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Biomimetic hydroxyapatite and caries prevention: a systematic review and meta-analysis

Exploring barriers to oral health care experienced by individuals living with autism spectrum disorder

Effectiveness of propolis in maintaining oral health

Dentigerous cyst in a young child

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EDITORIAL

COVID-19 passports: The new future?

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The mission of the *Canadian Journal of Dental Hygiene* is to publish high-quality, credible, and accessible research to inform practice, education and policy, and promote the oral health and well-being of the public.

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The *Canadian Journal of Dental Hygiene* is the official peer-reviewed publication of the Canadian Dental Hygienists Association (CDHA). Published in February, June, and October, the journal invites submissions of original research, literature reviews, case studies, and short communications of scientific and professional interest to dental hygienists and other oral health professionals. Bilingual *Guidelines for Authors* are available at www.cjdh.ca.

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†Study conducted using a 0.454% w/w stannous fluoride toothpaste; measuring Schiff score and DHEQ questionnaire.
‡Percentage improvement in Bleeding Index after 24 weeks, test 0.454% w/w stannous fluoride toothpaste vs. control sodium monofluorophosphate toothpaste. Study also showed 19% improvement in modified Gingival Index with the test toothpaste vs. control at Week 24. Both these measures are indicative of improvements in gum health.

1. Parkinson CR, *et al*. *Am J Dent*. 2015;28(4):190-196. **2.** GSK data on file. Study number 204930. 2017. **3.** GSK data on file. Study RH01515 topline summary. 2014.

PM-CA-SENO-20-00042

COVID-19 passports: The new future?

Salme E Lavigne*, PhD, RDH

As I was finally able to return to France this summer, after over a year and a half away from my partner, I was truly hoping to have a different focus for this October editorial rather than more on COVID-19. However, here we are, in the midst of a fourth wave of this seemingly never-ending pandemic!

Salme E Lavigne

With European borders opened this summer to fully vaccinated people from "green" countries (including Canada), there seemed to be a new level of excitement about the possibility of some return to normal. I was very surprised when I arrived in France to discover that the European Union (EU) now has a digital COVID Certificate for those fully vaccinated, which is required for travel between countries within the EU. Each country has also implemented their own form of passport for all public gatherings, sports events, trains, dining (both indoors and outdoors), etc. In France, for example, this passport is referred to as the "*passe sanitaire*."

When I first arrived in Paris, I was excited to visit my favourite shopping centre but was met at the entrance by a security guard with a scanner in hand, asking for my *passe sanitaire*. Fortunately, I had my vaccination card in my wallet and, after I explained I was a Canadian and didn't have the QR code for their *passe*, he examined my card and allowed me to enter. This scenario was repeated for outdoor restaurant dining as well as when I took the train to my final destination in the Loire Atlantique. Without my vaccination records, I would not have been able to travel anywhere in France or the EU, nor dine in any of the restaurants, nor visit any museums, etc. This *passe* has resulted in a steep increase in the vaccination rate in France, which is quickly catching up with Canada's impressive rate of 70% fully vaccinated!

I knew prior to leaving Canada that discussions were underway regarding development of a COVID-19 passport and that Quebec had already begun to move forward with this. After seeing such a passport in action first-hand, I decided to investigate Canada's progress on this matter. I was pleasantly surprised to learn that 5 of the 10 Canadian provinces have begun implementation of a vaccine passport of one sort or another, particularly since they collectively represent 80% of Canada's population.[1] While the other 5 provinces have no plans to do so, PEI will be requiring a mandatory PEI Pass for entry into the province, and individuals who are not vaccinated will be required to quarantine.[1] The 3 territories will not be implementing a vaccination pass but all are working towards having a vaccine registry that residents can readily access for proof of vaccination.[1] Both Yukon and Nunavut are looking for federal guidance. According to Minister of Immigration, Refugees and Citizenship Marco Mendicino, the federal government is working with the provinces and territories on a vaccine passport for international travel and hopes to have it available some time this fall.[2]

What is of real interest is that there is incredible support from several provincial chambers of commerce for such passports. In fact, there is even support in some provinces that are not yet implementing a passport, such as Nova Scotia.[1] According to BNN Bloomberg, the Ontario Chamber of Commerce actually pushed for a passport as a way to encourage higher economic growth and greater consumer confidence, while reducing the risk of further lockdowns. The Chamber added that the "gold standard would be to have a centralized Canada-wide approach."[1]

Table 1. Canadian provinces and territories with and without vaccine passports

PROVINCES		TERRITORIES	
Yes	No	Yes	No
Newfoundland & Labrador	PEI	–	Yukon
Quebec	Nova Scotia	–	NWT
Ontario	New Brunswick	–	Nunavut
Manitoba	Saskatchewan		
British Columbia	Alberta		

Source: BNN Bloomberg[1]

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Table 2. Provincial chambers of commerce for or against vaccine passports

Province	For	Against	Comments
Newfoundland & Labrador	–	–	Unsure
Nova Scotia	*		
New Brunswick	–	–	Clear that a digital record will be needed for travel
PEI	–	–	Mandatory PEI Pass for entry into province
Quebec	*		
Ontario	*		
Manitoba	*		
Saskatchewan	some	some	Government will support those businesses that are "for" with a QR code
Alberta		*	
British Columbia	*		

Source: BNN Bloomberg[1]

MANDATORY PASSPORTS?

The question of the day is whether these passports will become mandatory across Canada for entry into sporting events, concerts, conferences, restaurants, etc. It certainly appears to be heading in that direction. There are, however, numerous groups opposed to such a move; most are those who have chosen not to be vaccinated. Since over 80% of the eligible population in Canada has at least 1 vaccine dose, that leaves 20% who have not yet come forward to be vaccinated. This is truly a problem as the growing number of COVID-19 cases appears to be among the unvaccinated and in the younger age groups. Alarmingly, there appears to be a rising number of children being infected by COVID-19, since they cannot yet be vaccinated. According to a joint report from the American Academy of Pediatrics and the Children's Hospital Association, the number of child COVID-19 cases in the United States rose exponentially between August 5 and September 5, 2021. Prior to August, children represented 15.5% of the total number of cases, while for the week starting September 2, the percentage of children infected jumped over 10% to 28.9% reported.[3]

Although vaccine studies are currently being conducted for children between the ages of 5 and 11, those results are pending. This virus, particularly the more virulent Delta variant, seeks out those who are not vaccinated and will continue to evolve and mutate until there are no more susceptible humans to infect. Thus, the longer individuals who are not vaccinated wait, the more they are exacerbating the problem. Not only are they more susceptible to infection, but they can also spread it to their children who are more vulnerable and even to those who have been vaccinated. No one yet knows when herd immunity will be reached for this virus, but it is clear that we are not there yet!

WHAT CAN WE DO AS DENTAL HYGIENISTS?

As discussed in my June editorial, dental hygienists should all be making an effort to have the difficult conversation with their clients regarding their responsibility as citizens to help crush this pandemic. We should try to alleviate their concerns about the safety of these vaccines and discuss the importance of everyone being vaccinated, including those who have had COVID-19 in the past. It has been shown that the natural immunity from a previous COVID-19 infection is not strong enough to ward off a second infection and, in addition, the efficacy of the antibodies wanes after several months. The other argument to be made is that we have not yet reached herd immunity, meaning that the virus will continue to mutate and perhaps become even more virulent. We cannot return to a normal life until all those who can be vaccinated are vaccinated. In fact, it appears that a third vaccine dose may be required for everyone in the near future. Please urge your clients to do the right thing for the public health of all Canadians and get vaccinated!

> *"Salus populi suprema lex is the law of all courts in all countries. The individual right sinks in the necessity to provide for the public good."*[4]

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ISSUE AT A GLANCE

We are pleased to feature 3 review articles in this issue. **Hardy Limeback, Joachim Enax**, and **Frederic Meyer** examine the evidence of the effects of hydroxyapatite (HAP)-containing oral care products on caries reduction, concluding that HAP is as effective as fluoride in preventing dental decay (pp. 148–59). **Bianka Bernath** and **Zul Kanji** explore barriers to oral health care faced by individuals living with autism spectrum disorder and possible solutions (pp. 160–66). **Muhammad Ali Saeed, Abdul Khabeer, Muhammad Ali Faridi,** and **Ghulam Makhdoom** review the effectiveness of propolis, a combination of resin and wax produced by honey bees, in maintaining oral health (pp. 167–76).

In addition, this issue includes an original research article by **Karo Parsegian, Srinivas Ayilavarapu, Tulsi Patel, Harold Henson,** and **Nikola Angelov,** who report on the development and testing of flowcharts designed to improve the accuracy and speed of diagnosing periodontal conditions by dental and dental hygiene students (pp. 137–47). A short communication by **Stacey McKinney** and **Sherri Lukes** describes the case of an asymptomatic dentigerous cyst in a 4-year-old child (pp. 177–81). You will also find this year's winning entry in the fifth annual CJDH Student Essay Award competition, written by **Amanda McKay**, a recent graduate of the University of British Columbia (pp. 182–86). Finally, we are pleased to share the abstracts of the peer-reviewed oral and poster presentations that will be given at the Canadian Dental Hygienists Association's virtual conference later this month (pp. 188–94).

PLAIN LANGUAGE ABSTRACTS

Parsegian K, Ayilavarapu S, Patel T, Henson HA, Angelov N. Flowcharts improve periodontal diagnosis by dental and dental hygiene students. *Can J Dent Hyg.* **2021;55(3):137–47.**

Gingivitis and periodontitis are among the most common inflammatory diseases in adults. Oral health professionals must be able to recognize the clinical signs and symptoms of these conditions to make an accurate diagnosis and propose an effective treatment plan. This study evaluates two flowcharts of periodontal conditions and their impact on the accuracy and speed of periodontal diagnosis by dental and dental hygiene students. Junior students with limited exposure to the 2017 AAP/EFP periodontal classification system benefited the most from these illustrative flowcharts, which improved their understanding of the new staging and grading system and its application chairside.

Limeback H, Enax J, Meyer F. Biomimetic hydroxyapatite and caries prevention: a systematic review and meta-analysis. *Can J Dent Hyg.* **2021;55(3):148–59.**

Dental caries is one of the most prevalent diseases worldwide and the reason for an unacceptably high number of day surgeries for young children in Canadian hospitals. While fluoridated toothpaste has been proven to reduce caries, there are concerns about overexposing young children to fluoride-containing oral care products. Hydroxyapatite is found in human teeth and bones; these calcium phosphate crystallites are non-toxic when swallowed. This article reviews the results of 22 studies on the effectiveness of biomimetic hydroxyapatite in reducing tooth decay. The evidence shows that hydroxyapatite in oral care products in the absence of fluoride effectively reduces caries, which may be particularly appealing to parents of young children.

Bernath B, Kanji Z. Exploring barriers to oral health care experienced by individuals living with autism spectrum disorder. *Can J Dent Hyg.* **2021;55(3):160–66.**

Individuals with autism spectrum disorder (ASD) face many barriers when trying to access oral care services and maintain at-home oral health routines. This review of 21 studies reveals that behavioural challenges, inhibited social and communication skills, dependence on parents or guardians, the clinical environment, and attitudes and behaviours of oral health professionals all have an impact on the oral care experience of individuals with ASD. Dental hygienists should be aware of these barriers and work with their colleagues to create an environment that supports special care populations and their parents/guardians in their efforts to achieve good oral health.

Saeed MA, Khabeer A, Faridi MA, Makhdoom G. Effectiveness of propolis in maintaining oral health: a scoping review. *Can J Dent Hyg.* **2021;55(3):167–76.**

Propolis, a dark-coloured, dense, and adhesive combination of natural ingredients collected by honey bees from trees, buds, and flowers, has proven antibacterial, anti-inflammatory, and antifungal properties. Oral care products containing propolis are emerging in the market, prompting this study of its effectiveness in maintaining oral health. This review of 19 studies reveals that propolis-containing oral care products lowered plaque and gingival indices, inhibited the growth of bacteria, reduced oral flora diversity, and improved oral health. Further study is needed to investigate potential adverse effects of propolis in some individuals, but it is clear that propolis may have potential applications in oral health care.

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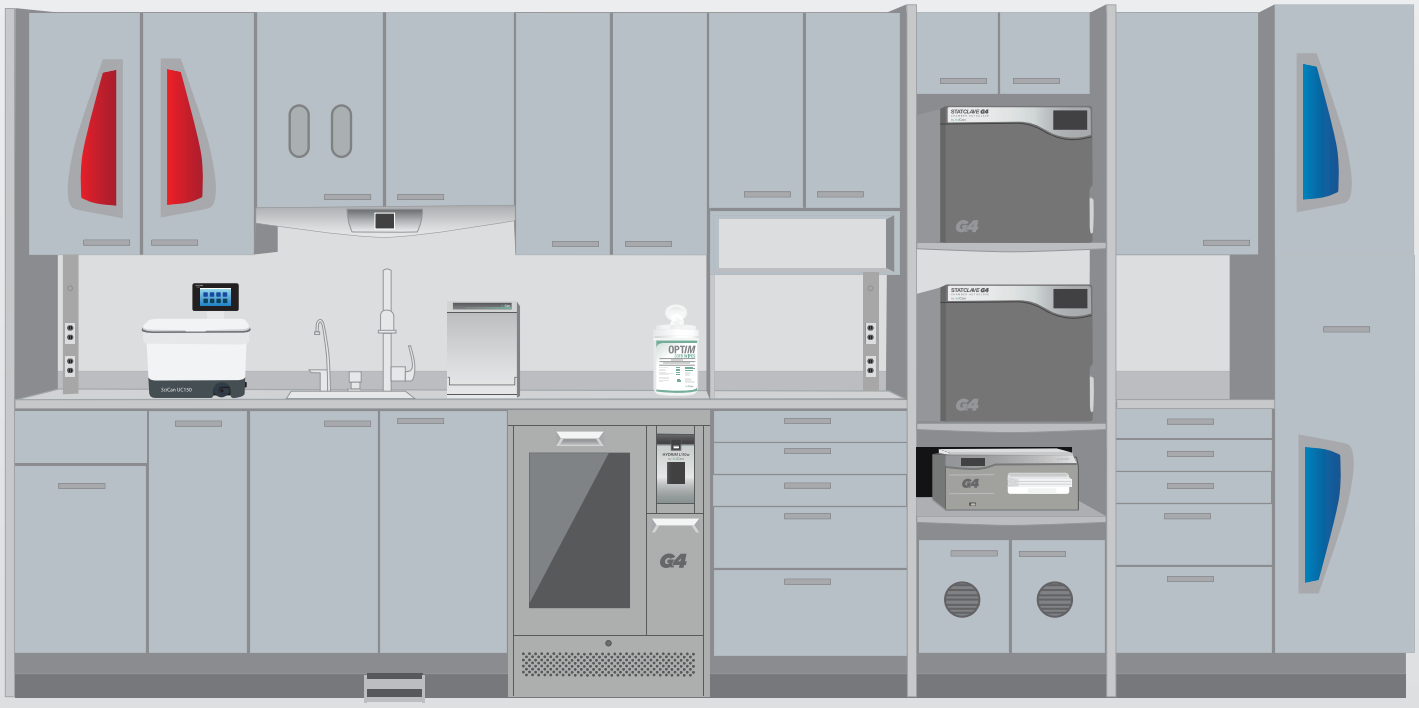

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Flowcharts improve periodontal diagnosis by dental and dental hygiene students

Karo Parsegian*, DMD, MDSc, PhD; **Srinivas Ayilavarapu***, DSc, MDS; **Tulsi Patel***, BSDH, MHA, RDH; **Harold A Henson***, PhD, RDH; **Nikola Angelov***, DDS, PhD

PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Understanding diagnostic determinants is essential to accurately diagnosing periodontal conditions.
- Dental and dental hygiene students with limited exposure to didactic periodontics and clinical care of clients with periodontal conditions may have inadequate skills to accurately diagnose them without the use of additional educational aids.
- Flowcharts offer a straightforward approach to improving the accuracy of diagnosing periodontal conditions in a time-effective manner.

ABSTRACT

Background: In 2017, the American Academy of Periodontology and the European Federation of Periodontology updated the classification of periodontal and peri-implant diseases and conditions. The goal of the present crossover study was to develop straightforward, illustrative flowcharts and determine their impact on the accuracy and speed of diagnosing periodontal conditions by predoctoral dental students (DS) and dental hygiene students (DHS). **Methods:** Two flowcharts (a decision-tree flowchart and one based on the periodontal disease/condition entity) were developed using updated diagnostic determinants proposed by the 2017 classification. A total of 26 second-, third-, and fourth-year DS (DS2, DS3, and DS4, respectively) and second-year DHS (DHS2) took a mock examination consisting of 10 periodontal clinical cases. The participants first diagnosed periodontal conditions using only their curricula-based knowledge (control) and then using the flowcharts (test). They also completed an optional post-examination questionnaire to provide feedback on the flowcharts. Statistical significance was detected at $p \leq 0.05$. **Results:** Combined test groups had significantly higher accuracy in diagnosing periodontal conditions compared to controls (73.5% vs 50.0%, respectively), with the most substantial improvement in DS2 (66.3% vs 30%, respectively) and DHS2 (70.0% vs 41.4%, respectively). Combined test groups also completed the examination more quickly compared to controls (14.92 vs 20.85 minutes, respectively). The participants provided positive feedback and constructive criticism on the flowcharts, and also suggested converting them into application software. **Conclusion:** The flowcharts significantly improved the accuracy of diagnosing periodontal conditions in academic settings, especially among junior, less experienced participants.

RÉSUMÉ

Contexte : En 2017, l'Académie américaine de parodontologie et la Fédération européenne de parodontologie ont mis à jour leur classification des maladies et des affections parodontales et péri-implantaires. L'objectif de la présente étude croisée était de créer des organigrammes simples et représentatifs et de déterminer leur effet sur l'exactitude et la vitesse de diagnostic des affections parodontales par les étudiants en médecine dentaire, prédoctorat (ÉD) et les étudiants en hygiène dentaire (ÉHD). **Méthodes :** Deux organigrammes (un organigramme d'arbre décisionnel et un graphique basé sur l'entité de la maladie ou de l'affection parodontale) ont été élaborés à l'aide des déterminants diagnostiques actualisés, comme proposés dans la classification de 2017. Un total de 26 étudiants de deuxième, troisième et quatrième année (ÉD2, ÉD3 et ÉD4, respectivement) en médecine dentaire et des étudiants de deuxième année en hygiène dentaire (ÉHD2) ont passé un examen fictif portant sur 10 cas cliniques parodontaux. Les participants ont d'abord diagnostiqué les affections parodontales en utilisant seulement leurs connaissances fondées sur leur programme d'études (témoins) et en utilisant ensuite les organigrammes (tests). Ils ont aussi rempli un questionnaire optionnel après avoir passé l'examen afin de fournir des commentaires sur les organigrammes. La signification statistique a été décelée à $p \leq 0,05$. **Résultats :** Les groupes de tests combinés avaient une exactitude considérablement plus élevée dans le diagnostic des affections parodontales par rapport aux groupes témoins (73,5 % contre 50,0 %, respectivement), et l'amélioration la plus importante était chez les ÉD2 (66,3 % contre 30 %, respectivement) et les ÉHD2 (70,0 % contre 41,4 %, respectivement). Les groupes de tests combinés ont aussi terminé l'examen plus rapidement par rapport aux groupes témoins (14,92 contre 20,85 minutes, respectivement). Les participants ont fourni des commentaires positifs et des critiques constructives sur les organigrammes et ont aussi suggéré de les convertir en logiciels d'application. **Conclusion :** Les organigrammes ont considérablement amélioré l'exactitude du diagnostic des affections parodontales dans les milieux d'enseignement, surtout chez les participants débutants et moins expérimentés.

Keywords: decision trees; dental hygiene; education, dental; periodontal diseases; periodontics; students, dental; surveys and questionnaires
CDHA Research Agenda category: capacity building of the profession

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INTRODUCTION

Periodontal diseases, including gingivitis and periodontitis, are multifactorial conditions of inflammatory origin that involve complex interactions between the microbiota, a susceptible host, and contributory environmental and epigenetic factors.[1,2] Both gingivitis and periodontitis are among the most common inflammatory diseases diagnosed in 32% to 53%[3,4] and 42%[5] of US adults, respectively. Therefore, understanding their clinical signs and symptoms is essential for periodontists, dental hygienists, general practitioners, and other oral health professionals to diagnose and successfully manage clients with periodontal conditions.

At the 2017 World Workshop in Periodontics, both the American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP) presented the updated Classification of Periodontal and Peri-Implant Diseases and Conditions,[6] which replaced the classification system used since 1999.[7] The new classification aimed to address several deficiencies and confusing points in the 1999 classification, which were comprehensively discussed in a series of publications and summarized in Table 1. The key changes were reflected in the precise definitions of clinical gingival (periodontal) health[6,8] and biofilm-induced gingivitis (both conditions could be diagnosed on an intact and reduced periodontium),[6,8-10] and the new concept of periodontitis[11,12] based on the staging and grading system (adapted, to a certain extent, from the staging diagnosis description system in oncology). In contrast to the 1999 classification, which determined the severity of periodontitis based on the previous periodontal breakdown, the new classification uses various diagnostic determinants to establish the disease severity and complexity (a staging concept), progression and risk factors (a grading concept), and extent (localized and generalized).[6,11] The diagnosis of periodontal conditions is established based on the presence and extent of clinical attachment levels (CAL), radiographic bone loss (RBL), pocket depth (PD), and bleeding on probing (BOP).

Several studies demonstrated that the proposed classification updates accurately reflected client characteristics and improved the diagnostic accuracy of periodontal conditions.[13] A recent National Health and Nutrition Examination Survey III-based study also showed

Table 1. Changes proposed to the classification of periodontal diseases and conditions by the 2017 World Workshop of Periodontics

Periodontal condition	Changes
Periodontal (gingival) health[6,16]	• Introduced a section on periodontal (gingival) health
Dental biofilm-induced gingivitis[9]	• Accepted bleeding on probing (BOP) as the single reliable criterion to evaluate gingival inflammation • Defined a "gingivitis case" • Introduced the term "dental biofilm" • Provided clear-cut criteria to discriminate a client with gingivitis vs gingival health • Provided criteria to discriminate between localized vs generalized gingivitis
Non-dental biofilm-induced gingival diseases[22]	• Introduced comprehensive nomenclature for pathological gingival conditions • Used the Tenth International Classification of Diseases (ICD-10) diagnostic codes to classify and code all diagnoses, symptoms, and procedures recorded in conjunction with hospital care in the USA
Periodontitis[11,12,19,23]	• Defined a periodontitis case • Introduced the staging and grading concepts of periodontitis • Eliminated aggressive periodontitis as a separate disease entity due to insufficient evidence to consider its pathophysiology different from chronic periodontitis
Necrotizing periodontal diseases[22]	• Introduced the term "necrotizing periodontal diseases" • Eliminated the term "ulcerative" from necrotizing gingivitis, periodontitis, and stomatitis
Periodontitis as a manifestation of systemic diseases[24]	• Used the Tenth International Classification of Diseases (ICD-10) diagnostic codes to classify and code all diagnoses, symptoms, and procedures recorded in conjunction with hospital care in the USA
Systemic diseases or conditions affecting periodontal supporting tissues[25]	• Used ICD-10 codes to classify the primary systemic disease
Periodontal abscesses[26]	• Eliminated the term "acute" from the diagnosis of abscesses • Eliminated the terms "pericoronal abscess" and "pericoronitis abscess"
Endodontic-periodontal lesions (EPLs)[26]	• Grouped all EPLs under a single section "Periodontitis Associated with Endodontic Lesion" since they can occur in clients with or without periodontitis • Eliminated the category "Combined EPLs" since it was too generic and did not allow for specific, discriminatory treatments for each lesion
Mucogingival deformities and conditions[27]	• Introduced the classification of gingival recession by Cairo as a part of the periodontal classification • Included types of periodontal biotypes
Traumatic occlusal forces[28]	• Included orthodontic forces
Dental prostheses- and tooth-related factors[29]	• Replaced the term "biological width" with "supracrestal connective tissue attachment"
Peri-implant diseases and conditions[30]	• Introduced peri-implant diseases and conditions

that the updated periodontitis case definitions improved the accuracy performance of full-mouth partial diagnostic protocols compared to those proposed by AAP and the Centers for Disease Control in 2012.[14]

Although the criteria defining these conditions were clearly described, their chairside application might pose some challenges due, at least in part, to a similar array of determinants used to diagnose different periodontal conditions, shared etiologies of these diseases (such as periodontitis and gingival recession of an inflammatory origin), and unclear thresholds for certain periodontal conditions (such as reduced periodontium). A variety of possible clinical scenarios with overlapping clinical and radiographic findings resulted in "gray zones," which made the accuracy of a periodontal diagnosis even more challenging.[12] To promote the comprehension of the diagnosis of periodontitis (including stages and grades), AAP and EFP published several illustrative diagrams and tables.[6,11] However, they did not include decision-tree approaches to establishing a diagnosis of periodontitis and other gingival/periodontal conditions (such as clinical gingival health, gingivitis, and CAL associated with the gingival recession). Such approaches might be especially helpful for individuals who have limited experience in periodontics and may find a differential diagnosis of these conditions confusing. For example, non-periodontists found the new classification challenging to comprehend and apply chairside, as evidenced by significantly lower accuracy of periodontal diagnosis compared to periodontal residents.[15] Although this difference could be due to the staging and grading system of the new classification not yet being commonly incorporated into curricula outside of graduate periodontics, it could also indicate that individuals with limited exposure to periodontics and periodontal classification find the currently available illustrative approaches inadequate for their needs.

Similar to non-periodontists, predoctoral dental students (DS) and dental hygiene students (DHS) commonly have limited exposure to periodontics, and therefore, may be less accurate in diagnosing periodontal diseases. In addition, since the classification was introduced to dental curricula relatively recently, these students have not had long-term, repeated exposure to it. However, their ability to accurately diagnose periodontal conditions is essential for an appropriate and clinically justified treatment choice. Therefore, the goals of the present crossover study were to 1) develop straightforward and illustrative flowcharts of periodontal conditions and 2) evaluate their impact on the accuracy and speed of diagnosing periodontal conditions by DS and DHS. The outcomes of the study will be helpful for DS and DHS to better understand the 2017 periodontal classification and apply it chairside.

METHODS

Development of the flowcharts

The flowcharts were developed by the first author (KP) based on the reviewed articles outlining the 2017 World Workshop in Periodontics (and referenced in the study). Two flowcharts were constructed. The first one represented a decision tree that uses a series of straightforward questions to lead users to make a diagnosis of clinical gingival health (on an intact and reduced periodontium),[6,8,16] gingivitis (on an intact and reduced periodontium),[6,9,17] periodontitis,[6,11] and outcomes of periodontal treatment[16] (Figure 1). Since CAL is considered a key diagnostic determinant of the 2017 classification,[11,12] the first question that users are asked is whether a client presents with CAL and, if so, is it associated with periodontal (inflammatory) or non-periodontal (non-inflammatory) factors. If the client has no CAL, then the diagnosis depends on the percentage of BOP+ sites (clinical gingival health on an intact periodontium for BOP <10%[8,16] and dental biofilm-induced gingivitis [localized or generalized] on an intact periodontium for BOP ≥10%).[8,9,17] If the client has CAL associated with non-periodontal factors (listed in Figure 1), they are diagnosed with either clinical gingival health or biofilm-induced gingivitis (both on a reduced periodontium) based on the same BOP criteria as for the respective conditions on an intact periodontium. If a client has CAL due to periodontal breakdown, the next question is whether that client has a history of periodontal treatment and regular periodontal maintenance. If the client has no history of periodontal treatment and regular periodontal maintenance or is treated and maintained adequately but still displays progressive (≥2 mm) CAL, then they would be diagnosed with active periodontitis,[8,18] and its extent, stage, and grade should be determined according to the established criteria.[8,11,19] If a client has a history of periodontal treatment followed by regular periodontal maintenance, then they could be diagnosed with clinical gingival health on a reduced periodontium in a stable periodontitis client,[8,16] gingivitis on a reduced periodontium in a stable periodontitis client,[8] and periodontal disease in remission/control on a reduced periodontium.[16] The differences between these diagnoses depend on BOP and PD.[8]

The second flowchart provides an alternative, disease-entity-based approach to diagnosing periodontal conditions (Figure 2). It includes 3 categories: 1) clinical gingival health,[6,8,16] 2) gingivitis,[6,9,17] and 3) periodontitis.[6,11] Both clinical gingival health and gingivitis can occur on an intact periodontium, reduced periodontium in a non-periodontitis client, and reduced periodontium in a treated, stable periodontitis client. Periodontitis, by definition, could occur only on the reduced periodontium, and treated periodontitis clients who display the partial resolution of periodontal breakdown would be diagnosed with periodontal disease remission/control on a reduced periodontium. For simplicity of the diagram, other conditions proposed in the classification (such as periodontitis as a manifestation of systemic disease and peri-implant diseases and conditions) were excluded.

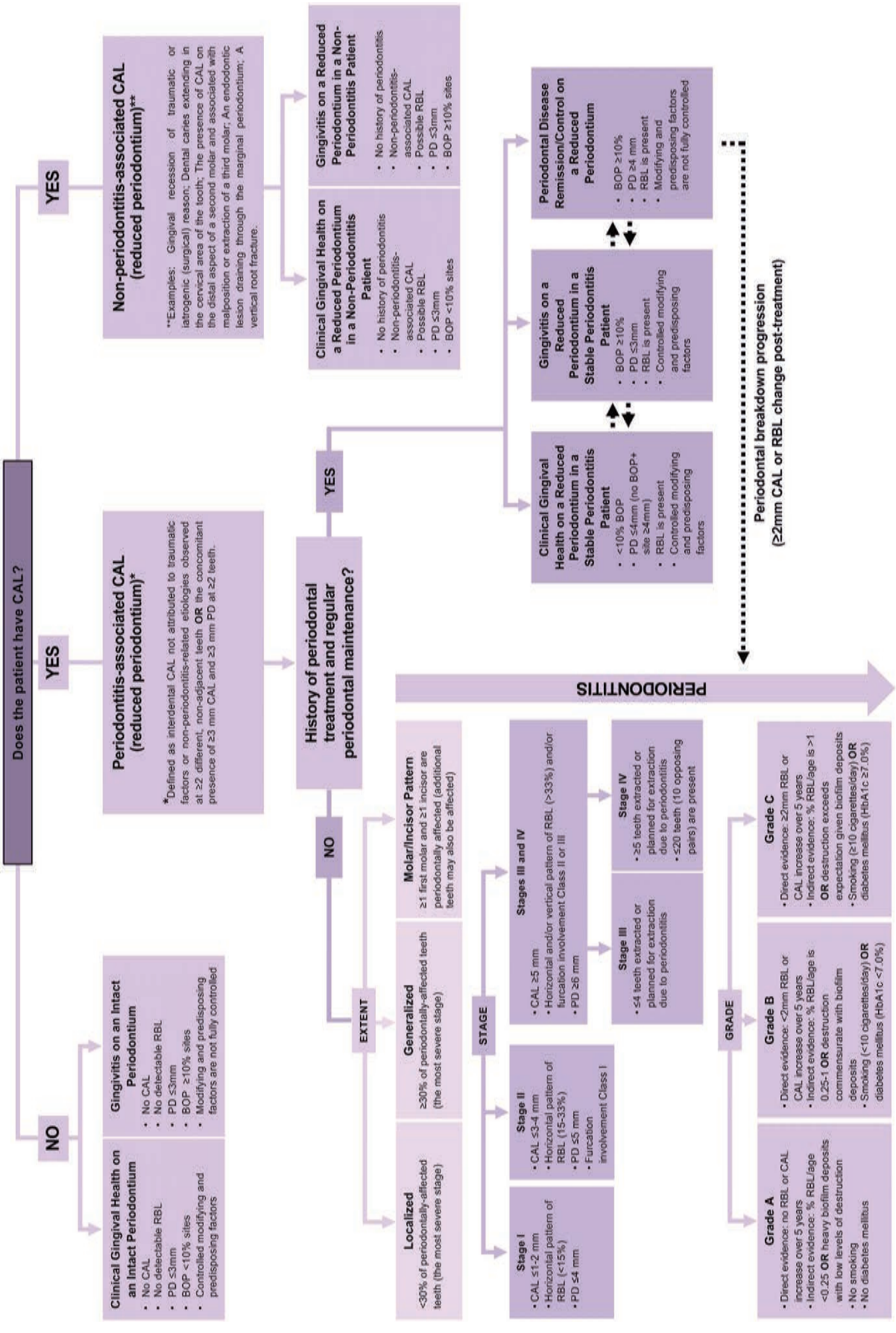
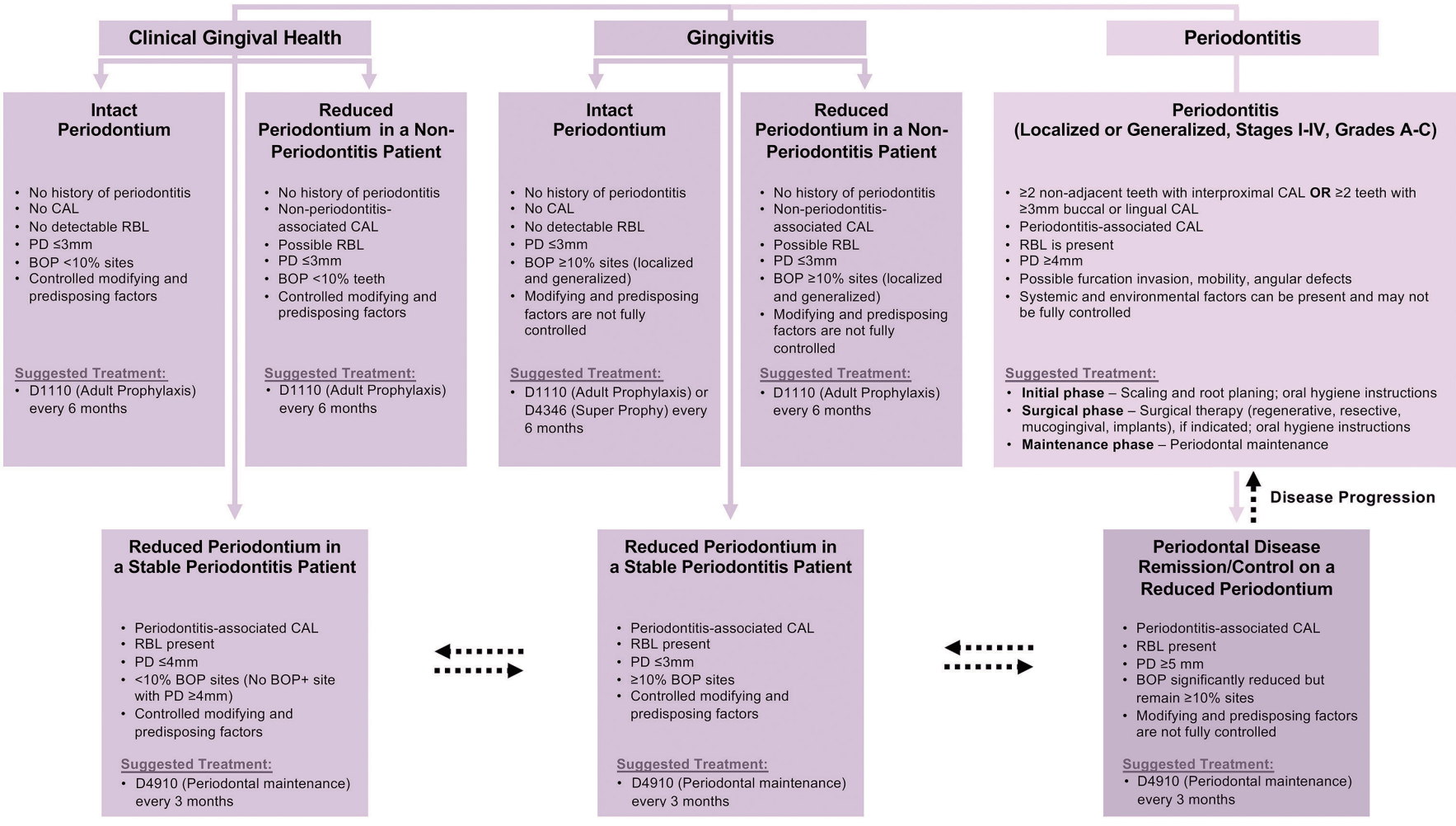


Figure 1. The decision-tree flowchart based on the 2017 Classification of Periodontal and Peri-Implant Diseases and Conditions

The flowchart includes clinical gingival health, biofilm-induced gingivitis, periodontitis, and outcomes of periodontal therapy. CAL: clinical attachment loss; RBL: radiographic bone loss; PD: probing depth; BOP: bleeding on probing; SRP: scaling and root planing.

Figure 2. The disease entity-based flowchart based on the 2017 Classification of Periodontal and Peri-Implant Diseases and Conditions



Suggested therapeutic approaches are based on evidence in the literature and are not officially proposed by the 2017 World Workshop in Periodontics. CAL: clinical attachment loss; RBL: radiographic bone loss; PD: probing depth; BOP: bleeding on probing; SRP: scaling and root planing.

The AAP diplomate authors of the study (KP, SA, and NA) validated both flowcharts by reviewing them to determine 100% agreement. If the authors disagreed with any aspect of the flowcharts (such as diagnosis definitions and determinants and schematic outline), the referenced studies from the 2017 World Workshop in Periodontics were used to resolve the disagreement.

Study design, population, and ethics

This crossover study involved DS entering their second, third, and fourth year of training (DS2, DS3, and DS4, respectively) and DHS entering their second year of training (DHS2). First-year DS and DHS were excluded, as they were not taught the new classification prior to conducting the study and did not begin providing focused periodontitis care until the following year of their training. The Institutional Review Board of the University of Texas Health Science Center at Houston approved all experimental protocols proposed in the study (protocol #HSC-DB-19-0824).

Methodology

In June 2020, all DS2, DS3, and DS4 (102, 107, and 99 students, respectively; a total of 308 students) and 39 DHS2 received an online invitation to participate in the study with examination links generated specific to the year of training. The students were informed that participation in the study was voluntary and would have no effect on their grades. The consenting students took an online examination that consisted of 10 descriptive clinical periodontal cases (Table 2). The cases were developed by the authors of the study who agreed on the expected diagnosis prior to conducting the exam. The anonymised participants were asked to diagnose periodontal conditions using their curricula-based knowledge without any additional tools (control group). Immediately after the examination, the same students completed the second online examination, which consisted of the same clinical cases, but used the flowcharts as an additional aid (test group). All participants were proctored by ExamSoft (ExamSoft, Dallas, TX, USA) during the examination. The duration of each examination was recorded using ExamSoft's "Elapsed Time" feature that automatically calculated the time when the examination was started and completed. A single faculty member (KP) was responsible for collecting the examination responses and determining their accuracy. The accuracy of periodontal diagnosis served as the primary outcome of the study, and the duration of the mock examination served as the secondary outcome. Blinding was deemed impossible due to the crossover study design and because all participants were aware of the use of the flowchart. A single faculty member (KP) was responsible for collecting the questionnaire responses.

Table 2. Clinical cases presented during the online mock examination

Case description	Periodontal findings[a]	Diagnosis[b]
The 20-year-old patient presented with a chief complaint, "I came to have my teeth cleaned." Medical history was unremarkable.	• No history of periodontal therapy • Good oral hygiene with insignificant plaque and calculus deposits • No interdental CAL • No RBL • 1 mm to 3 mm PD • 7% BOP	Clinical gingival health on an intact periodontium
The 30-year-old patient presented with a chief complaint, "I need to have my 6-month dental cleaning." Medical history was unremarkable.	• No history of periodontal therapy • Excellent oral hygiene with minimal plaque and calculus deposits • 1 mm to 2 mm interdental CAL in the form of the gingival recession of traumatic (non-inflammatory) origin • 10% RBL • 1 mm to 2 mm PD • 5% BOP	Clinical gingival health on a reduced periodontium
The 45-year-old patient presented with a chief complaint, "I have bleeding gums, and my teeth are getting loose." Medical history was unremarkable.	• No history of periodontal therapy • Fair oral hygiene with abundant plaque and calculus deposits • 5 mm to 6 mm interdental CAL on 27% of teeth throughout the dentition. No data on the progression of CAL over time are available • 25% RBL • 5 mm to 8 mm PD • 82% BOP • 3 teeth were extracted due to periodontitis by the patient's local dentist	Localized periodontitis stage III grade B
The 46-year-old patient presented to you with a chief complaint, "I want you to check my gums and teeth." Medical history was unremarkable.	• You performed SRP on 7 mm to 8 mm PDs and then saw the patient for periodontal maintenance every 3 months for the next 1.5 years • Fair oral hygiene with some plaque and calculus deposits • 1 mm to 2 mm interdental CAL with no progression beyond the re-evaluation levels • 5 mm to 6 mm PD • 35% BOP	Periodontal disease remission/ control on a reduced periodontium

Table 2. *continued*

Case description	Periodontal findings[a]	Diagnosis[b]
The 55-year-old patient presented with a chief complaint, "I had gum treatment recently, and I'm here for my 3-month cleaning." Medical history was unremarkable.	• History of periodontal therapy (SRP and periodontal flap surgery) • Fair-to-poor oral hygiene • RBL and CAL around several teeth • 5 mm PDs **Therapeutic outcomes:** • During the next 2 years, you performed periodontal maintenance at a 3-month interval for this patient. Despite your best efforts, the patient had not improved his oral hygiene and his PDs and CAL increased up to 7 mm in 15% of the probing sites with the deepest radiographic bone defect reaching 60%.	Localized periodontitis stage III grade C
The 65-year-old patient presented with a chief complaint, "I want to save my remaining teeth." The patient reported type 2 diabetes mellitus (most recent A1C was 8.3) and a history of smoking 1 pack/day for the past 5 years.	• History of periodontal therapy (SRP) and periodontal maintenance 5 years ago. Since then, CAL changed by 2 mm to 3 mm in 40% of his teeth throughout the dentition. • Poor oral hygiene with significant plaque and calculus deposits • 5 mm to 6 mm interdental CAL • 50% RBL • 6 mm to 7 mm PD • 27% BOP • 5 teeth were extracted due to periodontitis by his local dentist	Generalized periodontitis stage IV grade C
The 40-year-old patient presented with a chief complaint, "I want you to check my gums." Medical history was unremarkable.	• History of periodontal therapy and regular periodontal maintenance 10 years ago. No major changes in periodontal health since then • Good oral hygiene with insignificant dental biofilm and calculus deposits • 1 mm to 2 mm interdental CAL due to previous periodontal treatment • 10% RBL • 2 mm to 3 mm PD • 15% BOP	Gingivitis on a reduced periodontium in a stable periodontitis patient
The 35-year-old patient presented with a chief complaint, "I came to have my teeth cleaned." Medical history was unremarkable.	• No history of periodontal therapy • Good oral hygiene with some plaque and calculus deposits • No necrotizing gingival and oral mucosa changes • No interdental CAL • No RBL • 1 mm to 3 mm PD • 26% BOP	Localized biofilm-induced gingivitis on an intact periodontium
A 22-year-old African American patient presented with a chief complaint, "I am concerned about some of my teeth, as they are getting looser." Medical history was unremarkable.	• No history of periodontal therapy • Good oral hygiene with insignificant amounts of biofilm and calculus • Up to 7 mm PD around teeth #2, 3, 8, and 19 • Up to 5 mm CAL around teeth #2, 3, 8, and 19 • Up to 40% radiographic bone loss around teeth #2, 3, 8, and 19	Molar-incisor pattern periodontitis stage III grade C
A 50-year-old patient presented with a chief complaint, "I want to have my gums checked to make sure they are healthy." Medical history was unremarkable.	• No history of periodontal therapy • Fair oral hygiene with no gross plaque and calculus deposits • 3 mm to 4 mm interdental CAL on 20% of teeth throughout the dentition. You do not have any data on the progression of CAL over time • 20% RBL • Up to 5 mm PD • 47% BOP	Localized periodontitis stage II grade B

[a]CAL: clinical attachment loss; RBL: radiographic bone loss; PD: probing depth; BOP: bleeding on probing; SRP: scaling and root planing.
[b]The correct answers are shown in the table for demonstration purposes and were not displayed anywhere during the examination.

At the end of each examination, a 5-point Likert scale was used to evaluate the participants' response to the optional question, "How difficult do you find the 2017 Classification of Periodontal and Peri-Implant Diseases and Conditions?" with and without the flowchart. Possible answers were "very easy," "easy," "moderate," "difficult," and "very difficult."

Null hypothesis

The null hypothesis stated that the use of the flowcharts did not have statistically significant effects on the accuracy and speed of diagnosing periodontal conditions.

Power calculation

Power analysis was performed using Stata/MP 17 software

(StataCorp, College Station, TX USA). It was determined that, for the comparison of group means to a reference value (including standard deviation), a sample size of at least 20 participants was required to achieve 80% power (0.05 significance level).

Statistical analysis

Statistical analysis was performed using GraphPad Prism 9 (GraphPad Software, San Diego, CA, USA). The comparison between control and test groups within the same class (DS2, DS3, DS4, and DHS2) was performed using a parametric paired 2-tailed test of significance. The comparison within the respective control and test groups (DS2, DS3, DS4, and DHS2) was performed using 1-way analysis of variance with a Holm-Šídák multiple comparisons test. The null hypothesis was rejected when the p value was ≤ 0.05. The word "significant" throughout the analysis of the results refers to statistical significance.

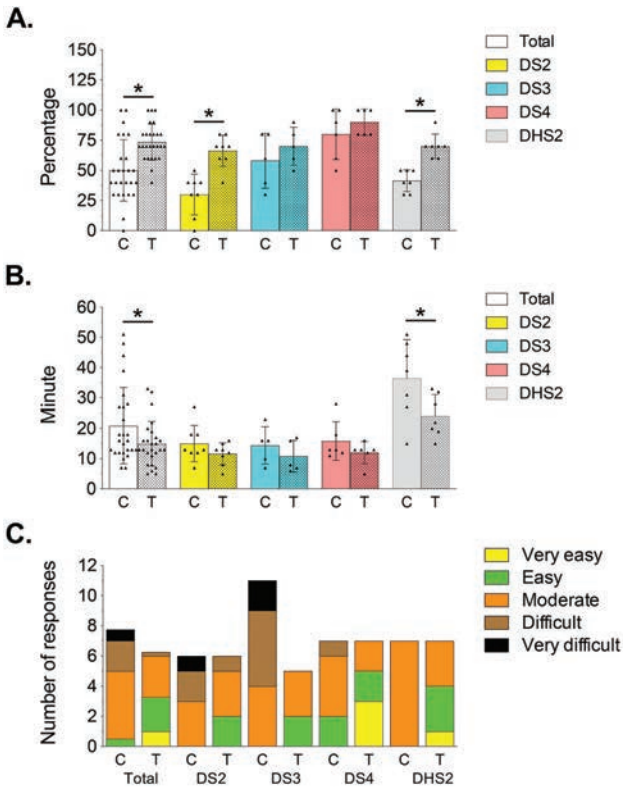
RESULTS

A total of 26 students (8 DS2, 5 DS3, 6 DS4, and 7 DHS2; 7.5% overall response rate) participated in the study. Figure 3A shows that, in all groups (DS2, DS3, DS4, and DHS2), the use of flowcharts was associated with increased accuracy of periodontal diagnosis compared to the respective controls (73.5% vs 50.0%, respectively; 1.47-fold; $p < 0.001$). The most substantial and statistically significant increases were observed in the classes of DS2 (66.3% vs 30%, respectively; 2.2-fold; $p < 0.001$) and DHS2 (70.0% vs 41.4%, respectively; 1.7-fold; $p = 0.002$), whereas DS3 (70% vs 58%, respectively; 1.2-fold; $p = 0.46$) and DS4 (90% vs 80%, respectively; 1.1-fold; $p = 0.28$) had more modest and statistically insignificant increases. The accuracy of periodontal diagnosis in control and test DS groups was significantly associated with the increased year of training ($p < 0.001$ and $p < 0.01$, respectively). The accuracy of periodontal diagnosis was significantly higher in the control DS2 group but not the test DS2 group compared to the respective DHS2 groups ($p = 0.025$ and $p = 0.53$, respectively).

Figure 3B shows that, in all groups (DS2, DS3, DS4, and DHS2), the use of flowcharts was associated with a significantly decreased duration of the examination compared to control (20.85 minutes vs 14.92 minutes (min), respectively; ~1.4-fold; $p < 0.001$). The extent of these decreases was similar in all DS groups compared to the respective controls; specifically, for DS2 (11.6 min vs 15 min, respectively; 1.29-fold; $p = 0.20$), DS3 (10.8 min vs 14.4 min, respectively; 1.33-fold; $p = 0.43$), and DS4 (12.0 min vs 15.8 min, respectively; 1.32-fold; $p = 0.22$). There were no statistically significant associations between the duration of the examination and the year of training in both control and test DS groups ($p = 0.93$ and $p = 0.89$, respectively). The use of the flowcharts was also associated with a significant decrease in the duration of the examination only for DHS2 (24.1 min vs 36.4 min, respectively; 1.51-fold; $p = 0.01$). The duration of the mock examination was significantly shorter in both control and test DS2 groups compared to the respective DHS2 groups ($p = 0.004$ and $p = 0.019$, respectively).

Figure 3C shows the participants' optional comments in response to the question, "How difficult do you find the 2017 Classification of Periodontal and Peri-Implant Diseases and Conditions?" The flowchart appeared to make the comprehension of the 2017 classification easier and more straightforward for students of all years of training. Table 3 shows optional, unedited feedback from the participants on the use of the flowcharts. The students noted that, although they found the flowcharts to be simple and helpful, their layout could be improved further. Interestingly, several students also proposed that the use of a similar decision-tree-based software application would make diagnosing periodontal conditions even more straightforward.

Figure 3. The effects of the flowcharts on the accuracy of periodontal diagnosis (A), the duration of the mock examination (B), and the feedback of students on the difficulty of the periodontal classification (C)



Graphs A and B: Results represent mean ± standard deviation (SD). The asterisk represents the statistical significance defined by the p value ≤ 0.05. **Graphs A, B, and C**: C = control; T = test.

DISCUSSION

The 2017 periodontal classification, including updated concepts of clinical gingival health, gingivitis, and periodontitis, was implemented into the curricula of the

Table 3. Student feedback on the use of the flowcharts

Positive feedback	Constructive criticism	Suggestions
1. "These flowcharts are clear and concise. Very helpful! They put all of the information we learned together in one place and greatly reduced the complexities of diagnosis of periodontal conditions."	1. "The flowchart is very easy to use and follow along. The only thing that makes it difficult is the amount of text in each text box."	1. "It would be greater if there is a software format or app where clinicians do several clicks based on some questions provided (e.g., clinical attachment loss –> yes or no) in the app, in which it gives the final diagnosis."
2. "The questions were reasonable and accurately represented what you would be presented within the clinic."	2. "Teaching the rationale for and definitions included in it is helpful, but I still found the diagnosis of treated periodontitis patients challenging, especially if treatment was performed a long time ago and a patient was not maintained properly since then."	2. "It would be helpful if the charts were integrated into dental software like axiUm and other sources."
3. "The flowchart makes me able to confidently diagnose periodontal conditions. Without them, I tend to misdiagnose several conditions. They have made clinical diagnosis very swift and became much more easily memorized than the original document."		

institutional undergraduate dental and dental hygiene courses in summer 2018. DS2 and DHS2 were taught the updated periodontal classification during their introductory periodontics course in spring/summer 2020. Since the students had not started their clinical training before the study was conducted, they were not able to practise the revised classification system in a clinical learning environment. Both DS3 and DS4 were taught the updated periodontal classification during the introductory periodontics course in summer 2018 and have applied and enhanced their knowledge of the classification chairside since then. Therefore, DS2 and DHS2 had a similar but more limited amount of time to memorize the updated classification and exercise their curricula-based knowledge compared to both DS3 and DS4. Student knowledge was evaluated through formative assessment methods, and they were further evaluated on their application of knowledge through their respective clinical courses.

In addition, the new disease entities were added to the university's axiUm® dental software (Henry Schein, Melville, NY, USA), and students were required to diagnose periodontal conditions using these updated entities in their daily clinical cases and competency examinations. Therefore, the ability of students to comprehend the 2017 classification became an important factor that determined their didactic performance and appropriate client care (including diagnosis-driven treatment selection).

The current study proposed the use of straightforward schematics to increase the accuracy of periodontal diagnosis made by DS and DHS. This study focused on these groups of trainees since they were actively treating clients with periodontitis but had more limited knowledge and depth of experience in periodontics compared to experienced periodontists and dental hygienists. Among control DS, the diagnostic accuracy was the lowest among DS2 and significantly increased with advanced years of training. However, even the DS2 had a significantly higher accuracy of periodontal diagnosis compared to the DHS2 class. When the flowcharts were used, the diagnostic accuracy significantly increased with advanced years of DS training, but the greatest extent of increases was seen in the DS2 class (2.2-fold) followed by DS3 and DS4 (up to 1.23-fold). Although only second-year DHS participated in the examination, the increases in their diagnostic accuracy were relatively comparable to that of DS2 (1.7-fold). Interestingly, in contrast to control groups, the respective DS2 and DHS2 groups had a similar accuracy of periodontal diagnosis. These results demonstrate that the flowcharts could be particularly useful to those individuals with limited experience in using the 2017 classification.

In both control and test DS groups, no statistically significant associations between the duration of the examination and the year of training were observed. At the same time, compared to control, the use of the flowcharts significantly decreased the duration of time to complete the examination (~1.4-fold). However, when stratified based on the class, only test DHS2 had significant decreases as compared to control (~1.51-fold), but when compared to test DS2, their examination time was significantly longer. Overall, these results suggest that all DS worked through the flowcharts and determined an accurate diagnostic path irrespective of their year of training, but DHS2 took a longer time to complete these tasks.

The results also show that, not only did DS and DHS diagnose periodontal conditions faster using the flowcharts, but they also improved their comprehension of the 2017 classification. Overall, the participating students provided positive and encouraging feedback. However, a few critical points were highlighted, which will be used to further improve the flowcharts. For example, the participants noted that they still found the classification of previously treated periodontal clients challenging, especially when

the treatment was performed a long time ago without proper periodontal maintenance. In addition, they noted that, once the flowcharts included multiple conditions, they became more challenging to follow. Interestingly, several students also suggested providing the flowcharts in the form of application software that could automate the diagnosis process and possibly become an integral part of the dental electronic health record software. This study's authors have developed such software and are currently testing its accuracy in clinical settings.

Although the current classification was introduced several years ago, only a few studies have published illustrative charts to diagnose periodontal conditions in a more time- and effort-effective manner. Tonetti and Sanz[20] developed a comprehensive decision-tree approach that followed the AAP/EFP diagnostic determinants (including CAL, RBL, PD, and BOP) to distinguish between various gingival and periodontal conditions and accurately determine the stage and grade of periodontitis. However, clinical scenarios of treated clients with periodontitis (periodontal stability, remission/control, and "reactivation" of periodontitis due to unsuccessful periodontal treatment) remained unaddressed. Recently, Sutthiboonyapan and colleagues[21] also proposed the use of a flowchart to simplify periodontal diagnosis. However, it used PD as an initial diagnostic criterion for gingival conditions. In contrast, the present study proposed using CAL as the primary diagnostic criterion, according to the guidelines outlined by the AAP and EFP. The Sutthiboonyapan et al. study[21] was also primarily focused on the step-by-step diagnosis of periodontitis (including the stages and grades). However, similar to Tonetti and Sanz's study, it did not address the clinical scenarios of treated clients with periodontitis. In addition, both studies focused on the illustrative approach to diagnosing periodontal conditions, whereas the current study not only reported on the development of the flowcharts but also determined their impact on the accuracy and speed of periodontal diagnosis.

Limitations

This study had a lower-than-expected response rate from students, especially among DS. Despite several recruitment emails, those students showed modest interest in participating in the study, therefore increasing the risk of nonresponse bias. The low response rate justifies the need to conduct a large-scale study to ensure that the results of the present study are replicable. Nevertheless, the results of this pilot study are worth disseminating, as they show the feasibility of the flowcharts as an educational aid.

Second, the online mock examination included the same group of students who reviewed the questions twice—the first time without the flowchart and the second time with the flowchart. Therefore, the increased accuracy in diagnosing periodontal conditions and/or reduced duration of the examination could be at least, in part, a result of familiarity with the cases.

Third, this study responded to the students' feedback on avoiding excessively complicated charts and intentionally excluded local (e.g., dental prostheses, overhanging restorations, and tooth crowding), systemic (e.g., obesity and rheumatoid arthritis), and other contributory factors (e.g., traumatic occlusal forces, periodontal-endodontic lesions, abscesses, necrotizing soft tissue changes, systemic conditions affecting periodontal supporting tissues, various types of gingivitis, mucogingival conditions, and peri-implant conditions), as well as a distinction between localized and generalized conditions. To rectify these omissions and to address the students' suggestions for the development of an automated diagnostic tool, the authors of the study have developed and are currently testing application software that includes the entire spectrum of periodontal conditions, allowing for their comprehensive and accurate diagnosis.

Fourth, because the students took both examinations online, the efficiency of the flowcharts used chairside needs to be further explored.

Finally, since the study was performed in academic settings, the importance of its outcomes in non-academic settings (such as private practices) is unknown.

CONCLUSION

This study reported on the development of illustrative flowcharts, which consisted of several straightforward questions and answers leading to the suggested periodontal diagnosis of clinical gingival (periodontal) health, biofilm-induced gingivitis, periodontitis, and outcomes of periodontitis therapy. When tested among DS and DHS, the flowcharts significantly improved the accuracy of periodontal diagnosis in a time-efficient manner, especially among individuals with limited periodontal experience. The developed flowcharts may be used by DS, DHS, and dental faculty in academic settings to ensure a more accurate and time-effective diagnosis of periodontal conditions based on the 2017 classification.

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CONFLICTS OF INTEREST

The authors have declared no conflicts of interest associated with the study.

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Biomimetic hydroxyapatite and caries prevention: a systematic review and meta-analysis

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Studies show that biomimetic hydroxyapatite-containing, fluoride-free oral care products are effective in reducing dental decay.
- Dental hygienists can recommend fluoride-free, hydroxyapatite-containing oral care products to their clients to effectively reduce their risk of dental decay.
- For families seeking to limit their children's exposure to fluoridated oral products, dental hygienists can recommend fluoride-free, hydroxyapatite-containing toothpastes specially formulated for toddlers and preschool children.

ABSTRACT

Dental caries is still one of the most prevalent diseases worldwide. Research has shown that fluoride has a role in caries prevention. For many reasons there are concerns about young children using fluoride-containing oral care products. Consequently, there is a need to identify effective fluoride-free products. A large body of literature now exists on the use of biomimetic hydroxyapatite (HAP) as an active ingredient in oral care products to combat caries. **Aim:** To conduct a systematic review of the clinical evidence of the effects of HAP-based fluoride-free oral care products in caries reduction and conduct a meta-analysis of available randomized clinical trials (RCTs). **Methods**: Using the PICO question "In individuals of all ages (P), do fluoride-free oral care products containing HAP as the anti-caries agent (I), compared to products with fluoride or without caries control products (C), reduce the risk of dental caries (O)?" Ovid MEDLINE (PubMed), Scopus, EMBASE, and Web of Science databases were searched using the following keywords: apatite, hydroxyapatite, caries, dental decay, dentin(e), enamel, toothpaste, dentifrice, mouthwash, gels, biofilm, (dental) plaque, ero(de, ded, sion), (de, re)mineral(ise, ized, ised, ization, isation). Reviews, tooth whitening, tooth sensitivity, and in vitro studies were excluded. PRISMA was used for the search and GRADE was used to assess quality. Clinical trials were subjected to the Cochrane Risk of Bias assessment followed by meta-analysis. **Results**: 291 studies were retrieved; 22 were suitable for systematic review, 5 were clinical caries trials and 4 were RCTs. A meta-analysis of 3 RCTs was possible showing HAP provided 17% protection against caries. The other 17 trials had simpler proxy outcomes for anticaries effects. Some trials showed non-inferior performance of HAP products compared to those with fluoride. **Conclusion**: There is good evidence that hydroxyapatite in oral care products in the absence of fluoride effectively reduces caries.

RÉSUMÉ

La carie dentaire demeure l'une des maladies les plus répandues dans le monde. La recherche a montré que le fluorure joue un rôle dans la prévention des caries. Pour plusieurs raisons, l'utilisation de produits de soins buccodentaires contenant du fluorure chez les jeunes enfants suscite des inquiétudes. Par conséquent, un besoin existe de cibler des produits efficaces sans fluorure. Un grand éventail de littérature existe maintenant sur l'utilisation d'hydroxyapatite biomimétique (HAP) comme ingrédient dans les produits de soins buccodentaires pour lutter contre la carie. **Objectif :** Mener une revue systématique des données probantes cliniques sur les effets des produits de soins buccodentaires sans fluorure à base d'HAP pour la réduction de caries et réaliser une méta-analyse d'essais cliniques randomisés (ECR) offerts. **Méthodes :** Des recherches ont été effectuées dans les bases de données Ovid MEDLINE (PubMed), Scopus, EMBASE et Web of Science avec la question PICO : « Les produits de soins de santé buccodentaires qui contiennent de l'HAP à titre d'agent anti-carie (I) réduisent-ils le risque de caries dentaires (O) chez les personnes de tous les âges (P) en comparaison aux produits contenant du fluorure ou n'ayant aucun produit de contrôle de la carie (C)? Les mots clés suivants ont aussi été utilisés : apatite, hydroxyapatite, caries, carie dentaire, dentin(e), émail, pâte dentifrice, dentifrice, bain de bouche, gels, biofilm, plaque (dentaire), éro (der, dée, sion), (de, re) minéral (iser, isée, isation). Les analyses documentaires, ainsi que les études sur le blanchiment des dents, la sensibilité dentaire, et les études in vitro ont été exclus. PRISMA a été utilisé pour la recherche et le système GRADE a été utilisé pour évaluer la qualité. Les essais cliniques ont été sujets à l'évaluation de risques de biais de Cochrane suivis par une méta-analyse. **Résultats :** 291 études ont été repérées : 22 études étaient propices à la revue systématique, 5 étaient des essais cliniques sur les caries et 4 étaient des ECR. Une méta-analyse de 3 RCT a été possible montrant que l'HAP avait fourni une protection de 17 % contre la carie. Les 17 autres essais avaient des résultats de substitution plus simples pour les effets anti-carie. Certains essais ont montré une performance comparable des produits d'HAP par rapport à ceux contenant du fluorure. **Conclusion** : Il y a de bonnes preuves que l'hydroxyapatite dans les produits de soins buccodentaires, en l'absence de fluorure, réduit la carie de façon efficace.

Keywords: caries; caries prevention; dentin; early childhood caries; enamel; hydroxyapatite; meta-analysis; primary teeth; randomized clinical trial; systematic review; toothpaste

CDHA Research Agenda categories: risk assessment and management; capacity building of the profession

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INTRODUCTION

Despite advances in general oral health over the last few decades, dental caries continues to be a major health problem in Canadians, especially in children.[1] While many children never experience dental decay before the eruption of their permanent teeth, primary teeth in general are more susceptible to dental decay.[2] When one or more carious lesions are present in the primary dentition this is known as early childhood caries (ECC), which can range from mild to severe.[3] Severe ECC (type II or III) or nursing bottle caries can be caused by bottle feeding of infants with sugary beverages or even milk at night time.[4]

Caries is a worldwide problem occurring much too frequently in children with many etiological risk factors.[5] The number of day surgeries, which is between 8.8 and 24.3 per 100 children (ages 12 to 59 months) in Canadian hospitals due to ECC, is a good proxy for the prevalence of this disease.[6] While ECC is not associated with exposure to fluoride[7] there are some risk factors for ECC that can be mitigated. Improving oral hygiene habits, limiting sugar intake, and using new and effective toothpastes and toothbrushes, for example, are approaches that might improve the oral health of children as well as adults in Canada.[5]

For decades, fluoride has been the pre-eminent ingredient in consumer products to prevent dental caries. The evidence that fluoridated toothpaste significantly reduces caries is well documented.[8,9] It is now widely accepted that fluoride prevents dental decay by encouraging topical remineralization of early white spot, incipient lesions. New non-fluoride remineralization strategies have emerged that seem to be promising.[10]

The primary concern with fluoridated toothpastes used by children under age 6 is the increased risk of dental fluorosis from fluoride ingestion.[9,11] It was established years ago that children under age 3 are unable to expectorate toothpaste efficiently and they tend to swallow significant proportions of the toothpaste placed in their mouth.[12] A recent update by the Centers for Disease Control and Prevention in the United States showed that preschoolers and toddlers were still being exposed to greater than recommended amounts of fluoridated toothpaste early in life.[12] Ingestion of fluoride during development of the permanent teeth (birth to age 6 years) results in varying degrees of dental fluorosis.[13,14] Dental professionals routinely advise their clients that fluoridated toothpaste use should be limited to a pea-sized amount in 3 year olds and even less for babies and toddlers.[15,16] A pea-sized amount is approximately 0.25 g of toothpaste but children still use more toothpaste, and the majority of those ages ≤3 years use it 2 times a day or more often.[17] There is no direct evidence that these smaller amounts of toothpaste can prevent cavities: the "rice-sized smear" may even be ineffective in preventing caries formation.[18] There is not only concern about dental fluorosis from too much fluoride ingestion from all sources in early developmental ages, but recent studies indicate that there may also be concern about fluoride's potential neurotoxicity on developing brains.[19–21]

Dental manufacturers are continually improving dental products for use by consumers at home. Old formulations are refined and new formulations developed with the goal of improving the oral health of the population. Toothpaste manufacturers have reformulated and rebranded their products to focus on trends in cosmetic and preventive oral health care. These include antiplaque, antitartar, antigingivitis, remineralization, whitening, breath freshening, antisensitivity, and anti-erosion claims.[22] However, most of these products continue to contain fluoride for basic caries prevention. Products validated by the Canadian Dental Association are listed on the Canadian Dental Association's website.[23]

Hydroxyapatite (HAP) is the primary calcium phosphate mineral in human mineralized tissues, i.e., teeth and bones. Calcium phosphate crystallites, including HAP, have been extensively studied and determined to be biocompatible in humans. They are non-toxic when swallowed, at least in doses that are normally applied during toothbrushing.[24] HAP has been successfully used as a biocompatible (biomimetic) active mineral to encourage better bone healing[25] and implant placement.[26] Biomimetic means that the synthesized material exhibits chemical–physical features close to those found in the human body. Hydroxyapatite crystals can be synthesized to the same formulation as found in the mineralized tissues of dentin and enamel and can be made to resemble the same crystal structure. However, not all hydroxyapatite-based materials are biomimetic.[27] Since HAP generally is biocompatible with and beneficial to mineralized tissues it would seem logical to add it to toothpaste to benefit tooth enamel and dentin.[28] After thorough testing, HAP-containing toothpastes were first approved for sale in Japan in the 1980s to treat dentin hypersensitivity and for caries prevention.[29]

One of the roles of dental hygienists is to provide evidence-based recommendations in their practice to improve oral health. The purpose of this systematic review is to highlight the extent of the literature and, in particular, the state of the evidence from clinical trials on the oral health benefits of biomimetic hydroxyapatite. In addition, this review is the first meta-analysis of clinical caries trials on HAP toothpaste. As fluoride has been determined to be a suitable anticaries agent for all ages, this study sought to examine the literature on HAP's anticaries effects in clients of any age to determine its universal application. Of particular interest, though, was the evidence for its benefit in children so that fluoride-free oral care products specifically formulated for young children (toddlers, preschoolers, and children in grade school) might be recommended.

METHODOLOGY

The PICO framework

The PICO framework was used to guide the focus of this review.

- **P** (*Patient, Problem, Population*): clients of all ages, with primary, mixed or permanent dentitions.
- **I** (*Intervention*): the introduction of one of the following oral care products containing biomimetic hydroxyapatite as an active ingredient: toothpaste, mouthwash or gel.
- **C** (*Comparison, Control*): hydroxyapatite free oral care products versus fluoride-containing products, placebo or no intervention.
- **O** (*Outcome*): a measurable oral health effect that is either a direct measurement of reduced dental decay or a suitable proxy for reduced caries risk.

Databases searched

Following the PRISMA guidelines for literature searches[30] (Supplemental Table S1, available at cjdh.ca), Ovid MEDLINE (PubMed), EMBASE, Scopus, and Web of Science were chosen as the primary databases. The University of Toronto Library provided the databases and the electronic journals from which full texts and supplementary information were extracted for each publication. FM and JE independently collected full papers from their literature searches and all authors agreed on the final list of selected publications. Google Scholar was also searched to check for any publications that were missed on the broad search. HL scanned the titles of all papers in all the databases; FM and JE searched PubMed independently and produced almost the same list of publications to screen. The search was not limited to English-language publications. Any foreign language publication was included if it was considered relevant to the review. FM and JE translated the full texts that were in German, and the publications in Korean and Russian were translated by HL with the help of Google Translate.

The authors searched the literature up to and including March 15, 2021, using the following inclusion and exclusion criteria. Studies on animals were excluded from the review. Those conducted in vitro were extracted and read in full to understand proof of concept for HAP as an effective anticaries agent for use in the oral cavity. However, these studies were also excluded from the systematic analysis. All studies that were conducted in vivo in humans, which had any implication of an anticaries effect on the dentition were included in the qualitative synthesis. Studies that focused on tooth whitening and desensitization of teeth, although showing important tooth enamel interactions, did not meet the inclusion criteria. Clinical trials and in vivo experiments examining effects of HAP on dental biofilm

Table 1. Summary of clinical trials of anticaries effects of hydroxyapatite (HAP) with GRADE assignments

Study author (country)	Subjects	HAP product	Controls	Study design & length	Experimental conditions
Paszynska et al. 2021[36] (Poland)	177 children, ages 3 to 7 years	Kinder Karex (10% HAP)	Elmex Kinder Zahnpasta (500 ppm fluoride)	Randomized clinical caries trial one year	New caries measured using ICDAS[b]
Grocholewicz et al. 2020[37] (Poland)	92 subjects Age ranging from 20 to 30 years Mean age 23.3 years	ApaCare Repair (10% HAP gel)	1. Ozone (OzonyTron application) 2. HAP gel + ozone No non-treatment control	Randomized clinical caries trial 2 years	Interproximal digital radiography of incipient caries remineralization
Badiee et al. 2020[38] (Iran)	50 subjects after orthodontics 10 years to 35 years old (173 teeth)	6.7% HAP toothpaste formulated for the trial	Fluoride toothpaste positive control	Randomized clinical caries trial 6 months	Remineralization of white spot lesions measured using ICDAS, DIAGNOdent, photographic pixel changes
Schlagenhauf et al. 2019[39] (Germany)	150 subjects ages 12 to 25 years	Karex (10% HAP)	Toothpaste containing 1400 ppm fluoride (amine fluoride + stannous fluoride)	Randomized clinical trial 6 months	New caries measured using ICDAS
Kani et al. 1989[40] (Japan)	181 children in grade school	Apato toothpaste (5% HAP)	Placebo (Kirara; HAP and fluoride free)	Clinical placebo-controlled trial comparing groups Randomization of individuals not possible 3 years	Teacher supervised after-lunch tooth brushing No extra preventive care instructions given

[a]The quality of the evidence and grade graphics are based on Richards[32]
[b]ICDAS: International Caries Detection and Assessment System (see ref. 36)
[c]DMFT: decayed missing filled teeth

and enamel surfaces were considered to have sufficient proxy for anticaries effects. Studies conducted in situ in humans that tested for remineralization of enamel blocks imbedded in prostheses were considered similar in terms of clinical anticaries evidence to clinical trials.

Qualitative synthesis

Qualitative synthesis was conducted on the included studies. The caries clinical trials were suitable for Cochrane Risk of Bias (RoB) analysis and meta-analysis. For the RoB analysis, study authors used the methods of Sterne[31] and the guidance and graphics provided by Richards.[32]

Quantitative synthesis and meta-analysis

For the meta-analysis, caries incidence was used to calculate a weighted odds ratio on the caries preventive effect of the hydroxyapatite group. The null hypothesis tested in the clinical trials was that HAP-containing toothpaste did not affect the incidence of caries compared to the control. The ratios were weighted based on the number of participants included in the respective study. The odds ratio was used for the meta-analysis. Both odds ratio and meta-analysis were calculated using the open source software R, version 3.6.3. In addition to the standard R packages, this study used the packages *oddsratio* and *forestplot*.[33,34]

RESULTS

There were 12,042 studies that mentioned "hydroxyapatite" and "caries"; 23,024 mentioned "hydroxyapatite" and "enamel." After the search protocol was applied and duplicates and irrelevant papers were excluded, the authors identified 291 publications relevant to HAP in oral care products in the prevention of dental diseases. The details of the search are provided in Supplemental Table S2; Supplemental Table S3 lists all 291 publications found as well as the focus and experimental design of each study (both are available at cjdh.ca). All 291 studies were read in full. The authors determined that 269 publications were not suitable for this systematic review because they were either reviews or their focus was on tooth whitening or desensitization, rather than specific HAP anticaries mechanisms. A large proportion of the studies were experiments conducted in vitro showing that HAP interacts favourably with tooth surfaces, suggesting HAP could be a useful anticaries agent. While all 291 publications are relevant for understanding how HAP interacts with enamel and why it may have an anticaries effect on human teeth, only 22 addressed the PICO framework of the current study. Figure 1 summarizes the search results and criteria used to extract the studies for the systematic review.

Blinding	Examiner calibration	Conclusions	Comments	Quality of evidence[a]	GRADE graphic[a]
Double blinded	Kappa = 0.91 to 0.93	Caries progression in primary teeth was slowed by the fluoride control toothpaste; the HAP toothpaste was not inferior to the fluoride control toothpaste	A well-conducted head-to-head RCT of good length using a state-of-the-art caries measurement (ICDAS) Subjects were young children with primary dentitions	HIGH	●●●●
Single blinded	Not reported	HAP gel provided significant remineralization effects (reversed caries), which was enhance by ozone treatment	A well-conducted RCT of good length using a superior measurement of reversal of proximal caries	HIGH	●●●●
Single blinded	Not reported	Both pastes significantly reduced enamel white spot lesions HAP toothpaste outperformed the fluoride toothpaste in remineralizing white spot lesions	A well-conducted RCT with unique measurements for incipient caries reversal Subjects included some children	HIGH	●●●●
Double blinded	Kappa = 0.80	Karex with HAP works as well as regular strength fluoride toothpaste in preventing progression of caries in high risk clients	Head-to-head RCT against fluoride using an improved caries monitoring system (ICDAS) Subjects included some children	HIGH	●●●●
Not reported	Not reported	Significant reduction in DMFT[c] by HAP toothpaste after 3 years	Longest trial, measured caries progression using DMFT Subjects were children in grade school	MODERATE	●●●

Figure 1. Flow diagram summary of systematic review search strategy and results

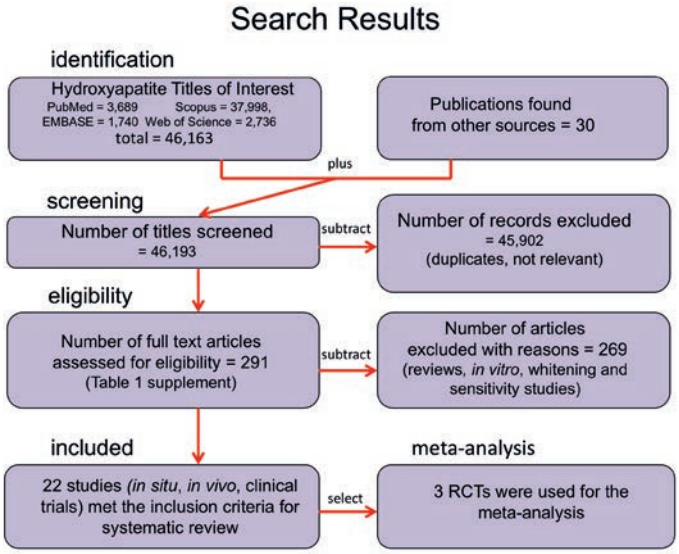
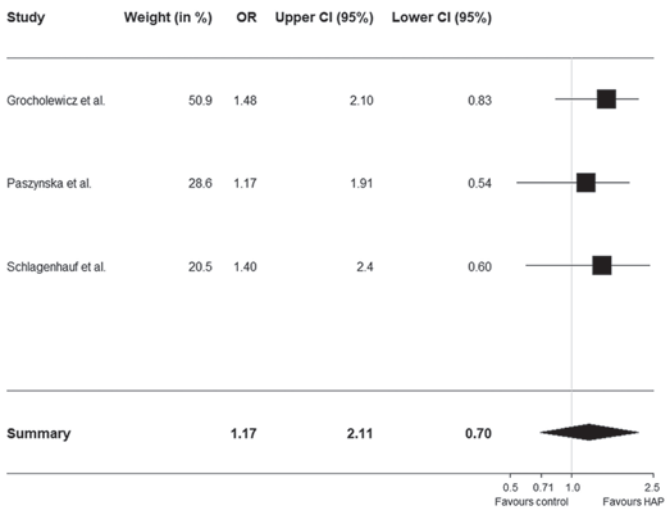


Figure 2. Forest plot of the meta-analysis results of 3 RCTs of hydroxyapatite toothpaste



OR: odds ratio; CI: confidence interval. The diamond indicates the overall magnitude of the combined trials showing that caries reduction favours HAP toothpaste.

PubMed, EMBASE, and Web of Science produced different search results that ranged from 1,740 (EMBASE) to 2,736 (Web of Science) to 3,689 (PubMed/MEDLINE). The Scopus search, in contrast, produced 10-fold more publications than PubMed of potentially relevant papers (37,998 titles) when the search was conducted for "all fields." After screening all 4 data sources and eliminating duplicates, as well as adding 30 publications that were not found in the databases, 291 publications clearly indicated an anticaries role for HAP in oral care products. Many open access publications in peer-reviewed journals not listed in PubMed were found in Scopus and Web of Science databases, indicating that these sources are important to screen for relevant publications. Administering the inclusion criteria, the 291 publications were further reduced to 22 studies. This smaller group of studies showed that HAP in oral care products has antibacterial properties or interferes with dental biofilm accumulation, has enamel and dentin remineralization effects, prevents tooth surface demineralization or erosion, has favourable deposition on tooth surfaces and biofilm, and provides calcium and phosphate deposits or release of these ions in biofilm and saliva. Among those 22 studies, 5 clinical trials reported the direct measurement of anticaries effects in young adults and children after exposure to HAP toothpaste. Four of those trials were well-conducted, randomized controlled clinical trials (RCTs). The 5 trials were used in the RoB analysis; 3 of them reported enough information and were similar in clinical design to permit a quantitative synthesis (meta-analysis) using the R-statistics program as described in the Methods.

An additional study that used a questionnaire to ask clients about the subjective improvements to their oral health after using HAP toothpaste was found but it[35] was deemed unsuitable for the systematic analysis. Table 1 summarizes the details of the 5 clinical caries trials that were included in the RoB and meta-analysis.

Four of the five clinical studies were well-conducted, randomized, single or double blinded clinical trials on HAP-containing toothpaste. All were conducted in children or young adults. They were rated according to the GRADE graphics ratings following the recommendations of Richards[32] for use in reviews in dentistry. The ratings were determined on the basis of the power of the trial design (e.g., sample size), method of randomization, the level of blinding, length of the trial, placebo controls, positive controls (comparison to the known positive benefits of fluoride toothpaste), whether the differences were statistically significant (strength of the findings), and whether the outcome supported the mechanism of reduction in dental caries.

The RoB analysis based on Sterne et al[31] of the 5 clinical trials indicated that 4 of the 5 clinical trials had low risk of bias (Table 2). The Japanese placebo-controlled trial by Kani et al[40] could not have been blinded and did not provide enough information so it was deemed to have high risk of bias.

A meta-analysis was performed on 3 of the 4 well-conducted clinical trials. The trial conducted by Badiee et al[38] did not provide enough data to estimate an odds ratio and was therefore excluded. The meta-analysis of 3 HAP toothpaste anticaries RCTs is shown in Figure 2.

In vivo evidence

Studies in vivo and in situ of benefits of HAP-containing oral care products on the reduction of risk of dental decay are summarized in Supplemental Table S4 (available at cjdh.ca).

The qualitative synthesis comprised 17 human studies. There were 8 in vivo trials, 5 of which showed antiplaque properties of HAP. Four of the studies were RCTs. One in vivo trial showed how HAP improves the calcium/phosphate deposits in biofilm. One in vivo trial showed how HAP protects against acid erosion, and another showed favourable HAP deposits on enamel surfaces. There were 9 trials conducted in situ; 2 showed biofilm reduction on tooth blocks worn in situ and 7 measured the effects of HAP on the remineralization of enamel or dentin blocks exposed in the oral cavity or the researchers measured the protection against acid erosion. Three in vivo trials (biofilm reduction) were conducted on children, and 3 studies examined human primary enamel blocks imbedded in appliances worn in situ by adult volunteers. Except for one study that used human enamel from adult teeth, the remaining in situ studies involved bovine enamel and dentin blocks worn in adults as well as other blocks made from materials commonly found in the oral cavity, such as titanium.

This variety of experimental designs made it difficult to conduct a quantitative synthesis of the data. The heterogeneity, however, did not diminish the evidence from the individual studies in Supplemental Table S4 for anticaries properties of the active ingredient HAP in the oral care products under investigation. Each study was assessed for the quality of the trial and whether the results supported the conclusions presented.

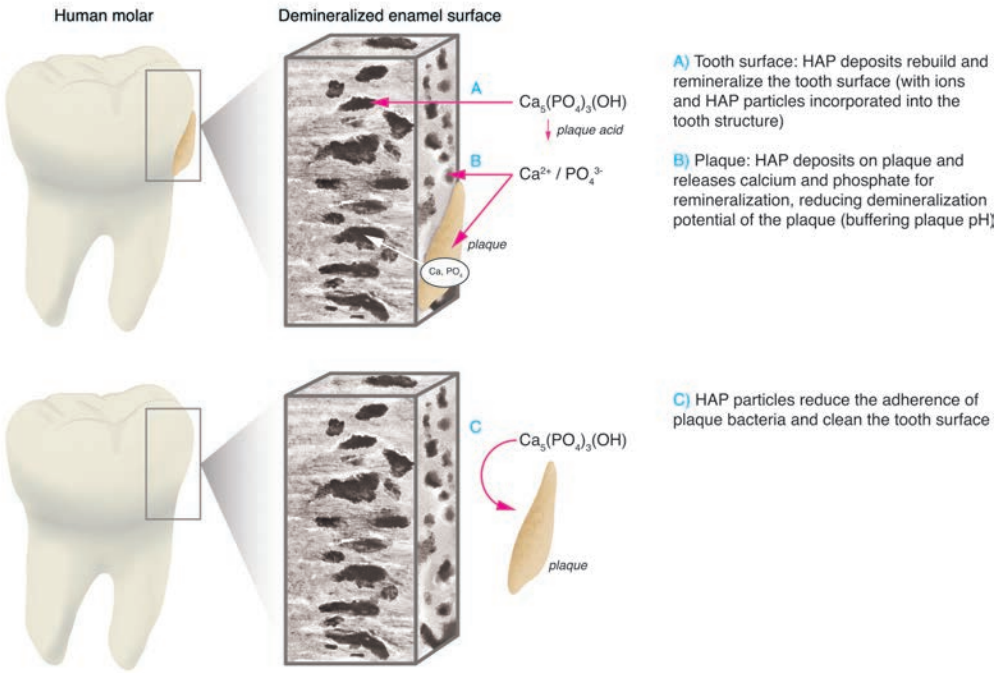
DISCUSSION

The studies on the benefits of HAP toothpaste have been largely ignored in the United States and Canada perhaps because of a lack of available toothpastes and funding for research. In 2015, Oral Science's X-Pur Remin™ was the first Canadian fluoride-free HAP adult toothpaste to be approved for sale for the purpose of reducing dental decay.[58] A handful of others listed with Health Canada containing the ingredient calcium phosphate hydroxide (a different way of saying hydroxyapatite) have been approved since then. No HAP toothpaste has been formulated specifically targeting children under the age of 2 years.

Mechanism of action of HAP

Previously Enax et al[59] proposed the mechanisms of action between HAP and the tooth surface. Figure 3 shows how HAP prevents demineralization of enamel, promotes

Figure 3. Diagrammatic summary of how hydroxyapatite functions to reduce the risk of caries



A) HAP particles penetrate enamel defects on the surface and below the surface to adhere to existing enamel structure. B) The ions produced as a result of biofilm acid dissolution of some HAP particles also contribute to the remineralization of enamel as it repairs after the acid attack is over. Some of the acid is buffered by HAP. In addition, those ions deposited in biofilm contribute to the rebuilding of tooth structure. C) HAP particles have been shown to bind to biofilm bacteria, inhibit their activity, and act as an abrasive to prevent biofilm accumulation. All 3 mechanisms serve to reduce the risk of caries progression in the dentition.

Table 2. Risk of Bias (RoB) analysis of the clinical trials on hydroxyapatite from Table 1

Bias domain and signalling question	Paszynska et al. 2021[36]	Grocholewicz et al. 2020[37]	Badiee et al. 2019[38]	Schlagenhauf et al. 2019[39]	Kani et al. 1989[40]
RANDOMIZATION					
Was the allocation sequence random?	Y	Y	Y	Y	N
Was the allocation sequence concealed until the participants were assigned to the intervention?	PY	PY	NI	PY	N
Did the baseline difference suggest a problem with the randomization process?	N	PN	NI	N	PY
Risk of bias judgement[a]	+	+	?	+	-
DEVIATIONS FROM INTENDED INTERVENTIONS					
Were participants aware of the assigned intervention?	N	Y	N	N	PN
Were people delivering interventions aware of the participants' assigned intervention?	N	Y	PN	N	Y
If yes, were there deviations from the intended intervention that arose because of trial context?		N			Y
If yes, were these deviations likely to have affected the outcome?					N
If yes, were these deviations balanced between the groups?					
Was an appropriate analysis used to estimate the effect of assignment to intervention?					
If no, was there potential for substantial impact on the result?	Y	Y	Y	Y	PN
Risk of bias judgement	+	?	+	+	-
MISSING OUTCOME DATA					
Were data for this outcome for all or nearly all participants randomized?	Y	Y	PY	Y	N
If no, is there evidence that the result was not biased by missing outcome data?					NI
If no, could the absence of outcome data depend on its true value?					NI
Risk of bias judgement	+	+	+	+	-
MEASUREMENT OF THE OUTCOME					
Was the method of measuring the outcome appropriate?	Y	Y	Y	Y	Y
Could measurement of the outcome have differed between intervention groups?	N	N	N	N	PN
If no, were outcome assessors aware of the intervention received by the study participants?	N	Y		N	Y
If yes, could assessment of the outcome have been influenced by the knowledge of if the intervention was received?					
If yes, is it likely that this occurred?		N			PN
Risk of bias judgement	+	+	+	+	?
SELECTION OF THE REPORTED RESULT					
Were the data that produced the results analysed in accordance to the prespecified analysis plan that was finalized before unblinded outcome data were available for analysis?	Y	NI	NI	Y	NI
Is the numerical result being assessed likely to have been selected, on the basis of the results, from:					
a) multiple eligible outcome measurements?	N	N	N	N	NI
b) multiple eligible analyses of the data?	N	N	N	N	NI
Risk of bias judgement	+	+	+	+	-

Table 2. *continued*

Bias domain and signalling question	Paszynska et al. 2021[36]	Grocholewicz et al. 2020[37]	Badiee et al. 2019[38]	Schlagenhauf et al. 2019[39]	Kani et al. 1989[40]
OVERALL BIAS	+	+	+	+	-

[a]Risk of bias judgement was based on RoB2 by Sterne et al.[31]
Y: yes; N: no; PY: probably yes; PN: probably no; NI: not indicated; Low risk: + questionable risk: ? high risk: -

Table 3. Fluoride-free toothpaste brands[a] suitable for children, their availability, and their ingredients

	Availability in Canada	Active ingredient	Sweeteners	Biofilm disrupters	Other ingredients
Fluoride-free toothpastes with HAP marketed to children					
Kinder Karex (Dr. Kurt Wolff GmbH & Co. KG, Johanneswerkstr. 34-36, 33611 Bielefeld, Germany)	International online import	10% hydroxyapatite (HAP)	xylitol	silica HAP SMCT (sodium methyl cocoyl taurate)	cellulose gum aroma 1,2-hexanediol caprylyl glycol hydrogenated starch hydrolysate sorbitol
Risewell Kids (Risewell. 82 Beaver Street New York, NY 10005 USA)	Online import from the USA	hydroxyapatite (HAP)	xylitol stevia rebaudiana extract erythritol sorbitol	silica calcium carbonate Echinacea Purpurea extract	glycerin propanediol vanilla planifolia fruit extract potassium cocoate cellulose gum gluconate xanthan gum
Biorepair™ Kids 0/6 Age with Peach Extract (COSWELL SPA Via P. Gobetti n. 4 – 40050 Funo di Argelato (BO), Italy)	Online import	15% hydroxyapatite (HAP)	sorbitol sodium saccharin	silica sodium myristoyl sarcosinate sodium methyl cocoyl taurate	glycerin zinc PEG-32 cellulose gum aroma (fragaria vesca juice, anethole, menthol, mentha piperita oil) citric acid sodium benzoate potassium sorbate phenoxyethanol benzyl alcohol
Fluoride-free calcium-based toothpaste					
X-Pur Remin™ (Oral Science. 9575-C, Ignace Street Brossard, QC J4Y 2P3)	Drug stores (Shoppers Drug Mart, London Drugs by request) Online shipping from the manufacturer	10 % hydroxyapatite (HAP)	xylitol	zeolite itanium oxide cetylpyridinium chloride	dimethyl silicic anhydride PEG 400 polyvinylpyrrolidine glycyrrthenic acid glycerin castor oil sodium lauroyl glutamate carragenan ethanol flavour CMC

Table 3. *continued*

	Availability in Canada	Active ingredient	Sweeteners	Biofilm disrupters	Other ingredients
Fluoride-free calcium-based toothpaste					
MI Paste (GC America Inc. 3737 W 127th St, Alsip, IL 60803, USA) Only "MI Paste Plus" with fluoride is currently a registered trademark (TM) in Canada	Dental offices Order directly from the USA	casein phosphoprotein-amorphous calcium phosphate (CPP-ACP)	D-sorbitol Na-Saccharin xylitol	CPP-ACP Ti, Zn, Mg oxides	glycerol guar gum carboxymethyl cellulose propylene glycol propyl, butyl p-hydroxybenzoate
Non-HAP fluoride-free "training toothpaste"					
Colgate™ fluoride-free toothpaste (Colgate-Palmolive Canada Inc. 2 Morneau Shepell Centre, 6th Floor, 895 Don Mills Road, Toronto, ON M3C 1W3)	Drug stores Grocery stores Online orders	green tea extract baking soda	xylitol	papain silica sodium lauryl sulfate	polyethylene glycol-12 cellulose gum benzyl alcohol
Orajel™ fluoride-free toothpaste (Church & Dwight Canada 5485 Ferrier St, Mount Royal, QC H4P 1M6)	Drug stores Grocery stores Online orders	none	sodium saccharin sorbitol	poloxamer 407	simethicone propylene glycol glycerin cellulose gum citric acid aroma
Crest™ Baby Training Toothpaste (Procter & Gamble Inc. PO Box 355, Station A Toronto, ON M5W 1C5)	Drug stores Grocery stores Online orders	none	xylitol	none	glycerin propylene glycol carbomer sodium benzoate sodium hydroxide flavour
Burt's Bees™ Baby Fluoride-Free Toothpaste (The Burt's Bees Products Co. 1221 Broadway, Oakland, CA 94612, USA)	Drug stores Grocery stores Online orders	none	stevia rebaudiana extract	hydrated silica titanium dioxide	glycerin sodium cocodyl glutamate aroma xanthan gum carrageenen

[a]Products listed with a trademark symbol (™) have registered their names in Canada.

remineralization, and interferes with dental biofilm.

Based on the evidence published to date one can conclude the following:

1. Biomimetic HAP particles rebuild tooth mineral.
2. HAP reverses and remineralizes early carious lesions by providing the ions (calcium and phosphate) required for remineralization.
3. HAP provides additional calcium and phosphate in saliva and biofilm for improved remineralization conditions in the oral cavity. Adding calcium and phosphate to biofilm is an important mechanism for remineralization.[60,61]
4. HAP works differently from fluoride and works at least as well as fluoride in preventing dental decay in the primary and secondary dentitions.

Fluoride-free oral care products containing HAP as an active ingredient can be obtained in Canada but none are sold over the counter, whereas fluoridated toothpastes dominate the toothpaste aisles. Table 3 lists a selection of fluoride-free toothpaste brands that can be obtained in Canada. There are other fluoride-free toothpastes with HAP available internationally by online order but they are not formulated for children under 2 years. There are also many fluoride-free toothpastes for adults and children that

have natural ingredients but they have not been tested against fluoride toothpastes for caries reduction in clinical trials. Some fluoride-free training toothpastes sold in Canadian stores for use in babies and toddlers are included in the table for comparison but none have been shown to be effective against dental decay.

There have been many studies on the benefits of calcium and phosphates added to fluoride toothpastes and professional fluoride products, but this review focused on hydroxyapatite added to oral care products without fluoride. Some of the evidence in support of the anticaries effects of HAP oral care products was obtained in adults. Because of the concern for fluoride toxicity in infants, toddlers, preschoolers, and children who still have most of their primary teeth, the US Food and Drug Administration (FDA) required warning labels on toothpaste starting in 1997. The American Dental Association took this into consideration by lowering the recommended amount of toothpaste on the toothbrushes for toddlers under age 3 years.[16] A simple and convenient solution to the problem is to substitute fluoride in toothpastes targeted for young children with an effective and safe anticaries agent. Some fluoride-free toothpaste formulations have been tested in school-based, once-a-day exposure clinical trials and not surprisingly, due to the absence of any active ingredient or avoidance of fluoridated products at home, they did not show much of an additional benefit.[62]

In a recent review of the non-fluoride formulations for caries prevention in the primary dentition, Wang et al.[63] reviewed arginine, chlorhexidine, triclosan, and xylitol, but did not mention any study on HAP. Some of the evidence reviewed was on dental products other than toothpaste (e.g., xylitol wipes, arginine-containing mint confections). Their conclusion was that there is a need for high-quality randomized controlled trials to make any recommendations. The same conclusion was reached by Philip[64] who published a review on non-fluoride enamel remineralization in which it was mentioned that there was some evidence that HAP by itself had anticaries properties. However, the author also noted that RCTs were lacking. In fact, the original placebo-controlled 3-year clinical trial that was published in 1989 by Kani et al[40] was not mentioned because it is not found in PubMed.

In a 2018 review by Epple et al.[24], the safety of calcium phosphates, including biomimetic HAP, was reviewed and it was concluded that HAP can be safely swallowed when used in oral care products. Hydroxyapatite is an active biomimetic crystallite that has been shown to prevent caries in the primary dentition with similar results to fluoridated toothpaste. HAP-containing toothpastes specially formulated for babies, toddlers, and young children have been available in Europe and in the US by online order. None have been approved in the US for the "anticaries" claim that is afforded the fluoride toothpastes sold in that country. However, in Canada, X-Pur Remin™ toothpaste by Oral Science has a Health Canada-approved anticaries claim.[58] Although this toothpaste is approved for use in children over 2 years of age, it is not specifically formulated for toddlers ages 6 months to 2 years.

The Canadian market is ready for additional HAP toothpastes for use in babies after their first primary teeth erupt (age 6 months), in toddlers who swallow toothpaste, in pre-schoolers, and in young children (see Table 3 for a list of toothpastes for toddlers). HAP toothpastes will reduce the risk of dental fluorosis and other potential health complications from ingestion of too much fluoride at a very young age. In addition, HAP has been shown to be safe if accidentally swallowed, reassuring parents of babies and toddlers that toothpastes made with this active ingredient are safe to use as soon as the primary teeth erupt. Having a toothpaste that is not only safe to use but also as effective as a fluoride toothpaste is a good way to encourage oral hygiene and at the same time protect newly erupted primary teeth from dental decay. There are clinical trials showing that HAP added to fluoride-containing toothpaste improves the anticaries effectiveness of fluoride but these were not included in this systematic review. The current study was interested in only those trials showing that HAP independently had anticaries effects. Oral health professionals should now feel more comfortable recommending fluoride-free oral care products containing just HAP as the active ingredient. Even so, more RCTs comparing HAP with fluoride as anticaries agents are needed to bolster the support that dental hygienists and dentists may already have for HAP as an alternative to fluoride for reducing caries. This systematic analysis provides an up-to-date, thorough review of the evidence that HAP is an effective anticaries agent in oral care products and provides the first meta-analysis of clinical trials on the anticaries effects of HAP toothpaste.

Included in this systematic review were studies that used Biorepair™, a HAP-containing toothpaste that is supplemented with zinc. Although HAP itself has antiplaque properties, it should be noted that zinc adds to the antibacterial properties when combined with HAP in toothpaste and mouthwash. The studies by Wierichs,[42] Bossù,[45] Al Asmari,[47] Hagenfeld,[48] Kensche,[50] Harks,[51] Hegazy,[52] Lelli,[55] and Hannig[56] (Supplemental Table S4) used Biorepair™ in their experiments.

Limitations

This systematic review was based on the assumption that caries evaluation was consistent across the studies, as sources of heterogeneity were difficult to identify. Thus, an analysis of heterogeneity was not performed due to the limited number of similar studies. In addition, there were inherent difficulties with statistical analysis given that the studies themselves were the unit of analysis, and even when appropriate weights were used, the authors were unable to determine how random effects might influence the meta-analysis.

CONCLUSION AND RECOMMENDATION

Based on this systematic review and meta-analysis, it can be concluded that biomimetic hydroxyapatite-containing, fluoride-free oral care products are effective in reducing dental decay, especially in children. Additional RCTs similar to those included in this review would strengthen this conclusion and validate the extent of the effect.

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CONFLICTS OF INTEREST

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Exploring barriers to oral health care experienced by individuals living with autism spectrum disorder

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Dental hygienists should be aware of barriers faced by individuals with ASD and methods to overcome them to improve access to oral health care.
- Integrating special care education into dental and dental hygiene curricula can help educators provide future dental professionals with additional educational experiences and increased confidence in working with special care populations.

ABSTRACT

Background: Autism spectrum disorder (ASD) is a developmental disorder that affects behaviour and communication skills. ASD is estimated to affect approximately 1 in 66 Canadians, with symptoms typically arising within the first 3 years of life. Individuals with ASD present with an increased burden of disease and face heightened barriers to oral care. **Objective**: This narrative literature review aims to raise awareness of the additional needs that individuals with ASD have when seeking oral care and to identify how barriers to such care may be reduced. **Methods**: Twenty-one articles were included in this review, with a wide range of study designs and methodologies. Search terms in PubMed, Education Source, and CINAHL databases included autism spectrum disorder, barriers, dental, dental hygiene, developmental disability, oral health, and unmet needs. **Results and discussion**: Key themes that emerged as barriers to care were behavioural challenges, inhibited social and communication skills, parental dependence, clinic environment, and abilities of oral health professionals to treat clients with special care needs. **Conclusion**: Current literature reveals that individuals with ASD face numerous barriers when accessing oral care and attempting to achieve adequate oral health, thus contributing to an increased burden of disease. Oral health professionals should aim to improve their understanding of special care populations such as the ASD community and raise awareness among health care professionals to work towards diminishing the barriers to care these populations experience.

RÉSUMÉ

Contexte : Les troubles du spectre autistique (TSA) sont des troubles du développement qui affectent le comportement et les capacités de communication. On estime que les TSA touchent environ 1 Canadien sur 66, et les symptômes se manifestent typiquement au cours des 3 premières années de la vie. Les personnes atteintes de TSA sont confrontées à un fardeau accru de maladies et à des obstacles plus importants en matière de soins buccodentaires. **Objectif :** La présente revue narrative de la littérature vise à susciter une prise de conscience des besoins supplémentaires qu'ont les personnes atteintes de TSA lorsqu'elles cherchent des soins buccodentaires et à cibler les façons qui permettent de réduire les obstacles à obtenir ces soins. **Méthodes :** Vingt-et-un articles comprenant un vaste éventail de modèles et de méthodologies d'études ont été inclus dans cet examen. La recherche dans les bases de données PubMed, Education Source et CINAHL comprenait les termes : troubles du spectre de l'autisme, obstacles, dentaire, hygiène dentaire, déficience développementale, santé buccodentaire et besoins non satisfaits. **Résultats et discussion :** Les thèmes clés qui ont émergé comme étant des obstacles aux soins buccodentaires étaient : les défis comportementaux, l'inhibition des aptitudes sociales et de communication, la dépendance parentale, l'environnement clinique et la capacité des professionnels de la santé buccodentaires à traiter les clients ayant des besoins spéciaux en matière de soins. **Conclusion :** La littérature actuelle révèle que les personnes atteintes de TSA font face à de nombreux obstacles lorsqu'elles accèdent aux soins buccodentaires et essaient d'atteindre une santé buccodentaire adéquate, ce qui contribue à un fardeau accru de maladies. Les professionnels de la santé buccodentaires devraient viser à améliorer leur compréhension des populations ayant des besoins de soins spéciaux, comme les personnes atteintes de TSA et à conscientiser les professionnels de la santé afin de réduire les obstacles aux soins auxquels sont confrontés ces populations.

Keywords: autism spectrum disorder; barriers; dental; dental hygiene; developmental disability; oral health care; unmet needs
CDHA Research Agenda category: access to care and unmet needs

INTRODUCTION

Autism spectrum disorder (ASD) is a developmental disorder affecting communication skills and behaviour, with signs and symptoms typically arising within the first 3 years of life.[1] Caregivers of children with ASD tend to notice atypical behaviours, such as a lack of response to the caregivers' presence, voice or touch, or disinterest in social interaction with peers, and delayed development in speech and communication.[1,2] Repetitive movements,

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avoidance behaviours, and the presence of comorbidities such as seizure disorders, sleep disturbances, diabetes, cardiovascular diseases, and gastrointestinal disorders are commonly noted as well.[1-4]

In 2020 an estimated 1 in 54 children were diagnosed with ASD in the United States, while the most recent Canadian statistics from 2018 reported a diagnosis in 1 in 66 children, with males 4 times more at risk than females.[5,6] The increase in ASD diagnoses over the last few decades may be a result of greater awareness of indicators of ASD among parents and health professionals and improvements in diagnostic tools and assessments rather than a true increase in prevalence.[7] Although the etiology of ASD is unknown, risk factors may include a genetic component, being born to older parents or low birth weight.[5] ASD is considered a spectrum disorder because it presents differently across individuals.[8] Because of this variability, signs and symptoms range from mild to extreme, but typically include difficulty interacting in social situations, difficulty adjusting to changes in routine, repetitive behaviours, and elevated sensitivity to sensory input such as light and noise.[8] Historically, diagnoses of autism were further categorized into subdiagnoses of autistic disorder, Asperger syndrome, pervasive developmental disorder not otherwise specified, and disintegrative disorder.[9] However, the diagnostic criteria in the latest edition of the *Diagnostic and Statistical Manual of Mental Disorders* now combines these subcategories into one diagnosis of autism spectrum disorder to allow for a diagnosis better supported by research and clinical experiences.[9]

Literature indicates that individuals of all ages with ASD present with a high burden of oral disease, with caries and periodontal disease being the most prevalent disorders.[10-13] Oral issues may be associated with ASD-related behaviours that inhibit adequate maintenance of oral health.[14] Communication limitations, personal neglect, dietary habits, medication side effects, resistance to receiving oral care, and avoidance of social contact can affect the oral health of individuals with ASD.[14] Research shows that food selectivity and refusal are more common among children with ASD than their typically developing counterparts, which can contribute to nutritional deficiency and increased caries risk.[15] Additionally, children with ASD often do not receive necessary oral care due to elevated levels of distress and anxiety that may be associated with the many sensory stimuli in a typical dental office.[4,12] People living with ASD often have a lower tolerance for dental visits, and their care is not necessarily easily accommodated in typical dental practice settings.[16] Individuals with ASD also have an increased likelihood of being nonverbal and presenting with intellectual disabilities that impact their daily functions.[13] Consequently, children with ASD face significant barriers when accessing oral care and present with many unmet needs, decreasing their overall quality of life.[17] Furthermore, dependence on caregivers and lack of autonomy in personal self-care habits act as barriers to oral health.[18]

Trends indicate that the prevalence of ASD has increased in recent years, and as self-regulated health care professionals, it is incumbent on dental hygienists to understand how to better serve the needs of this population and reduce their barriers to care.[5,6] This narrative literature review thus aims to increase awareness of the additional needs that individuals with ASD have when accessing care and to identify how barriers to oral and systemic health care may be reduced.

METHODS

An electronic literature search of the PubMed, Education Source, and CINAHL online databases was conducted using a combination of the following search terms: autism spectrum disorder, barriers, dental, dental hygiene, developmental disability, oral health, and unmet needs. Relevant and credible literature was identified using the following inclusion criteria: full-text, peer-reviewed original articles published within the last 10 years and published in the English language. Twenty-one studies were reviewed, including longitudinal cohort studies, randomized controlled trials, and cross-sectional studies which employed quantitative, qualitative, and mixed-methods designs. Literature that did not include data on individuals with ASD, was not peer reviewed or was published prior to 2009 was excluded from this review. However, studies published earlier than the last decade were considered to evaluate evolving trends in the literature on ASD.

RESULTS

The examination of the literature on barriers to care faced by individuals with ASD identified a collation of key themes: behavioural challenges, inhibited social and communication skills, parental dependence, clinical environment, and attitudes and behaviours of dental professionals (Table 1).

Behavioural challenges

Children with ASD have a heightened sensitivity to physical, social, and emotional stimuli.[19] As a result, daily oral health care routines have the potential to be a significantly challenging task for both children and their caregivers as compared to their typically developing counterparts. Research reveals that children with ASD display a wide range of behavioural challenges, which extends to their tolerance of oral care, both in office and at home.[1,2,12,16,19-23] Parents of children with ASD report that there is inconsistency and variability in their behaviours and tolerance for daily activities, which often results in inadequate oral hygiene care and, thus, increased caries risk.[2,16,24] Although oral aversion is commonly reported in children with developmental disabilities, some children tolerate electric toothbrushes better than manual toothbrushes due to their vibratory motions.[16] An

Table 1. Themes associated with barriers to care faced by individuals with ASD

Themes	Impact on oral care
Behavioural challenges	• Limited ability to adhere to and comply with a recommended oral hygiene routine[1,2,4,12,16,19-24] • Oral aversion; limited tolerance of toothbrush & toothpaste[16] • Higher tolerance for an electric toothbrush than a manual brush due to vibratory motions[16] • Inconsistency in behaviour; steps to seeking care cause clients to feel overwhelmed[23] • Food selectivity, often resulting in a highly cariogenic diet[15] • Altered response to behavioural conditioning when compared to typically developing counterparts[16] • Worse behavioural ratings on Frankl scale are common at dental appointments[25]
Inhibited social & communication skills	• Often unable to communicate pain, dental concerns or needs to caregivers or oral health professionals [23,26] • Non-verbal communication is essential when working with individuals with ASD[12,13] • Diminished ability to understand their own oral health needs[16] • Lack of cooperation with home care routine and oral examinations[20]
Parental dependence	• Individuals with ASD may not be able to perform oral self-care independently[24] • Oral care is often not prioritized by guardians who may be overwhelmed with other aspects of caring for an individual with ASD such as feeding[16] • Guardians may not feel comfortable advocating for their child's oral care due to the intimidating nature of dental professionals[19] • Guardians struggle to ask for special accommodation at dental offices as they feel their children already create an additional burden for oral health personnel[16,19]
Clinical environment	• The physical dental clinic environment is often not conducive to treating individuals with ASD due to many visual, auditory, and tactile stimuli that create stress[19] • The waiting area is often busy and filled with strangers; waiting times tend to increase agitation and anxiety in individuals with ASD and their family members[16,19]
Oral health professionals	• Many professionals lack the educational preparedness to treat special care populations such as those with ASD[19] • Many families have been refused care for their child with ASD[20] • Oral health professionals must provide highly individualized care to promote successful home oral care[16] • It is essential for oral health professionals to involve individuals with ASD and their caregivers when treatment planning for successful outcomes[4]

additional challenge in children with ASD is their altered response to behavioural conditioning.[16] Individuals with ASD do not generally demonstrate an effective response to negative consequences for bad behaviour or rewards for good behaviour as their typically developing counterparts do.[16] Furthermore, food selectivity is a common behavioural challenge in children with developmental disabilities, resulting in a predominantly cariogenic diet and, thus, increased caries risk when coupled with other risk factors such as inadequate biofilm control.[15,19,21]

Literature shows that behavioural challenges are a predominant barrier to access to in-office oral care.[20] The Frankl behaviour scale is a ranking system commonly used in dentistry to assess a child's behavioural compliance during a dental appointment.[25] This scale typically ranges from 1 to 4, with a rating of 1 being the most behaviourally challenging (Table 2).[25] Children with ASD are more likely to be placed in the "negative" or "definitely negative" categories, exemplifying the behavioural challenges that this population experiences as a barrier to care.[20,25]

Individuals with ASD feel most comfortable when they develop a consistent routine; unfamiliar stimuli and environments tend to cause distress and agitated behaviours in this population.[12,18,19] These behavioural challenges are often associated with personal self-care habits, both at home and in dental offices, which deter individuals with ASD and their caregivers from engaging in oral health actions.[19]

Inhibited social and communication skills

A commonly noted manifestation of ASD is a diminished ability to communicate and interact with other individuals in social situations.[2,18-21] This symptom in individuals with ASD acts as a barrier to optimal oral and overall health as it often impedes their ability to advocate for themselves and their health.[18,19] As a result, individuals with ASD are often unable to communicate their oral health needs to their caregivers or to their oral care providers. Guardians of children with ASD reported difficulty in recognizing dental pain in their children due to inhibited verbal communication skills.[26] This limitation emphasizes the importance of non-verbal communication methods for both caregivers and oral health professionals when working with this population.

Depending on the type and severity of ASD, social interactions have the potential to provoke anxiety among this population who are at an increased risk of anxiety disorders specifically related to oral care.[16-19,21,27] An additional barrier arises from the inability of some individuals with ASD to understand their oral health needs,

Table 2. Frankl behaviour ranking scale[25]

Frankl score	Behaviour presentation
1	• Definitely negative • Refusal of treatment, forceful crying, fearfulness, evidence of extreme negativism
2	• Negative • Reluctance to accept treatment, uncooperative, some evidence of negative attitude, but not pronounced
3	• Positive • Acceptance of treatment, cautious behaviour at times, willingness to comply with dentist, some reservation, follows directions cooperatively
4	• Definitely positive • Good rapport with the dentist, interest in dental procedure, laughter, enjoyment

contributing to a lack of cooperation with oral home care and clinical examinations in office settings.[21] Although most of the literature on ASD and access to oral and overall health care focuses on children, adults with ASD often face additional challenges as they do not always have access to caregivers to aid them in their daily lives.[23] More specifically, adults who are labelled as "high functioning" individuals with ASD have difficulty maintaining social relationships and living independently as they are often not eligible for the same services as individuals with more severe manifestations of the condition.[23] This is a significant barrier that prevents access to oral care services and optimal oral and overall health.

Parental dependence

Children with ASD are typically dependent on their guardians, to varying degrees, to perform tasks in their daily lives. This dependence extends to oral hygiene home care which is often a challenging aspect of daily routines and not prioritized by guardians of children with ASD.[16,19,21] Parents often report that their child's immense dependence on them quickly leads to parental exhaustion and burnout, and oral care is typically a low priority; other essential tasks such as feeding their children and meeting their needs create a sense of overwhelm.[16] Since individuals with ASD are often unable to perform their own oral care and may not tolerate the act of brushing their teeth, parents may have to resort to restraining their children, which can be both physically and emotionally challenging on a daily interval.[16,19,28] An additional barrier faced by individuals with ASD with strong guardian dependence is the ability of their caregivers to advocate for their oral care. Studies suggest that parents often find oral health professionals to be intimidating and struggle to ask for special accommodations at dental offices as they feel their children are already placing an additional burden on oral health personnel.[16,19]

Clinical environment

The physical environment of typical dental offices is generally not conducive to treating individuals with ASD. With several visual, auditory, and tactile stimuli, the dental environment itself is a barrier to care for individuals with ASD.[12,16,19] Sensory processing disorders are a common manifestation of ASD; they interfere with receiving adequate oral care, both preventive and restorative.[2,19] With the dental office being an unfamiliar and uncomfortable setting for most individuals, the clinical ambiance of most dental offices tends to increase anxiety levels in populations living with ASD.

The waiting room adds another layer of difficulty in accessing oral care. The toys that generally appeal to neurotypical children may not appeal to children with autism, and waiting times can increase anxiety and agitation, potentially resulting in outbursts and tantrums.[16,19] Being surrounded by strangers in busy areas with clients and office personnel also increases the stress levels of both children with ASD and their caregivers, who report that they feel embarrassed when people stare at their children in moments of outbursts or other negative behaviours.[16,19]

The literature has reported success in implementing "desensitization" programs in which behavioural therapy is used to overcome fears and anxiety disorders through relaxation and stress management techniques, with gradual exposure to distressing situations.[29] A study exploring the effects of a mobile desensitization application coupled with in-office visits found it to be beneficial for children with ASD in reducing anxieties provoked by the unfamiliarity of clinical environments while increasing their understanding of positive oral health behaviours.[22] However, it is important to note that caregiver support, together with positive attitudes and behaviours of oral health professionals, are critical for successful outcomes in desensitizing individuals with ASD to oral care.[22,29]

Knowledge, attitudes, and behaviours of oral health professionals

Another barrier to care for individuals with ASD remains the oral health professionals themselves. The knowledge, attitudes, and behaviours of oral health personnel have a significant impact on the comfort, compliance, and satisfaction of individuals with ASD as well as their caregivers. Although there is limited literature on the

education of dental hygienists on ASD, there are evident gaps in the knowledge of dentists when treating this special care population. Literature indicates that there is a reluctance among dentists to treat children with autism as they do not feel confident in their educational preparation.[19,20,30] Research reveals that a significant proportion of dentists do not feel their dental education adequately prepared them to work with special care populations and, thus, are less likely to provide care to developmentally disabled individuals post-graduation.[31-33] In contrast, those who received didactic and clinical training with special care populations reported increased positive attitudes and more confidence in providing treatment.[31-33] Dental hygiene students who had opportunities to work with children living with ASD in their entry-to-practice programs were better able to identify the characteristics associated with ASD and to develop and use visual supports to assist children with ASD in order to control their anxiety during dental prophylaxis procedures.[34] These findings emphasize the importance of incorporating experiences with special care populations within dental and dental hygiene curricula to promote competent oral health professionals who are comfortable working with clients with complex needs.

Although personalized oral care is essential for all clients, studies show that care must be highly individualized for clients with ASD.[16,19] The oral health team must work as a coherent unit and be confident in their ability to adapt the environment to clients with intellectual and developmental disabilities. This adaptation extends to front desk staff as well, as they typically speak with the guardians over the phone and are often the first person clients see upon entering a dental clinic.[19]

Dental specialists may be better equipped to provide care for individuals with ASD due to a clearer understanding of behavioural management techniques. However, cost is often a restraining factor for families as many do not have dental insurance to cover the extensive care or sedation often required for treatment.[16,17,19,20,35] Specialists such as pediatric dentists often have greater experience treating children with behavioural challenges, which may result in children with ASD receiving better care in an environment better suited to their needs. However, clearer directions for oral health professionals on where to refer clients with ASD are essential to improving access to care.[30]

Literature indicates that individuals with special care needs, such as those with ASD, have a significantly higher probability of being refused services by oral health practitioners, usually due to inadequate experience with this marginalized population.[20] Studies reveal that most oral health professionals who refuse to treat individuals with autism do so because they lack confidence in treating special care clients and fear causing harm to their clients because of their behaviours and difficulty remaining still for longer periods of time.[30]

DISCUSSION

Despite ASD's variability in presentation across individuals, common trends in barriers to oral care services were noted throughout the literature. These trends illustrate a pertinent need for a solution to the barriers experienced by this population.

Overcoming barriers

A clear theme in the literature indicates that the involvement of guardians in the oral care process for their child with ASD has the potential to create a positive experience and be beneficial in reducing some barriers to care. The input of guardians allows for transfer of valuable information about what works best for their child so that the process of providing oral care can be facilitated in a manner that feels more comfortable to the child.[12,16,19-21] When interviewed, parents indicated that the use of a "pre-visit" questionnaire could be extremely beneficial, allowing both the family and oral health professional to adequately prepare for the visit.[16] Questions to incorporate include those encompassing:

1. Child's developmental status, behavioural issues, and other diagnoses
2. Previous dental experiences and challenges
3. Current home care and challenges
4. Parental concerns and goals for dental visit
5. Useful preparation strategies for a dental visit
6. Factors that trigger both good and poor behaviour
7. Specific child or parent preferences[16]

The implementation of such a process could significantly reduce some anxiety and uncertainty surrounding dental appointments, which are often experienced by individuals with ASD as well as their family members. In addition, a reduction in anxiety could potentially reduce the need for sedation or general anesthesia, which is commonly requested or required to complete oral care with this population, further reducing barriers to care.

A clear referral pathway has also been identified in the literature as a way to improve access to care for individuals living with ASD.[19] Parents report that their child's history of poor compliance during dental appointments may result in their not receiving necessary care by general dentists and that accessing care at a specialty office, such as a pediatric clinic, could result in better delivery of care if dentists are better equipped to treat special care populations.[16] As there are higher costs associated with specialty clinics and sedation, greater access to funding through the government could improve access to care for this population.

Research gaps and future recommendations

A review of the literature revealed limited representation of adult populations living with ASD as most studies

evaluated access to care for children and youth up to 18 years of age. Additionally, it would be beneficial to understand the perspective of individuals living with ASD regarding their own self-described barriers to oral care, as the literature focused on the context of guardians' perceptions and experiences.

Directions for future research include a greater representation of all oral health professionals, such as dental hygienists, dental therapists, and certified dental assistants, in the experiences of individuals with ASD and their families. Although current research tends to focus on dentists, it would be beneficial to explore how those with ASD perceive other members of the oral health care team to understand how to better serve this population. Additionally, more research on the perspective of oral health care providers is required to understand their outlook and attitudes towards treating special care populations and how they could be better supported to increase their confidence in providing adequate care to all individuals, regardless of their background or special needs. Further methods of implementing entry-level education, whether in dental and dental hygiene curricula or through continuing education courses, should be explored to ensure better educational preparedness for all oral health professionals.

CONCLUSION

Current literature has shown that individuals with ASD face numerous barriers in accessing oral care and achieving adequate oral health, thus contributing to an increased burden of disease. Discussions stemming from this research articulate the importance of providing accessible and adequate care to special care populations. Augmenting curricula on special care populations in entry-to-practice dental and dental hygiene programs is paramount. Oral health professionals should aim to improve their understanding of special care populations such as the ASD community and raise awareness among health care professionals to work towards reducing the barriers to care that these populations currently experience.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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Effectiveness of propolis in maintaining oral health: a scoping review

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Toothpastes, dentifrices, and mouthwashes containing propolis have been shown to be effective in lowering plaque and gingival indices by inhibiting pathogenic microflora.
- Although further studies are required to weigh the risks against the benefits, given potential side effects, propolis may have potential applications in oral health care.

ABSTRACT

Background: Research has revealed that periodontal diseases are caused by inflammation that results from a dysbiosis of the oral microbiome where oral bacteria multiply into larger communities referred to as dental biofilm. To help control this overgrowth of bacteria, a variety of toothpastes, dentifrices, and mouthwashes have been developed. Although not as common in North American toothpastes, propolis as an active ingredient in dentifrices has begun to emerge, as laboratory studies have suggested it has anti-inflammatory, immunomodulatory, antioxidant, antimicrobial, and antidiabetic properties. The purpose of this scoping review was to explore the literature on the effectiveness of propolis in maintaining oral health. **Methods:** This review used the following criteria: *Population:* studies involving healthy humans; *Intervention:* propolis in the form of toothpaste, dentifrice, and mouthwash; *Comparison:* fluoride, chlorohexidine, and placebo; *Outcomes:* plaque and gingival indices, improvement in oral hygiene, and inhibition of bacteria. Relevant research articles were selected from Web of Science, PubMed, MEDLINE, and Scopus databases using the search parameter "propolis[tw] AND (toothpaste*[tw] OR dentifrice*[tw] OR mouthwash*[tw])". Only original articles published after 2009 and written in the English language were included. **Results:** A total of 19 original papers met the criteria and showed varying levels of success achieved with the use of propolis. It was responsible for a significant lowering of specific plaque and gingival indices, inhibited the growth of bacteria, reduced oral flora diversity, and consistently improved periodontal condition, oral hygiene, and oral health. **Conclusion:** Propolis may play a role in initiating, sustaining, and maintaining oral health as its desirable properties have the potential to improve various oral hygiene related indices.

RÉSUMÉ

Contexte : Les recherches ont révélé que les maladies parodontales sont causées par de l'inflammation résultant d'une dysbiose du microbiome buccal, lorsque les bactéries buccales se multiplient en communautés plus importantes appelées biofilm dentaire. Afin d'aider à maîtriser cette prolifération de bactéries, une variété de pâtes dentifrices, de dentifrices et de bains de bouche ont été conçus. Bien qu'elle ne soit pas aussi courante dans les pâtes dentifrices de l'Amérique du Nord, la propolis commence à émerger comme ingrédient actif dans les dentifrices, puisque les études de laboratoire ont suggéré qu'elle a des propriétés anti-inflammatoires, immunomodulatrices, antioxydantes, antimicrobiennes et antidiabétiques. Le but de cet examen de la portée était d'explorer la littérature sur l'efficacité de la propolis dans le maintien de la santé buccodentaire. **Méthodes :** Cette revue a utilisé les critères suivants : *Population* : études portant sur des humains en bonne santé; *Intervention* : propolis sous forme de pâte dentifrice, dentifrice et bain de bouche; *Comparaison* : fluorure, chlorohexidine et placebo; *Résultats :* indices de plaque et de gencive, amélioration de l'hygiène buccodentaire et inhibition des bactéries. Les articles de recherche pertinents ont été sélectionnés dans les bases de données de Web of Science, PubMed, MEDLINE et Scopus à l'aide de paramètres de recherche « propolis[tw] ET (pâte dentifrice*[tw] OU dentifrice*[tw] OU bain de bouche*[tw]) ». Seuls les articles originaux publiés après 2009 et rédigés en anglais ont été inclus. **Résultats :** Un total de 19 articles originaux ont répondu aux critères et ont montré des taux de succès variables, atteints à l'aide de la propolis. Elle était responsable d'une diminution considérable des indices propres la plaque et aux gencives, de l'inhibition de la croissance de bactéries, de la réduction de la diversité de la flore buccale et de l'amélioration constante de l'état du parodonte, de l'hygiène buccodentaire et de la santé buccodentaire. **Conclusion :** La propolis peut jouer un rôle dans l'initiation, le maintien et l'entretien de la santé buccodentaire, car ses propriétés intéressantes ont le potentiel d'améliorer divers indices liés l'hygiène buccodentaire.

Keywords: chlorhexidine; dentifrice; honey; mouthwash; propolis; toothpaste
CDHA Research Agenda category: risk assessment and management

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INTRODUCTION

In recent years, there has been much interest in oral health education programs, with the main aim of increasing the adoption of favourable oral health behaviours that are expected to translate to better oral health.[1] At the same time, there has been an increase in demand for evidence that can help both policymakers and individuals make better choices regarding oral health.[1] Since many individuals are now aware of and concerned about improving their oral health, there is sustained support for the development of new products and substances to keep the oral cavity clean and healthy.[2] Some of these products have emerged as a result of extensive research aimed at finding the best ingredients to sustain oral health with few or no side effects. Understanding the role of dental biofilm is important to the development of new anticariogenic and antigingivitis/periodontitis products. Biofilms commonly comprise both Gram-positive and Gram-negative microbes which, when out of balance, can lead to dental caries and periodontal disease.[3] Dental biofilm has been shown to be a soft, non-mineralized bacterial deposit that adheres to the hard surfaces of the oral cavity when adequate oral hygiene is not sustained.[4]

Poor oral hygiene is one of the factors leading to the imbalance of the oral microbiome, referred to as dysbiosis. Studies have shown that only a limited quantity of pathogenic bacteria are present at a healthy site in a host, which suggests, therefore, that oral diseases are caused by dysbiosis.[5] When microbial dysbiosis occurs, an overgrowth of pathogenic bacteria creates a community of microbes in the form of a biofilm.[6] Since dysbiosis results in biofilm formation, the rational thing is to destroy or reduce the population of these bacteria in the mouth, either by mechanical or chemical means, such as the use of toothpastes and mouthwashes.[3,7] Toothpastes and mouthwashes have gained wide acceptance because of their perceived benefits, and especially because of sustained advertising and marketing.[3,7,8] Their popularity reflects the tendency among consumers to seek food or pharmaceutical products that can help them achieve healthier lives.[9] Unfortunately, many people purchase and use these products without verifying their efficacy; marketing campaigns may not be a guarantee of efficacy or antibacterial activity in the case of toothpastes.[10]

There are varying compositions, consistencies, and types of toothpastes and mouthwashes available in the North American market. One of the most commonly used ingredients is stannous fluoride, which has undergone years of research and has shown effective antibacterial properties. More recently, herbal products containing natural compounds such as mentha, guarana, eucalyptus extract, mastic, Arab acacia, and miswak, all of which also have significant antibacterial properties, have been introduced. One of these natural compounds is propolis, which has been used in many toothpastes, mouthwashes, and dentifrices as an important natural product in preventing oral diseases.[8,11-13]

Propolis, also known as bee glue, is a dark-coloured, dense, and adhesive combination of resin and wax, consisting of active natural ingredients such as volatile oils, plant balsams, phenolic acids, flavonoids, aromatic alcohols, fatty acids, mineral salts, and vitamins.[14] It is collected by honeybees from trees, buds, flowers, and other botanical products.[15,16] It is well established from laboratory-based studies that propolis has antibacterial, anti-inflammatory, antioxidant, antiviral, antifungal, antitumour, and hepatoprotective properties.[12,13,16,17] The chemical composition of propolis is 50% to 60% resin, 30% to 40% wax, 5% to 10% essential oils, 5% pollen, along with some microelements.[13,18,19]

To demonstrate the health benefits of propolis, some studies have shown that its application can heal oral ulcers and gingivitis in many clients.[16,20,21] It has activity against *Streptococcus mutans*, facultative anaerobes, and Gram-positive cocci within the oral cavity.[13] In addition, multiple studies have shown that the ability of propolis to kill periodontal pathogens may be of significant clinical value.[22-24] To harness this huge potential, many companies have added propolis to their toothpaste and mouthwash products with the aim of preventing tooth decay and gingivitis.[13] The use of varying types of toothpastes, dentifrices, and mouthwashes containing propolis has been shown to have excellent anti-inflammatory effects in addition to facilitating biofilm removal and prevention.[25]

It is important to evaluate the specific roles of propolis in the oral cavity, given various studies that have reported clinical outcomes regarding its potential benefits. Therefore, this study aimed to review and evaluate the literature on the role of propolis in achieving and maintaining oral health.

METHODOLOGY

This review included studies involving healthy humans, with an intervention based on the use of propolis in the form of toothpaste, dentifrice, and mouthwash. A comparison was made with other oral hygiene maintaining agents such as fluoride, chlorhexidine, and placebo. The studies reporting outcomes on plaque and gingival indices, impact on oral hygiene, and changes in bacterial load were included. Relevant research articles were sought and selected from Web of Science, PubMed, MEDLINE, and Scopus databases. The following search parameter was entered into the search engine: "propolis[tw] AND (toothpaste*[tw] OR dentifrice*[tw] OR mouthwash*[tw])". This search parameter was based on 4 major keywords: propolis, toothpaste, dentifrice, and mouthwash. Articles were selected based on originality (primary research papers), the use of toothpastes and/or dentifrices and/or mouthwashes containing propolis in the study, and follow-up periods of 2 weeks or more. In addition, only randomized, non-randomized, and cohort clinical studies published from 2009 to 2020 and written in English,

utilizing green or red propolis, were included in the review. Narrative reviews and case–control studies were excluded. Studies involving subjects with denture-based stomatitis, tumours or those undergoing chemotherapy were excluded.

Assessment of the quality of the studies was based on the study design, the methodologies adopted, and the outcomes. Data were extracted using tables that identified the characteristics of each study's participants, type of intervention (propolis alone, propolis versus placebo, propolis versus other agents), and the outcomes of the study.

RESULTS

The parameters produced a total of 237 citations. Of those 237 studies, 94 were duplicate studies and 40 studies were discarded because they were written in a language other than English and were older than 2009. An additional 23 articles were discarded because they were not clinical studies (including a review article, an editorial, a conference paper, and an erratum). The full text of the remaining 80 articles was examined in greater detail, from which 61 were either in vitro studies or did not fulfil the inclusion criteria. A total of 19 studies with methodologies and outcomes matching the focus of this review were included (Figure 1).

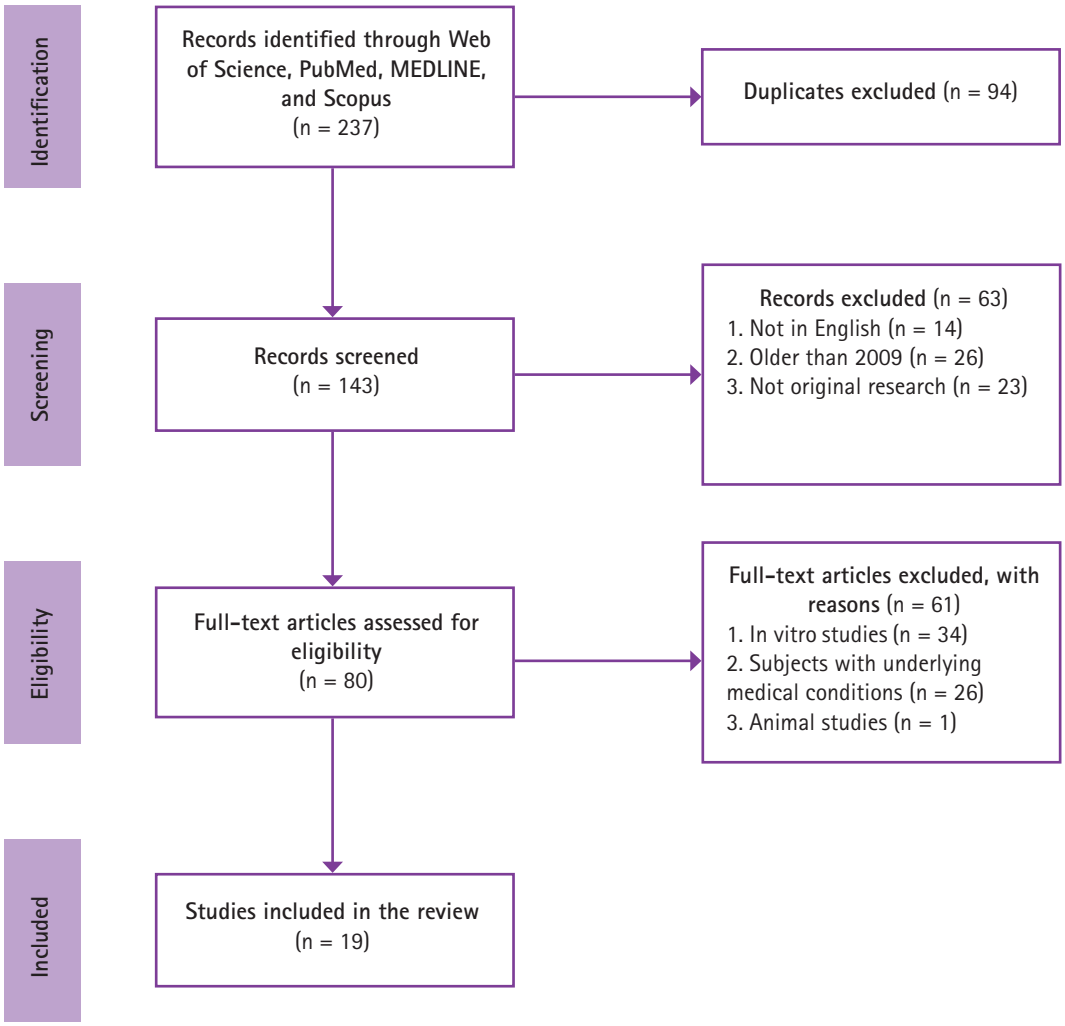
Plaque and gingival indices

Twelve studies evaluated plaque and gingival indices. The results of these studies revealed significant improvements in plaque accumulation and reduction in sulcular or papillary gingival bleeding when propolis was used compared to agents without propolis (Table 1).

Impact on oral hygiene

Five studies evaluated the impact of propolis-containing agents on oral hygiene. The outcomes showed that propolis-containing agents produced significant improvements in oral health (Table 2).

Figure 1. Flowchart for identification, screening, and selection of studies



Source: http://prisma-statement.org/PRISMAStatement/FlowDiagram.aspx

Table 1. Clinical studies showing the effect of propolis on plaque and gingival indices

No.	Author and year	Origin of propolis	Type of study and no. of subjects	Type of intervention	Results[a]	Outcomes
1	Furtado Junior et al. 2020[22]	Brazil	Randomized clinical trial (n = 92)	Fluoride dentifrice with propolis incorporated vs fluoride dentifrice	Both groups significantly reduced the GBI	Dentifrice containing propolis demonstrated similar clinical activity to dentifrice containing fluoride only
2	Sparabombe et al. 2019[43]	Italy	Randomized controlled clinical trial (n = 34)	Mouthwash containing propolis vs placebo	A statistically significant decrease in BS and PS compared with the placebo group	Propolis mouthwash in clients with moderate or severe periodontitis is effective in reducing BS and PS, after 3 months, compared with placebo
3	Dehghani et al. 2019[44]	Undisclosed	Randomized clinical trial (n = 37)	Propolis mouthwash vs chlorhexidine mouthwash	Improvement in the plaque, gingival, and periodontal indices before and after administration of the experimental mouthwashes	There was no statistically significant difference between 2 mouthwash groups
4	Piekarz et al. 2017[45]	Poland	Randomized clinical trial (n = 51)	Toothpaste with tea tree oil (TTO) and extracts of propolis (EEP) vs normal toothpaste	A statistically significant reduction of approximal PI and sulcular BI was observed after 7 and 28 days of using the toothpaste with TTO and EEP, as compared to the value upon the initial visit	The use of a toothpaste containing TTO and EEP helps to maintain gingival health The findings of the study do not specify whether the results were affected by the addition of TTO or EEP
5	Machorowska-Pieniazek et al. 2016[33]	Brazil	Randomized clinical trial (n = 96)	Propolis vs placebo	A statistically significant reduction in GI and PI was recorded in the propolis group compared to placebo	Propolis may be an effective agent in improving gingival health
6	Ercan et al. 2015[12]	Undisclosed	Randomized clinical trial (n = 10)	Propolis mouthwash vs propolis chewing gum	Significantly lower PI and GI were recorded in the propolis mouthwash group than in the propolis chewing gum group	Propolis mouthwashes are necessary for improved oral hygiene and reduced dental biofilm
7	Bhat et al. 2015[17]	Undisclosed	Randomized clinical trial (n = 20)	Propolis vs miswak vs Colgate® Total	Propolis resulted in a consistently and significantly lower modified gingival marginal plaque index mean scores compared to Colgate® Total and miswak toothpastes.	Propolis is safe and effective in lowering biofilm accumulation
8	Fereidooni et al. 2014[46]	Undisclosed	Randomized clinical trial (n = 40)	Toothpastes containing propolis vs normal toothpaste	The PI scores in propolis toothpaste was 28.8±6.1% and in regular toothpaste was 39.7±6.3%	Both toothpastes reduced PI, however reduction was greater in propolis toothpaste than regular toothpaste
9	Bretz et al. 2014[47]	Brazil	Randomized controlled trial (n = 38)	Propolis mouthrinse vs 0.05% sodium fluoride plus 0.05% cetylpyridinium chloride mouth rinse	Propolis and control groups did not differ significantly for average papillary BS	Propolis rinse was equivalent to a positive control rinse during a 21-day no-hygiene period
10	Skaba et al. 2013[13]	Brazil	Clinical cohort study (n = 64)	Propolis vs placebo	There was a decrease in approximal PI, OHI & sulcular BI when propolis was used compared to placebo	Propolis supports removal of dental biofilm and improves state of marginal periodontium
11	Machorowska-Pieniazek et al. 2013[14]	Brazil	Randomized clinical trial (n = 41)	Propolis vs placebo	There was a statistically significant decrease in oral PI, GI, and the compared with baseline in propolis group subjects	Propolis is responsible for improved oral health in subjects

Table 1. *continued*

No.	Author and year	Origin of propolis	Type of study and no. of subjects	Type of intervention	Results[a]	Outcomes
12	Pereira et al. 2011[48]	Brazil	Prospective clinical trial (n = 25)	Propolis mouthwash alone	24% reduction in approximal PI and GI after 45 days and 40% reduction in approximal PI and GI after 90 days use of propolis mouthwash	Propolis mouthwash showed evidence of its efficacy in reducing PI and GI The study did not compare propolis with another agent, therefore, superiority of propolis over other agents cannot be suggested

[a]GBI: Gingival Bleeding Index; BS: Bleeding Score; PS: Plaque Score; PI: Plaque Index; GI: Gingival Index; OHI: Oral Hygiene Index

Table 2. Clinical studies showing the role of propolis in improving oral health

No.	Author and year	Origin of propolis	Type of study and no. of subjects	Type of intervention	Results[a]	Outcomes
1	Peycheva et al. 2019[49]	Bulgaria	Randomized clinical trial (n = 70)	Marketed toothpastes vs toothpaste incorporating 10 drops of propolis extract	The cytokine levels in toothpaste incorporating propolis showed significantly lower levels of IL-1β and IL-18 when compared to the other group	The addition of propolis to the toothpaste resulted in a reduction of the gingival inflammation in adolescents with moderate gingivitis
2	Piekarz et al. 2017[45]	Poland	Randomized clinical trial (n = 51)	Toothpaste with tea tree oil (TTO) and extracts of propolis (EEP) vs normal toothpaste	A statistically significant improvement in OHI value was observed after 28 days of using the toothpaste with TTO and EEP, as compared to the value upon the initial visit	The use of a toothpaste containing TTO and EEP helps improve oral hygiene The findings of the study do not specify whether the results were affected by the addition of TTO or EEP
3	Wiatrak et al. 2017[26]	Poland	Randomized clinical trial (n = 37)	Propolis vs placebo	In the propolis group, there was a decrease in the number of isolated microorganisms, improvements in hygiene & condition of periodontium, & a reduction in oral flora diversity after 4 weeks of active toothpaste use as against the control group	Propolis improves oral hygiene and condition of the periodontium
4	Morawiec et al. 2013[25]	Brazil	Randomized cohort study (n = 16)	Propolis vs placebo	Propolis-containing toothpaste was distinctively effective in improving oral health and the occurrence of gingivitis triggered by dental biofilm	Positive effect of propolis-containing toothpaste on oral hygiene
5	Tanasiewicz et al. 2012[50]	Brazil	Randomized clinical trial (n = 80)	Toothpaste and gel containing propolis vs toothpaste and gel without propolis	Toothpaste and gel containing propolis showed effective results in improving OHI without causing pathological changes to the periodontium	The OHI improved after the use of toothpaste and gel containing propolis

[a]GBI: Gingival Bleeding Index; BS: Bleeding Score; PS: Plaque Score; PI: Plaque Index; GI: Gingival Index; OHI: Oral Hygiene Index

Table 3. Clinical studies showing the role of propolis in altering the pathogenic bacterial load

No.	Author and year	Origin of propolis	Type of study and no. of subjects	Type of intervention	Results[a]	Outcomes
1	Furtado Junior et al. 2020[22]	Brazil	Randomized clinical trial (n = 92)	Fluoride dentifrice with propolis incorporated vs fluoride dentifrice	Fluoride dentifrice with propolis incorporated reduced Gram-negative and *Streptococcus mutans* bacteria significantly compared to fluoride dentifrice only	Dentifrice containing propolis demonstrated better microbiological activity compared to fluoride dentifrice only
2	Peycheva et al. 2019[51]	Bulgaria	Randomized clinical trial (n = 70)	Marketed toothpastes vs toothpaste incorporating 10 drops of propolis extract	The addition of propolis resulted in the complete eradication of *Streptococcus mutans*, *Candida albicans*, *Fusobacterium varium*, Gram-negative cocci, Gram-positive rods, *Porphyromonas asaccharolyticus*, *Prevotella bivia*, *Prevotella intermedia*, *Prevotella melani,* and *Streptococcus intermedius*	The addition of propolis to the toothpaste resulted in a reduction of gingival inflammation in adolescents with moderate gingivitis
3	Mohsin et al. 2015[27]	South Korea	Clinical-microbiological prospective study (n = 367)	Propolis alone	The mean *Streptococcus mutans* count at first and fourth weeks showed significant reduction, compared to baseline scores. Statistically significant difference was found between baseline & first week, third week & fourth week follow up	Propolis dentifrice reduced in vivo microbial load The study did not compare propolis with another agent, therefore, superiority of propolis over other agents cannot be suggested
4	Skaba et al. 2013[13]	Brazil	Clinical cohort study (n = 64)	Propolis vs placebo	There was a time-dependent microbial action of propolis at 50 mg/L concentration, with antimicrobial activity against Gram-positive bacteria	Propolis improves the state of marginal periodontium
5	Netto et al. 2013[11]	Brazil	Randomized clinical trial (n = 60)	Propolis mouthrinse vs 0.12% chlorhexidine mouthrinse vs placebo mouthrinse	Propolis was superior to chlorhexidine at 14-day and 28-day visits in suppressing the salivary levels of *S. mutans* Propolis was significantly superior to chlorhexidine in suppressing the levels of salivary lactobacilli at the 28-day visit	Propolis mouthwash was superior to chlorhexidine and placebo mouthwash at 28-day
6	Machorowska-Pieniazek et al. 2013[14]	Brazil	Randomized clinical trial (n = 41)	Propolis vs placebo	There was a statistically significant decrease in the percentage of the *Actinomyces spp.* and *Capnocytophaga spp.* compared with baseline in propolis group subjects	Propolis is responsible for improved oral health in subjects
7	Morawiec et al. 2013[25]	Brazil	Randomized cohort study (n = 16)	Propolis vs placebo	Propolis-containing toothpaste triggered qualitative & quantitative changes in oral bacteria spectrum	Positive biological activity of propolis-containing toothpaste on oral microbial flora

[a]GBI: Gingival Bleeding Index; BS: Bleeding Score; PS: Plaque Score; PI: Plaque Index; GI: Gingival Index; OHI: Oral Hygiene Index

Changes in pathogenic bacterial load

Seven studies reported the effectiveness of propolis in altering the bacterial load. The outcomes suggested that propolis helped reduce the pathogenic bacterial load compared to other agents without propolis or placebo (Table 3).

DISCUSSION

From the results of the studies presented in the tables, it is evident that propolis has significant positive effects on gingival health, oral hygiene, and the reduction of pathogenic bacteria. It has been argued that the diverse

chemical content inherent in propolis is responsible for its many useful properties.[8] Studies have shown that propolis has effective antibacterial activity against a range of oral pathogens. A study conducted by Yoshimasu et al.[24] reported that certain compounds derived from propolis have bacteriostatic activities while other compounds have bacteriocidal properties against various oral species including *Porphyromonas gingivalis*. Considering its antibacterial, anti-inflammatory, antifungal, antiviral, anticancer, and immunomodulation abilities, it is easy to understand why propolis is useful for maintaining oral health.[2]

Plaque index, gingival indices, and oral hygiene

The study by Bhat et al.[17] showed the effect of propolis in reducing the accumulation of dental biofilm. Among the group of 30 healthy students split into 3 groups, the Forever Bright (propolis-containing) tooth gel group had the lowest mean modified gingival marginal plaque index (MGMPI) score, which was significantly different from the other 2 groups. This double-blind randomized study demonstrated the ability of propolis-containing tooth gels or toothpastes to reduce the rate of biofilm accumulation, which is one of the major risk factors for poor oral health.[13,17,26] This finding by Bhat et al.[17] is similar to results obtained in studies conducted by Ercan et al.[12] and Skaba et al.[13]

It can be argued that a confounding factor, which might have been responsible for the slow rate of biofilm accumulation in the Bhat et al. study, was the oral prophylaxis conducted before the start of the experiment.[17] The point of the oral prophylaxis was to remove calculus, as calculus on its own can promote the rate of formation of biofilm due to the rough surface that it provides.[17] However, by removing the calculus, all the subjects were rendered the same at baseline, which makes subsequent statistical deductions more precise and accurate. This procedure was also done in the study by Ercan et al.[12] but not by Skaba et al.,[13] even though they both recorded significant biofilm reduction with the use of propolis-containing agents. The study by Skaba et al., which did not perform oral prophylaxis before the experiment, corrected for this by focussing on the progressive reduction in plaque indices on subsequent visits of the study participants; the differences between the indices before and after the intervention were found to be significant.[13] Nevertheless, the results of the study by Skaba et al. raise a question of reliability as the lack of oral prophylaxis may make the results less generalizable and comparable to similar studies.[13]

Similarly, the results of another study on 96 clients with orthodontic appliances showed a statistically significant reduction in the gingival index and plaque index among those who used Brazilian propolis toothpaste against the control.[14]

Dentures are another potential source for providing a favourable environment for the growth of bacteria and dental biofilm, and worsening periodontal health.[26] For clients with dentures and other prosthetic appliances, it is equally important to maintain optimal oral hygiene through use of products that can help prevent periodontopathy. Wiatrak et al.[26] showed that propolis can achieve this result. In their randomized cohort study on 37 clients with acrylic partial dentures, they observed statistically significant reductions in the approximate plaque index, simplified Greene-Vermilion hygiene index, and gingival bleeding index after 7 to 28 days of application of propolis toothpaste.[26]

Changes in pathogenic bacterial load

In addition to biofilm reduction, propolis was also found to inhibit the growth of specific organisms. Mohsin et al.[27] conducted a study investigating the effect of a dentifrice containing propolis on *Streptococcus mutans*. Study results revealed a statistically significant reduction in *S. mutans* by the third and fourth weeks. Although these findings provide some evidence to support the use of propolis in controlling bacterial biofilms, the study sample was small and not generalizable as the 30 male participants were between 7 and 12 years of age. Skaba et al.[13] also reported similar findings from a sample size (n = 32) of 15 male and 17 female clients. They reported the ability of propolis to inhibit the glucosyltransferase activity of *Streptococcus mutans*, *Streptococcus sobrinus*, and *Streptococcus cricetus* both in vivo and in vitro.[13]

Other pathogens that have been found to be susceptible to the action of propolis include *Lactobacillus rhamnosus*,[28] *Actinomyces spp.* and *Capnocytophaga spp.*,[17] and *Candida spp.*[13,14,25] Of particular interest are findings from a study conducted by Machorowska-Pieniazek et al.[14] who reported that 2 facultative anaerobic bacteria (*Actinomyces spp.* and *Capnocytophaga spp.*) in their samples were responsive to propolis, which significantly reduced their count. It is important to note that *Streptococcus mutans* was not found in this study, which is unusual. Previous studies have suggested that *Streptococcus spp.* and *Actinomyces spp.* coexist and are crucial in the early phases of the formation of dental caries.[29,30] However, it is possible that the type of study population was responsible for this finding since all 41 non-syndromic cleft lip and palate subjects in the study had fixed orthodontic appliances.[14] It has been established that the presence of orthodontic appliances alters the oral environment, resulting in the presence of atypical flora.[31,32] Nonetheless, propolis reduced this bacterial flora.

To further corroborate, another study by Machorowska-Pieniazek et al. in 2016 also reported the effectiveness of propolis in reducing the presence of *Actinomyces spp.* and *Capnocytophaga spp.*, and many other isolated species in the oral cavity of denture wearers.[33] However, the study by Wiatrak et al.[26] observed the presence of *Streptococcus mutans*, which was absent in the study by Machorowska-Pieniazek et al.[33]

Other potential roles of propolis

Most of the studies reviewed focused on the influence of propolis in reducing the formation of biofilm and growth of microorganisms generated in vivo. However, it has been suggested that toothbrushes contaminated with microorganisms may also cause oral infections through their bristles.[34-36] Even after eradicating those within the oral cavity, the use of the already contaminated toothbrush can reintroduce bacteria into the mouth, and the cycle begins again. This was the focus of the study by Bertolini et al.[34] who compared the ability of *Aloe vera* and propolis to reduce the contamination of toothbrush bristles by *Streptococcus mutans*. Even though there was no significant difference between the effects of the 2, it is evident that propolis still retains some in vitro activity, being able to reduce the contamination of bristles by *Streptococcus mutans*.

Opportunistic infections can arise from the colonization of microflora which adhere to various surfaces in the oral cavity.[37] The incidence of these opportunistic infections is usually due to the imbalance between the commensal and pathogenic bacteria caused by the poor immune response of the host or other health conditions affecting the oral environment.[38] Individuals with such conditions who do not maintain adequate oral hygiene are the most susceptible to developing such opportunistic infections. It has been suggested that propolis helps in the suppression of bacterial peptides.[39] Moreover, a study conducted by Dalenberg et al.[40] reported that propolis can help improve microbial colony health by changing the microbiome in favour of commensal bacterial, which outcompete pathogenic bacteria.

Furthermore, propolis has been shown to play a positive role in maintaining the oral health of clients with inflammatory oral conditions such as recurrent aphthous stomatitis or chemotherapy-induced stomatitis.[41,42] A study conducted by Samet et al.[42] reported a significant reduction in the recurrence of ulcer formation and improved quality of life in clients who received 500 mg of propolis, compared to the placebo group. Moreover, another study by Piredda et al.[41] reported propolis was well tolerated and effective in reducing the frequency of oral mucositis in clients receiving chemotherapy.

Limitations and gaps in the literature

Despite the evidence supporting the clinical efficacy of propolis in maintaining oral health, certain shortcomings in the literature must be noted. One of the concerns is the difference in study methodology, with previous studies utilizing follow-up periods ranging from 2 weeks to 3 months, making it difficult to compare study outcomes. In addition, some individuals experienced adverse effects from propolis, such as edema of the mucous membranes, swelling of the conjunctiva, hypotension, and/or cardiac arrhythmias.[13] These adverse effects have not been sufficiently studied.

In light of these limitations, future randomized clinical trials should use longer follow-up periods with a homogenous model. Studies should also compare propolis products with traditional ingredients such as stannous fluoride and chlorhexidine. Moreover, future studies must investigate the safety issues as well as the dose-benefit relationship, with emphasis on the therapeutic dose necessary to eliminate target microbes with the fewest possible side effects.

CONCLUSION

The literature explored in this scoping review demonstrates that propolis, with its established bactericidal and bacteriostatic properties, may have a positive role to play in initiating, sustaining, and maintaining oral health. Current gaps in the literature highlight the need for studies with larger sample sizes and longer follow-up periods, comparative studies with other traditional products, and further exploration of the side effects of propolis.

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CONFLICTS OF INTEREST

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Dentigerous cyst in a young child: a case report

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ABSTRACT

Dentigerous cysts are one of the most common developmental types of odontogenic cysts occurring in the oral cavity and often manifest as incidental findings on dental radiographs and/or as asymptomatic swellings. These cysts develop from remnants of reduced enamel epithelium around the crown of an unerupted or impacted tooth, attached at the level of the cementoenamel junction. Most are considered developmental. However, in young clients they may be inflammatory in origin, the result of caries in the primary dentition. This short communication highlights a case of an asymptomatic dentigerous cyst identified in a 4-year-old child and subsequent enucleation under general anesthesia. A thorough clinical and radiographic assessment of the oral cavity in pediatric clients merits a review of dentigerous cysts by the dental hygienist.

RÉSUMÉ

Les kystes dentigères sont parmi les types développementaux de kystes odontogènes les plus courants qui apparaissent dans la cavité buccale et se manifestent souvent comme des découvertes imprévues sur les radiographies dentaires ou comme des enflures asymptomatiques. Ces kystes se développent à partir de restes d'épithélium d'émail réduit autour de la couronne d'une dent incluse ou enclavée, attachés au niveau de la jonction cémento-émail. La plupart des kystes sont considérés comme développementaux. Cependant, chez les jeunes clients, ils peuvent être d'origine inflammatoire, la conséquence de caries dans la dentition primaire. Cette brève communication souligne un cas de kyste dentigère asymptomatique décelé chez un enfant de 4 ans et une énucléation subséquente sous anesthésie générale. Une évaluation clinique et radiographique approfondie de la cavité buccale des clients pédiatriques justifie que l'hygiéniste dentaire se renseigne sur les kystes dentigères.

Keywords: child, deciduous, dental caries, tooth, impacted; dentigerous cyst; dentition, mixed; odontogenic cysts; radiography, panoramic; tooth, unerupted

CDHA Research Agenda category: risk assessment and management

INTRODUCTION

Dental clients present with a variety of soft tissue and intraosseous pathologies noted by the dental hygienist during the assessment and treatment phases of the dental hygiene process of care. A thorough knowledge of these pathologies will be an invaluable asset when assisting the dentist in developing the diagnosis and treatment plan.

Dentigerous cysts (DCs) of the oral cavity are odontogenic cysts, attached to the cervical region of an unerupted tooth and enclosing the crown. Their exact etiology is unknown and may be referred to as a follicular cyst. Most are considered developmental, with a typical histology of a wall of loose fibrous tissue, lined by thin, regular epithelium, evolving from remnants of reduced enamel epithelium around the crown of an unerupted or impacted tooth. These remnants undergo cystic degeneration with fluid accumulation in the central portion of the lesion which is attached at the cementoenamel junction.[1] The inflamed DC is characterized by the presence of hyperplastic epithelium with an inflammatory cellular infiltrate.[2] This type is believed to predominantly develop as a result of periapical inflammation from an overlying primary tooth, affecting the developing tooth follicle.[2]

DCs are the second most common odontogenic cyst (second only to the periapical cyst) making up approximately 20% of all epithelial lined cysts of the jaws. The highest incidence of DCs occurs during the second and third decades with a slight male predilection. Teeth most commonly affected are mandibular third molars, followed by maxillary canines and mandibular premolars.[1,3,4]

DCs often manifest as incidental findings on dental radiographs and/or as asymptomatic swellings clinically.[1-4] The typical radiographic appearance is of a well-circumscribed, unilocular, symmetric radiolucency around the crown of an impacted tooth. However, the cyst-to-crown relationship may show varied radiographic appearance. The most common central variety appears with the cyst surrounding the crown of the tooth, the crown projecting into the cystic lumen, and the root(s) outside the cyst. In the lateral variety, the cyst appears to expand laterally along the root surface, partially surrounding the crown, as can be the case with a partially erupted mesioangular impacted mandibular third molar. The circumferential variety presents radiographically as the cyst surrounding the crown yet extending for

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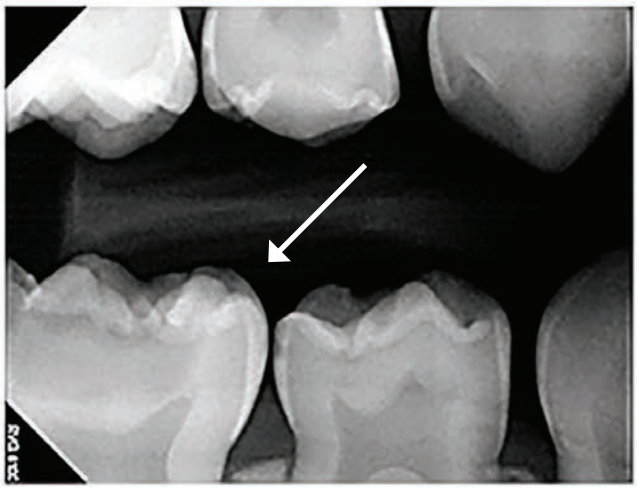
some distance vertically along the root, appearing that a portion of the root is within the cystic lumen.[5,6] Large DCs may appear multilocular, resulting in a radiographic appearance comparable to other pathologies.[7] In the case of an inflammatory DC, radiographically the cystic lesion would most often be observed in relation to an overlying necrotic primary tooth.[2] To receive a true diagnosis, radiographic appearance along with an incisional biopsy are necessary to rule out other lesions that may require more aggressive treatments.[3-6]

CASE DESCRIPTION

A 4-year-old Caucasian male presented for a comprehensive oral evaluation and prophylaxis at a private pediatric dental office in the United States. His medical history was unremarkable, with no systemic problems and no report of pain. Despite having private dental insurance, he had prior inconsistent dental care. Bitewing radiographs were obtained, and several carious lesions were noted, including a large multisurface lesion on the mandibular right primary second molar (85) and occlusal caries on the adjacent primary first molar (84) (Figure 1).

When the client returned for restorative treatment of 85 3 months later, a periapical image was obtained of that area (Figure 2). The pediatric dentist was unable to complete the treatment due to client sensitivity despite maximum allowable delivery of local anesthetic; a temporary filling was placed. The client returned 5 months later for treatment of 85 and another periapical radiograph was obtained (Figure 3), which revealed part of an adjacent radiolucency as well as resorption of a portion of the distal root. Due to this finding a panoramic image was also obtained. The

Figure 1. Initial bitewings show several carious lesions, specifically large DOB caries on #85



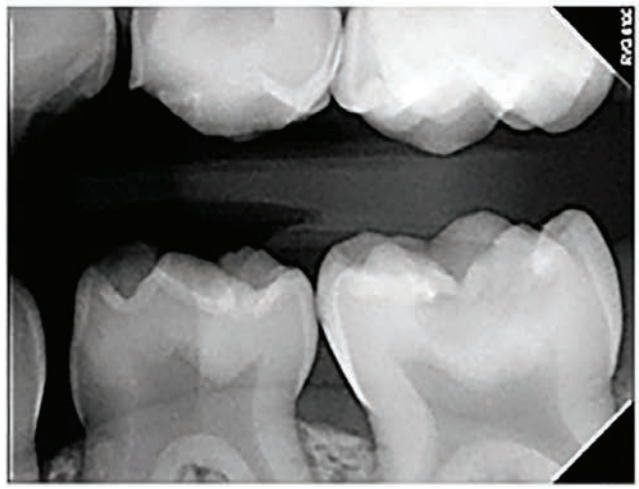
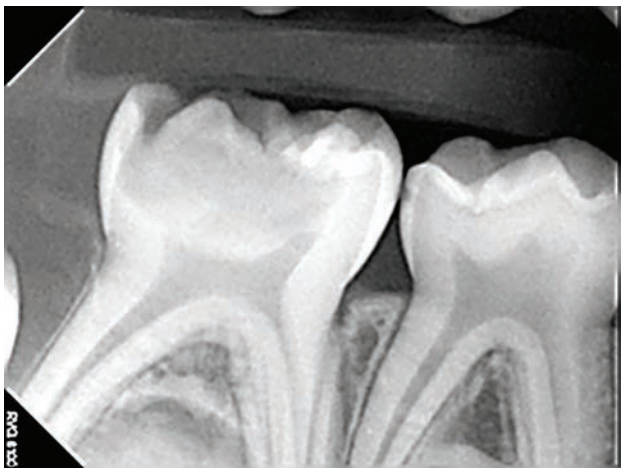


Figure 2. Periapical radiograph of primary right second molar prior to restoration

Figure 3. Periapical radiograph of primary right second molar prior to second attempt at restoration



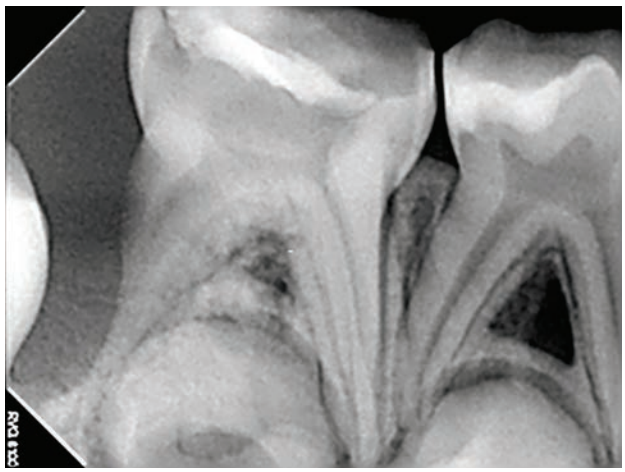
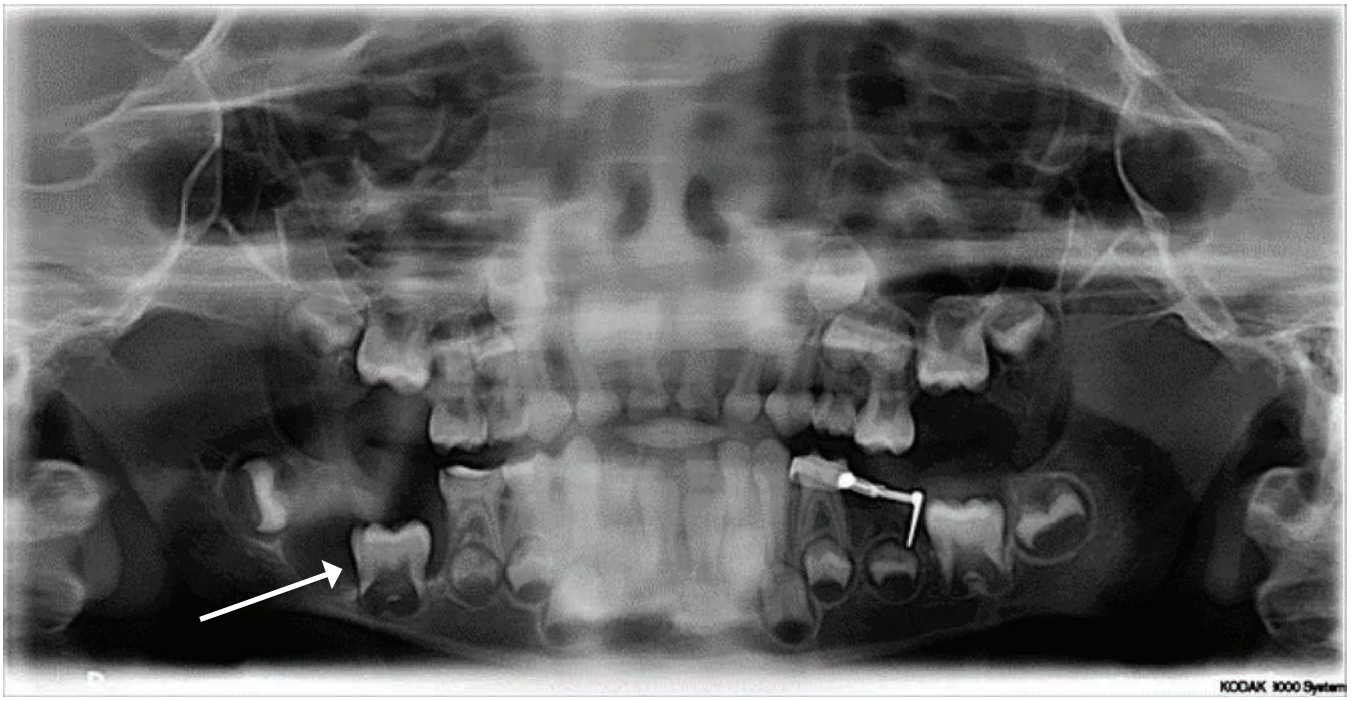


Figure 4. Panoramic image revealing a large radiolucent lesion associated with the crown of tooth #46



panoramic image revealed a large radiolucency associated with the crown of tooth 46 (Figure 4), tooth 47 was displaced posteriorly, and a missing maxillary right lateral incisor was also noted. Based on radiographic presentation the pediatric dentist made a differential diagnosis of lateral dentigerous cyst associated with the unerupted tooth 46. A referral was made to a local oral surgeon for the following day.

The oral surgeon elected to perform a punch biopsy, received a diagnosis of dentigerous cyst from the histopathologic report, and scheduled a surgery under general anesthesia to enucleate the cyst one month later.

During surgery, tooth 85 was extracted as well as a small amount of buccal bone. The lateral wall of the cyst was revealed and mobilized from the bony walls. Special care was taken to elevate the cyst and detach it from the cervical attachments of tooth 46, while at the same time holding the tooth in its normal position to prevent dislodgement as shown in Figure 5.

The cavity was curetted and irrigated thoroughly to remove remnants of the cyst lining. The flap was repositioned and secured with multiple interrupted gut sutures. The specimen was submitted for histopathologic evaluation which later confirmed the diagnosis of a dentigerous cyst. The pathology report did not include specific histology of the specimen. It simply stated the diagnosis as dentigerous cyst.

RESULTS

Follow-up exam appointments were rescheduled by the client's mother multiple times with the pediatric dental office, making the follow-up exam 1 year and 5 months post-surgery. Clinically, normal healing of all soft tissue in the area of the cystic lesion was noted. A new panoramic radiograph revealed tooth 46 tipped distally and possible vertical impaction underneath 47 as seen in Figure 6. It was recommended that the client return 6 months later for a periapical radiograph to recheck the positioning of 46. If the position had not improved in 6 months, a referral would be made to the appropriate specialist.

Figure 5. Cyst detached from cervical attachment of #46

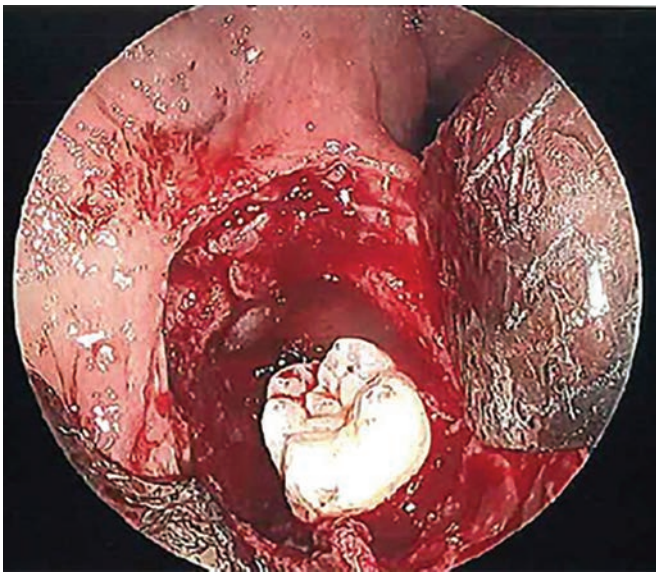


Figure 6. Follow up panoramic 1 year and 5 months later showing impeding #46

DISCUSSION

Cyst location in the case presented is consistent with the literature concerning DCs as most frequently observed in the mandible (70%). Much of the literature also states a slight male predilection, and second in prevalence to the radicular cyst. When looking specifically at children, however, there is some variation. A large study by Zhang and colleagues[3] found that, among children, DCs were the most common odontogenic cyst and more common in females. In general, most DCs are considered developmental and occur most commonly in the second and third decades and are associated with third molars and maxillary canines. Again, this is not the case in very young children, making this case uncommon because developmental DCs are rare in the first decade of life.[3,7] Radiographic appearance alone is not sufficient for definitive diagnosis. Differential diagnosis in this case could also include ameloblastic fibroma, odontogenic keratocyst, and possibly unicystic ameloblastoma emphasizing the need for early detection and intervention.[4,7,8,9]

The oral surgeon performed a punch biopsy 1 month prior to removing the cyst by enucleation. This is a best practice approach for diagnosis as some practitioners may be tempted to forego this step in the diagnostic process.[3] Histologic examination is always the gold standard in definitive diagnosis.[3,10] Several treatment options are suggested for removal of DCs, while the aim of treatment is complete elimination of pathology and maintenance of dentition with minimal surgical intervention.[9] The choice of therapeutic approach is based on the size and location of the cyst, integrity of the cystic epithelial lining, client age, proximity of the cyst to adjacent vital teeth, and relationship with anatomical structures. Children have a much greater and quicker capacity to regenerate bone than adults, and immature teeth have a greater eruptive capacity.[7,9] A conservative surgical approach is preferred for function and esthetic value, rather than cyst/tooth removal as is the treatment for many developmental DCs located in the third molar and maxillary canine regions of older clients.[1,9] The clinician in this case chose cyst enucleation and preservation of the involved permanent tooth due to the location of the cyst and involved teeth. As noted in the literature, this method of treatment was the best option for this case to preserve the impacted tooth.[7,9]

This case may beg the question as to the type of dentigerous cyst in this child. Is it a rare case of a developmental cyst, or is it perhaps of inflammatory origin? The pathology report did not include specific histology; it simply documented the lesion as being a dentigerous cyst. Benn and Altini[2], some of the first researchers to categorize some DCs as inflammatory, note that inflammatory DCs occur in immature teeth as a result of inflammation from a diseased deciduous tooth or other source spreading to involve the tooth follicle. This case was of a DC around the crown of a first permanent molar which had no overlying deciduous tooth, making it unlikely to be of inflammatory origin. A more specific microscopic description of cellular content of the lesion components by the pathologist could have assisted in determining the particular type of cyst in this case, as we know that histologic examination is the gold standard.[3,10]

As seen in Figure 6, the tooth has continued to develop normally, although it appears that it may be impeding

the eruption of 47. Orthodontic intervention may be in order for proper eruption and alignment of the permanent teeth as seen in other cases in the literature.[7,9,11] Several authors have noted the necessity of orthodontic treatment after cyst diagnosis and removal.[9,11] Miyawaki et al[12] note that there is an optimal period for surgical treatment of a dentigerous cyst in order for the tooth to be able to erupt. This further emphasizes the importance of early detection and treatment.

The frequency of dental anomalies detected in pediatric panoramic radiographic images is close to 30%.[13] The current radiographic guidelines of the American Academy of Pediatric Dentistry recommend posterior bitewings and panoramic exam after the eruption of the first permanent tooth. The guidelines also state, however, that clinical judgment be exercised as to the radiographic need based on clinical signs and symptoms.[14] In this case, the only baseline radiographs were bitewings that did not show the cyst, nor did the periapical image exposed at the initial restoration appointment. Upon obtaining the periapical film of 85 prior to the second attempt at restoring, a portion of the cyst was observed in the image, necessitating the panoramic image. Early diagnosis and removal of this cyst is important considering future complications that may arise with the lesion. If undetected and left untreated, more serious lesions sometimes develop from cellular change within a DC, such as the ameloblastoma, intraosseous mucoepidermoid carcinoma, and odontogenic keratocyst.[7]

Dental hygienists are often the oral health professional responsible for suggesting exposure of the appropriate radiographs and noting findings for further examination by the dentist. This case can serve to raise awareness among dental hygienists of the possibility of dentigerous cysts occurring in young children rather than the typical presentation around third molars and maxillary canines. This client had not only a DC, but also a congenitally missing maxillary lateral incisor, in addition to extensive decay. This case also emphasizes the important role of dental hygienists in reviewing radiographs for incidental findings. Knowledge of DCs and other pathologies and their possible ramifications can aid in clinical decision making for radiographic assessment, as well as treatment and referral options in young children.

CONCLUSION AND RECOMMENDATIONS

Dental hygienists are in a unique position to assist in identifying oral abnormalities during the assessment phase of the dental hygiene process of care. Although most dentigerous cysts are considered developmental in origin and primarily associated with third molars and permanent maxillary canines, it is important to recognize that they may also present in young children, could be of inflammatory origin, and may affect developing permanent teeth.

This case study confirms the importance of carefully reviewing radiographs and the implications of unidentified and untreated disease. Equipped with knowledge about oral pathology, dental hygienists can greatly assist the dentist in diagnosis and referral, and provide anticipatory guidance for parents of young children as they seek to establish optimum oral health for their clients of all ages.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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How access to online health information affects the dental hygiene client experience

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CJDH STUDENT ESSAY AWARD

The *Canadian Journal of Dental Hygiene*'s Student Essay Award competition, proudly sponsored by PHILIPS Sonicare, encourages students in a diploma, baccalaureate or degree-completion program to develop a love for writing and research and to recognize the possibilities that such endeavours offer for personal and professional growth. The editorial board is delighted to publish the winning entry from its 2020–2021 competition, which ably addresses the Canadian Dental Hygienists Association's 2015-2021 dental hygiene research agenda category of "capacity building of the profession."

ABSTRACT

Objective: Due to the widespread availability of online information, oral care providers are no longer the main source of oral health information for clients. This shift in the balance of knowledge has the potential to alter clients' experiences and relationships with their oral care providers, including dental hygienists. This review explores how access to online health information has influenced clients' experiences with their dental hygienists. **Method:** A narrative literature review of quantitative, qualitative, and mixed-method studies concerning clients' experiences with online health information and how it has influenced the client–health care professional relationship was completed. The electronic databases searched were Google Scholar™, PubMed, and CINAHL. Twenty-three studies published between 2005 and 2020 were included. **Results and discussion***:* The majority of clients used the internet to access health information to be better informed about health issues. Both clients and health care providers had concerns about the legitimacy and accuracy of various online information sources. Clients faced various communication facilitators and barriers when discussing this information with their health care provider. A positive response by the health care provider led to an improved client–clinician relationship, whereas a negative response led to distrust among all parties. Clients would be open to e-health literacy training by their dental hygienists. **Conclusion:** Clients' access to online health information can either improve or worsen their experiences and relationships with their dental hygienists, depending on the response by the dental hygienist when these topics are broached. Dental hygienists should consider taking time to provide e-health literacy training to clients during consultations.

RÉSUMÉ

Objectif : Étant donné la grande disponibilité d'information en ligne, les prestataires de soins buccodentaires ne sont plus la source principale d'information sur la santé buccodentaire pour les clients. Ce changement dans la répartition des connaissances a le potentiel de modifier les expériences et les relations que les clients ont avec leurs prestataires de soins buccodentaires, notamment avec les hygiénistes dentaires. Le présent examen explore comment l'accès à l'information sur la santé en ligne a influencé les expériences des clients avec leurs hygiénistes dentaires. **Méthode :** Une revue narrative de la littérature a été effectuée sur les études quantitatives, qualitatives et à méthodes mixtes relatives aux expériences des clients en matière d'informations sur la santé en ligne et la façon dont elles ont influencé la relation entre les clients et les professionnels de la santé. Des recherches ont été menées dans les bases de données électroniques Google Scholar[MD], PubMed et CINAHL. Vingt-trois études publiées entre 2005 et 2020 ont été retenues. **Résultats et discussion :** La majorité des clients ont utilisé Internet pour accéder à de l'information sur la santé afin d'être mieux informés sur les questions de santé. Tant les clients que les prestataires de soins de santé avaient des préoccupations quant à la légitimité et à l'exactitude des diverses sources d'information en ligne. Les clients ont fait face à divers facilitateurs et obstacles de communication lorsqu'ils discutent de cette information avec leur prestataire de soins de santé. Une réponse positive du prestataire de soins de santé a contribué à une amélioration de la relation client–clinicien, alors qu'une réponse négative a semé la méfiance entre les partis. Les clients seraient réceptifs à obtenir une formation sur la littératie en cybersanté par leurs hygiénistes dentaires. **Conclusion :** L'accès des clients à l'information sur la santé en ligne peut soit améliorer ou empirer les expériences ou les relations qu'ils ont avec leurs hygiénistes dentaires, selon la réponse de l'hygiéniste dentaire lorsque ces sujets sont abordés. Les hygiénistes dentaires devraient songer à prendre le temps de donner une formation sur la littératie en cybersanté aux clients pendant les consultations.

Keywords: dental client; dental hygiene; dental hygiene client experience; dentistry; health communication; internet; online health information
CDHA Research Agenda category: capacity building of the profession

INTRODUCTION

The development and growth of the internet has exponentially expanded society's ability to share ideas and knowledge. Increasingly, people are using this source to access health information and to gain knowledge about their health conditions.[1–8]

The option of having easily accessible health information at one's fingertips has caused a shift in the balance of knowledge between health professional and client.[5,9] Health care providers (HCP) are no longer the only source of health information for their clients, which has

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allowed the traditional one-sided conversation to evolve into an informed discussion.[7,9]

As HCPs, dental hygienists need to be cognisant of both the positive and negative effects of online health information on clients.[5] To best serve their clients, it is necessary for dental hygienists to be conscious of the unique expectations and needs of the internet-informed client. Using this knowledge, dental hygienists can better adapt to provide clients with effective, tailored care.

State of the literature

Most of the literature that explores how access to online health information has affected clients' experiences with their health providers has focused on the relationship between clients and their medical doctors. There is a paucity of research focused specifically on dental hygiene clients' online habits and their interactions with an oral health professional. Of the current studies or literature reviews with a dental focus, each focused more readily on the clients' online information-seeking habits or oral health providers' perceptions, and less on the clients' experience during their dental appointments.[10-13] This narrative literature review aims to explore how access to online health information has influenced clients' experiences with their dental hygienist and discuss how dental hygienists may adapt to better treat internet-informed clients.

METHODS

For this narrative review, searches of the electronic databases of Google Scholar™, PubMed, and CINAHL for full-text and qualitative studies using the following topics: online health information, internet-informed patient or patient experience were undertaken. Only full-text and peer-reviewed articles were included in the review. Any study older than 2000, or not published in English, was excluded. Primary search terms were online health information, patient experience, internet, dental patient, dentistry, health communication, online health seeking, and clinician–patient relationship.

Twenty-three studies fulfilled the eligibility criteria and were included in the review: 7 quantitative studies, 13 qualitative studies, and 3 mixed-methods studies. All studies were published between 2005 and 2020.

RESULTS AND DISCUSSION

Why and how do clients use the internet?

An overwhelming theme across the literature confirmed that clients used the internet to access health information to be better informed about health issues.[2,6,7,10,14-18] Commonly, studies found that clients used this information as a guide to determine whether or not to seek professional health care advice, or additionally, to prepare for the consultation.[1,10,14,19-22]

Clients also frequently sought online health material to clarify information after consultations with their health providers.[1,2,7,14,17,21] By expanding their knowledge of their health conditions through online health information seeking, clients gained a sense of empowerment over their conditions.[15-17,19]

Studies found that many clients used Google® as their starting point, as opposed to searching specific health sites.[15,18] Overwhelmingly, clients chose to use the internet as a health information source as they valued the anonymity, convenience, and quantity of information that the internet provides with just a click of a button.[2,4-6,17,18] While it was found that clients would prioritize the knowledge of the HCP, describing it as more trustworthy and reliable, clients still liked to use online health information as a supplemental source.[2,4,7,14,19]

While the majority of the research was based on systemic health issues, studies have found that these patterns are also being seen with oral health.[10,13,23] Many dental hygiene clients had also obtained oral health information online.[13] Studies have reported that dental clients research specific topics online such as cosmetic dentistry, gingivitis, tooth grinding, dental amalgams, and implants, among others.[10,23]

Concern with online information

Studies commonly reported that clients had concerns about the credibility and limitations of online sources of health information.[2,4,7,17] Many clients were wary of health information found on websites where they felt that companies or people were attempting to sell them products, or that were sponsored by third parties.[2,17] More frequently, clients expressed concerns over their own e-health literacy skills to evaluate the accuracy and legitimacy of online health information.[15,19]

While oral health providers found online health resources useful for their personal continuing education, they also expressed worries over clients misinterpreting this oral health information and treatment options.[23] Oral health providers were concerned that clients may not fully understand how the information found may or may not apply to their own specific needs.[23]

Clients also frequently reported information overload when attempting searches online.[14,15,17] Some felt this led to an increase in anxiety after searching online health information.[14]

Communication of internet use with clinicians

Several studies found that the majority of clients never showed or discussed their online findings during consultations with their HCP.[7,14,21] Some clients revealed they used the online material as a guide to discern what questions to ask their HCP or to increase their own confidence in bringing up questions, although they would not disclose their sources.[16,19]

Alternatively, when the topic of online health information was raised, it was equally initiated by HCPs and clients.[21] The majority of clients discussed their online findings to support their relationship with their HCP, not to challenge it.[7]

HCPs found there was generally a 3-pronged response when clients initiated the topic of online health information.[3] First, clients would ask a clarification question to better understand the topic.[3] Second, they would see if this information could be applied to their situation.[3] Third, clients would ask for tests or diagnoses based on what they had found online.[3]

Communication facilitators and barriers

The decision of the client to discuss online health information or not was influenced by multiple factors. Facilitators included if their HCP listened, acknowledged their efforts to be more informed, and offered to further the discussion about the information.[3,7] The body language of the HCP when the topic was first broached was an extremely important factor in whether or not clients continued this conversation.[7] The HCP initiating the topic and asking open, unassuming questions to understand the motivations of the clients was very helpful in making clients feel confident in discussing their online habits truthfully.[3,14]

Studies found that clients often experienced barriers to communicating this online information, such as resistance, fear of judgement, embarrassment, and lack of time.[2,7,14] Clients were often worried about offending their HCP or did not want to be seen as telling them how to do their jobs.[7,14] Additionally, clients did not want to mention sources they were not confident were credible or information they did not fully understand.[7,14] Once the topic was broached, any negative reaction from their HCP, such as the HCP becoming disinterested or pre-emptively discrediting the information, prevented the client from continuing the conversation or from bringing up online information in the future.[3,7]

Effect on the client–clinician relationship and health outcomes

The HCP's reaction to the client's online seeking habits had a significant impact on the client–clinician relationship.[7,14,20] Generally, the HCP reacted in 1 of 2 ways: either negatively or with a positive, client-centred approach.[1]

When online information seeking was introduced, some HCPs reacted by feeling threatened and defensive.[1] Several HCPs experienced anxiety when information beyond their area of expertise was discussed, which may have contributed to their defensive, dismissive behaviour.[7] Additionally, some oral health providers expressed frustrations regarding the amount of time needed during consultations to first break down online misinformation and then reinform their clients of the correct treatment.[23] This negative response by the provider led to feelings of distrust between both the HCP and the clients, resulting in a deteriorated relationship.[4,7,14,20]

Alternatively, a positive, client-centred response from the HCP led to an improved client–clinician relationship.[7] A positive response included if the HCP was sensitive to and supportive of the client's needs and took their findings into consideration in the decision-making process.[8] This client-centred approach, with open, honest, and empathetic communication between all parties enhanced client satisfaction with their health care services and increased clients' trust in their HCP.[3,8,21] Additionally, clients found their provider more trustworthy when the HCP was honest about their level of knowledge of the online information.[7] Clients did not expect their HCP to know everything, but instead desired to be engaged in a research partnership with their HCP.[17]

Mutual trust in the client–clinician relationship is important as it can improve the client's experience within the health care system and lead to improved health outcomes.[7,8,24,25] When online health information was discussed with clients, the clients reported improved satisfaction and recalled medical information more accurately than when online information was not discussed.[21] Dental hygienists should encourage clients to be better informed, as well-informed clients are more compliant and report more satisfaction with health care services, thus also aiding in improving health outcomes.[3]

As a profession, where do dental hygienists go from here?

These studies reiterated the importance of dental hygienists being cognisant of how their communication styles may act as a barrier to or facilitator for effective communication and subsequently influence the client's experience during the consultation.[7,14] If dental hygienists initiate conversations about online health information with a positive, client-centred focus, they may remove barriers clients experience, leading to improved discussions, better-informed clients, and increased trust between all parties.[7,14]

Leading positive discussions about online health information does not always mean agreeing with the findings or saying "yes" to the proposed tests or diagnoses.[26] When a provider disagrees with the information, it is important to first validate the client's efforts and show the client that they are taking the information, and the client, seriously.[26] When providers validated clients' efforts to be better informed, clients reported increased satisfaction and reduced concerns with their providers.[26]

Dental hygienists can facilitate better communication during appointments by setting aside time to carefully evaluate and critique the client's online health information and fully answer any questions that the client may have.[7] As clients commonly expressed a desire for education on how to use the internet to find credible information, dental hygienists should also focus on teaching basic e-health literacy skills to clients.[7,10,14,15,17,20] This training may lead to greater client satisfaction with dental hygiene services and potentially improve oral health outcomes.[24,25]

As many HCPs discussed lack of time as a main barrier to being able to provide this service, future research is needed on efficient ways for dental hygienists to provide this service effectively to their clients within the real-life constraints of a dental hygiene appointment.[7,13,22]

CONCLUSION

This review explored how access to online health information has influenced clients' experiences with their dental hygienist and how dental hygienists can use this information to best serve the internet-informed client. The consistent trend in the literature was that clients' access to online health information either improves or worsens clients' experiences and relationships with their dental hygienist depending on how the dental hygienist responds to these topics during the consultation.[7,14,16,19] A client-centred response led to an improved client–clinician relationship, whereas a negative response by the HCP led to distrust between the HCP and the client and slowly deteriorated the relationship.[7,14,20]

This information can be used by practising dental hygienists to improve their communication techniques and thus facilitate better discussions with their clients.[7] This in turn may lead to more successful client–clinician relationships, increased trust between all parties, and potentially to improved health outcomes for dental hygiene clients.[7,14,24,25]

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CONFLICTS OF INTEREST

The author has declared no conflicts of interest.

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The scientific program is an integral part of the Canadian Dental Hygienists Association's biennial national conference. The following studies will be presented as part of a pre-recorded session on October 29, 2021.

ORAL PRESENTATION ABSTRACTS

Assessing dental hygiene students' readiness for interprofessional learning

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Objective(s): The need for interprofessional education (IPE) has been well documented and communicated by many prominent government bodies and health organizations. However, more longitudinal outcomes research is needed to demonstrate the impact of IPE on students' attitudes and behaviours. This study assessed dental hygiene students' readiness for IPE and collaborative practice at the University of British Columbia. **Methods:** Ethics approval was granted by the university's behavioural research ethics board (H18-02026). This study employed a mixed-methods approach. A modified Readiness for Interprofessional Learning Scale (RIPLS) survey was completed by 23 (96% response rate) second-year dental hygiene students prior to commencing the university's newly integrated 4-week IPE curriculum and immediately following its completion approximately 1 month later. A focus group comprising 5 students then explored learning experiences and impact on attitudes towards collaborative practice in greater depth. Curriculum content included professionalism, ethical practice, Indigenous cultural safety, and resiliency. **Results:** Attitudinal shifts were observed in 3 of the RIPLS measures, suggesting that students found greater clarity regarding their professional roles and became more receptive to learning clinical problem-solving skills with other disciplines. No statistically significant differences were found between the pre-attitudinal and post-attitudinal RIPLS measures. The focus group revealed 3 prominent themes: greater role clarification, recognition of similarities in knowledge and practice of other professions, and cultivation of professional identity, collegiality, and respect. **Conclusions:** Dental hygiene students gained greater clarity about professional roles and developed an enhanced appreciation for working with other health professions after completing the university's month-long integrated IPE curriculum.

Fourth-year dental hygiene students' educational preparedness: Self-confidence ratings of the CDHA baccalaureate competencies (2017–2019)

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Objective(s): To examine the confidence levels of fourth-year baccalaureate students in their ability to demonstrate the *Canadian Competencies for Baccalaureate Dental Hygiene Programs* (CCBDHP), first published in 2015 by the Canadian Dental Hygienists Association (CDHA). This document is the first articulation of dental hygiene baccalaureate competencies in North America. However, there is little evidence to support that baccalaureate graduates are acquiring these abilities. **Methods:** This 3-year longitudinal study rated the self-confidence levels of fourth-year students as they neared graduation from the University of British Columbia from 2017 to 2019. It involved an online, anonymous survey using a 5-point scale ranging from not confident to confident. Respondents rated their self-confidence in the 110 subcompetencies articulated within the 13 competency domains of the CCBDHP. **Results:** Responses were received from 54 of the 70 graduating students for a cumulative 77% response rate. Respondents expressed the most confidence in the competency domains of clinical therapy (100%), collaboration (100%), disease prevention (100%), professionalism (100%), and oral health education (90%) but expressed less confidence in research use (73%), health promotion (70%), leadership (67%), policy use (20%), and advocacy (11%). **Conclusions:** These data suggest that curriculum revisions are needed in 5 domains but such changes may not be sufficient. Transition support may be warranted to assist graduates as they enter practice, while some competencies may be more appropriate for graduate studies. The study contributes to an international discussion about the educational preparedness of baccalaureate graduates and the boundaries between diploma, baccalaureate, and master's level education.

Dental hygiene student competence and comfort levels in treating transgender clients

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Objective(s): Transgender individuals face barriers to health care such as harassment, violence, and refusal of care. Current literature shows a lack of instruction on caring for sexual minority clients in dental and allied dental education programs, which contributes to the barriers to care encountered by this population. The purpose of this quasi-experimental study was to determine the effectiveness of an educational workshop on dental hygiene student competence and comfort levels in treating transgender clients. **Methods:** Dental hygiene students' competence and comfort levels in treating transgender individuals were evaluated using an adapted version of the Assessing Medical Attitudes Toward Transgender Care survey. A panel of experts established content validity of the adapted survey. Primary data were collected online from a convenience sample of dental hygiene students (n = 45) who attended an educational workshop about caring for transgender individuals. Data were collected at week 1 (baseline) and week 6 (post-workshop). Ethics approval was obtained from AT Still University and Texas Woman's University. **Results:** The Wilcoxon signed-rank test was used to analyse the data. The results showed a statistically significant increase from pre-test to post-test in competence (1.6667–3.0000; z = 5.373) and comfort (3.0000–3.8000; z = 4.799) scores after attending the educational workshop, $p < 0.001$. There was a statistically significant increase from pretest to post-test in the score for all competence and comfort questions. **Conclusions:** The findings of this study suggest that education on transgender health care increases competence and comfort levels among dental hygiene students and should, therefore, be included in dental and allied dental education curricula. When creating and revising dental hygiene curricula, educators and policymakers should ensure this content is included in sufficient scope and depth to prepare graduates to care for this population.

Relationship between original research experiences and evidence-based practice among undergraduate dental hygiene students: a mixed methods study

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Objective(s): For the progression of the dental hygiene profession, a need exists for researchers who focus on creating theoretical concepts and disseminating evidence specific to dental hygiene. Engaging undergraduate dental hygiene students in research experiences may foster interest in and overcome barriers to graduate education and may improve the implementation of evidence-based practice. The purpose of this study was to explore the relationships between original research experiences and evidence-based practice among undergraduate dental hygiene students. **Methods:** Following ethics approval (TUI 1209), this study utilized a mixed-methods research design involving a quantitative survey and qualitative case study. The target population was undergraduate dental hygiene students in the last year of their entry-level dental hygiene programs. The Wessex Research Network (WREN) spider instrument measured original research experience and the KACE instrument measured evidence-based knowledge, attitudes, access, and confidence in implementing evidence-based practice. Survey invitations and 2 email reminders were sent to program directors of US dental hygiene programs to forward to dental hygiene students in their final year. Semistructured interviews and focus groups were conducted with participants who had original research experiences. The data were analysed using descriptive statistics, bivariate analysis, linear regression, and thematic analysis. **Results:** The responses from 128 participants were analysed. The level of research experience was M = 27.63 (SD = 7.88) and the level of evidence-based practice was M = 92.80 (SD = 15.04). Research experience was significantly correlated with evidence-based attitudes, access, and confidence ($p < 0.01$). Research experience was found to be a significant predictor of evidence-based practice ($p < 0.001$). Thematic analysis revealed how research experiences affected evidence-based practice through knowledge, attitudes, access, and confidence. **Conclusions:** The extent of research experiences impacted the level of evidence-based practice among undergraduate dental hygiene students. Incorporating original research experiences into the dental hygiene curriculum may improve the implementation of evidence-based practice.

Identifying oral health activities among Canadian health care providers

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Objective(s): Improving oral health for priority populations, those most at-risk for oral diseases, may be accomplished by integrating basic oral health care into primary health care, including health, school, and community-based social services. Seven entrustable professional activities (EPAs) have been identified that facilitate the integration of oral health assessment and management into primary health care. The purpose of this study was to identify which Canadian health care provider (HCP) groups may

be entrusted with professional oral health activities. An additional aim was to explore the degree to which the scopes of practice of the entrustable health professionals align with the 7 EPAs. **Methods:** Three criteria were used to identify entrustable health professionals whose practice aligns with the EPAs: 1) HCP groups were identified using the Canadian Institute for Health Information Workforce Database; 2) oral health professionals and professionals with no direct patient contact were excluded; 3) national competency profiles of included HCP groups were analysed by 3 independent reviewers to identify whether specific competencies encompassed one or more of the EPAs. Discrepancies among reviewers were resolved through discussion to consensus. Once identified, applicability of EPA competencies to the competency profile was confirmed by a consultant with expert knowledge of the scope of practice of each HCP group. **Results:** Thirty HCP groups were identified. Three oral health provider groups, three HCP groups without patient contact, and three without a national competency profile were excluded. Findings suggest that 20 of 21 identified HCP competency profiles align with one or more EPAs, most notably, oral health assessment, education and treatment, and referral to an oral health professional. **Conclusions:** Several HCP groups may be able to incorporate one or more of the EPAs into their practice. Future research should explore the current oral health-related knowledge, attitudes, and practice patterns of the identified HCP groups.

The systemic inflammatory response following hand instrumentation versus ultrasonic instrumentation

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Objective(s): A positive correlation has been reported between periodontal treatment time and serum C-reactive protein (CRP) levels 24 hours after treatment. This study sought to investigate the immediate systemic inflammatory response following full-mouth debridement within a 24-hour period, and to determine any differentiation between use of hand compared with ultrasonic instruments. Secondary outcomes were aimed at evaluation of clinical parameters and time taken for treatment. **Methods:** Thirty-nine periodontitis clients were randomized to treatment with full-mouth debridement using either hand instruments alone or ultrasonic treatment alone, completed within 24 hours. Serum and periodontal clinical parameters were collected at baseline, day 1, day 7, and day 90 post-treatment. Differences in systemic inflammatory markers were assessed using general linear models at each timepoint, corrected for age, gender, smoking status, body mass index, and baseline levels of each marker. **Results:** Across all clients, serum CRP increased at day 1, with no differences between hand and ultrasonic groups (p[adjusted] = 0.22). There was no difference between groups in interleukin-6 (p[adjusted] = 0.29) or tumor necrosis factor α (p[adjusted] = 0.53) at day 1. Inflammatory markers returned to baseline levels by day 7. Treatment resulted in equal and marked improvements in clinical parameters in both groups. However, total treatment time was on average shorter for ultrasonic instruments (p[adjusted] = 0.002). **Conclusions:** Treatment time for hand instrumentation correlated positively with disease severity, while ultrasonic treatment time was stable regardless of disease levels. Ultrasonic treatment was overall shorter and resulted in comparable clinical outcomes. Levels of serum CRP at day 1 were similar following debridement with hand or ultrasonic instruments.

Analysis of basement membrane defects in lichenoid lesions with dysplasia

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Objective(s): Oral lichen planus is a mucosal lesion often encountered by oral health professionals. Microscopically, these lesions present with a band of immune cell infiltrate at the epithelial–connective tissue junction. This heavy inflammation may induce reactive changes in the epithelium resembling dysplasia, casting uncertainty on the true malignant potential of lichenoid lesions with dysplasia (LLD). Some theorize that there are subtypes with primary lichenoid and secondary dysplastic features (L1D2), or primary dysplastic and secondary lichenoid features (D1L2) that have differing malignant risks. This study aimed to analyse whether these subgroups exist and to compare the proportion of malignant progression in these groups. **Methods:** Ethics certification was obtained from the University of British Columbia Research Ethics Board (REB #H19-01785). Clinical and outcome data (defined as progression to severe dysplasia, carcinoma in situ, or squamous cell carcinoma) and formalin-fixed paraffin-embedded tissue sections were collected from patients with a diagnosis of low-grade LLD, no history of head and neck cancer, and at least 5 years of follow-up. Using a case-control design, 11 cases and 33 controls were required to detect a significant difference with 5% significance and 80% power on 2-tailed tests. Basement membrane (BM) degeneration was analysed using immunohistochemistry to detect collagen IV; normal tissue was used as a positive control. Inferential statistical analysis was performed

using logistic regression. **Results:** BM degeneration was seen in both the cases (n = 10) (70%) and controls (n = 32) (78%), with no statistically significant difference between groups (p = 0.69). **Conclusions:** The results of this pilot study suggest that the proposed subtypes of LLD with the absence or presence of basal cell/BM degeneration do not have differing malignant risks. Rather, any dysplasia in lichenoid lesions is indicative of malignant potential and should be monitored clinically.

Health is created in settings where people live, learn, work, and play

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Objective(s): Health is created in settings where people live, work, learn, and play. Inherent to healthy learning are structures, policies, and strategies that enable health. Still, evidence mounts that the dental hygiene (DH) and dental (DMD) learning environments and curricula challenge student health; further, that program focus remains treatment- and prevention-oriented. This study explored DH and DMD students' sense of coherence (SOC) and perceptions of their programs from a salutogenic, healthy-learning perspective. A moderate SOC signifies a health-oriented or salutogenic life disposition. Healthy learning positions students to be workforce health-promoting agents. **Methods:** Sequential exploratory mixed methodology guided the study. First, 40% and 33% of the DH and DMD senior students, respectively, at a single institution participated in focus groups. Thematic analysis followed; the themes informed the Health-Promoting Attributes survey's content (Cronbach's alpha > 0.70). Then, 79.5% of the students with 1 year of program experience completed the survey, including the Sense of Coherence-29 (SOC-29) questionnaire, a validated salutogenic measure. Survey data analysis involved inferential statistics. The study received ethics approval (HS 21378; H2017:421). **Results:** Seven themes emerged from the focus groups: realizing health-of-self; sensing program as health-promoting learning setting; experiencing health-of-self curriculum; programming structure; programming strategy; health-promoting people; and facilitating learning environment. The DMD program predicted realizing health-of-self and program structure. The DH program predicted health-of-self curriculum, program strategy, and health-promoting program-based people. Students perceived a lack of and limited environmental support for a health-of-self curriculum. The SOC-29 scores indicated a moderate SOC for both student groups with a small effect (r = –0.25, p = 0.004) seen between programs (DMD: M = 127.37 SD = 19.08; DH: M = 116.60 SD = 17.19). **Conclusions:** Students possess a moderate SOC enabling them to navigate health-challenging programs. However, DH and DMD programs need to become healthy-learning settings so graduates can enter practice as healthy workplace advocates.

Healthy and respectful workplaces: Dental hygienists' experiences in Canada

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Objective(s): The aim of this study was to describe dental hygienists' experiences related to healthy and respectful workplaces. Specifically, it sought to 1) understand the scope of issues related to healthy and respectful workplaces; 2) determine the prevalence of harassment, bullying, abusive and violent behaviours in the workplace; and 3) explore the factors associated with these behaviours. **Methods:** An online self-administered survey was sent to all members of the Canadian Dental Hygienists Association. Respondents were asked to report the occurrence and frequency of mistreatment experienced over their career as a dental hygienist and any negative impacts experienced as a result of mistreatment. Descriptive univariate and bivariate statistics were performed on SPSS. **Results:** Responses were received from 3,780 dental hygienists (response rate = 22%). More than 70% of respondents experienced some form of mistreatment over their career, from dentists, office managers, coworkers or clients. Older, more experienced dental hygienists with higher levels of education and without policies in their workplace to address these issues had significantly higher odds of experiencing an incident of mistreatment. Of those who experienced mistreatment, 67% reported losing the respect they felt for the offending person, 55% reported experiencing symptoms of depression, and 30% quit their job. **Conclusions:** Mistreatment of dental hygienists appears to be prevalent in Canadian dental care settings resulting in negative consequences for mental and financial well-being.

POSTER PRESENTATION ABSTRACTS

Transitioning into an online dental hygiene degree-completion program

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Objective(s): The University of British Columbia's dental hygiene degree-completion (DC) program has offered an academic pathway for dental hygienists to earn a degree

exclusively through an online delivery format since 2006. The students' experiences transitioning to online learning and related student support needs have not been previously studied. Thus, this study investigated students' experiences as they entered an online dental hygiene DC program. **Methods:** An online survey with open- and closed-ended questions was distributed to all 53 enrolled dental hygiene DC students in September 2019. Survey questions asked for demographic information, academic transitional experiences, social integration, and sense of belonging in the faculty and university, perceived barriers and challenges, and suggestions for future students. **Results:** Thirty-two students completed the survey for a 60% response rate. Most student respondents (78%) had no prior experience with online education. Only 59% of respondents were confident in their abilities to navigate a web-based learning environment. Three-quarters (75%) of respondents felt like a valued member of the Faculty of Dentistry community but only 47% felt they belonged to the larger university community. Most (72%) were familiar with the support resources within the faculty but fewer than half (41%) were aware of additional resources outside of the faculty. Students aged 30 years and older felt more comfortable reaching out to faculty and staff members (90% versus 55%; $p = 0.05$). Students with prior online learning experience were more aware of student support resources outside of the faculty (57% versus 36%; $p = 0.05$). **Conclusions:** Lessons learned from this study have informed several recommendations to better support student transition to online learning that can be applicable to this program and in other institutions.

Evaluating ultrasonic instrumentation curricular change: a comparison study

***Joanna Asadoorian**, PhD, RDH[1]; ***Dani Botbyl**, RDH[2]; **Marilyn J Goulding**, BSc, MOS, RDH[3]

[1]George Brown College, Toronto, ON, Canada; [2]Dentsply Sirona Canada; [3]Dentsply Sirona Consumables

Objective(s): The objective of the study was to compare student perceived outcomes of 2 dental hygiene cohorts following differing ultrasonic instrumentation (USI) curricula. **Methods:** A 2-group observational comparison study was conducted with a senior class following a "traditional" USI curriculum and a junior class following a "contemporary" USI curriculum. The junior class USI curriculum was introduced earlier in their programming, with more and different inserts and with a greater philosophical emphasis on USI. Students' use, confidence, and preparedness in USI were measured through online questionnaires at 2 times. Ethical approval was received from the Multi-College Ethics Review Process from the host institution. Quantitative analysis calculated proportions, means, and t-tests comparing groups; significance was set at 0.05. **Results:** The response rate ranged from 21.5% to 52.9%. There were no significant differences between the 2 groups in the time students used ultrasonic versus hand instruments; students used ultrasonics approximately 60% of debridement time throughout programming. Regarding specific aspects of USI, earlier in their programming, the junior group was significantly more prepared with water control and fulcruming and had greater preparedness with curved inserts than the senior class. Initially, the senior students had statistically significant greater confidence levels than junior students. Towards the end of the program, the junior class had higher confidence than the seniors, but this finding was not statistically significant. However, the junior cohort confidence levels significantly increased from Time 1 to Time 2. **Conclusions:** Although all students demonstrated a similar level of use of USI, students following a "contemporary" ultrasonic curriculum were shown to have higher levels of preparedness with some aspects of USI and with curved inserts, and were found to have improving levels of confidence by the end of dental hygiene programming. The study reveals the need for ongoing evaluation to determine how best to implement USI curriculum.

HPV immunization counselling in dental practices: an interprofessional training module

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Objective(s): Human papillomavirus (HPV)-related oropharyngeal cancers (OPC) have increased significantly despite the availability of the HPV vaccine. HPV-positive oropharyngeal cancer (OPC) is becoming more prevalent than tobacco-related OPC. Dental health care professionals (DHPs) screen for OPC and known risk factors, but many are not prepared to address immunization. The purpose of this study was to prepare DHPs and students to deliver effective prevention and immunization education against HPV-related OPC. An online training module was created to accomplish 3 specific aims: 1) increase DHPs knowledge of HPV infection; 2) increase DHPs confidence in their ability to provide effective HPV immunization counselling; and 3) improve DHPs attitude towards recommending HPV immunization to their clients during dental encounters. **Methods:** This study was declared exempt from ethical approval. Thirty-seven dental hygiene students completed a pre-test survey and then viewed an interactive online training module in HPV-related OPC and immunization counselling. Students completed a post-test survey one week later. Knowledge, confidence, and attitudes towards HPV prevention and immunization counselling, pre-test and

post-test, were compared. **Results:** Respondents showed a significant increase (CI = 0.5, $p = 0.00$) in knowledge of HPV prevention, with mean scores ranging from 8.75 to 13.32 based on a 15-point scale. Respondents showed an increase ($p < 0.05$) in confidence and comfort in providing HPV immunization counselling. Similarly, there was an increase ($p < 0.05$) in positive attitudes towards recommending HPV immunization. **Conclusions:** Dental health care professionals' role in disease prevention should include immunization counselling. Effective education and preparation for HPV counselling can be accomplished through specific modular-based education. This type of education would be beneficial in an institutional or professional setting. Texas A&M College of Dentistry Educational Research Grant provided funding for this project.

E-cadherin and beta-catenin in the malignant progression of oral epithelial dysplasia

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Objective(s): Epithelial-mesenchymal transition (EMT), a biological process characterized by a decrease in epithelial features and increase in mesenchymal traits, has been proposed as a critical mechanism in cancer development. The loss of E-cadherin, a cell-surface protein involved in epithelial cell–cell adhesion, is a hallmark feature of EMT. A potential mechanism in which E-cadherin contributes to malignant progression is via beta-catenin signaling through the Wnt pathway. E-cadherin and beta-catenin expression is altered from normal oral mucosa, oral epithelial dysplasia (OED), to oral squamous cell carcinoma (OSCC), but there is no longitudinal research on the role of these biomarkers in malignant progression. The objective of this study was to explore the expression of E-cadherin and beta-catenin in OED that progressed to oral cancer and to determine if these expression patterns predict malignant progression. **Methods:** 74 non-progressors and 37 progressors were included in this matched case-control study. Patient samples with a baseline biopsy of low-grade (mild or moderate) OED were obtained from the Oral Cancer Prediction Longitudinal Study. Samples that progressed to severe OED, carcinoma in situ or OSCC were progressors, and samples that did not progress were non-progressors. Immunohistochemistry performed on fixed paraffin-embedded tissue samples to visualize expression patterns of E-cadherin and beta-catenin is ongoing. Logistic regression will predict progression. **Results:** There was no significant difference in age, sex, ethnicity, smoking history, and lesion size, appearance, colour, risk site, and grade of dysplasia between non-progressors and progressors. We hypothesized reduced epithelial E-cadherin expression and reduced membranous and increased cytoplasmic and/or nuclear beta-catenin expression in progressors compared to non-progressors, and that OED with this expression pattern would show greater likelihood of progression. **Conclusions:** This research enhances the understanding of EMT's role in malignant progression and potentially aids in the prevention and early identification of oral lesions at risk of progression to cancer.

Barriers to pursuing further education among Canadian dental hygienists: a qualitative pilot study

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Objective(s): Canada has seen a growing movement towards the development of new pathways to further dental hygienists' education, in order to strengthen cognitive and practice outcomes. According to the 2019 Canadian Dental Hygienists Association (CDHA) Job Market and Employment Survey, only 18% of respondents held a bachelor's degree. This study investigated barriers to pursuing further education among Canadian dental hygienists who practise with a diploma as their highest educational credential. **Methods:** Purposeful maximum variation sampling was used to select Canadian dental hygienists across 10 provinces and 1 territory for 3 focus groups (n = 17) conducted through videoconferencing. Selected participants were CDHA members who practise with a dental hygiene diploma as their highest educational credential. The e-focus group discussions were transcribed verbatim and underwent thematic analysis for barriers to pursuing further education using Saldaña's approach to descriptive and in-vivo coding. Member-checking was completed in 2 phases: transcripts were provided to participants, followed by thematic summaries to confirm emerging themes. Ethics approval was granted by the University of British Columbia's Behavioural Research Ethics Board (H20-00455). **Results:** Barriers included family obligations, accessibility, perceptions of eligibility, lack of employer support, and financial restrictions. Other prevalent themes were awareness of programs offered and the benefits of completing a degree. A few participants also raised concerns around the stress and anxiety of being in school. **Conclusions:** These focus group findings were used to supplement answer options for a national online survey that has been distributed to all CDHA members. Survey results will then inform CDHA, provincial associations, and educational institutions of barriers to pursuing further education, strategies to reduce those barriers, and

facilitate the furthering of degree education for Canadian dental hygienists.

Integrating online daily clinical assessments in Canadian dental hygiene education

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Objective(s): The impact of high-stakes clinical summative assessments on student learning, well-being, achievement, and self-efficacy has been well documented. The literature has highlighted that multisource feedback and continuous, low-stakes assessments provide a more comprehensive and accurate representation of students' developing clinical competence. The study's purpose was to conduct a clinical program evaluation, as part of an internal quality assurance process, to explore student and faculty perspectives and experiences of high-stakes summative clinical assessments and the transition towards multisource, low-stakes, online daily assessments in the dental hygiene degree program (DHDP) at the University of British Columbia (UBC). **Methods:** The project received exemption from the institution's behavioural research ethics board. Two independent focus group discussions were conducted on a purposeful sample of graduating dental hygiene students (n = 8) and clinical instructors (n = 4). The discussions were audiorecorded, transcribed verbatim, and Saldaña's framework of descriptive and in vivo coding was utilized for analysis and thematic development. Two rounds of member-checking were also conducted to increase trustworthiness of the findings. **Results:** Student and instructor participants favoured the provision of multisource feedback and continuous, online, lower-stakes assessments indicating that it more accurately represented students' developing clinical competence, while one-time, high-stakes assessments were more often influenced by a multitude of variables including stress, interexaminer differences, and failure to fail. **Conclusions:** Results from this research provided valuable insight into student and faculty experiences and perspectives of a high-stakes assessment environment and a subsequent multisource, lower-stakes assessment approach for the appraisal of clinical competency. Findings further strengthen understanding of assessment approaches for the evaluation of clinical competence and will inform curricular design and future assessment methodologies in the DHDP at UBC.

Nurse practitioner and oral health students interprofessional education initiative to promote oral–systemic health

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Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB, Canada

Background/Goal(s): The University of Manitoba established a pilot project that placed nurse practitioner, dental hygiene, and dental students in a learning environment together. The goal of the interprofessional initiative was to create an innovative and experiential learning opportunity for the students to enhance their understanding of oral–systemic health and bridge the oral health care setting with primary care. **Objective(s):** The aim of the study was to explore patient and nurse practitioner, dental hygiene, and dental students' perceptions of an interprofessional education (IPE) initiative on oral and systemic health. It was important to know if students learned from the collaborative experience and if patients perceived improved care. **Approach:** Senior nurse practitioner, dental hygiene, and dental students participated first in online, face-to-face, and simulation learning experiences. Then in the College Dental Clinic, they worked in small interprofessional teams to assess patients' oral and overall health and create interprofessional care plans with referrals to primary care. Students and patients completed surveys after each session, and patients were contacted for follow-up and referral. Descriptive statistics were used to analyse data. The University of Manitoba Human Ethics Research Board approved the project. **Evaluation:** Though the COVID-19 pandemic interrupted the study, preliminary data analysis reveals the majority of students perceived the interprofessional collaborative practice experience as beneficial. The follow-up process with patients was greatly impacted by the pandemic. In process is the complete analysis of the student and patient data. The feedback supports the time and effort needed to deliver an oral–systemic clinical experience that brings together students as they prepare to enter practice. The experience fosters a spirit of interprofessional collaboration to improve client care and outcomes.

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SUBJECT INDEX

AUTHOR INDEX

MISCELLANEOUS

An Invitation for Authors

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Timothy Donley DDS MSD is currently in the private practice of Periodontics and Implantology in Bowling Green, KY. Dr. Donley is a sought-after speaker whose courses are always highly rated. His forte lies in taking the latest research and packaging it in a way that makes sense. Dentistry Today recently listed him among its Leaders in Continuing Education. Dr. Donley co-authored the first-ever comprehensive textbook on ultrasonic debridement. He lectures and publishes frequently on topics of interest to clinical dentists and hygienists.

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