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Dear Colleagues,

It is with great pleasure that I welcome you to the first issue of the new year. In this issue, reviews of new developments in the field of dentistry and original researchs are included. One of our most important goals is to mediate appropriately the sharing of knowledge and experience among dental professionals, researchers and academicians. In this issue, we share with you five articles covering various topics in dentistry.

The first article of our journal, "Comparison of caries risk between patients using e-cigarettes or e-cigarettes and patients using conventional cigarettes: a cross-sectional study" is an original article and the authors aimed to compare e-cigarettes and conventional cigarettes in terms of caries risk. The second article "YouTube as a source of information about apical resection: a metodological study" is an original article. The authors have evaluated the use of YouTube as a source of information about apical resection, using a methodological approach. Many anti-caries agents have been researched and started to be used in order to prevent demineralization and ensure remineralization in pediatric dentistry. The third article of our journal, "Caries risk assessment and caries management by risk assessment after graduation: university dental school alumni use, attitudes, and beliefs" is an original article and the authors argue that graduates who graduated after the implementation of the competitive exam used CAMBRA more than those who graduated before its implementation, indicating a possible paradigm shift.The fourth article, "Preventive and remineralization agents in pediatric dentistry: review of the literature". In this study, remineralization agents supported by remineralization studies especially in primary teeth are presented. The fifth article ''Dental caries and demineralization in head and neck cancer patients undergoing radiotherapy" is a review article. In this review, the authors examined the issues that should be taken into consideration when planning restorative dental treatment for head and neck cancer patients before, during and after radiotherapy. Finally, the sixth article ''Treatment of wedge-shaped lateral incisors with direct composite veneer restorations: two case presentations" is a case report. Wedge-shaped lateral incisors are dental anomalies that are characterized by small and pointed shapes and have increased in frequency today. We thought this case would attract attention in today's world where aesthetics are important.

I would like to thank the authors, reviewers, editorial team and publisher for their hard work and dedication in bringing this issue to fruition. We look forward to providing you with the latest insights and developments in dentistry, and we welcome your feedback and suggestions.

Sincerely,

Assoc. Prof. Elif Pınar BAKIR, PhD
Editor-in-Chief

Journal of
Dental Sciences
and Education

CONTENTS

Volume: 2 Issue: 1 Year: 2024

ORIGINAL ARTICLES

REVIEWS

CASE REPORT

Journal of Dental Sciences and Education

Original Article

DOI: 10.51271/JDSE-0024

A comparison of the caries risk between patients who use vapes or e-cigarettes and those who use conventional cigarettes: a cross-sectional study

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ABSTRACT

Aims: Both conventional cigarette use and e-cigarette/vape use appear to have detrimental effects on oral health by promoting the development of both dental caries and periodontal disease. This study aims to compare the effects of the two with regards to dental caries risk level.

Methods: A cross-sectional study on patient records was conducted. 1251 patients who attended the dental school clinics and met the inclusion criteria were included. The Kruskal-Wallis test and multivariable ordinal logistic regression were used to compare the e-cigarette/vaping only, conventional cigarette use only, and dual e-cigarette/vaping and conventional cigarette use groups in terms of caries risk.

Results: A total of 1251 patient records met the inclusion criteria. There were 130 reported active users of e-cigarettes/vapes, 1094 active users of conventional cigarettes and 27 active users of both e-cigarettes/vapes and conventional cigarettes. The Kruskal-Wallis test showed no statistically significant difference between caries risk level among the 3 groups with 88.9% of the dual smokers (both conventional and e-cigarettes/vapes), 83.1% of the e-cigarette/vape only users, and 82.5% of the conventional cigarette only smokers being placed in the high/extreme caries risk category (P=.693). The comparison was also not significant (P=.719) when adjusting for age and gender.

Conclusion: Though the percentage of patients in the high/extreme caries risk category was highest in the dual smokers group, followed by the vaping/e-cigarette use group and lastly the conventional cigarette group, there was no statistically significant evidence of a difference between these groups.

Keywords: Vaping, smoking, dental caries, caries risk

INTRODUCTION

The popularity of e-cigarette/vape use has progressively increased over time. E-cigarettes were initially recommended as an effective aid to smoking cessation. In fact they were marketed as a safer alternative to conventional cigarettes. The detrimental systemic effects of e-cigarette/vape use have been well documented, with the outbreak of deaths due to E-cigarette or Vaping use-associated lung injury (EVALI) in 2019 resulting in a total of 68 deaths and 2,807 hospitalizations in the United States as of February 18th 2020.[2]

Vaping/e-cigarette use has been shown to significantly increases gingival inflammation.[3-8] Peri-implant parameters have been shown to be compromised in vaping patients as a result of an increased inflammatory response, indicated by an increase in the following inflammatory mediators: Tumor Necrosis Factor-alpha (TNF-a) and Interleukin-1 beta (IL-1).[9,10] In addition to elevated TNF-a and Interferon-gamma (IFN-y) levels use of both e-cigarettes and conventional cigarettes has been shown to increase the red and orange complex periodontal bacteria.[11]

Research on the effects of vaping and e-cigarette use on dental caries prevalence is limited. A case series highlighted 3 patients who presented to a private practice with atypical patterns of dental caries. All 3 patients admitted to being avid vapers using THC containing e-liquids.[12] A cross-sectional study assessed 4,618 records from the 2017-2018 National Health and Nutrition Examination Survey. This study concluded that both participants who smoked e-cigarettes as well as dual smokers were more likely to have untreated caries compared to non-smokers and non-dual smokers respectively. Dual smokers were those who used both vapes/e-cigarettes as well as conventional cigarettes.[13] A more recent cross-sectional study on patient records assessed a total of 13,098 patients. This study found that there was a

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significantly lower caries risk level for the non-e-cigarette using/non-vaping control group compared to the e-cigarette/vaping group (P<.001), with 14.5%, 25.9% and 59.6% of the control group being in the low, moderate, and high caries risk categories respectively and 6.6%, 14.3% and 79.1% of the e-cigarette/vaping group being in the low, moderate, and high caries risk categories respectively.[14]

The mechanism by which e-cigarettes may propagate dental caries has been hypothesized based on in vitro studies as follows: Some of the components of e-cigarette aerosols are sweet tasting and may act as a substrate for cariogenic bacteria. The by-products of propylene glycol, a component of e-liquids, are hygroscopic and can bind water in saliva resulting in hyposalivation, predisposing individuals to dental caries.[15] Lastly, the growth pattern and biofilm formation is thought to be influenced by vape/e-cigarette aerosols. A study found that e-cigarette aerosols significantly increased biofilm formation by *Streptococcus Mutans* (*S. mutans*) but did not affect biofilm formation of the 2 commensals. They also found that *S. mutans* exhibited higher hydrophobicity and coaggregation abilities as well as higher attachment to epithelial cells. They concluded that e-cigarettes may have the ability to dysregulate the homeostasis of oral bacteria.[16]

The effects of tobacco use on oral health have been well investigated with evidence suggesting that it leads to the progression of both periodontal disease and dental caries.[17] Tobacco smoking affects the ecology of the oral microbiome by deprivation of oxygen, antibiotic effects and other mechanisms which lead to microbiome dysbiosis.[18] Long term smoking has been linked with xerostomia. A recent systematic review reported that the overall prevalence of xerostomia in the general population was 26%, with 24% of combustible tobacco smokers and 33% of e-cigarette users having a diagnosis of xerostomia, that had been determined by measured low salivary flow rates or the patients' subjective sensation of dry mouth.[19]

Both conventional cigarette use and e-cigarette/vape use appear to have detrimental effects on oral health by promoting the development of both dental caries and periodontal disease. The effects of the two have not yet been compared with regards to dental caries risk level. The rationale of this study was to compare the caries risk of vaping/e-cigarette using patients and patients who smoke conventional cigarettes at a University dental school. This study is a follow-up to a previous study, conducted at the same institution, that established a significantly higher caries risk level in vape/e-cigarette-using patients when compared to a non-vaping/e-cigarette-using control. The null hypothesis was that there is no difference in caries risk between vaping/e-cigarette-using patients and patients who smoke conventional cigarettes.

METHODS

This was a cross- sectional patient record based study. Ethical approval was obtained from the Tufts University Health Sciences Institutional Ethics Review Board (Date: 03.03.2023, Decision No: (HS-IRB STUDY00003596). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. An electronic search was performed on axiUm electronic records.

The inclusion criteria were: Patients of the University dental school clinics from 01.01.2019 to 02.01.2023, above the age of 16, with a diagnosis of dental caries and a Caries Risk Assessment on record. These patients also answered 'yes' to current use of e-cigarettes and vaping and/or conventional cigarettes in the Health History questionnaire.

The exclusion criteria were: Patients without a diagnosis of dental caries and a Caries Risk Assessment on record as well as patients who answered 'no' to current use of e-cigarettes and vaping and no to conventional cigarette use in the Health History questionnaire.

The university's Caries Management By Risk Assessment (CAMBRA) form included the following 7 questions:

- Are there new or active or progressing visible cavitated carious lesions, radiographic radiolucencies in dentin?
- Are there restorations or extractions due to caries within the past 3 years or since the previous caries risk assessment?
- Is there visible heavy biofilm?
- Are there new or active or progressing initial occlusal, smooth surface, or radiographic proximal lesions not in dentin?
- Is there inadequate saliva flow per observation or measurement?
- Does the patient have a diet high in carbohydrates, sugar, acids, or frequent snacking?
- Is the patient at risk of erosion?

The CAMBRA tool has been validated in both pediatric and adult populations with numerous assessments showing a clear relationship between CAMBRA and different levels of caries; low, moderate,high and extreme risk levels.[20-25]

The patient records software, based on a pre-determined algorithm, assigned each patient to a caries risk level: low, moderate, high or extreme.

A query was made in axiUm (dental records software) by IT using Current Dental Terminology[26] codes D0120 (periodic oral evaluation-established patient) and D0150 (comprehensive oral evaluation, new or established patient). The data that were retrieved were the patient's diagnosis of dental caries, patient's age, patient's gender, the patient's caries risk assessment status, the patient's history of e-cigarette/vape use, the patient's history of conventional cigarette use and their axiUm record number. The participants were then assigned identification codes to ensure confidentiality of the patient records in the data set. The caries risk categories were 'low', 'moderate' and 'high' (the high and extreme categories were combined for analysis). These categories were combined to be in alignment with several studies that have assessed the efficacy of CAMBRA as a caries risk prediction tool.[27-29] The included participants were grouped according to age into 3 categories: 16-25 years, 26-40 years and 41 years or older.

Statistical Analysis

A convenience sample was obtained from patients who attended the university dental clinics who met the inclusion

criteria. Descriptive statistics (frequencies and percentages) were calculated. Bivariate analyses were conducted using the Mann-Whitney U test and the Kruskal-Wallis test. Multivariable analysis was also performed using ordinal logistic regression in order to adjust for gender and age category as potential confounding variables. The significance level was set at α=.05. SPSS v. 28 (IBM Corp., Armonk, NY, USA) was used in the analysis.

RESULTS

Of the 1251 patients who attended the university dental clinics from 01.01.2019 to 02.01.2023 who met the inclusion criteria, 130 patients reported active use of e-cigarettes/vapes only and 1094 patients reported active use of conventional cigarettes only. A total of 27 patients reported use of both e-cigarettes/vapes and conventional cigarettes. Of the total participants, 61.1% self reported as male while 38.9% self reported as female. When categorized based on age 3.4% of the participants were in the 16-25 years group, 31.8% in the 26-40 years group and 64.8% were in the 41 years or older group.

The distribution of the participants into the CRA categories was as follows: 3.9% were in the low caries risk group, 13.3% were in the moderate caries risk group and 82.7% were in the high/extreme caries risk group. There was no significant difference in caries risk level between the age or gender categories (p=.248 [Kruskal-Wallis test], p=.257 [Mann-Whitney U test] respectively). The Kruskal-Wallis test showed no statistically significant difference in caries risk level among the 3 groups with 88.9% of the dual smokers (both conventional and e-cigarettes), 83.1% of the e-cigarette/vape only users and 82.5% of the conventional cigarette only smokers being placed in the high/extreme caries risk category (p=.693) (Table 1).

Table 1. Cross-tabulations of age, gender, and e-cigarette/vape and conventional cigarette groups with caries risk level

Variable	Category	CRA Level			p
		Low	Moderate	High or extreme	
Age	16-25 (n=42)	0 (0%)	5 (11.9%)	37 (88.1%)	0.248*
	26-40 (n=398)	10 (2.5%)	52 (13.1%)	336 (84.4%)	
	41+(n=811)	39 (4.8%)	110 (13.6%)	662 (81.6%)	
Gender	Male (n=764)	31 (4.1%)	93 (12.2%)	640 (83.8%)	0.257**
	Female (n=487)	18 (3.7%)	74 (15.2%)	395 (81.1%)	
Study group	E-cigarette/vape and cigarette use (n=27)	1 (3.7%)	2 (7.4%)	24 (88.9%)	0.693*
	E-cigarette/ vape use only (n=130)	3 (2.3%)	19 (14.6%)	108 (83.1%)	
	Cigarette use only (n=1094)	45 (4.1%)	146 (13.3%)	903 (82.5%)	
	Total (n=1251)	49 (3.9%)	167 (13.3%)	1035 (82.7%)	

*Kruskal-Wallis test, **Mann-Whitney U test

Table 2 presents the results of the multivariable ordinal logistic regression. The regression model showed no significant evidence of misfit (p=.275). There was no significant difference in caries risk level among the age groups (p=.252), genders (p=.234), or e-cigarette/vape and conventional cigarette groups (p=.719) when adjusting for one another.

Table 2. Results of the multivariable ordinal logistic regression model including age, gender, and e-cigarette/vape and conventional cigarette groups as factors and caries risk level as the outcome

Variable	Category	OR	95% CI for OR		p*
			Lower limit	Upper limit	
Age	16-25	1.88	0.68	5.15	0.252
	26-40	1.25	0.90	1.75	
	41+**	1	.	.	
Gender	Male	1.20	0.89	1.61	0.234
	Female**	1	.	.	
Study group	E-cigarette/vape and cigarette use	1.54	0.46	5.16	0.719
	E-cigarette/vape use only	0.91	0.54	1.53	
	Cigarette use only**	1	.	.	

*All p-values are from multivariable ordinal logistic regression, **Reference category

DISCUSSION

Though the percentage of patients in the high/extreme caries risk category was highest in the dual smokers group, followed by the vaping/e-cigarette use only group and lastly the conventional cigarette only group, there was no statistically significant difference, even after adjusting for age and gender as potential confounders. Therefore, the null hypothesis was not rejected. A cross-sectional study done on records from the 2017-2018 National Health and Nutrition Examination Survey demonstrated that participants who were dual smokers (smoked e-cigarettes and conventional cigarettes) were more likely to have untreated caries when compared to non dual smokers.[13] These results are similar to those of this current study, with the exception that their results were statistically significant.

Use of tobacco has been shown to increase the prevalence of dental caries by inducing hyposalivation as well as causing a shift in the homeostasis of the oral microbiome.[17-19] E-cigarettes/vape use is hypothesized, through in vitro studies, to have the same effect on the oral environment. In addition to this, e-cigarette/vape use provides a sweet substrate to cariogenic bacteria through their flavoring.[15,16]

In this study, 88.9% of dual smokers, 83.1% of e-cigarette/vape only users and 82.5% of cigarette only smokers were in the high/extreme caries risk category. Though the statistical significance of these differences was not established, there is evidence of a large proportion of the subjects in these groups being in the high/extreme caries risk category. This outcome is concerning, especially when compared to a previous study that compared the caries risk level of vape/e-cigarette using patients and non-smokers. The study found that only 59.6% of non- smokers were classified as high/extreme caries risk. In comparison 79.1% of vape/e-cigarette users were classified as high/extreme caries risk (p<.001).[14]

Tobacco use has been associated with one third of all cancer deaths annually.[30] Sufficient evidence has shown a causal relationship between tobacco use and lung, laryngeal, oral, pharyngeal, esophageal, pancreatic, bladder, kidney and cervical cancers, among others.[31] Evidence on the potential carcinogenicity of e-cigarettes/vapes is still preliminary with molecular science studies showing aberrant morphology, cytotoxicity, reduced viability, oxidative stress, fibroblast

migration and genotoxicity when head, neck and oral cells were exposed to e-cigarette aerosols.[32] E-cigarettes/vape liquids contain both potential and definite oncogens such as nicotine and its derivatives, heavy metals and aldehydes.[33] Given an expected lag time of approximately 20 years, extrapolating from tobacco studies, it may take several years before all the detrimental effects of e-cigarette/vape use fully manifest in the population.[33]

Limitations

The limitations of this study are that it was dependent on the accuracy of patient records which cannot be guaranteed. There was a low percentage of e-cigarette/vape only using patients as well as dual smokers. This could have impacted the findings as smaller sample sizes increase the likelihood of a type II error. Social desirability bias may have played a role in the low number of self reported e-cigarette/vape only users as well as dual smokers. Data on the duration of conventional smoking or e-cigarette/vape use were not collected. The authors hypothesize that since e-cigarettes/vapes are relatively newer to our population, it is more likely that conventional cigarette smokers have been engaging in the habit for a longer time period. There are several confounding variables that could not be accounted for such as socioeconomic status, education level, diet and oral hygiene, which have been associated with drug use in general.[34-37] Lastly, despite having been validated among various populations[38-40], the CAMBRA tool is only 70% predictive of the caries outcome in high risk groups.[38]

Future clinical studies investigating the exact pathophysiology of the increased caries risk among e-cigarette/vape users are recommended. In addition to this, future clinical studies on the potential carcinogenicity of e-cigarette/vape use are highly recommended by the study team.

CONCLUSION

Within the study limitations, it was concluded that though the percentage of patients in the high/extreme caries risk category was highest in the dual smokers group, followed by the vaping/e-cigarette use group and lastly the conventional cigarette group, there was no statistically significant evidence of a difference between these groups. Dental health care providers are encouraged to screen for e-cigarette/vape use in addition to conventional cigarette smoking when gathering information on health history. Further clinical studies are recommended.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Tufts University Health Sciences Institutional Ethics Review Board (Date: 03.03.2023, Decision No: HS-IRB STUDY00003596).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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YouTube as a source of information about apical resection: a metadological study

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ABSTRACT

Aims: This study aims to evaluate the use of YouTube as a source of information about apical resection, using a methodological approach.

Methods: The search term " apicectomy " was identified using the Google Trends application. On 18th January 2024, between 10:00 and 13:00, the term "apicectomy" was searched on YouTube videos. The URLs of the first 250 videos were copied and the 53 videos that met the inclusion criteria were evaluated and scored for Global Quality Score (GQS), Modified DISCERN (mDISCERN) scale and completeness. Statistical analysis was conducted using descriptive statistics, as well as the Shapiro-Wilk and Mann-Whitney U tests.

Results: Of the 53 videos analysed, 5 were found to have excellent content, 30 were found to have average content and 18 were found to have poor content. Videos uploaded by dentists/specialists had significantly higher numbers of views, longer durations, more likes, comments, and view rates compared to those uploaded by commercial and other sources ($p<0.05$). GQS, DISCERN, definition, indication, surgical technique, retrograde filling materials, prognosis and total score were significantly higher in the dentist/expert source compared to commercial and other sources ($p<0.05$).

Conclusion: The level of excellence of YouTube videos on apical resection was found to be "moderate". All videos with an excellent content level were uploaded by a dentist/specialist source. More comprehensive and informative videos about apical resection in dentistry should be uploaded to YouTube by dentists and specialists.

Keywords: Apicectomy, endodontics, internet, social media, YouTube

INTRODUCTION

Apical resection, also known as apicectomy, root apex resection, or root amputation, is the process of cleaning a lesion that develops in the periapical tissues of the tooth, cutting the infected root apex, and covering it with a retrograde filling material.[1,2] The objective of this procedure is to eradicate the infection in the apical region and seal the root canal system, thereby preserving the tooth's function and aesthetics and enabling it to remain in the mouth for as long as possible.[1,3]

Apical resection is indicated in root fractures located in the apical third, when a pathology involves 1/3 of the root tip, when the root canal is occluded or has extruded paste or gutta-percha, in teeth with perforated or lateral canals during treatment, and in cases where root canal re-treatment is not appropriate.[3,4] Prior to performing apical resection, it is essential to evaluate the restorative and periodontal status of the tooth, the size of the periapical lesion, its relationship with anatomical structures, the presence of vertical root fracture and traumatic occlusion, and the patient's systemic suitability for the operation.[1,5]

Success rates for apical resection vary between 44% and 95%.[1,6,7] It is not advisable to determine the success of apical resection based on X-ray images taken in a short time since radiological ossification may take between 6 months and 1 year to complete. In some cases, the radiolucent image may even indicate healthy scar tissue.[1,8] Recurrence of the lesion may be indicated by symptoms such as swelling, pain, and pus around the apex during clinical examination, as well as the presence of radiolucency that increases in size during radiological examination. In such cases, options such as reapplication of periapical surgery, reimplantation, or tooth extraction may be considered.[1,2,8]

In the current digital age, numerous individuals utilise various online platforms to access health-related information.[9] The internet is widely regarded as a valuable source of health information, with many people conducting research on their health status online.[10] YouTube, a free online video sharing social media platform with over 1 billion users, is one such platform.

Since its establishment in 2005, over 5 billion videos have been uploaded to YouTube, which is used by approximately

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1.9 billion people per month. Patients often prefer YouTube over other social media platforms due to its provision of visual and audio information.[11] However, the accuracy of YouTube videos is being questioned due to the proliferation of video sources and their potential influence on patients.[12]

YouTube videos on medicine and dentistry have been evaluated in previous studies.[13-17] However, no study has been conducted to evaluate YouTube videos related to apical surgery using the keyword 'apicectomy'. Therefore, the aim of this study was to analyze the accuracy and reliability of the information obtained from YouTube videos on apical surgery.

METHODS

Google Trends is a service that provides statistical information about word or phrase queries searched on Google. In this study, we used the search terms 'apicectomy', 'apical surgery', 'root resection' and 'apical resection' in the Google Trends application. We found that 'apicectomy' was the most frequently searched term on the topic. On 18th January 2024, a search was conducted on YouTube (http://www.youtube.com) between 10:00 and 13:00 to find videos on apical resection in endodontics using the search term 'apicectomy'. The search results were sorted by relevance, which is the default option on YouTube.

The first 250 videos found were included in this study. Two observers, each with at least 7 years of clinical experience in the field, rated these videos separately. 197 videos that had no visual or audio content, were not in English, were longer than 15 minutes, were uploaded more than ten years ago, were duplicates, or were irrelevant to the topic were excluded from the analysis. The remaining 53 videos that met the inclusion criteria were analysed by two observers. All video links were included, as search results may change over time after the exclusion criteria have been applied. Local ethics committee approval was not required for this study as the survey data are publicly available on YouTube. All procedures were carried out in accordance with the ethical rules and the principles.

A literature review was performed to assess the accuracy and timeliness of the videos. The investigators scored each video from 0-2 (0=incomplete, 2=very complete) according to the information content regarding the definition, indications, contraindications, surgical technique, retrograde filling materials and prognosis of apical resection, resulting in a total score of 12. According to the sum of the scores, the videos were classified as low content (0-4 points), medium content (5-8 points) and high content (9-12 points). Another scoring method used was the 5-point Global Quality Score (GQS) index (Table 1). The GQS is a 5-point Likert scale based on the quality, flow and usability of information available online. Videos were scored from 1 to 5 based on quality, usefulness to patients, flow, educational value and overall quality. The reliability and accuracy of the information presented in the videos was assessed using the 5-point Modified DISCERN (mDISCERN) scale, developed from the DISCERN reliability tool (Table 2).

The source from which all videos were uploaded, the duration of the video, the total number of views, the number of days since upload, the number of likes, the number of comments and the view rate were recorded. The view rate was calculated by dividing the number of views by the number of days since upload and multiplying by 100%. Videos were categorised according to their source as dentist/specialist, commercial and other. In cases where there was disagreement between the researchers on the classification and scoring of videos, a consensus was reached through an impartial and careful literature review.

Table 1. Global quality score

Scores description
1. Poor quality; Very unlikely to be of any use to patients
2. Poor quality but some information present; Of very limited use to patients
3. Suboptimal flow, some information covered but important topics missing; Somewhat useful to patients
4. Good quality and flow, most important topics covered; Useful to patients
5. Excellent quality and flow; Highly useful to patients

Table 2. The modified DISCERN score (1 point for every yes, 0 points for no)

Item Questions
1.Are the aims clear and achieved?
2.Are reliable sources of information used? (i.e., publication cited, speaker is specialist in diabetes)
3.Is the information presented both balanced and unbiased?
4.Are additional sources of information listed for patient reference?
5. Are areas of uncertainty mentioned?

Statistical Analysis

Data analysis was performed using SPSS 21.0. Interobserver agreement was assessed using Fleiss kappa analysis. The normal distribution of the data was checked using the Shapiro-Wilk test, and the Mann-Whitney U test was used for pairwise comparisons because the parameters were not normally distributed. In the analyses, the confidence interval was set at 95% (significance level 0.05, $p<0.05$).

RESULTS

The descriptive statistics of the video shares are presented in Table 3.

Table 3. Descriptive statistics for YouTube videos

Quantitative variable	Min	Max	Mean	SD
Views	23.00	900000.00	32864.11	131595.33
Likes	0.00	3300.00	194.25	608.63
Comments	0.00	477.00	24.74	75.14
Duration	0.48	14.90	3.64	3.34
Days since upload	90.00	3600.00	1743.96	991.61
Viewing rate	2.12	31250.00	1549.98	5332.25

Min: Minimum, Max: Maximum, SD: Standart deviation

The average length of YouTube videos on apical resection was 3.64 minutes. The videos had an average of 32,864 views (min:23/max:900,000) and a view rate of 1,549.98 (min:2.12/max: 31,250). The average number of likes was 194.25 (min:0/max:33,300) and the average number of comments was 24.74 (min:0/max:477). The videos were uploaded an average of 1,743.96 days ago (min:90/max:3,600) (Table 3).

Table 4 shows a comparison of the quantitative data of the videos based on their source category.

Table 4. Comparison of quantitative data based on the source of uploaded videos

	Dentist/Specialist (n=33)	Commercial (n=11)	Other (n=9)	
Quantitative variable	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**p**
Views	51071.85±164976.23	1140.36±1903.09	4875.89±7544.63	p<0.05[a]
Likes	298.82±755.43	4.45±6.71	42.78±67.91	p<0.05[a]
Comments	34.91±91.46	0.18±0.40	17.44±43.91	p<0.05[a,c]
Duration	4.88±3.52	1.07±0.52	2.24±2.27	p<0.05[a,b]
Days since upload	1650.00±1005.90	1865.45±716.72	1940.00±1265.70	>0.05
Viewing rate	2387.87±6647.11	58.57±72.01	300.53±600.54	p<0.05[a]

n: Number of videos, SD: Standart deviation, p: Significance level, a: Dentist/Speacialist≠Commercial, b: Dentist/Specialist≠Other, c: Commercial≠Other

Based on the video upload source, there were 33 videos in the dentist/specialist source, 11 videos in the commercial source, and 9 videos in other sources. The number of views followed the order of dentist/specialist, other, and commercial channels from highest to lowest (Table 4). No statistical difference was found in terms of the number of days elapsed based on the video source (p>0.05). Statistical differences were found in the number of views, video duration, number of likes, number of comments, and view rate based on the video source (p<0.05). Videos uploaded by dentists/specialists had significantly higher numbers of views, longer durations, more likes, comments, and view rates compared to those uploaded by commercial and other sources (Table 4).

Descriptive statistics of GQS, DISCERN and Information completeness scores are presented in Table 5. The weighted kappa value of interobserver agreement for GQS, DISCERN and completeness scores were 0.84, 0.80 and 0.80, respectively.

The mean GQS score of YouTube videos on apical resection is 3.81 (min:2/max:5), the mean DISCERN score is 4.02 (min:2/max:5), the mean disease description score is 1.17 (min:0/max:2), the mean indication score is 1.09 (min:0/max:2), the mean contraindication score is 0. 06 (min:0/max:2), the mean surgical technique score was 1.51 (min:1/max:2), the mean retrograde filling materials score was 0.92 (min:0/max:2), the mean prognosis score was 0.92 (min: 0 / max: 2) and the mean total score was 5.70 (min:2/max:11) (Table 5).

The comparison of completeness, GQS and DISCERN scores by source category is shown in Table 6.

There was no statistical difference in mean contraindication score according to video source (p>0.05) (Table 6). There was a statistical difference in GQS, DISCERN, disease definition, indication, surgical technique, retrograde fillers, prognosis and total score according to video source (p<0.05). GQS, DISCERN, definition, indication, surgical technique, retrograde filling materials, prognosis and total score were significantly higher in the dentist/expert source compared to commercial and other sources (Table 6).

Of the 53 videos analysed, 5 were found to have excellent content, 30 were found to have average content and 18 were found to have poor content. The comparison of the quantitative data of the videos according to the excellence of the videos is shown in Table 7.

According to the results of the comparison test according to the perfection status, no statistical difference was found in the number of views, number of likes, number of comments, number of days elapsed and view rates according to the perfection status of the videos (p>0.05). There was a statistical

Table 5. Descriptive statistics for GQS, DISCERN an completeness scores

Scores	Min	Max	Mean	SD
GQS (1-5)	2.00	5.00	3.81	0.98
DISCERN (1-5)	2.00	5.00	4.02	0.87
Definition	0.00	2.00	1.17	0.64
Indication	0.00	2.00	1.09	0.66
Contraindication	0.00	2.00	0.06	0.30
Surgical technique	1.00	2.00	1.51	0.50
Retrograde filling materials	0.00	2.00	0.92	0.87
Prognosis	0.00	2.00	0.92	0.70
Overall score (0-12)	2.00	11.00	5.70	2.10

SD: Standart deviation

Table 6. Comparison of completeness, GQS and DISCERN scores according to the source of the uploaded videos

	Dentist/ Specialist (n=33)	Commercial (n=11)	Other (n=9)	
Scores	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**p**
GQS (1-5)	4.36±0.60	2.73±0.79	3.11±0.78	p<0.05[a,b]
DISCERN (1-5)	4.48±0.57	3.18±0.75	3.33±0.71	p<0.05[a,b]
Definition	1.30±0.59	0.64±0.50	1.33±0.71	p<0.05[a,c]
Indication	1.30±0.68	0.82±0.40	0.67±0.50	p<0.05[a,b]
Contraindication	0.09±0.38	0.00±0.00	0.00±0.00	p>0.05
Surgical technique	1.73±0.45	1.09±0.30	1.22±0.44	p<0.05[a,b]
Retrograde filling materials	1.24±0.87	0.36±0.50	0.44±0.73	p<0.05[a,b]
Prognosis	1.12±0.70	0.55±0.52	0.67±0.71	p<0.05[a]
Overall score (0-12)	6.79±1.71	3.45±0.69	4.44±1.67	p<0.05[a,b]

n: Number of videos, SD: Standart deviation, p: Significance level, a: Dentist/Specialist≠Commercial, b: Dentist/Specialist≠Other, c: Commercial≠Other

Table 7. Comparison of quantitative data of the videos according to the perfection status of the videos

	Excellent (n=5)	Medium/Poor (n=48)	
Quantitative variable	**Mean ± SD**	**Mean ± SD**	**p**
Views	70275.40±153020.23	28967.10±130393.30	p>0.05
Likes	642.40±1319.57	147.56±487.91	p>0.05
Comments	100.20±210.82	16.88±42.38	p>0.05
Duration	6.54±2.99	3.34±3.26	p<0.05
Days since upload	1008.00±591.54	1820.63±997.24	p>0.05
Viewing rate	4959.10±10582.46	1194.86±4534.49	p>0.05

n: Number of videos; SD: Standart deviation; p: Significance level

difference in video duration according to perfection status (p<0.05). The video duration of the videos in excellent condition was significantly higher than the video duration of the videos in fair/poor condition (Table 7).

The comparison of completeness, GQS and DISCERN scores according to the excellence of the videos is shown in Table 8.

Table 8. Comparison of completeness, GQS and DISCERN scores according to the excellence of the videos

	Excellent (n=5)	Medium/Poor (n=48)	p
Scores	Mean ± SD	Mean ± SD	
GQS (1-5)	4.80±0.45	2.94±0.87	p<0.05
DISCERN (1-5)	4.80±0.45	3.33±0.84	p<0.05
Definition	2.00±0.00	0.78±0.65	p<0.05
Indication	1.80±0.45	0.61±0.50	p<0.05
Contraindication	0.40±0.89	0.00±0.00	p>0.05
Surgical technique	2.00±0.00	1.11±0.32	p<0.05
Retrograde filling materials	1.80±0.45	0.39±0.61	p<0.05
Prognosis	1.40±0.55	0.56±0.51	p>0.05
Overall score (0-12)	9.40±0.89	3.44±0.62	p<0.05

n: Number of videos, SD: Standart deviation, p: Significance level

According to the results of the comparison test performed according to the perfection status, no statistical difference was detected according to the perfection status of the videos in terms of mean scores for contraindication and prognosis (p>0.05) (Table 6). There was a statistical difference in the GQS, DISCERN, definition, indication, surgical technique, retrograde cavity materials and total scores according to the perfection status of the videos (p<0.05). The GQS, DISCERN, definition, indication, surgical technique, retrograde cavity materials and total scores of excellent videos were significantly higher than those of moderate/poor videos (Table 8).

The relationship between completeness, GQS and DISCERN scores of videos and quantitative data is shown in Table 9. A positive and significant (p<0.05) relationship was found between GQS score and number of views, number of likes, number of comments, video duration, and view rate (Table 9). A positive and significant (p<0.05) relationship was found between DISCERN score and the number of views, number of likes, number of comments, video duration and view rate (Table 9). A positive and significant (p<0.05) relationship was found between total score and the number of views, number of likes, number of comments, video duration and view rate (Table 9).

DISCUSSION

It is widely acknowledged that communication is predominantly facilitated through the internet and social media. Additionally, individuals often seek advice on health-related matters from online sources. Individuals search social media accounts for health information and reviews, but these sources may contain incorrect or incomplete information. Therefore, it is important to access up-to-date and reliable sources for accurate and comprehensive health information.[18] At this point, there are many studies in the fields of dentistry and medicine in which content analysis is made of videos uploaded to YouTube, which is a widely used area.[13-20] But, no other study has analysed English YouTube videos related to apical resection using the keyword apicectomy. Our study is the first to analyse the usefulness of English videos on YouTube about apical resection, making it an original study.

Fifty-three videos that met the inclusion criteria were included in our study among the first 250 videos accessed when "apisectomy" was typed into the YouTube search engine. There are various studies in the literature that use a similar number of videos as our study.[13-15] Various filters are available for sorting videos, including 'views', 'upload date', and 'video duration'. For this study, the default filter for YouTube search was 'sort by relevance', as it Because this is the most commonly used option by invudials. Furthermore, 'sort by relevance' was found to be the most preferred filtering option in these studies.[20-24]

Many studies[14,25,26] that have evaluated the quality of health-related YouTube videos have reported that the videos contain

Table 9. Comparison of completeness, GQS and DISCERN scores with quantitative data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. GQS	1														
2. DISCERN	0.67**	1													
3. Definition	0.41**	0.26	1												
4. Indication	0.52**	0.42**	0.42**	1											
5. Contraindication	0.15	0.25	0.11	0.28*	1										
6. Surgical technique	0.48**	0.50**	0.26	0.21	0.00	1									
7. Retrograde filling materials	0.57**	0.51**	0.05	0.12	0.02	0.61**	1								
8. Prognosis	0.30*	0.23	-0.20	0.09	0.16	0.16	0.17	1							
9. Overall score	0.78**	0.66**	0.48**	0.61**	0.23	0.70**	0.67**	0.46**	1						
10. Views	0.41**	0.47**	0.29*	0.33*	0.16	0.43**	0.37**	0.00	0.50**	1					
11. Likes	0.46**	0.50**	0.37**	0.37**	0.19	0.56**	0.45**	0.10	0.64**	0.89**	1				
12. Comments	0.52**	0.37**	0.29*	0.24	0.16	0.32*	0.34*	0.23	0.53**	0.76**	0.81**	1			
13. Duration	0.56**	0.55**	0.33**	0.31**	0.28**	0.63**	0.59**	0.39**	0.79**	0.58**	0.74**	0.71**	1		
14. Days since upload	-0.06	0.00	-0.13	-0.05	0.02	-0.03	-0.04	-0.18	-0.14	0.37**	0.20	0.17	-0.08	1	
15. Viewing rate	0.46**	0.49**	0.35*	0.36**	0.15	0.50**	0.39**	0.07	0.58**	0.94**	0.91**	0.78**	-0.22	0.08	1

*: p<0.05, **: p<0.01

insufficient information. In this study, the videos were found to have moderate quality information content. This could be attributed to the fact that the majority of the installers were professionals, which is in line with Yavuz et al.'s[27] study.

Singh et al.[28] developed the mDISCERN Score to estimate the reliability and clarity of information in YouTube videos. In this study, we used the mDISCERN Score to investigate the reliability and accuracy of videos. The quality of patient information was assessed using the global quality scale (GQS), consistent with previous studies.[13,14] Furthermore, the quality and accuracy of the information presented in the videos were evaluated using the completeness score, as in previous studies.[13,14,17] The GQS and DISCERN scores of the dentist/expert upload source were significantly higher than those of commercial and other sources. Additionally, the GOS, DISCERN, and completeness scores of the dentist/expert source were statistically higher than those of all other sources. Consistent with previous studies,[14,16,17] it is expected and acceptable that videos uploaded by dentists and specialists have higher quality, accuracy, and completeness scores than those uploaded by other sources.

Viewers on YouTube can interact with videos by liking and commenting. However, these interactions should not be considered reliable evidence for dentistry. Nonetheless, dentists can use these features to gauge the usefulness of their videos and share more informative content.

Like previous studies,[29-31] the study used GQS, DISCERN and completeness scores; the relationship between the number of views, the number of likes, the number of comments, the video duration and the viewing rate was examined and a positive and significant relationship was detected. It is worth noting that the ranking of videos on YouTube can affect viewers' engagement.[15] However, it is expected that higher quality videos receive more interaction as they are discovered, which is compatible with the YouTube algorithm.

Limitations

One limitation of this study is that the results may vary depending on the selected keywords. In this study, we selected the single most popular keyword based on Google Trends application data. The lack of overlap between the results of the study examining apical resection videos with multiple keywords is likely due to this important difference.[32] It should be noted that the data collection method used in this study was ad hoc, which is a limitation shared with similar studies.[14,16,17] Additionally, the study's results are limited as only English videos were included. It is important to consider that there are many countries where English is not the native language.

Out of the 53 videos that were examined, it was determined that 5 of them were excellent, 30 were average, and 18 were poor. Based on the findings of this study, it can be concluded that YouTube may be a moderately useful source of information for apical resection.

CONCLUSION

The level of perfection of YouTube videos on apical resection was found to be 'medium'. All videos with an excellent content level were uploaded by a dentist/specialist source. The quality and accuracy of videos about apical resection uploaded by dentists and specialists are higher than those uploaded by other sources. More comprehensive and informative videos about apical resection in dentistry should be uploaded to YouTube by dentists and specialists.

ETHICAL DECLARATIONS

Ethics Committee Approval

No ethics committee decision is required for this study.

Informed Consent

No informed consent is required for this study.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors reports no conflicts of interest in this work.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Caries risk assessment and caries risk management by risk assessment after graduation: university dental school alumni use, attitudes, and beliefs

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ABSTRACT

Aims: This project examined the acceptance and use of Caries Management by Risk Assessment (CAMBRA) by the university dental school alumni after graduation.

Methods: In 2011, a university dental school implemented a CAMBRA Competency Examination (CE) for assessing students' ability to conduct a caries risk assessment and preventive plan. A survey was distributed in 2020 to 5,000 university dental school alumni who graduated between 1975 and 2019 which assessed their use and beliefs regarding Caries Risk Assessment (CRA). Alumni were placed into two groups for purposes of analysis: Group 1(G1): those who graduated prior to 2013 (n=373) and Group 2 (G2): those who graduated in or after 2013 (n=213).

Results: There was an overall response rate of 12% as 586 alumni responded to the survey. Overall, most (82.59%) of the survey respondents routinely assessed for caries risk, with 31.82% using a standardized tool. 42.83% of the respondents strongly agreed that CRA could predict the risk of future caries. There were significant differences between groups in terms of routine use of CRA (39.68% in G1 vs 48.36% in G2); very strong belief that a dentist's use of CRA can predict the future risk of caries (39.68% vs 48.36%); extreme importance of active caries when determining a preventive plan (38.16% vs 53.43%); and always treating children with incipient lesions with in-office fluoride (61.56% vs 76.02%) (all p<.05).

Conclusion: The alumni who graduated after the implementation of the competency examination used CAMBRA to a greater extent than those who graduated before its implementation, suggesting a possible paradigm shift.

Keywords: CAMBRA, alumni, competency, caries risk assessment

INTRODUCTION

It is estimated that oral disease affects approximately 3.5 billion people worldwide, with caries of permanent teeth being the most common condition. Globally, approximately 2 billion people suffer from caries of their permanent teeth and 520 million children suffer from caries of their primary teeth.[1] The medical model of caries management is among the principles of minimally invasive dentistry that encourages the prevention of disease or the interception of the disease process in its early stages in order to preserve tooth structure. CAMBRA (Caries Management by Risk Assessment) is a philosophy that has been developed over the past decades to help the practitioner assess the patient's risk for developing caries. This assessment is used to best manage the patient's treatment. The protocol involves determining the caries risk level by evaluating the many risk factors and protective factors of the patient. Treatment, depending on the caries risk, is multifaceted and could include the use of prescription fluoride, nutritional counseling, oral hygiene instructions, placement of silver diamide fluoride, placement of dental sealants, dry mouth intervention, and increased frequency of diagnostic radiographs/check-up.

Several caries risk assessment tools have been described in the literature such as the American Dental Association tool, American Academy of Pediatric Dentistry tool. The California Department of Health Care Services tool, Cariogram, among others. Several of these caries risk assessment tools have not been validated by clinical studies. Both CAMBRA and the Cariogram have been examined in multiple clinical studies and have been found to have good risk assessment capabilities.[5] Studies have demonstrated that the clinical significance of implementing the CAMBRA protocol in the reduction of dental caries worldwide.[3-5] In support of this in practice, a randomized controlled trial trained 30 dentists in private practice to utilize the CAMBRA protocol, and demonstrated that caries risk level, and caries disease indicators, were significantly reduced in the patients who were randomized to utilize the study protocol as compared to those who did not.[3] In 2009, most dental school students responded to having caries risk assessment training in their predoctoral program.[6] This university dental school is no exception, largely due to the introduction of the CAMBRA competency examination

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(CE) that has been in effect since 2011 with the graduating class of 2013 being the first class to complete a CAMBRA CE. The CAMBRA competency was a patient-based exam. This was essentially a performance assessment, and two calibrated faculty would use a rubric to evaluate their skill/knowledge. Students were encouraged to screen their patient at either the routine exam appointments and choose higher risk individuals. The student would then schedule the competency exam and they would be evaluated. Although the concept for CAMBRA is taught and is considered the ideal care, there is no evidence that this philosophy is practiced post-graduation. The aim of this project was to determine the use, attitudes and beliefs of dental school alumni regarding CAMBRA since the inception of the Clinical CAMBRA competency exam. The hypothesis was that the use, attitudes and beliefs of alumni who graduated after 2013 would be in greater alignment with CAMBRA philosophy in their practices than those who graduated before 2013.

Although the concept for CRA (Caries Risk Assessment) and management is taught to the undergraduate students and exists as a clinical guideline, there is no evidence that this philosophy is practiced post-graduation. Alumni have certainly gained the knowledge to surgically treat teeth and are expected to use this skillset to treat patients, but whether or not they were assessing the patient's caries risk and educating their patients about disease management prior to treatment planning was unclear. The CAMBRA clinical curriculum at this university dental school may help to determine the application of this philosophy in the everyday practice of the alumni.

METHODS

Ethics

The study was carried out with the permission of Tufts University Health Sciences Institutional Ethics Review Board (Date: 30.01.2020, Decision No: STUDY00000226). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The present study evaluated the success of the CAMBRA clinical curriculum at this university dental school through use of a questionnaire survey that was sent to alumni of this program who had graduated between 1975 and 2019.

Study Population

The study population consisted of those who graduated from a university dental school's Doctor of Dental Medicine (DMD) program between 1975 and 2019, who were actively practicing dentistry one or more days a week, and who practiced General Dentistry, Pediatric Dentistry, Prosthodontics, or Public Health Dentistry.

The year 2013 was the transition period when the training and implementation of the CAMBRA CE was fully supported. Since we wanted to examine differences in the beliefs, attitudes, and use of CAMBRA between those who had CAMBRA CE in clinic and those who did not, two comparison groups were created: Group 1 (G1) were those who graduated between 1975 and 2012 and Group 2 (G2) were those who graduated in or after 2013 to 2019.

The selected specialties were primary care dentists, who are often first points of contact to patients and provide comprehensive care management, including preventive services. The 1975 cut off year was decided upon since those who graduated at this early date would be close to retirement (or retired). The survey instrument described below was distributed to 5,000 university dental school alumni in 2020.

Survey

The research team created an electronic survey on Qualtrics to assess the use, attitudes and beliefs of CRA and CRM principles based on the CAMBRA philosophy. Content and face validity testing were conducted for quality assurance of the survey. The survey was updated based on responses received in this exercise. The 68-question survey was focused on topics regarding the use of CAMBRA, as well as the beliefs of this evidence-based science. The survey questions consisted of 44 Likert Scale, 7 demographic, 7 multiple-choice, 5 yes/no, and 5 qualifying questions. The estimated time to complete the survey was 15 minutes. Each survey link included an Information Sheet, which contained all required elements of consent to which the participants were required to agree. The survey is included as a supplement in the Appendix.

Survey Administration

The research team distributed the survey through two different venues. The first venue was during a 2020 dental congress at the university dental school alumni booth. Participants could access the survey with their electronic handheld device by scanning a QR Code provided by Qualtrics or with an iPad provided by the study team and scanning an anonymous link provided by Qualtrics. The second venue was via the university dental school alumni emails linked to Qualtrics.

Recruitment Methods

The IRB approved recruitment script was read to interested participants at the alumni booth. Displayed was a poster detailing the research study and promoting a raffle of gift cards as incentive for study participation and survey completion; paper copies of the information sheet were made available if subjects preferred to read a printed copy. Participants taking the survey at the dental congress were eligible to win one $500 American Express gift card.

In addition, a recruitment email with the survey link was distributed through the university dental school alumni network. The research team distributed the survey in January 2020. Six reminders were sent spanning 10 weeks after the initial distribution. Participants taking the survey in response to the email blast were eligible to win one of ten $100 American Express gift cards. Recruitment emails contained language that asked participants who had already responded to the survey to ignore the reminder.

Statistical Analysis

Frequencies and percentages were calculated for each item on the survey. Differences in selected demographic, CRA and CRM (Caries Risk Management)factors between the two comparison groups were assessed using the chi-square test for categorical variables and the Mann-Whitney U test for Likert scale questions. The statistical significance level was set at 0.05 for global tests. SAS Version 9.4 (SAS Institute Inc., Cary, NC) was used for analyses. Cronbach statistical test was performed to assess the internal consistency of the questionnaire.

RESULTS

Study Population Characteristics

The survey response rate was 12% and the total number of participants who completed the entire survey was 586. The survey was administered to 4,883 of the approximately 8000 graduates of the dental school up to 2019. The study population was divided into 2 comparison groups: G1 (n=373): those who graduated before 2013, and G2 (n=213): those who graduated in/or after 2013 up to 2019. In this study sample, 48.29% of the respondents were men and 51.71 % were women. Most (87.37%) of the participants were engaged in general dentistry, 7.00 % were pediatric dentists, 1.71% were prosthodontists and 3.92% were involved in Public Health. Of the study population, 63.99% had been in practice for nineteen years or less. Specifically, 24.06% had been in practice for less than 5 years, 19.11% for 5-10 years, 20.82% for 10-19 years, 17.58% for 20-29 years, 17.92% for 30-39 years and 0.51% for over 40 years.

The place of employment differed between the two graduation groups with more participants from G1 (82.59%) being involved in private practice than in G2 (67.61%). Additionally, more diverse places of employment were reported from participants in G2, such as corporate, Armed forces, and Mobile Dental Health Clinics. (Table 1).

Table 1. A table demonstrating the study population characteristics

Categories	Subcategories	Group 1 n (%)	Group 2 n (%)
Age	<35 years	8 (2.1)	178 (83.6)
	35-44 years	130 (34.9)	32 (15.0)
	45-54 years	97 (26.0)	3 (1.4)
	55-64 years	119 (31.9)	0 (0)
	65 years and over	18 (4.8)	0 (0)
Gender	Male	207 (55.5)	76 (35.7)
	Female	163 (43.7)	135 (63.4)
	Prefer not to answer	3 (0.8)	2 (0.9)
Race	White	263 (70.5)	133 (62.4)
	Black or African American	6 (1.6)	13 (6.1)
	American Indian or Alaskan Native	1 (0.3)	1 (0.5)
	Asian	69 (18.5)	59 (27.7)
	Native Hawaiian or Pacific Islander	4 (1.1)	0 (0)
	Other	12 (3.2)	4 (1.9)
	Prefer not to answer	25 (6.7)	10 (4.7)
Ethnicity	Latino	16 (4.3)	15 (7.0)
	Non-Hispanic	308 (82.6)	177 (83.1)
	Prefer not to answer	49 (13.1)	21 (9.9)
Place of employment (*)	Private practice	308 (82.6)	144 (67.6)
	Corporate health center	8 (2.1)	23 (10.8)
	Armed forces	6 (1.6)	8 (3.8)
	Other government services	6 (1.6)	2 (0.9)
	Mobile dental clinic	22 (5.9)	21 (9.9)
	Community health center	10 (2.7)	7 (3.3)
	Academic institution	4 (1.1)	4 (1.9)
	Hospital	9 (2.4)	4 (1.9)
	Other (text)	6 (1.6)	3 (1.4)

The Cronbach- alpha value was 0.75, indicating that the internal consistency of the questionnaire was acceptable.

CRA & CRM Use, Attitudes and Beliefs

Overall, most (82.59%) of the survey respondents routinely assessed for caries risk, with G1 representing 80.16% and G2 representing 86.85%. The chi-square test concluded that there was a statistically significant association between graduation groups and routinely assessing patient's risk of developing caries (p=.04). The p-value for the Mann Whitney U test demonstrated a statistically significant difference between graduation groups on how strongly they thought a CRA could predict the risk of caries in the future. There were 39.68% of G1 and 48.36% of G2 participants who reported that they strongly agreed that a dentist's assessment of caries risk could predict whether or not the patient develops caries(p=.02). (Table 2) For those who did not use a standardized tool (68.18%), there was a significant difference between graduation groups and how often they gave an individualized preventive treatment plan (p=.004) with 45.00% of G1 and 42.59% of G2 reporting that they frequently gave individualized preventive treatment plans.

Table 2. A table summarizing the CRA use and attitudes for graduation groups 1 and 2

Q: How strongly do you agree with this statement: a dentist's assessment of caries risk for a patient can predict whether or not that patient develops new caries in the future

Response	Very strongly agree	Strongly agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Group 1, %	39.68	33.51	3.45	17.24	16.09
Group 2, %	48.36	31.46	4.69	3.76	11.74

P=.02

Overall, the majority of survey respondents' belief was that 76% strongly agreed or agreed that CRA could predict the future of caries risk; 39.68% in G1 strongly agreed compared with 48.36% in G2. Approximately fifty six percent (55.97%) overall believed that having a specific protocol /form increased the reliability of a CRA.

When the attitudes of the participants were assessed, these were the findings: when asked about their ability to complete a CRA, 90.27% answered "very good or good". When asked about their ability to complete a preventive treatment plan, 85.32% answered "very good or good". Approximately eighty-six (85.51%) percent of the respondents gave individualized preventive plans to "almost every patient" or "with most patients". Of the 31.82% of the population who used a standardized CRA tool, ninety percent (90.26%) used it "with almost every patient" or with "most patients".

Treatment of Children

The Mann Whitney U test displayed significant differences between graduation groups on how often they administered an in-office fluoride application such as fluoride gel or varnish (p=.0004), how often they recommended an OTC fluoride rinse (p=.001) and how often they recommended xylitol chewing

gum or mints (p=.004) to children (ages 6-17) with at least one white spot lesion. 61.56% of G1 participants and 76.02% of G2 participants always administered in-office fluoride application. 33.53% of G1 participants and 27.04% of G2 participants always recommended OTC fluoride rinse while 33.53% of G1 participants and 39.80% of G2 participants rarely recommended xylitol chewing gum (Table 3). Additionally, results showed significant differences between groups on the importance of decreased salivary flow (p=.05) and socio-economic status (p=.01) when deciding on a preventive treatment plan for children. 57.80 % of G1 participants and 50.00% of G2 participants reported that decreased salivary function was extremely important when deciding on a preventive treatment plan. 23.99% of G1 participants and 32.14% of G2 participants reported that the patient's socioeconomic status was very important when deciding on a preventive treatment plan. (Table 4) Additionally, 37.24% from G2 and 35.26% of G1 believed that the history of caries (within the last 3 years) was very important when deciding on a preventive treatment plan, and 45.92% of G2 and 39.60% of G1 participants believed that the presence of dental appliances was very important when developing a preventive treatment plan. When asked about the application of dental sealants, 58.67% of G2 and 55.49% of G1, always applied sealants on permanent teeth with pits & fissures.

Treatment of Adults

For patients over 18 years, Mann Whitney U test demonstrated a statistically significant difference between graduation groups when participants were asked about the importance of active carious lesion (p=<.0001), the importance of several large restorations(p=.04) as well as the importance of root exposure and recession(p=.0043) when deciding on a patient's preventive treatment plan. Of G1 participants 38.16% and 53.43 % of G2 participants reported that the presence of active caries was extremely important in deciding on preventive treatment plans. 42.16% of G2 participants and 37.05% of G1 participants reported that the presence of large restorations was very important in deciding on treatment. 37.60% of G1 participants and 27.45 % of G2 participants reported that recession and root exposure were extremely important in deciding on preventive treatment plans (Table 5).

Table 3. A table comparing the differences in graduation groups on how often they administer in-office fluoride application, recommend OTC fluoride rinse or xylitol chewing gum in children with white spot lesions.

Q: How often do you prescribe in office fluoride, OTC fluoride rinse or xylitol chewing gum in children with white spot lesions?

	Response	Always	Frequently	Sometimes	Rarely	Never	P values
Group 1, %	In-office fluoride	61.56	30.35	5.78	2.02	0.29	.0004
	OTC Fluoride rinse	33.53	38.44	19.65	6.65	1.73	.001
	Xylitol chewing gum	5.78	13.01	28.32	33.53	19.38	.004
Group 2, %	In-office fluoride	76.02	20.92	2.55	0.51	0.00	
	OTC Fluoride rinse	27.04	28.57	26.02	13.78	4.59	
	Xylitol chewing gum	4.08	8.67	21.43	39.80	26.02	

Table 4. A table comparing the differences between graduation groups on the importance of decreased salivary flow and socio-economic status when deciding on treatment plans for children

Q: How important are decreased salivary flow and socio economic status when deciding on treatment plans for children?

	Response	Not at all	Slightly important	Important	Very important	Extremely important	P values
Group 1 %	Decreased salivary flow	1.16	3.76	7.23	30.06	57.80	.05
	Socioeconomic status	16.47	15.90	28.90	23.99	14.74	.01
Group 2 %	Decreased salivary flow	1.02	3.57	13.78	31.63	50.00	
	Socioeconomic status	6.12	12.76	35.71	32.14	13.27	

Table 5. A table comparing the differences between graduation groups on the importance of the presence of active carious lesions, several large restorations or root exposure when deciding on the treatment plans of adult patients

Q: How important are the presence of active carious lesions, several large restorations or root exposure when deciding on the treatment plans of adult patients?

	Response	Not at all	Slightly important	Important	Very important	Extremely important	P values
Group 1 %	Active carious lesions	0.56	5.85	15.60	39.83	38.16	<.0001
	Large restorations	0.84	7.52	27.58	37.05	27.02	.04
	Root exposure	0.56	5.01	14.48	42.34	37.60	.0043
Group 2 %	Active carious lesions	0.49	0.00	11.27	34.80	53.43	
	Large restorations	0.,00	6.86	19.12	42.16	31.86	
	Root exposure	0.98	5.39	23.04	43.14	27.45	

DISCUSSION

The CAMBRA protocol consists of evidence-based clinical recommendations for the most effective interventions in the arrest or reversal of non-cavitated and cavitated dental caries, using non-restorative treatments in children and adults. These recommendations have been formulated by an expert panel that made 11 clinical recommendations, each specific to lesion type, tooth surface, and dentition. These recommendations include the use of 38% silver diamine fluoride, sealants, 5% sodium fluoride varnish, 1.23% acidulated phosphate fluoride gel, and 5,000 parts per million fluoride (1.1% sodium fluoride) toothpaste or gel, among others.[8]

In this study 39.68% and 33.51% of G1 and 48.36% and 31.46% of G2 participants either strongly or frequently agreed that the dentist's assessment of caries risk was a predictor for the patient's future caries risk. This was similar to the results from a study on dental hygienists in 2015 where 34% and 55% of the participants strongly agreed and agreed with this statement.[9]

Though the overall results demonstrated some alignment with the CAMBRA philosophy when treating adults; and a much greater alignment with the philosophy, when treating children[6], several results favored G2 participants and therefore suggest that the introduction of the CAMBRA CE for the G2 participants may have had a significant role in influencing their implementation of CAMBRA philosophy in their daily practice. Based on these results of this study the hypothesis was accepted. G2 participants were generally in alignment with the CAMBRA principles in their practices.

The G2 participants, however, differed from the expected trajectory with the belief that salivary function was extremely important when deciding on a preventive treatment plan. This may be attributed to the recent shift in caries research with a greater emphasis on biofilm and biofilm modulation.

Questions regarding the importance of recognizing disease indicators (the history of caries, the presence of current caries, extractions due to caries and the presence of white spot lesions) in determining a caries risk level were also asked. In all but one category, G2 found the presence of the following disease indicators to be of greater importance when determining caries risk level: the presence of existing decay and the history of caries within the last 3 years was very important. Other factors that a majority of the participants deemed extremely important or very important in determining a preventive treatment plan were socio economic background (very important); presence of dental appliances (very important); age (extremely important); understanding the caries process (very important); and patient/guardian's commitment to follow up (very important). In the latter case, G1 found the presence of these factors of greater importance when determining a caries risk level than those in G2. These results demonstrated slightly greater, but statistically insignificant, knowledge in G1 with regards to the available evidence on the risk indicators and risk predictors of dental caries.[10-12]

When looking at the impact of socioeconomic factors on the caries experience, a systematic review found that among the children with dental caries, 35.9% were of low socioeconomic status (SES), 35.34% were of middle SES and 24.51% were of high SES. Children of low SES had 52.00% higher chance of acquiring dental caries while the high SES children had a 3% higher chance of acquiring dental caries.[13] A more recent study evaluated data that was extracted from the Bigmouth Dental Data Repository and found that the odds of being in the high-risk group were higher for people 49-64 years of age, people with co-morbidities, people with a Social Deprivation Index score above the 75th percentile as well as people with Black and Hispanic ethnicities.[14]

The results exhibit a statistically significant increase in the beliefs and use of CAMBRA philosophies and implicate a shift from the "drill and fill" mindset to a more evidence-based non-restorative management of caries, in those who graduated after the implementation of the CAMBRA CE. However, although this research leads us to believe that alumni beliefs of CAMBRA are shifting, there is still the need for more emphasis on the implementation of this science. Perhaps, more proactive methods of encouraging the implementation of CAMBRA principles such as using dental quality measures within electronic health records or with the use of artificial intelligence via clinical decision support tools should be put in place. A systematic review demonstrated that by implementing quality measures that focused on preventive or oral health services, practitioners can be prompted to prescribe caries prevention plans to at risk patients. The use of clinical decision support tools has the potential to improve caries diagnosis and management, based off of results extrapolated from a study on pediatric dental trauma. Medical students with limited knowledge on pediatric dental trauma reported significant improvement in the diagnosis and management of pediatric dental trauma after use of clinical decision support tools.[15-18]

Limitations

A limitation of this study is the assessment of a single caries assessment tool (CAMBRA). The study findings were also dependent on self-reported data, which may be subject to social desirability bias.

CONCLUSION

Within the limitations of the study, it was concluded that here was significantly higher implementation of the CAMBRA philosophy in the participants who graduated after the introduction of the CAMBRA CE in this school's curriculum with more practitioners including non-operative management of caries in their practice. There is however a need for more emphasis on this philosophy to increase implementation post-graduation.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Tufts University Health Sciences Institutional Ethics Review Board (Date: 30.01.2020, Decision No: STUDY00000226).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Review

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Preventive and remineralization agents in pediatric dentistry: review of the literature

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ABSTRACT

Tooth decay, which is most common in childhood, especially in the 2-5 age group, is a health problem that should be addressed as a priority. It has been reported that the application of remineralizing agents to early stage caries reduces early material loss and stops the progression of caries. In studies conducted from the past to the present, various caries preventive agents have been investigated and utilized within the scope of preventive dentistry for the early diagnosis of caries and prevention of carious lesions.

Keywords: Pediatric dentistry, primary teeth, remineralization agents

INTRODUCTION

The aim of modern and preventive dentistry is to protect oral and dental health and to take protective measures for this purpose. It includes; diet control, oral hygiene education, chemical and mechanical plaque removal, professional fluoride applications, fissure sealants and protective resin restorations. It has been reported that the application of remineralizing agents to caries at the initial stage reduces early material loss and stops the progression of caries especially decidious teeth.[1] From past to present, fluoride has been accepted as the gold standard in the treatment of enamel caries. In addition to fluoride, nanotechnological products for remineralization have also been the subject of research. For this purpose, agents such as nanohydroxyapatite (nHA), bioactive glass (calcium sodium phosphosilicate, NovaMin®), tricalcium phosphate (TCP) containing toothpastes and casein phosphopeptide amorphous calcium phosphate (CPP-ACP) have been developed. In addition, it has been reported in many studies in the literature that herbal-derived agents may also have remineralization effects. These agents have been reported as chitosan, licorice, galla chinensis, theobromine, propolis, grape seed extract, rosemary, and ginger.[2]

Many anti-caries agents have been researched and started to be used in order to prevent demineralization and ensure remineralization in pediatric dentistry. In this study, remineralization agents supported by remineralization studies especially in primary teeth are presented.

MINERAL AND ION TECHNOLOGIES

Fluoride Ion

Fluoride, recognized as the gold standard for preventing dental caries, continues to be widely accepted due to its antibacterial effects, inhibition of acid production by plaque bacteria, prevention of plaque formation, promotion of the formation of fluorohydroxyapatite from hydroxyapatite in tooth structure, and acceleration of calcium and phosphate deposition on tooth surfaces.[3-5] Systemic or topical application of fluoride has been reported to be more effective and safer in topical applications.[3,4]

Fluoride can be used alone as a caries preventive agent or in combination with other agents. In a study by Nalbantgil et al.[6], applying sodium fluoride (NaF)-containing fluoride varnish around orthodontic brackets, it was reported that fluoride varnish was more effective in remineralizing demineralized surfaces of teeth. Chu et al.[7] evaluated the effects of applying NaF and silver diamine fluoride (SDF) gels regularly to children aged 5-7 years with initial enamel caries for 12 months. The study reported that NaF and SDF gels prevented demineralization and promoted remineralization. In a study by Calvo et al.[8], it was reported that the application of 1.23% acidulated phosphate fluoride (APF) gel to demineralized tooth surfaces was an effective method for remineralization.

In addition to fluoride gels and varnishes, restorative materials containing fluoride have also been found to be highly effective in promoting remineralization. Alsaffar et al.[9] compared fissure sealants with and without fluoride in their studies and reported that fluoride-containing fissure sealants were more successful in preventing demineralization. In studies evaluating fluoride-releasing glass ionomers on demineralized lesions, Rodrigues et al.[10] reported that restorative materials with high fluoride release had higher remineralization efficacy.

When the results of studies in the literature are evaluated, it is widely accepted that fluoride and fluoride compounds are the

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most preferred materials in preventive dentistry applications due to their high remineralization efficacy, antibacterial properties, and easy accessibility. On the other hand, research on alternative remineralization agents continues due to the toxic effects of using fluoride at high concentrations in early childhood.[2]

Silver Ion

Silver ions, in the form of silver nitrate, have been employed in dentistry for desensitization of milk and permanent teeth, cavity disinfection, and caries prevention. It has been reported that silver ions facilitate the remineralization of demineralized tooth tissue even at low salivary pH values.[10-12] Studies have led to the development of silver diamine fluoride (SDF) due to the synergistic effect of silver with fluoride. SDF is used in different concentrations (10-12-30-38), with the 38% concentration being the most preferred in pediatric dentistry. SDF is utilized to prevent the formation and progression of caries, especially in young children with limited cooperation. Its main advantages include being non-invasive, cost-effective, easy and quick to apply, while disadvantages include causing black discoloration on the applied tooth surface and not being well-liked by pediatric patients.[13,14] Mei et al.[15] reported that a 38% SDF solution exhibited bactericidal effects on cariogenic bacteria, prevented demineralization, and reduced mineral loss from tooth surfaces.

SUGAR ALCOHOLS

Xylitol

Xylitol, a five-carbon sugar alcohol derived from cellulose, has been included in the composition of various products such as toothpaste, mouthwash, gum, medications, and gels. Xylitol cannot be fermented by cariogenic bacteria, reducing the adhesion of these bacteria to the tooth surface and lowering extracellular polysaccharide levels. Xylitol's antibacterial effect and its role in reducing *S. mutans* levels have been established. It has been reported that xylitol effectively buffers the decrease in plaque pH by increasing saliva flow rate. The increased levels of calcium and phosphate in stimulated saliva limit demineralization and enhance remineralization.[16] In an in vitro study, Siqueira et al.[17] found that a varnish containing xylitol had a significantly higher remineralization capacity compared to non-xylitol varnishes.[18]

Sorbitol

Sorbitol is referred to as a non-cariogenic sugar because it is fermented more slowly by cariogenic bacteria compared to sugars like glucose, sucrose, and fructose. Therefore, it causes less reduction in plaque pH. The caries-preventive effect of sorbitol has not been found to be as successful as xylitol when compared.[19]

Isomalt

Isomalt is commonly found in the content of sugar-free candies and gums. Like xylitol, it cannot be fermented by cariogenic bacteria, making it antimicrobial and non-cariogenic. It has the ability to bind calcium, thereby enhancing remineralization. Although isomalt's effect on caries is reported to be less successful than xylitol, it has been suggested that it may be more effective when used in combination with fluoride.[20,21]

PLANT-DERIVED AGENTS

Chitosan

Chitin is an amino polysaccharide found in the cell walls of insects, the shells of fungi, and the exoskeletons of crustaceans. Chitosan, obtained by the deacetylation of chitin, is biocompatible and has been used in medicine since the 1960s in wound dressings, surgical sutures, and bandages. It later found applications in wound treatment, cholesterol medications, and contact lenses. Chitosan is preferred in dentistry due to its antifungal and antibacterial effects. It has been reported to elevate plaque pH by buffering the effects of acids produced by cariogenic bacteria, thus supporting remineralization.[22] In a study by Hayashi et al.[23], individuals chewing gum containing chitosan reported a significant decrease in *S. mutans* counts in their saliva. In an in-vitro study examining the penetration of chitosan into enamel and its inhibition against demineralization, Arnaud et al.[24] reported that chitosan intervened in the demineralization process by inhibiting phosphorus release, resulting in higher microhardness values for teeth treated with chitosan.

Licorice Root

The medicinal use of *Glycyrrhiza glabra*, or licorice root, dates back to ancient times. It possesses anti-inflammatory, antiviral, antiallergic, and antioxidant effects. In dentistry, it is preferred in pediatric toothpaste formulations.[25,26] The presence of glycyrrhizic acid in licorice root has been found to inhibit the glucosyltransferase activity of *S. mutans*, preventing the synthesis of glucans in the biofilm. Due to this effect, it has been reported to have both caries-preventive and remineralization-promoting properties.[27,28]

Galla Chinensis

Galla chinensis (G. chinensis) is an extract derived from a traditional Chinese plant. Its use as a caries preventive agent is under investigation. Chu et al.[29] reported that this plant prevented demineralization and enhanced remineralization. In a study examining the mechanism of action of *G. Chinensis*, Zhang et al.[30] stated that it slowed down demineralization on the outermost layer of carious lesions, allowing ion penetration towards the lesion body.In in-vitro studies, Huang et al.[31] reported that using *G. chinensis* in combination with nanohydroxyapatite significantly increased the remineralization of initial enamel lesions. In comparative studies by Abdel-Azem et al.[32], it was reported that NaF and *G. chinensis* yielded similar results in terms of remineralization efficacy.

Theobromine

Theobromine, an alkaloid from the methylxanthine family, is found in high amounts in cocoa beans. While belonging to the same xanthine family as caffeine, their effects on teeth are different. It has been reported that caffeine increases the solubility of dental hard tissues, whereas theobromine reduces solubility. In an in-vitro study, Amaechi et al.[33] reported that theobromine increased the remineralization potential of teeth comparably to fluoride. Sulistianingsih et al.[34] reported that theobromine increased the microhardness of teeth with initial enamel caries and could be used for remineralization purposes.

Propolis

Propolis is a mixture containing resin produced by honey bees (*Apis mellifera*) from plant exudates to fill gaps in their hives. The active components of propolis, flavonoids, have antioxidant, antibacterial, antiviral, antifungal, and anti-inflammatory properties. It is effective against both Gram-positive and Gram-negative bacteria, particularly exhibiting strong efficacy against *Staphylococcus aureus* and *Salmonella*. The effectiveness of propolis in inhibiting the glucosyltransferase enzyme activity of *S. mutans* and *Streptococcus sobrinus*, both in vivo and in vitro, has been supported by studies. Additionally, propolis has been reported to have antibacterial activity against some anaerobic oral pathogens.[35-37] Zaleh et al.[38] reported that propolis significantly increased the microhardness of enamel lesions in initial enamel caries, and some studies on propolis's remineralization effect have yielded similar positive results.[39]

Grape Seed Extract (Polyphenols)

Polyphenols possess antioxidant, antitumoral, anti-inflammatory, and antibacterial effects. Proanthocyanidins, with high antioxidant capacity, are present in grape seed extract. One of the essential properties of proanthocyanidin is its ability to strengthen tissues containing collagen by increasing cross-linking of collagen. Some studies have reported that proanthocyanidin indirectly promotes hydroxyapatite growth by increasing exogenous collagen cross-links and inhibiting the glucosyltransferase enzymes of *S. mutans*, preventing caries.[40,41] In a study by Benjamin et al.[42], grape seed extract was reported to be significantly effective in remineralization. Mirkarimi et al.[43] noted in an in-vitro study on primary teeth that grape seed extract significantly increased the microhardness of teeth with initial enamel caries. A study by Nagi et al.[44] found grape seed extract to be effective in remineralization, consistent with the findings of other studies.

Rosemary

Rosemary (*Rosmarinus officinalis Lamiaceae*) is known for its antioxidant, anticarcinogenic, anti-inflammatory, antifungal, and antibacterial properties. The polyphenols it contains, such as carnosic acid and rosmarinic acid, provide these characteristics. It has been reported to have an inhibitory effect on Gram-positive bacteria such as *S. mutans*.[45,46] In a study by Al-Duboni et al.[47], the effectiveness of rosemary extract in the remineralization of initial enamel caries was examined. The results of fluorescence and microhardness evaluations indicated the effectiveness of rosemary in remineralization. Bilgin et al.[48], in their studies examining the remineralization capacities of various plant products, reported that a mixture of ginger-honey-rosemary increased the microhardness of initial enamel caries and was effective in remineralization. In an in-vitro study by Hossam[49], the remineralization capacity of fluoride, ginger, and rosemary was investigated, with rosemary being found to have remineralization capacity similar to fluoride.

Ginger

Ginger (*Zingiber officinale* Roscoe, *Zingiberacae*) is a plant that has been used since ancient times worldwide. It is known for its anti-inflammatory, antibacterial, and non-toxic properties and has been approved for safety by the US Food and Drug Administration (FDA). It finds applications in various medical fields, including gastrointestinal diseases, cardiovascular diseases, joint diseases, cancer, and symptomatic relief (sore throat, nausea) in some viral diseases. Gingerol, found in ginger, imparts antibacterial properties by causing the dissolution of bacterial cell membranes. Polyphenols in ginger, such as beta-carotene, ascorbic acid, flavonoids, and flavonols, provide antioxidant properties. Especially flavonoids and their derivatives, being lipophilic, disrupt bacterial cell membranes, exhibiting antibacterial effects. Inhibition efficacy against both Gram-positive and Gram-negative bacteria has been observed. Ginger has also been reported to inhibit the growth of respiratory pathogens such as Haemophilus influenza, *Staphylococcus aureus, Streptococcus pyogenes*, and *Streptococcus pneumoniae*.[50-52] Ginger has demonstrated inhibitory effects on oral flora, including *S. mutans, Porphyromonas gingivalis, Prevotella intermedia*, and *Porphyromonas endodontalis*.[50,53] In an in-vitro study conducted by Hassan et al.[54], the remineralization capacities of ginger, rosemary, and fluoride varnishes were examined, and all three materials were reported to be usable for remineralization, with the ginger group showing the highest remineralization efficacy. In another in-vitro study by Hossam[49], the remineralization activities of ginger, rosemary, and fluoride varnishes were investigated for initial enamel caries, and the ginger group exhibited the highest remineralization efficacy.

BIOACTIVE MATERIALS AND NANOTECHNOLOGICAL PRODUCTS

Bioactive Glass (Calcium Sodium Phosphosilicate, NovaMin®)

Bioactive glasses were first used in medical applications for bone regeneration in the 1960s. In dentistry, they are employed for vital pulp treatments, remineralization, and other purposes. Bioactive glasses consist of amorphous silicate compounds and are biocompatible. They can form a chemical bond with vital tissues. In the oral environment, they release calcium, sodium, and phosphate, reacting with oral fluids to create hydroxycarbonate apatite (HCA) and promoting remineralization. NovaMin® is a well-known brand associated with bioactive glass. Combining NovaMin® with fluoride in toothpaste has been found to prevent demineralization and enhance remineralization.[55,56] Bioactive glasses alter the plaqe pH by releasing ions at high concentrations, exhibiting antibacterial effects through this mechanism.[57] In an in-vitro study by Prabhakar and Arali[58], the remineralization efficacy of sodium fluoride and bioactive glass on initial enamel caries was compared, and it was suggested that bioactive glasses could be an alternative to fluoride-containing products.

Nanohydroxyapatite

Hydroxyapatite is a compound with the molecular formula $Ca_{10}(PO_4)_6(OH)_2$ and a calcium-phosphorus ratio of 1/67. Various forms of calcium phosphate exist in nature, with hydroxyapatite being the most stable and least soluble among them. The similarity of synthetic hydroxyapatite crystals to the hydroxyapatite structure in hard tissues such as bones and teeth has led to its widespread use in medical fields. These materials are bioactive and have proven successful in bone

regeneration. Synthetic hydroxyapatites fall within the class of biocompatible materials due to their close resemblance to hydroxyapatite structures in dental tissues.[59,60]

The synthesis of nanohydroxyapatites (nHA) can be achieved through various methods. As the method changes, the sizes of the synthesized nHA crystals also vary. nHA, with a Ca/P ratio of 1/67 using the sol-gel technique, is produced to be closest to the natural enamel structure and is most suitable for dental use. It has found applications in dental surgery, implantology, addressing dentin sensitivity, and remineralization. The morphological similarities of these nano-particles to dental hydroxyapatite contribute to their effectiveness in remineralization. An increase in the percentage and amount of nHA in the material used for remineralization enhances the precipitation of Ca_2+ ve PO_4^{3-} ions, leading to increased remineralization effectiveness.[61,62]

The exact working mechanism of nHA-containing products in remineralization is not fully determined. Some researchers report that remineralization occurs due to nHA deposition in the porous structures of the enamel[63,64], while others suggest that nHA acts as a depot, releasing calcium ions into the environment when needed.[65,66] In an in-vitro study conducted by Tschoppe et al.[67], toothpaste containing nHA showed higher remineralization compared to amine fluoride-containing toothpaste, as indicated by micro-radiography values. Swarup and Rao[68] compared the remineralization efficacy of 2% NaF with nHA agents in their in-vitro studies, reporting more significant mineral increase and formation of a surface morphology close to biological enamel in the nHA group.

Tricalcium Phosphate

Tricalcium phosphate (TCP) interacts with oral fluids, releasing ions due to its calcium and phosphate content. The ions released by TCP raise the pH of the environment and actively participate in the remineralization mechanism.[69] Various forms of TCP, including beta and functional TCP forms, have been combined with fluoride and incorporated into toothpaste formulations (e.g., 3M ESPE, Clinpro™ Tooth Crème). The combination of TCP with fluoride is reported to have a synergistic effect on remineralization.[70] Studies by Thimmaiah et al.[71] indicated that the combined form of TCP with fluoride increased the Ca/P mass percentage after demineralization. Hamba et al.[72] compared the remineralization efficacy of fluoride and non-fluoride TCP, reporting higher remineralization in the fluoride TCP group, suggesting independent mechanisms for fluoride and TCP in remineralization.

Casein Phosphopeptide Amorphous Calcium Phosphate (CPP-ACP)

Milk and dairy products have anticariogenic properties, but consuming large amounts is necessary for them to exhibit this effect naturally. Research has focused on isolating protective factors from milk to incorporate them into oral care products. Casein phosphopeptide (CPP), obtained through selective precipitation, is a phosphoprotein with a serine-serine-glutamate-glutamate amino acid sequence. This structure allows CPP to stabilize calcium and phosphate ions at high concentrations independently of pH (both acidic and basic pH). CPP-ACP-containing agents have been found to act as reservoirs for calcium and phosphate, promoting hydroxyapatite formation and remineralization even in conditions with decreased pH.[73,74]

Recaldent™ technology, marketed as MI Paste® in the United States and Japan and Tooth Mousse™ in Europe and Australia, contains 10% CPP-ACP.[75] In an in-vitro study by Iijima et al.[76], CPP-ACP-containing sugar-free gum showed superior remineralization compared to an equivalent gum without CPP-ACP. Morgan et al.[77] found that sugar-free gum containing CPP-ACP significantly slowed demineralization and increased remineralization compared to the control group.

Casein Phosphopeptide Amorphous Calcium Fluoride Phosphate (CPP-ACFP)

When combined with fluoride, CPP-ACFP exhibits a synergistic effect in both preventing cavity formation and promoting remineralization. CPP facilitates the prevention of decay and remineralization by depositing its calcium and phosphate ions on the tooth surface in the presence of demineralization. Fluoride, on the other hand, acts by forming fluoroapatite with fluoride ions in the teeth and dental plaque, contributing to decay prevention and remineralization. The significant advantage of CPP-ACFP is the presence of calcium, phosphate, and fluoride together in its composition.[78] In a study by Thimmaiah et al.[71], remineralization efficacy was compared for fluoride, TCP, nHA, and CPP-ACFP, with the best EDX values observed in TCP and CPP-ACFP agents. Yazıcıoğlu et al.[79] reported that applying CPP-ACFP for 4 minutes daily over 4 weeks significantly remineralized initial caries lesions. Imani et al.[80] stated that both CPP-ACP and CPP-ACFP could reduce caries prevalence and enhance remineralization during and after orthodontic treatment. Jayarajan et al.[81] compared the remineralization efficacy of artificial saliva, CPP-ACP, and CPP-ACFP in in-vitro studies, reporting significant remineralization in all three groups, with the highest values in the CPP-ACFP group.

Self-assembling Peptides

Self-assembling peptides can form a scaffold structure that allows ion accumulation on hard tissues, facilitating mineral accumulation and exhibiting a remineralization effect.[82] Kind et al.[83] demonstrated in their studies that the application of self-assembling peptide (P11-4) could support enamel mineralization, facilitating sub-surface remineralization of enamel lesions. Takahashi et al.[84] reported the effectiveness of self-assembling peptides in remineralization in their studies.

CONCLUSION

Today, many agents are used for remineralization purposes. Among these agents, fluoride is still considered the gold standard. Although claims that high-dose fluoride use in children may cause cognitive problems are not confirmed in the literature, they are met with concern by parents. For this reason, other remineralization agents are the subject of research as alternatives to flora.

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Referee Evaluation Process

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Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Review

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Dental caries and demineralization in head and neck cancer patients undergoing radiotherapy

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ABSTRACT

The number of head and neck cancer patients is steadily increasing, and the use of radiotherapy for treatment in this patient group has been associated with side effects such as mucositis, trismus, xerostomia, dental caries, periodontal disease, and osteoradionecrosis. Radiation caries can be atypical, and their treatment can be challenging. Preventing and treating RC become crucial as post-radiotherapy tooth extraction can pave the way for osteoradionecrosis. The aim of this review is to evaluate the restorative dental treatment for head and neck cancer patients before, during, and after radiotherapy. This includes examining the impact of radiotherapy on tooth decay and demineralization, and providing solutions to address these effects.

Keywords: Radiation caries, head and neck cancers, osteoradionecrosis, oral hygiene, saliva

INTRODUCTION

Head and neck cancers (HNC) encompass a broad term that includes epithelial malignancies affecting the oral cavity, nasal cavity, paranasal sinuses, salivary glands, pharynx, and larynx localized in the head and neck region.[1,2] These epithelial malignancies are predominantly identified as head and neck squamous cell carcinomas. Tobacco and alcohol consumption have been identified as the most significant risk factors.[2,3] HNC are reported to represent 6% of all malignancies.[4] Globally, it is estimated that over 550,000 individuals are diagnosed with HNC each year.[5,6] In 2020, it was reported as the sixth most common cancer worldwide, with over 870,000 new cases and 440,000 deaths.[7]

Treatment options for HNC patients involve surgical, radiotherapeutic, chemotherapeutic, or combined approaches, considering the condition of malignant tumors at the time of diagnosis, whether they are local, regional, or advanced.[8-10] Although surgical treatment is generally considered the primary choice, the selection depends on factors such as the location, size, and depth of infiltration of the cancer.[11] The most commonly used method is a combination of radiotherapy and surgery; however, for malignancies that cannot be removed surgically, simultaneous chemoradiotherapy has become a standard treatment, demonstrating higher survival rates compared to either radiotherapy or chemotherapy alone.[1,12]

Unfortunately, radiotherapy not only affects cancer cells but also damages normal cells in the irradiated area.[10,13] Side effects such as mucositis, trismus, SGD, dental caries, periodontal disease, and ORN are commonly documented outcomes of radiotherapy in HNC patients.[14-19]

To ensure individuals diagnosed with HNC receive the most effective treatment, a multidisciplinary approach is adopted. Scientific studies highlight the importance of consulting the restorative dental treatment clinic for HNC patients undergoing treatment to identify and address dental problems that may interrupt or jeopardize HNC treatment and maximize oral rehabilitation opportunities, thereby improving the quality of life during cancer treatment.[20]

Radiation caries (RC) are atypical and can be challenging to treat. Preventing and treating RC become crucial as post-radiotherapy tooth extraction can pave the way for ORN. Our aim in this review is to evaluate HNC patients undergoing radiotherapy before, during, and after treatment from the perspective of restorative dental treatment. We seek to provide solutions by examining the direct and indirect effects of radiotherapy on tooth decay and demineralization.

PRINCIPLE OF RADIOTHERAPY

Radiation is a physical agent used to destroy cancer cells, known as ionizing radiation, as it generates ions upon interaction and deposits energy in the cells of the traversed tissues. This accumulated energy can kill cancer cells or induce a series of genetic changes leading to their demise. High-energy radiation damages the genetic material (deoxyribonucleic acid, DNA) of cells.

Radiation can cause this damage in two ways:[21]

1. Direct effect of radiation: Radiation can directly interact with cellular DNA, causing damage.

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2. Indirect effects of radiation: Indirect DNA damage caused by free radicals resulting from the ionization or excitation of cellular water components.

Fractionated radiation treatment is based on the differing radiobiological characteristics of cancer and normal tissues. These regimens are applied to advantageously enhance the survival rate of healthy cells compared to cancer cells. While aiming to maximize the destruction of tumor cells, radiotherapy also seeks to minimize damage to normal cells.[10,13] After radiation application, healthy cells can often repair themselves and maintain normal activity levels more rapidly than cancer cells. However, differentiated cancer cells are not as effective in repairing radiation-induced damage as normal cells, making radiotherapy more effective in causing the death of cancer cells.[21]

Radiation therapy does not immediately kill cancer cells. Cancer cells begin to die hours, days, or weeks after the start of treatment, and the process of cancer cell death can continue for weeks or months after the completion of radiotherapy.[22]

ORAL SIDE EFFECTS OF RADIOTHERAPY

Typically, radiation for the treatment of HNCs is administered in fractions, with a total dose ranging between 50 and 70 Gray (Gy) over a period of 4-7 weeks. Despite advancements in radiation techniques, high doses of radiation can lead to various undesirable reactions in large areas, including the oral cavity, maxilla, mandible, and salivary glands. Common complications of radiotherapy include mucositis, candidiasis, taste alterations, RC, ORN, soft tissue necrosis, and xerostomia.[10]

SALIVARY GLAND DYSFUNCTION

Salivary glands produce and channel saliva, a secretion called "saliva", into the oral cavity mucosa and surrounding areas. Salivary gland dysfunction (SGD) is defined as "any alteration in the qualitative (qualitative) and quantitative (quantitative) structure of saliva due to hypersalivation (increase) or hyposalivation (decrease) resulting from salivary gland secretion".[23-25] In HNC treatment, SGD is commonly observed as a side effect.[26] In HNC patients, SGD manifests as xerostomia (dry mouth) and hyposalivation (low saliva flow).[24]

Saliva, a complex and dynamic biological fluid, consists of approximately 99.5% water, 0.3% protein, and 0.2% inorganic matter. Inorganic elements in saliva include sodium, chloride, calcium, potassium, bicarbonate, phosphate, fluoride, iodine, and magnesium. The majority of proteins in saliva are glycoproteins, including mucoproteins, immunoglobulins, lactoferrin, peroxidases, and agglutinins, contributing to the structure of saliva. Mucoproteins provide lubrication, while other glycoproteins have antimicrobial properties. Proteins rich in statherin and proline contribute to calcium balance in saliva, while defensins play a role in the natural immune response. Sialins are protease inhibitor proteins with antimicrobial and immunomodulatory properties.[27-29]

Saliva composition, both qualitatively and quantitatively, is affected by the pathophysiological conditions of the body. Thus, changes in saliva reflect not only alterations in the oral cavity but also systemic changes occurring throughout the body.[30]

In cancer patients, hyposalivation and xerostomia can lead to functional problems such as eating, speaking, and swallowing, increase the risk of dental caries and oral candidiasis, contribute to the emergence of psychological issues, and worsen existing problems.[31] Causes of hyposalivation and xerostomia in cancer patients may include chemotherapy, radiotherapy applied to the head and neck region, and dehydration.[32]

Studies conducted among HNC patients have reported irreversible damage to salivary glands in approximately 63% to 93% of cases when radiation is applied to the gland's location.[33] Saliva serves various functions, including oral cavity and tooth protection as a natural defense system with its antimicrobial activity.[34-35] In cases of xerostomia and hyposalivation, affecting these functions may lead to complications.[36]

While the enamel surface continually reshapes through demineralization and remineralization processes, if demineralization becomes dominant in this dynamic process, mineral loss can occur, leading to cavitation through the breakdown of matrix components.[37-38] The remineralization process relies on two main substrates found in saliva, calcium, and phosphate. Changes in saliva flow and content in HNC patients can disrupt the remineralization process and promote demineralization, as an adequate supply of calcium and phosphate is crucial for remineralization.[23,38-39]

Additionally, a study by Valstar et al.[40], published in September 2020, demonstrated the presence of bilateral seromucous-secreting glands located on the posterolateral nasopharyngeal wall. These glands, named tubarial glands, are positioned above the Torus tubarius and have been proposed as a new organ. Since the macroscopic glandular structure in the posterior pars nasalis pharyngis was previously unknown, it has not been included in the structures to be protected during radiotherapy. Based on these findings, researchers suggested that the detection of previously unnoticed salivary glands residing in the posterior pars nasalis pharyngis could help avoid side effects of radiotherapy in patients.[41]

CHANGES IN ORAL MICROBIOME

The microbiome is an ecological community composed of symbiotic, commensal, and pathogenic microorganisms, including all genes and genomes, along with their metabolites and protein products. In other words, it is a system that encompasses the microbiota and its metabolic and protein products.[42,43] The oral microbial flora includes viruses, protozoa, archaea, fungi, bacteria, and is considered one of the most complex bacterial populations associated with the human body after the intestines.[44-45] Understanding the relationship between the microbiome and the oral environment is crucial to comprehend the cause of diseases developing in the oral cavity. There are two regions in the oral cavity where bacteria can reside: the hard surfaces of teeth and the soft tissues that make up the oral mucosa.[46]

A decrease in saliva flow can alter the ecological environment, leading to an increase in bacterial sequences associated with tooth decay. In patients exposed to severe radiation, an increase in cariogenic oral bacteria of the streptococcus and lactobacillus types associated with tooth decay has been observed.[47] In patients with HNC, the transition to cariogenic microorganisms has been clearly documented

during and after radiotherapy. These bacteria have effects that increase the risk of tooth decay through acid production.[48] Additionally, candida infection can be observed in 17-29% of patients exposed to radiotherapy. The increased risk of oral candidiasis may be attributed to the decrease in saliva flow as a result of radiotherapy.[10]

Radiation Caries and Demineralization

The oral cavity is highly sensitive to the negative effects of radiation. This sensitivity may be attributed to the rapid renewal rate of cells in the oral mucosa, a complex oral microbiota, and constant trauma to tissues even during normal function. One of the problems arising in the oral cavity due to radiotherapy is radiation-induced caries. Radiotherapy is a significant risk factor for the rapid development of rampant caries, known as RC.[13]

RC is one of the chronic oral complications of radiotherapy with a multifactorial etiology.[48,50] Studies have shown that approximately 29% of HNC patients experience tooth decay after radiotherapy. Furthermore, the probability of developing tooth decay within two years after radiotherapy in the head and neck region is reported to be approximately 37%.[51] Unfortunately, the risk of tooth decay continues persistently after radiotherapy.[52] RC negatively impacts the quality of life of patients, leading to reduced chewing efficiency, pain, chronic oral infections, increased risk of ORN, and adverse effects on diet, speech, and aesthetics.[53] Clinically, radiation-induced tooth decay typically starts with superficial enamel demineralization and progresses to lesions that turn brown or black over time. As demineralization advances, enamel dissolves, exposing the dentin underneath, which becomes highly susceptible to the cariogenic oral environment.[54]

The clinical features of RC differ from those of bacterial caries and are commonly found in the lingual surfaces of mandibular anterior teeth, tubercle peaks, incisal parts of incisors, and most frequently in the cervical portions of teeth, where traditional dental caries are rarely encountered.[50] RC, progressing rapidly from the cervical part of the tooth, can lead to a decrease in the support of the dental crown, its fracture and loss, leaving an infection-prone dental root behind in the oral cavity.[50,55]

Three different types have been defined in the progression process of carious lesions clinically.[13]

- **Type 1:** The most common lesion type that affects the cervical surfaces of teeth. The development of circumferential caries extending up to the cement-enamel junction occurs, and crown fracture is common in this type.
- **Type 2:** Demineralization occurs on all surfaces of the teeth. Widespread erosion is observed along with wear on incisal and occlusal surfaces.
- **Type 3:** A condition with changes in dentin color. Dark brown or black lesions occur in the crown with incisal or occlusal wear.

The treatment of RC should include appropriate treatment, oral prophylaxis, and restorative procedures. Tooth extractions should be avoided to prevent the risk of ORN after radiotherapy.

Osteoradionecrosis

ORN is a serious pathological condition that occurs as a side effect of radiotherapy, where non-healing exposed necrotic bone persists in the jaw for at least three months, leading to an opening in the oral cavity or skin.[56] Situations that increase the risk of ORN in patients who have undergone radiotherapy include:[20]

- When the total radiation dose exceeds 60 Gy
- When the patient's immune system is compromised
- In case of inadequate nutrition
- Poor oral hygiene
- Local trauma caused by tooth extraction or inappropriate prosthesis
- Tumor proximity to bone
- Periodontal diseases
- Presence of a tumor in the posterior mandible due to compact and dense bone structure

A strong relationship has been shown between tooth extraction after radiotherapy and the development of ORN.[57] The incidence of ORN due to tooth extraction and infection resulting from periodontal disease is three times higher in patients who have undergone radiotherapy compared to edentulous patients. Therefore, it is recommended to extract decayed and periodontally compromised teeth before radiotherapy.[56]

Conditions requiring tooth extraction include:[20,58]

- Teeth with extensive periapical lesions
- Unrestorable deep and extensive caries
- Moderate to advanced periodontal disease, especially with advanced bone loss and mobile or furcation-involved teeth
- Roots
- Impacted third molars and unerupted teeth associated with the oral environment

Teeth with a poor prognosis should be extracted at least two to three weeks before radiotherapy.[57]

PREVENTING THE ORAL SIDE EFFECTS OF RADIOTHERAPY

Before Radiotherapy

The purpose of evaluating patients by a dentist before starting radiotherapy for HNC treatment is to enhance the quality of life, preserve necessary teeth for function, aesthetics, and speech during treatment, and prevent the occurrence of ORN due to tooth extraction after radiotherapy.[20] ORN, characterized by exposed and necrotic bone, has been reported to be predisposed by untreated dental caries before, during, and after radiotherapy.[53] Considering this, eliminating dental pathologies and providing patients with oral hygiene education to maintain these practices become crucial.

Surgical treatment of advanced lesions can result in aesthetic, functional, and psychological outcomes. Depending on the

type and location of the lesion, maxillary cancer surgery often includes the hard palate, maxillary sinus, and nasal cavity.[59] After surgical procedures, some patients may need to use maxillofacial prostheses. The main objectives of using maxillofacial prostheses are to restore oral functions and enhance facial aesthetics and the patient's quality of life. To minimize the risk of dental and periodontal problems due to difficulty in maintaining oral hygiene, good hygiene education is essential.[59]

Patients should pay attention to the following for maintaining oral hygiene:[60]

- Use a soft-bristled toothbrush with an atraumatic brushing technique.
- Use fluoride-containing toothpaste.
- Rinse with alcohol-free 0.12% chlorhexidine mouthwash.
- Use dental floss or interdental brushes for interproximal cleaning.
- Apply fluoride gel for 5 minutes daily using patient-specific appliances (twice daily during radiotherapy).
- Clean the tongue with a soft toothbrush or gauze.
- Perform saltwater gargles.

Radiotherapy and chemotherapy can make soft tissues highly sensitive to trauma, so irregularities in restorations and sharp areas of teeth should be smoothed out, and adaptations should be made to prevent trauma if patients have prostheses in their mouths.[20,57-58]

During Radiotherapy

The goal of oral treatment during radiotherapy is to prevent secondary infection associated with severe mucositis, control pain, and support the patient's nutrition. Changes in the diet of HNC patients during BBK treatment can increase the risk of tooth decay. Due to the risk of weight loss during cancer treatment, patients are often advised to consume frequent small meals with high-calorie foods. Increased meal frequency can complicate brushing between meals, and patients may be compelled to use liquid supplements containing refined carbohydrates that adhere easily to tooth surfaces and promote decay.

Pain arising from mucositis can make it challenging to mechanically remove plaque.[61] While maintaining oral hygiene does not prevent the onset of mucositis, it can reduce the risk of oral infections. If using a toothbrush is painful due to the presence of mucositis, mouth rinsing can be a good alternative. The use of 0.2% chlorhexidine gluconate is recommended three to four times a day. Differentiating between mucositis caused by fungi and that resulting from radiotherapy is crucial, with candidiasis being one of the most common oral infections during radiotherapy.[63]

After Radiotherapy

After completing cancer treatment, restorative dental treatment can be performed normally. Effective restoration of tooth decay should be done to prevent the progression of lesions and eliminate the need for extraction, reducing the risk of ORN development.[64] Access to RC can be extremely challenging due to trismus and surgical defects, and the restoration can be difficult due to the presence of decay in cervical and root lesions, providing minimal mechanical retention in the prepared cavity. Given these technical issues, the development of protective and therapeutic strategies is crucial for the early treatment of radiation-induced dental caries.[48]

The selected material for restoration should provide proper adhesion to the tooth, prevent secondary caries, and be resistant to acid erosion.[65] McComb and colleagues have stated that fluoride-releasing materials are effective in preventing secondary caries in patients who have undergone radiotherapy.[66] Glass ionomer cements, despite having shorter oral retention and a higher incidence of secondary caries compared to composites in the cervical area in a healthy population, have been found to be more effective in preventing secondary caries than composites in radiotherapy patients with a high risk of dry mouth.[67] In radiotherapy patients who do not routinely receive fluoride, glass ionomer cements may be a better option compared to other materials.[51] Composite materials and resin-modified glass ionomer cements can be considered as applied options over traditional glass ionomers (sandwich technique) due to their adhesive potentials and sealing capabilities.[62]

For patients with reduced mouth opening, post-treatment xerostomia, or those with a high intake of cariogenic diets, an increased risk of tooth decay should be considered, and a more intense fluoride regimen should be contemplated. High-concentration fluoride toothpaste can be prescribed with the recommendation for the patient not to rinse their mouth after brushing. Additionally, using a fluoride mouthwash at times other than toothbrushing may be advised.[68]

Application of tropical fluoride can increase resistance to tooth decay. Fluoride toothpaste has been shown to provide significant benefits in preventing and remineralizing root caries in patients who have undergone radiotherapy.[69] However, preventing tooth decay in HNC patients is not easy. In these patients, the effect of fluoride may be limited due to decreased calcium and phosphate in the oral cavity as a result of hyposalivation.[70] Since remineralization does not occur if there is not enough calcium and phosphate in saliva in relation to the tooth, cancer patients with SGD should be called for regular check-ups by dentists to reduce the risk of widespread caries, and the use of 1.1% sodium fluoride gel or fluoride toothpaste should be recommended.[23]

For preventing tooth decay in HNC patients, regular dental care, maintaining oral hygiene, applying sodium fluoride to teeth for 3-4 minutes daily using custom-made appliances (with instructions for the patient not to eat or rinse their mouth for the next half hour), and minimizing the intake of cariogenic and acidic foods are recommended.[31]

SALIVARY GLAND DYSFUNCTION AND ARTIFICIAL SALIVA

The use of artificial saliva should be considered to alleviate the negative effects caused by xerostomia. Substitutes for artificial saliva should closely resemble the composition of human saliva, exhibiting biophysical properties such as lubrication and mucoadhesive function, similar to natural saliva.[71] There are numerous commercially available substitutes for artificial saliva, with the essential characteristics of these products summarized in Figure.[72]

Sample	Main components	Instruction for daily use
Biotene® Oral Rinse	Hydroxyethyl-cellulose (HEC), xylitol and sorbitol.	With approximately 15 mL rinse for 30 seconds and then expel.
Biotene® Spray	Xanthan gum, glycerin and xylitol.	Administer as required.
Bioxtra Spray®	Hydroxyethyl-cellulose (HEC), lactoperoxidase, citric acid, xylitol and sorbitol.	Administer 3 or 4 times a day to the mouth cavity.
Xeros®	Hydroxyethyl-cellulose (HEC), sodium phosphate, xylitol and sorbitol.	With approximately 15 mL rinse for 30 seconds and then expel.
Glandosane®	Carboxymethyl-cellulose (CMC) and xylitol.	Administer 1 or 2 times a day to the mouth cavity.
GUM®	Xanthan gum, carrageenan and xylitol.	Administer as required.
Oralis®	Xanthan gum, benzoic acid lactoperoxidase, the dispenser. Rinse for 30-45 seconds and then expel.	Use the amount corresponding to lysozyme, lactoferrin and xylitol.
Saliva Natura®	Yerba Santa extract, citric acid, xylitol and sorbitol.	Administer as required.
Saliva Orthana®	Porcine gastric mucin (PGM) and xylitol.	Administer 3 or 4 times a day to the mouth cavity.
Saliveze®	Carboxymethyl-cellulose (CMC) and potassium phosphate.	Administer 2 or 3 times a day to the mouth cavity.
Xerostom®	Xylitol, PEG-40 Hydrogenated Castor Oil, Betaine, Glycerin, Olea Europaea	Administer 1 or 2 times a day to the mouth cavity.
Xerotin®	Carboxymethyl-cellulose (CMC), potassium phosphate and sorbitol.	Spray the product several times a day

Figure. Artificial saliva and the essential characteristics.[72]

SALIVARY GLAND DYSFUNCTION AND PHARMACOLOGICAL INTERVENTIONS

The literature discusses variety of pharmacological approaches to prevent radiation-induced salivary gland dysfunction.[77] Some examples of these interventions are:

1. Parasympathomimetic drugs, including choline esters and cholinesterase inhibitors, induce salivary secretion by activating the parasympathetic nervous system. This system, responsible for increasing bodily secretions like tears, gastric juices, mucus, and saliva, aids in defending the body and facilitating digestion. Pilocarpine hydrochloride, classified as a choline ester, stands out as the most commonly prescribed parasympathomimetic for treating radiation-induced salivary gland dysfunction, with licensing in numerous countries.[73,77]

2. Parasympatholytic medications exert effects contrary to those of parasympathomimetic drugs; they act as anticholinergics, thereby suppressing saliva secretion.[74,75,77] Findings from animal experiments and research conducted by Rode et al.[75] propose that inhibiting saliva secretion during radiotherapy could potentially safeguard against subsequent damage to the salivary glands and enhance saliva production post-treatment.

3. Cytoprotective agents are administered prior to, during, or following cancer therapy to reduce or prevent harm or toxicity to normal cells and tissues while maintaining therapeutic effectiveness. Amifostine serves as one such cytoprotective agent and has demonstrated accumulation in the salivary glands. Reports suggest that this accumulation may potentially decrease parotid parenchymal damage caused by radiotherapy and reduce the occurrence of radiation-induced xerostomia.[76,77]

CONCLUSION

Adhesive materials that prevent secondary caries should be used for the restoration of RC. Resistance to tooth decay can be increased by applying topical fluoride. Ensuring and maintaining oral hygiene during and after radiotherapy is essential.

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Case Report

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Treatment of wedge-shaped lateral incisors with direct composite veneer restorations: two case presentations

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ABSTRACT

Wedge-shaped lateral incisors are teeth associated with dental anomalies, often encountered in maxillary teeth, characterized by being smaller than normal and having cylindrical or pointed shapes. For achieving an aesthetic appearance in treatment, ceramic or composite restorations are commonly preferred. However, ceramic restorations are not recommended as the primary choice for treating wedge-shaped lateral teeth due to their tendency to cause more substance loss in dental tissues, higher costs, and challenging repairs compared to composite restorations. In cases where patients presented with bilateral wedge-shaped lateral incisors seeking aesthetic improvements, various treatment options were explained to them, and after evaluating their preferences, the decision was made to use direct resin composite restorations for aesthetic enhancement. The color of the teeth was determined, and an appropriate composite resin was selected. Following the completion of the restorations, finishing and polishing procedures were applied. The purpose of presenting these two cases is to demonstrate the use of direct composite veneer restorations in achieving aesthetic treatment for wedge-shaped lateral incisors.

Keywords: Dental aesthetics, composite dental resin, tooth anomalies, composite, wedge-shaped lateral, diastema

INTRODUCTION

Wedge-shaped lateral incisors, which can be associated with dental anomalies, are often smaller and have cylindrical or pointed shapes, commonly observed in maxillary teeth.1 Wedge-shaped laterals are more frequently encountered in females compared to males, and the prevalence of unilateral and bilateral cases is similar. In cases of unilateral occurrence, the prevalence on the left side (0.4%) is twice that on the right side (0.2%).[1-2] Besides negatively impacting the aesthetics of the smile, the shape, size, and position of wedge-shaped lateral teeth can lead to orthodontic and periodontal issues.[3-4] With the recent emphasis on minimal intervention dentistry, restorative methods that achieve success with the least tissue loss are commonly employed.[5] Modern composite resins can be applied to dental tissues with minimal substance loss.[6]

The aim of these two case presentations is to demonstrate the use of direct composite restorations in achieving aesthetic treatment for wedge-shaped lateral incisors.

CASE 1

A 20-year-old patient with bilateral wedge-shaped lateral incisors presented to our clinic with aesthetic expectations. After intraoral and radiological examinations, treatment options were explained to the patient, and based on the patient's preference, it was decided to apply direct composite veneers. After determining the tooth color, an appropriate composite resin (A2, OA2 Tokuyoma Estelite Σ Quick [Tokyo, Japonya]) was selected (Figure 1 and Figure 2).

Figure 1. Appearance of wedge-shaped lateral incisors while smiling before treatment

Figure 2. Wedge-shaped lateral incisors of the patient before treatment

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Before starting the treatment, a polishing procedure was performed. Total acid etching (Dentsply condıtıoner 36 acid jel 30 seconds) was carried out without tooth preparation. Following the acid etching, bonding (tokuyoma bonding force 11) application was applied, and 10 seconds for polymerization Led E plus polymerization filling device applied. The teeth were shaped with composite resin (A2, OA2 Tokuyoma Estelite Σ Quick [Tokyo, Japonya], 40 seconds for polymerization Led E plus polymerization filling device) to achieve a natural form, completing the treatment in a single session. After the application of composite resin was completed, the surfaces of the restorations were refined using special finishing burs and polishing disks. At the end of the treatment, the importance of oral hygiene and the rules to be followed regarding the restorations were explained to the patient (Figure 3).

Figure 3. Due to the patient being away from the city for an extended period, our opportunity to take photos of the lateral teeth was limited during this session. Additionally, the presence of bleeding in the lower anterior region occurred as a result of the necessary removal of tartar during this session

CASE 2

A 23-year-old patient with bilateral wedge-shaped lateral incisors presented to our clinic with aesthetic expectations. After intraoral and radiological examinations, treatment options were explained to the patient, and based on the patient's preference, it was decided to apply direct composite veneers. After determining the tooth color, an appropriate composite resin (OA2 Tokuyoma Estelite Σ Quick [Tokyo, Japonya]) was selected and steps were applied as in case 1 (Figure 4).

Figure 4. The patient's wedge-shaped lateral incisors before the treatment

The total acid etching procedure was performed without tooth preparation. Following the bonding application, the teeth were shaped with composite resin (OA2 Tokuyoma Estelite Σ Quick8 [Tokyo, Japonya]) to achieve a natural form, completing the treatment in a single session. Immediately afterward, the surfaces of the restorations were refined using special finishing burs and polishing disks. At the end of the treatment, the patient was instructed on the importance of oral hygiene and the rules to be followed regarding the restorations (Figure 5).

Figure 5. The patient's lateral teeth after the treatment

DISCUSSION

Esthetic problems in patients with wedge-shaped incisors may arise from both misshapen teeth and diastemas. Direct composite applications offer a minimally invasive, single-session treatment option for correcting shape irregularities and closing diastemas. In contemporary dentistry, restorative materials, particularly composite resins, have advanced significantly. The shortened working times of composite resins, increased resistance to chewing forces due to evolving adhesion technology, minimized color changes, and the ability to select colors at the patient's chairside are among the significant advantages of these materials.[7]

Wedge-shaped lateral incisors, when left untreated, can lead to aesthetic, periodontal, and orthodontic issues. Their smaller size and shape, which can disrupt the smile and harmony with other teeth, represent a common dental form abnormality that can negatively impact patient psychology.[8,11] Direct composite applications provide a minimal intervention, single-session, and cost-effective treatment option for correcting shape irregularities and diastemas. The advantages of modern dental restorative materials, such as composite resins, include shortened working times, increased resistance to chewing forces through advanced adhesion technology, minimized color changes, and the ability to select colors at the patient's chairside.[7]

Wall et al.[9] used resin composite laminate veneers in 68 patients to mask color changes or hypoplasia in their anterior teeth. The technique provided acceptable improvement in patients' aesthetics and function over a two-year period. The results of this clinical study showed a significant improvement in the condition of patients' gingiva between the initial evaluation visit and the placement of veneers. However, it

was observed that veneer restorations had harmful effects on the gingival tissues of patients who could not maintain oral hygiene. The condition of the gingival tissue was found to be associated with irregularities in the veneer's gingival margin. However, when evaluated as a whole, there was no correlation between marginal irregularity and gingival condition.[12]

Other advantages of direct composite restorations include lower cost compared to an indirect technique and the reversible nature of the procedure, allowing for future treatment approaches. Another significant advantage of resin composite restorations over other restorative materials is the possibility of intraoral repair.[10,13]

CONCLUSION

The use of composite resins in the treatment of wedge-shaped lateral incisors has yielded clinically satisfactory results in terms of physical properties, marginal integrity, and aesthetics. Considering the current findings, direct composite laminate veneer restorations can be considered as the first choice for the treatment of wedge-shaped lateral incisors.

ETHICAL DECLARATIONS

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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