, having undesirable impact on oral functions, self-confidence, systemic health and overall well-being of an individual. It is worth mentioning that the deleterious effects of Periodontal Disease (PD) are not limited to the oral cavity, but extends its clutches to gain ready access to the systemic circulation through the pocket epithelium, eliciting host immuno-inflammatory response, eventually resulting in systemic complications. PD starts as an inflammatory reaction confined to the gingival tissue (gingivitis), but when left untreated it progresses to involve the periodontal ligament, cementum and supporting alveolar bone, resulting in pocket formation which provides a favourable environment for the growth of pathogenic anaerobic microorganisms.[3]

The treatment of periodontitis requires removal of the etiology by maintaining oral hygiene, performing non-surgical periodontal therapy like scaling, root debridement, and risk factor modifications. Localized therapy has gained significant attention because of its site-specific nature and adverse effects of systemic antibiotics. Thus, Local administration of anti-infective agents, generally directly in the pockets has the potential to provide greater concentrations directly to the infected area and reduce possible systemic side effects.[4]

Clinicians choose local drug delivery systems (LDDS/LDD) over systemic antimicrobials especially in cases of moderate, localised periodontitis as increased drug concentration is made available at the site of infection with minimal adverse reactions.[3] Hence, this review aims to give an update on the current local drug delivery systems used for treating periodontal diseases.

Local Drug Delivery Systems (LDDs):

Over the past 50 years, systemic drug administration for treating oral infections has yielded positive results, but it also has disadvantages. These include dysbiosis, low drug concentrations at the target site, gastrointestinal issues, drug resistance, and toxicity. Therefore, over the past 30 years, local drug delivery systems (LDDSs) have obtained an interest in studying how to use drugs in specific site where it is needed and how to control their release.

The use of an LDDS offers more benefits than systemic administration. It bypasses gastrointestinal issues and the systemic metabolism of the drugs before they reach the site of interest, resulting in higher efficiency for LDDS. Furthermore, LDDS enables non-invasive drug administration in the subgingival pockets. Additionally, this method allows for the simultaneous loading of two or more drugs from different categories into the periodontal pockets.[5]

Types of local drug delivery systems[2]:

- Fibers
- Strips and films
- Microparticles
- Nanosystems
- Gels
- Membranes
- Scaffolds

Indications for Local Drug Delivery[6]:

- Localized periodontal pockets with probing pocket depth >5mm, after completion of successful phase I therapy.
- Medically compromised patients where surgical therapy is contraindicated or not suggested, as an adjunct to mechanical debridement.
- In patients suffering from recurrent or refractory periodontitis.

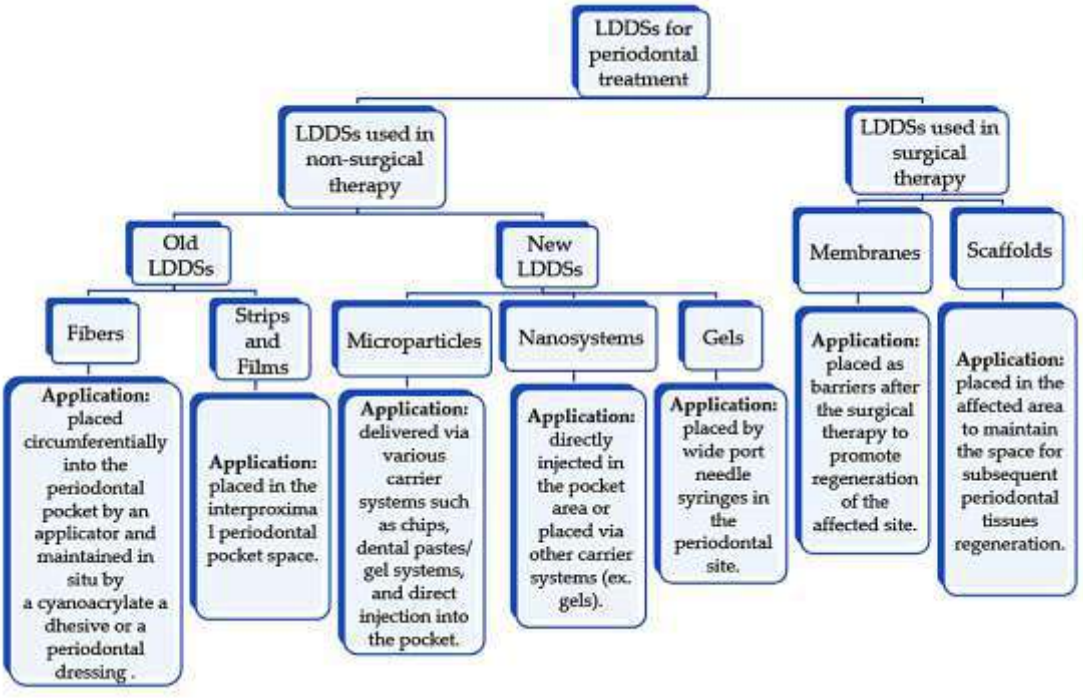

Figure 1: Classification of local drug delivery systems and their applications[2]

Newer treatment strategies for periodontal disease:

With the increasing antibiotic resistance among periodontal pathogens, the primary goal of periodontal therapy has shifted in recent years to restoring homeostasis. in oral microbiota and its harmonious balance with the host periodontal tissue. Periodontal pathogens use virulence factors to initiate & promote periodontal disease and its progression and a promising alternative to antibiotic therapy is targeting pathogenic bacteria's virulence factors.[7]

Following are the novel strategies for the treatment of periodontal diseases.

Antimicrobial Agents:

Tetracycline: Tetracycline is a bacteriostatic antibiotic that interferes with bacterial protein synthesis and inhibits tissue collagenase activity. It has a broad spectrum of activity, inhibiting both Gram-negative and Gram-positive organisms, including the beta lactamase-producing strains that occur in approximately 50% of 6-7 mm deep periodontal pockets and against which penicillin is ineffective.[4]

Minocycline: It is a broad-spectrum antibiotic that is a derivative of tetracycline. It exhibits bacteriostatic action. It has greater substantivity and lipid solubility than tetracycline. It is available in various forms such as film, microspheres, ointment, and gel.[6]

Doxycycline: Doxycycline is a bacteriostatic agent. Its effective against the matrix metalloproteinase (MMP's) and has the ability to down-regulate matrix metalloproteinase (MMP's) 28. MMP's are the periodontal biomarkers causing the destruction of periodontal connective tissue.[6]

Chlorhexidine: Chlorhexidine has shown to have a beneficial effect when used as an adjunct for periodontal treatment. It inhibits the microbial proteases produced by powerful periodontal pathogens and modifies the periodontal pocket's microflora and may act by reducing the pellicle formation, changing the adherence of bacteria to teeth, and altering the

cell wall of bacteria. The events leading to the antimicrobial effect of chlorhexidine could be an increase in permeability of the cell membrane, following which the cytoplasmic macromolecules present within the cell may coagulate.[8]

Metronidazole: It is a nitroimidazole compound. It is bacteriocidal to anaerobic organism. It acts by disrupting bacterial DNA synthesis. After delivery of Elyzol (25% Metronidazole), concentrations of above 100µg/ml of drug in GCF were measurable in the periodontal pocket for at least 8 h, and concentrations above 1 µ/ml were found after 36 h.[6]

Nanoparticles: The progress in nanotechnology has enabled the creation of nanomaterials with diverse functional characteristics for the supplementary treatment of periodontitis and the regeneration of periodontal tissues.

Silver NPs (AgNPs) with a size of less than 100 nm and a uniform spherical shape have high and broad-spectrum antimicrobial activity. Antibacterial mechanisms of AgNPs include but are not limited to, the released silver ions can disrupt the cell walls and cell membranes, denature ribosomes, interrupt adenosine triphosphate production, and interfere with DNA replication.

Platinum NPs (PtNPs) are agglomerations of platinum atoms that measure between 1 to 100 nanometers in size. PtNPs exhibit exceptional biocompatibility, remarkable durability, and possess surface chemistry, and are widely applied in the biomedical domain, particularly in the areas of cancer treatment and photothermal therapy. However, relatively few studies have been conducted on the application of PtNPs in periodontal treatment.

Unfortunately, at present, there are few clinical studies on NPs in the treatment of periodontitis, and most of them are still in the preclinical stage.[9]

Host Modulation:

The host response is basically protective by intent. Still, it can contrarily result in tissue damage that incorporates the collapse of connective tissue fibers in the PDL and breakdown of the alveolar bone. Host-modulating agents does not shut off the normal defence mechanism of the inflammation instead, they improve excessive or pathologically elevated inflammatory responses to increase the chances of wound healing and periodontal firmness.[10]

Host Modulation Therapies are systemically or locally delivered pharmaceuticals that are prescribed as a part of periodontal therapy and are used as adjuncts to conventional periodontal treatments, such as scaling and root planning (SRP) and surgery.

Potential Targets of Host Modulation Therapy:

- Matrix metalloproteinases: eg. TIMPs, Tetracylines
- Arachidonic acid metabolites: eg. NSAIDs
- Bone metabolism: eg. Bisphosphonates
- Pro-inflammatory Cytokines: eg. blockade of receptors for IL-1, TNF
- Other inflammatory mediators such as Nitric oxide (NOS) syntase activity (eg. mercapto ethyl guanidine), Nuclear factor kappa β, Endothelial cell adhesion molecules, Disruption of cell signaling pathways such as RANK/RANKL/osteoprotegerin axis.[11]

Agents Used In Host Modulation[10]:

A) Based on Mechanism of Action:

1. Antiproteinases
2. Anti-Inflammatory
3. Bone Sparing

B) Based on the Route of Drug Administration:

I) Systemic: 1) NSAIDS 2) SDD 3) Bisphosponates 4) Nitric Oxide Sparing Drugs

II)Local: 1) Tetracycline Fibres 2) Emp (Enamel Matrix Protein) 3) GF (Growth Factors)

C) Others:

1. Periodontal vaccines
2. Probiotics
3. Cimetidine

Studies clearly demonstrate that blocking specific inflammatory mediators and/or

enzymes can be efficacious in slowing periodontal disease progression. However, this concept needs to be validated further in controlled clinical trials. As new mediators and pathways of periodontal tissue destruction are identified, so will new host modulating strategies for blocking tissue destruction evolve.[11]

Photodynamic therapy[12]:

Photodynamic therapy (PDT) has attracted much attention as an alternative approach against periodontal diseases. PDT utilizes specific excitation light, photosensitizers (PS), and oxygen to generate reactive oxygen species (ROS), enabling a nonspecific attack on microorganisms. The PS (S0) is exposed to the light with a particular wavelength and converted into the excited singlet state (S1), and then translated to the excited triplet state (T1). After that, T1 reacts by two types of photochemical reaction mechanisms: type I and type II.

- Type I reaction releases neutral radical or ionic active groups by transferring with hydrogen or electrons in the tissue or bacteria, further reacting the formation of ROS: hydroxyl radical (·OH), superoxide anion radical (·O2-), and hydrogen peroxide (H2O2);
- type II reaction forms singlet oxygen (1O2) through energy conversion.

ROS produced during these reactions engage with a range of biomolecules like lipids, proteins, and nucleic acids, causing their oxidative inactivation. This leads to significant damage to various microorganisms, such as bacteria, viruses, and fungi, via intracellular cascades.

PDT has antibacterial effects and no bacterial resistance and has potential biological modulatory effects by inhibiting inflammatory mediators and cytokines, promoting cell chemotaxis, reducing bone loss, and promoting the repair of alveolar bone, thus promoting periodontal healing.

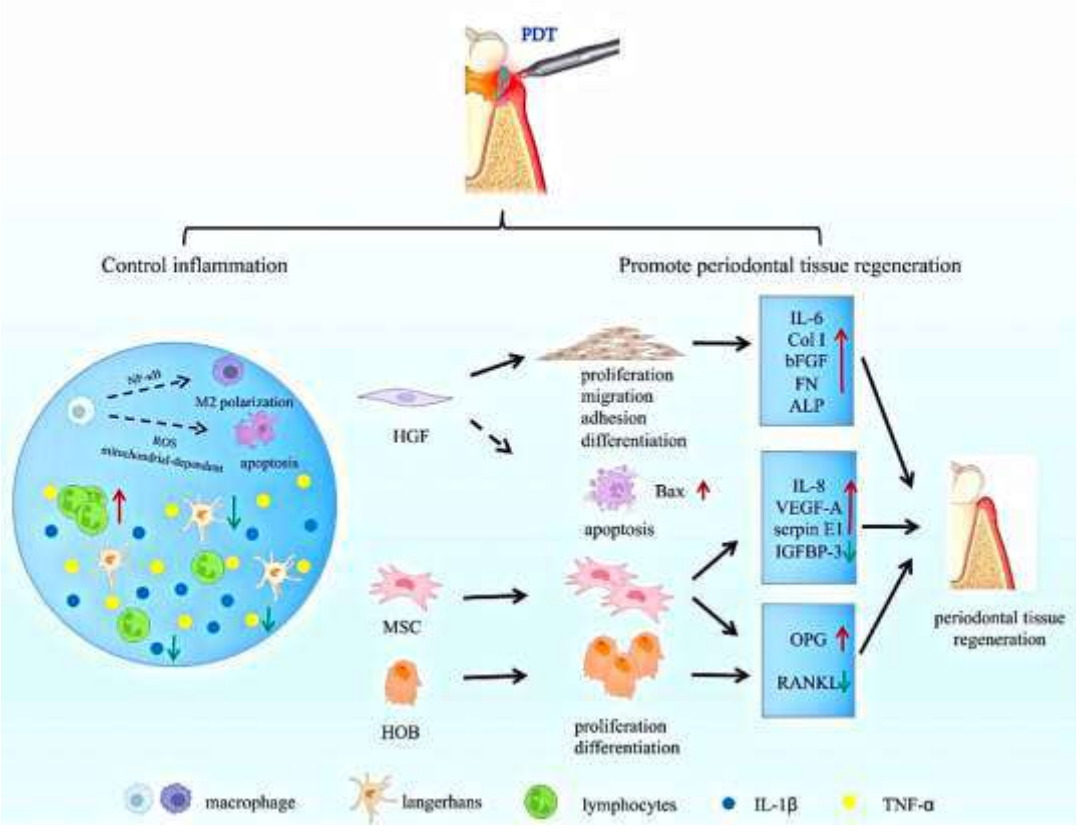

Figure 2: Mechanisms of Photodynamic Therapy in the management of periodontics

Gene Therapy:

A broad definition of gene therapy is the genetic modification of cells for therapeutic purposes. The goal of gene therapy is to transfer the DNA of interest (for example, growth factor and thrombolytic genes) into cells, thereby allowing the DNA to be synthesized in these cells and its protein (termed recombinant protein) expressed.

Fundamentals of gene therapy:

- A normal gene may be inserted into a nonspecifc location within the genome to replace a nonfunctional gene. This approach is most common.
- An abnormal gene could be swapped for a normal gene through homologous recombination
- The abnormal gene could be repaired through selective reverse mutation, which returns the gene to its normal function.
- The regulation (the degree to which a gene is turned on or off) of a particular gene could be altered.
- Spindle transfer is used to replace entire mitochondria that carry defective mitochondrial DNA.

Types of gene therapy:

1. Germ Line Gene Therapy - germ cells, i.e., sperm or eggs are modified by the introduction of functional genes, which are ordinarily integrated into their genomes.
2. Somatic Gene Therapy - the therapeutic genes are transferred into the somatic cells of a patient. Any modifications and effects will be restricted to the individual patient only, and will not be inherited by the patient's offspring.

Gene Delivery:

1. Viral - the most common vector is a virus that has been genetically altered to carry normal human DNA. The viruses used for delivering gene therapy are: Retrovirus, Adenovirus Herpes simplex and Adeno-associated viruses.
2. Non-viral - It is the direct introduction of therapeutic DNA into target cells. Another approach involves the use of an artificial lipid sphere with an aqueous core. This liposome, is capable of passing the DNA through the target cell's membrane.[13]

Phytotherapy:

Phytotherapy refers to treatment with herbal medicine. Herbal products are often favored over traditional chemical drugs due to their wide-ranging biological activity, increased safety margin, lower cost and fewer side effects[14]. They are generally well tolerated and accepted by patients. Herbs such as Turmeric (C. longa)[15], Pomegranate (Punica granatum)[16], Tea tree oil (TTO; Melaleuca alternifolia)[17], Garlic (Allium sativum)[18], Amla (Emblica officinalis)[19], Green tea[20], Propolis[21] and Polyherbs have been shown to be effective as supplemental periodontal phytotherapy. Herbs function as antioxidants, scavenging free radicals and thereby preventing oxidative stress. Oxidative stress is a significant factor in the cellular damage linked to the onset and progression of periodontitis. These herbal medicines may be utilized in tandem with conventional drugs or for treating multiple targets simultaneously, depending on the condition[14].

Conclusion

The introduction of local drug delivery systems has transformed the treatment options available for periodontitis, providing a targeted and sustained method to address this common chronic inflammatory disease. Traditional treatment methods often struggle due to the quick removal of drugs from the periodontal pocket by gingival crevicular fluid, requiring frequent administrations. Local drug delivery systems change this approach by delivering therapeutic agents directly to the site of infection. This allows for high concentrations of the drug to be maintained within the periodontal pocket while reducing systemic exposure. However, local drug delivery systems should only be considered as an adjunct and not a replacement for conventional non-surgical techniques for the management of periodontitis.

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ARTIFICIAL INTELLIGENCE (AI) FOR EARLY ORAL CANCER DETECTION- A REVIEW

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ABSTRACT

Oral cancer is one of the most common type of cancer in India, and it accounts for 3,00,000 detected cases per year. Tobacco consumption has been the predominant factor causing oral cancer. Oral screening may assist with early diagnosis and improve patient outcome. A thorough clinical inspection of the oral cavity can diagnose up to 99% of oral cancers. Artificial Intelligence (AI) is a novel method for the diagnosis of early cancer and it encompasses 2 distinct branches: traditional machine learning and deep learning. AI improves Clinical outcomes using new innovative methods. It helps in finding new biomarkers for early detection and to create an individual strategy to treat disease. AI techniques provide better results as the detection accuracy is above 90% mostly. AI is used to identify the site of cancer and to classify and grade the stages of cancer. AI also interprets images to interpret the clinical workflow of diagnosis, constant observation, and treatment suggestions. Digital pathology, referring to the creation and analysis of digital images from scanned pathology slides, is another important area of AI research relevant to early detection.

Keywords: Oral cancer, Artificial intelligence, deep learning, machine learning, biomarkers, ID Maps.

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INTRODUCTION

Cancer is a group of diseases characterized by uncontrolled growth and the spread of abnormal cells. If the spread of cancer cells which is known as metastasis is not controlled, it can result in death. Cancer is caused by many external factors like tobacco, chemicals, radiation and infectious organisms as well as some internal factors such as inherited mutations, hormones, immune conditions and random mutations. Many other factors are known to increase the risk of cancer, including dietary factors, certain infections, physical inactivity, obesity and environmental pollutants. These factors may act together to initiate or promote carcinogenesis in the human body.[1]

Cancer has become one of the leading causes of death in India. It is estimated that there are approximately 2 to 2.5 million cases at a given point of time. Over 7 lakhs new cases and 3 lakhs deaths occur annually because of cancer. Nearly 15 lakh patients require facilities for diagnosis, treatment and follow up at a given time.[2] Lip and oral cavity cancers are the 16th most common type of cancer globally. The incidence of head and neck cancer is constantly rising and it is expected to increase by 30 % by 2030. The regions with the highest incidence were Melanesia (ASR=19.8), followed by South-Central Asia (13.5), Central and Eastern Europe (10.3), Western Europe (10.0), and Australia and New Zealand (10.0). The occurrence of lip, oral cavity, and pharyngeal cancer increases with age, reaching its peak in the 70-85+ age group.[3]

Oral cancer is one of the most common types of cancer affecting a large population and it is an important health issue in India.

The low- income population is at the highest risk group due to the extensive exposure to various risk factors. Tobacco consumption has been the main risk factor causing oral cancer.

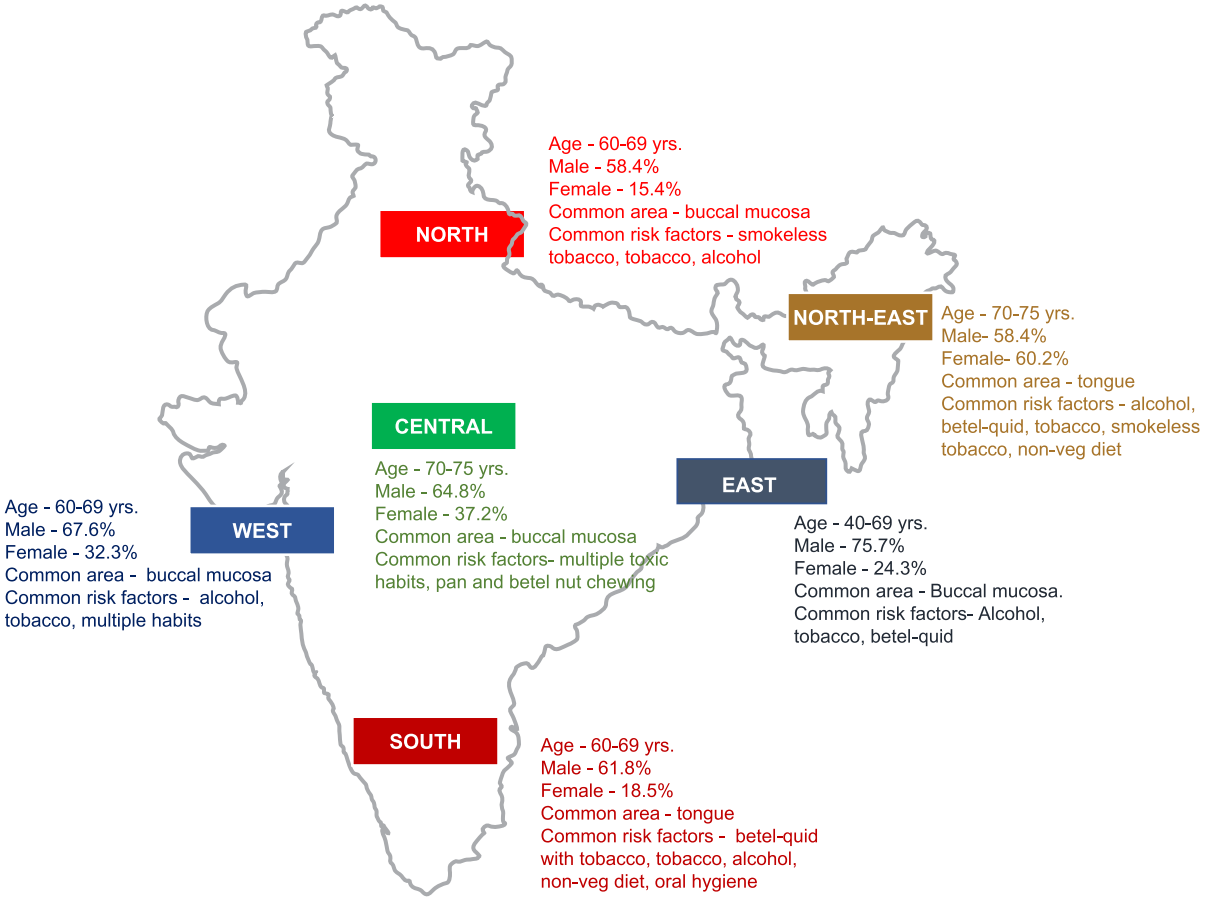


Fig 1. The distribution of oral cancer across India[4]

The continuous use of tobacco in various forms (gutka, zarda, mawa, kharra, khaini, cigarettes, bidi, hookah, etc) is a major cause of tumor development in the oral cavity in both young as well as the adult Indian population.[5]

Oral cancer is two to three times more prevalent in men than women. In worldwide reports, cancers of all regions of the oral cavity and oropharynx are grouped and it collectively represents the sixth most common cancer in the world. According to the latest reports of the International Agency for Research on Cancer (IARC) for oral cancer which includes lips, tongue, gingiva, floor of the mouth, parotid and salivary glands, annual incidence is higher around the world, which is over 3,00,000 diagnosed cases, and the annual mortality is about 145,000 death.[6]

Oral cancer screening has been defined as 'the process by which a practitioner evaluates an asymptomatic patient to determine if he or she is likely or unlikely to have a potentially-malignant or malignant lesion'. This may occur as 'population-based screening', when a population is assessed specifically for the purpose of detecting oral cancer, as 'opportunistic screening', when patients who are attending a health care provider for another purpose are examined for signs of oral cancer or potentially malignant diseases, or as 'targeted screening' when high risk individuals are selected for screening. Screening may assist with early diagnosis and improve patient outcomes. Diagnosis of lesions may be enhanced by the use of adjunctive aids such as toluidine blue, diffused white light, chemi luminescence or loss of tissue auto fluorescence.[5]

The objective of early detection of oral cancer is to recognize the oral cancer and also the potentially malignant diseases at the earliest stage as possible.[5] The detection process begins with clinical examination of oral cavity, which consists of visual inspection and digital palpation of the oral cavity. A thorough clinical examination of the oral cavity can detect up to 99% of oral cancers. Suspect lesions must be further assessed as initially proposed by the World Health Organization and the National Institute of Dental and Craniofacial Research and as stated in the recent evidence based protocol of the American Dental Association, any mucosal lesion persisting for two weeks or more, after removal of possible local irritants

TECHNIQUES USED FOR DIAGNOSIS OF ORAL CANCER:[4]

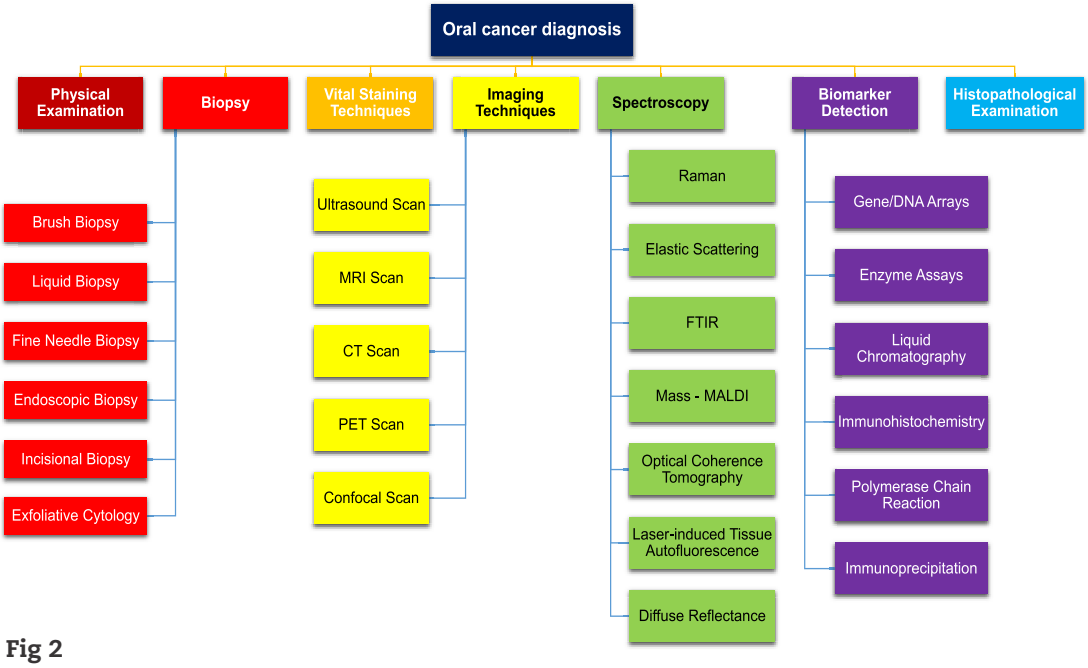


Fig 2

such as broken teeth, ill-fitting dental prosthetic devices and appliances, dental plaque, etc. , must be biopsied, as histological examination is the gold standard in diagnosis of oral squamous cell carcinoma.[7]

CURRENT CHALLENGES IN EARLY DETECTION

Traditional diagnostic methods, like visual inspection and biopsy, often fail to diagnose oral cancers at an early, more treatable stage. These drawbacks lead to delayed detection, adversely affecting prognosis. Additionally, there are significant disparities in access to advanced detection methods, specifically in low- and middle-income countries, exacerbating the global burden of oral cancer.[8]

It also have other limitations, including difficulties in recognizing benign lesions, limited specificity, and the inability to recognize early tumors and dysplasia. These methods have less practical applicability in the community, particularly in remote areas, since patients with late stages of oral cancer are still being detected. Considering these factors, there is a need for creating new methods for early diagnosis of oral cancer through screening.[9]

ADVANCEMENTS IN IMAGING TECHNOLOGIES

- **Advanced optical imaging**

  Recent advancements in optical imaging, such as fluorescence imaging and confocal microscopy, have improved early lesion detection. These techniques enhance visualization, allowing for earlier identification of malignant changes.

- **Digital imaging and artificial intelligence**

  The integration of digital imaging with artificial intelligence (AI) has transformed diagnostic oncology. AI algorithms analyze imaging data with high accuracy, detecting subtle changes that may be missed by humans. This has led to AI tools that assist in early cancer detection and diagnosis, offering improved accuracy and faster analysis. Additionally, AI systems can identify high-risk patients, monitor early signs of cancer, and create personalized treatment plans, ultimately enhancing patient outcomes and survival rates.

- **PET and MRI innovations**

  PET and MRI have made remarkable advancements, delivering superior

CURRENT AVAILABLE TECHNIQUES FOR CANCER DIAGNOSIS[10]

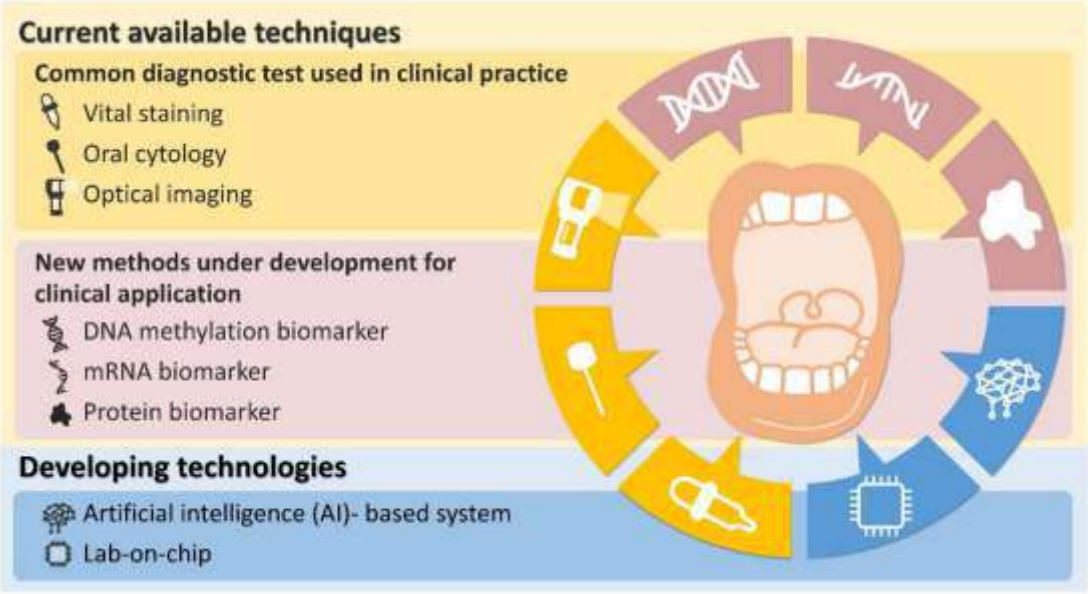


Fig. 3

visualization of oral lesions that ensure earlier and more accurate diagnoses. These innovations are essential for effectively staging the disease and strategizing treatment plans.[8]

BIOMARKERS AND MOLECULAR DIAGNOSTICS

- **Salivary biomarkers:** Saliva contains a wide range of biomarkers that can indicate the presence of oral cancer. Specific genetic and protein markers in saliva can be used for early diagnosis, offering a simple and painless alternative to traditional biopsies.
- **Circulating tumor DNA (ctDNA):** ctDNA analysis allows for the detection of cancer-specific genetic alterations, providing a non-invasive technique for early diagnosis and monitoring of oral cancer.
- **Proteomics and metabolomics:** Proteomics and metabolomics have numerous potential biomarkers for the early diagnosis of oral cancer. These molecular techniques analyse proteins and metabolites in body fluids, which gives the perceptions about the biochemical changes associated with cancer development.[8]

AI IN ONCOLOGY

Artificial intelligence (AI) is an area of computer science that can be defined as a machine's capacity to emulate a human's cognitive capacity[11]. It involves the use of algorithms and mathematical models to analyze and process large and complicated information[12]. AI is a broad term that is divided into 2 distinct branches: traditional machine learning and deep learning.

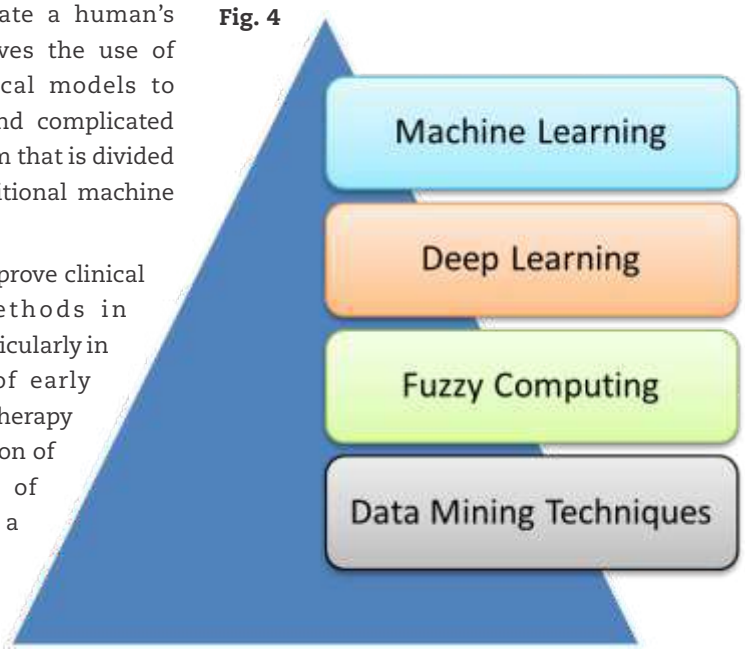
In healthcare, AI is used to improve clinical outcomes using new methods in diagnostics and treatment particularly in oncology. This comprises of early detection, tailored or targeted therapy by obtaining genetic information of the patient and predictions of future outcomes. ML is a valuable tool in oncology with large range of applications in precision medicine[13]. AI in imaging helps to improve diagnostic accuracy and efficiency. It also helps to analyze data in a short duration of time, which helps with faster diagnosis and therapy. AI is not only used to identify specific sites of cancer but also to classify and grade the stages of cancer. AI also interprets images of various modalities for the clinical workflow of detection, constant observation, and therapeutic suggestions.

Emerging healthcare data modalities are increasingly suitable for Artificial Intelligence analysis. Recent expansions in electronic healthcare record (EHR) infrastructures allow efficient storage and access to vast clinical data. The Digital Cancer Waiting Times Database seeks to enhance cancer referral pathways through user input, while digital pathology focuses on the analysis of digital images from scanned pathology slides, contributing to early diagnosis.[14]

ARTIFICIAL INTELLIGENCE TECHNIQUE

There are numerous AI techniques that can be used in the segmentation, feature extraction and classification process in order to obtain tremendous performance in the early diagnosis of oral cancer. The AI techniques immensely helps in automating the detection and classification of oral lesions or tumors.[15]

Fig. 4



TYPE OF AI APPLICATION IN ORAL CANCER

- **Machine learning:** Machine learning is a part of artificial intelligence that encompasses a broad range of algorithms and can learn from data to make decisions and predictions. Machine learning is effective in understanding different types of cancer.
- **Deep learning:** It is the core of AI methods and a subset of machine learning based on artificial neural networks that are capable of simulating the human brain. The most important property of deep learning is that it requires a large amount of data, which increases the processing power but significantly reduces the time in testing and provides an end-to-end solution. Deep learning is very efficient in automating the segmentation, feature extraction and classification process in diagnosing an oral cancer.
- **Fuzzy computing:** It uses machine intelligence and mathematical concepts for reasoning. The use of fuzzy systems along with machine learning techniques provides better accuracy. Fuzzy rules and consensus are useful for oral cancer assessment.
- **Data mining techniques:** Data mining is a process of extracting useful information from large data sets of data. It is useful in identifying the patterns such that will helpful in decision making. Data mining techniques are useful in designing a framework along with other AI techniques. It uses a data mining tools like DTREG and Weka to build classification models and association rules, respectively[15].

ROLE OF AI IN ANALYSING COMPLEX GENOMIC DATA

With the help of AI technologies, new biomarkers can be found for early detection of complex genomics and create an individual strategy for the therapy. AI algorithm can define the driver mutations and oncogenes which are the cause of cancer. Screening for the disease is very important in enhancing case identification at early stages hence enabling treatment thus reducing mortality. There are also machine learning algorithms for detecting cancer on the basis of genetic factors, anamnesis, and other indicators. AI can be used to analyse genomic data bases along with clinical features of cancer, which will provide a complex understanding of the oncogenic processes and can define possible targets for therapy.[16]

INTEGRATION OF AI INTO CLINICAL PRACTICE

- **Training and Education:** For innovations to be seamlessly integrated into clinical practice, it is imperative that healthcare professionals receive comprehensive training and education. Mastery of new diagnostic tools and techniques is not just beneficial, it is essential for their successful adoption.
- **Implementation Strategies:** It's essential to develop strategies for integrating innovative diagnostic tools into clinical practice. This involves creating guidelines, ensuring new technologies work with existing systems, and promoting collaboration among healthcare providers.
- **Cost-effectiveness and accessibility:** These are vital for advanced diagnostic tools. Ensuring these technologies are affordable and available to everyone, regardless of geographic or socioeconomic barriers, is essential for equitable healthcare.[8]

AI ACCURACY IN HISTOPATHOLOGICAL IMAGES

Histopathologic analysis is widely recognized as the gold standard for detecting and diagnosing oral cancer. This examination involves evaluating specific features and characteristics in histopathologic samples that enable pathologists to ascertain the presence of malignancy and determine its stage. However, the manual evaluation of these samples can include a margin of error due to the need for quantification, potentially leading to inaccurate results. This is where AI comes into play; it has significantly minimized these errors while enhancing the efficiency and accuracy in identifying the cytologic and histologic features associated with oral cancer.

Furthermore, AI technology has the capability to analyze large sample sizes, making it a valuable tool in the detection of oral cancer.[11]

FUTURE PERSPECTIVES

The conventional diagnostic methodologies are often expensive, time-consuming, and require expert technicians, with some even needing surgical intervention. Recently, biosensor-based oral cancer biomarker sensing techniques have shown enormous promise for integration into diagnostic practices. However, non-invasive, portable, easy-to-use, rapid, and cost-effective techniques that do not necessitate skilled professionals for processing, analysis, and interpretation of test results are still unavailable in India. It is essential for professionals to encourage and advocate for the integration of these emerging advanced commercialized techniques into clinical diagnostic practices.[4]

Artificial intelligence (AI) techniques significantly enhance detection accuracy, often exceeding 90% in many applications. This high level of accuracy is particularly beneficial in the medical field, where results can be delivered much faster compared to traditional medical procedures, which often require substantial time investment. Collaboration between researchers and medical professionals is essential to improve the representation of data, leading to quicker and more precise outcomes while reducing the likelihood of misclassification.

Additionally, AI methods are known for being cost-effective. Conventional medical procedures, such as scans and biopsies, tend to be expensive, while computer algorithms can generate results using images captured from mobile devices. Despite these advantages, several challenges remain, including limited datasets, misclassification issues, patch detection, and the need for multimodal solutions, as highlighted in recent surveys.[15]

The tumor evolves during the time required for its analysis and may contain subclonal populations. The process of integrating and analyzing multiple layers of omics data demands complex methods and significant computational resources. IDMap addresses these challenges using advanced techniques such as deep learning and network analysis to analyze complex data and identify patterns. IDMap is recognized as a groundbreaking innovation in the application of artificial intelligence and data science for identifying the genomic architectures of cancer cells. By integrating multi-omics data and leveraging AI, IDMap not only enhances early cancer detection but also contributes to the treatment of cancer and improves our understanding of cancer diseases.[16]

CONCLUSION

In conclusion, artificial intelligence (AI) has the potential to revolutionize early cancer detection by improving accuracy, efficiency, and patient outcomes. By leveraging AI-powered technologies, healthcare systems can enhance cancer diagnosis, treatment, and survival rates, ultimately saving lives and improving quality of life for patients worldwide.

AI in healthcare can transform early cancer diagnosis and help address capacity issues through automation. It enables effective analysis of complex data from various sources, such as clinical text, genomic, metabolomic, and radiomic data.[17] Privacy and confidentiality of patient data remain significant hurdles in the clinical application of AI in oncology. Additionally, there is the question of responsibility in the event of an error in AI-based analysis should it fall on the doctor or the software. Beyond these challenges, the introduction of AI in oncology practice also impacts the patient's autonomy and their relationship with the treating clinician.[11]

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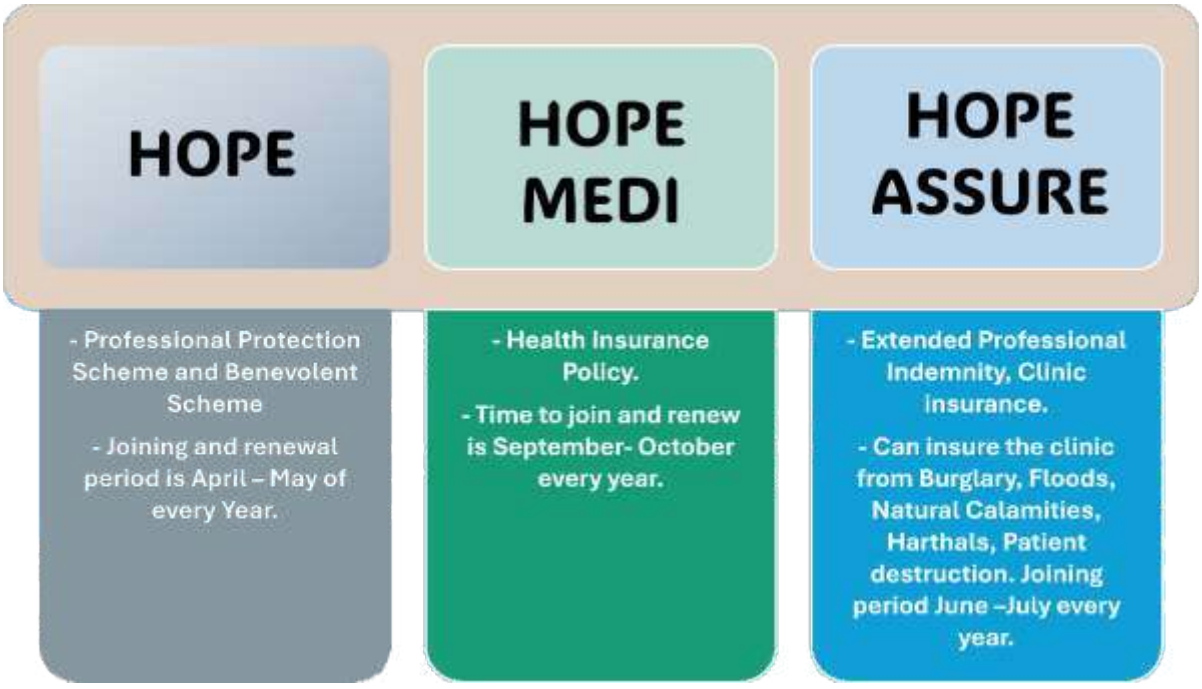
IDA HOPE is a merged policy of Public Protection Scheme (PPS) and Social Security Scheme (SSS), started in 2007 and running successfully ever since. It includes life insurance, health insurance, and clinic protection, along with legal support.

Categories of HOPE insurance:



Joining HOPE makes you eligible for HOPE Medi and HOPE Assure!

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For details regarding IDA HOPE
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(HOPE - Local Branch Representative, IDA Kochi)