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Review Article

Modern Approach to Pediatric Dental Caries Prevention and Treatment

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Abstract

Dental caries has been the most common disease in childhood. The World Health Organization (WHO) emphasizes that dental caries affects about 60 to 90% of schoolchildren and the majority of adults. The patterns of dental caries globally and regionally reflect the risk profiles of countries relate to social structure, living conditions, and existence of preventive oral health systems. However, dental caries is a preventable disease and can be potentially reversed in its early stages. The importance of primary prevention has been emphasized in young children. The use of fluoride to increase resistance of teeth to caries development has been widely used. Mechanisms of fluoride are both topical and systemic, but the topical effect is the most important over the life span. A great amount of time had been dedicated to the studies of enamel Remineralization. The modern approach has been suggested that "non-invasive treatment of early caries lesion by Remineralization has the potential to be the major advance in the clinical management of the disease". The introduction of nanotechnology in dentistry allowed developing materials ranging in the size 100 nanometers or smaller in at least one dimension. The use of nanotechnology simulated the natural biomineralization process to create the dental enamel. Hydroxyapatite is the principal inorganic constituent of bones and teeth. It is suggested that extensive research be performed to improve full capacity of nano-hydroxyapatite in a clinical setting, which has a great potential in providing preventive and therapeutic approach to dental caries for children worldwide.

ABBREVIATIONS

Nano-HA: Nano-Hydroxyapatite; ICDAS: International Caries Detection and Assessment System; ICCMS™: International Caries Classification and Management System

INTRODUCTION

The National Health and Nutrition Examination Survey 2011-2012 in the United States showed approximately 37% had dental caries experience among 2 to 8 years of age, and 23% in children 2 to 5 years of age had dental caries in primary teeth whereas, children 6 to 8 years of age had 55.7% dental caries experience. Among the races, the Hispanic of origin at 45.7% had the highest prevalence of dental caries followed by Non-Hispanic Black (43.6%), Non-Hispanic Asian (35.9%), and Non-Hispanic White children (30.5%). A total of 14.3% had untreated dental caries, 10% in 2 to 5 years of age and 20.1 % among children 6 to 8 years of age [1]. Caries prevalence rates are distinct in different age groups and populations [2]. Children from low-income families or minority groups are more likely to have caries. They have the highest burden, but their level of care is in the lowest. In addition, children who had earlier caries experience, low exposure to fluoride, poor oral hygiene, poor oral health knowledge and children with special health care needs had a higher risk to experience dental caries [3].

Etiology

Dental caries described as a complex process, involve numerous risk factors such as environmental, behavioral, socioeconomic, and biological factors (Figure 1) [3-5]. In general, the higher number of risk factors an individual, the greater probability the individual will have caries experience [4,6].

Streptococcus mutans

The human body is composed of approximately 10^{14} cells and majority of organisms consists of the resident microflora of the host, which is a natural process and acquired from birth. *Streptococcus mutans* is a major group in initiation of dental caries, gram-positive cocci, non-motile facultative anaerobic microorganism that can metabolize carbohydrates.

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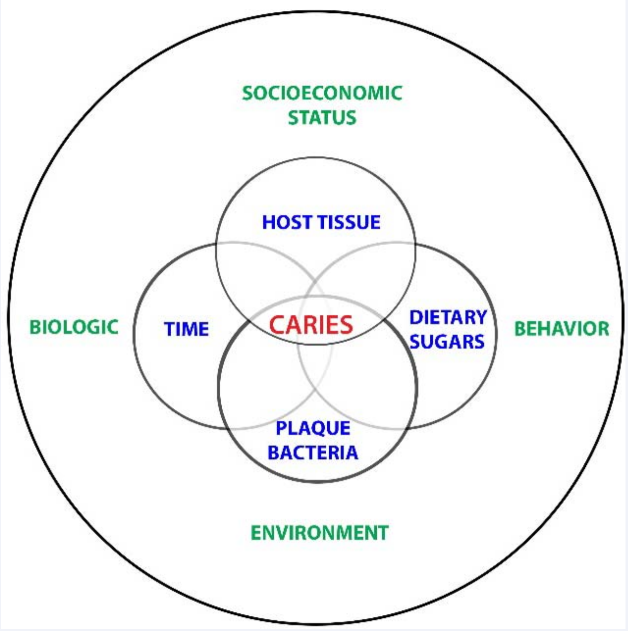

Figure 1 Schematic illustration of different factors involved in caries development (Adapted and Modified from Brambilla et al) [66].

S. mutans are able to adhere to the tooth surface through the dental plaque that is a highly structured, spatially organized, and metabolically integrated community of bacteria. Dental plaque creates a complex matrix, largely composed of glucan [5]. *S. mutans* produces high amounts of lactic acid that can survive at pH, and can cause demineralization of tooth enamel and the polysaccharides contribute to the process by providing sugars in low sugar intake [7]. The *S. mutans* generally only appear in the mouth following tooth eruption and vertical transmission of *S. mutans* from caregiver to child has been reported [6,8-12]. An initial colonization of the *S. mutans* acquired from the primary caregiver to the child occur in the "window of infectivity", which may begin at 10 to 14 months of age [13].

Substrate

Sucrose is a common naturally occurring carbohydrate; used as a sweetening agent and promotes selectively *S. mutans* with other acidogenic and acid tolerating species. Major biochemical and physiological changes in process of biofilm formation are caused by sucrose [14]. The adherence of bacteria to the teeth increases the number and level of virulence of bacteria as the sucrose consumption increases.[10,12] It serves as substrate for the synthesis of extracellular and intracellular polysaccharides in dental plaque. The pH levels drop rapidly after ingestion of sucrose, glucose and fructose due to the acid production of acidogenic and acid-tolerant bacteria that leads to the demineralized tooth structure [15]. The formed biofilm in the presence of sucrose has low concentrations of critical ions such as calcium, phosphate and fluoride that involved in the process of demineralization and Remineralization [16].

Host factors

Saliva: Saliva composed of more than 99% water and less than 1% solids, mostly electrolytes and proteins gives the viscosity characteristic of saliva. It is the main defense against caries in protecting the teeth also acts as a dilute and buffer the acids formed by the *S. mutans* by oversaturation with calcium and phosphate ions. Furthermore, It is composed of secretory immunoglobulin A (sIgA), which responds by binding selectively to the surface of *S. mutans* where it exhibits its influence [4].

The concentration of calcium increases slightly from unstimulated to stimulated state of secretion. Calcium, binds to proteins such as proline-rich proteins and statherin called as ionized calcium, then combines with free form calcium at given pH [17]. On the other hand, non-ionized calcium does not bind to proteins, but to inorganic ions such as bicarbonate and phosphate. More calcium is in the non-ionized form, when there is an increase of saliva pH and ionic strength at high flow rates [18]. Salivary flow rate is considered to be an important protective factor. The pH of saliva is strongly dependent on the section rate. In a healthy individual it varies between about 6.0 and 7.5, where the stimulated flow rate is the most alkaline [3].

Enamel: Enamel is the external hard surface of the tooth, mainly composed of hydroxyapatite contains other organic and inorganic components. It is composed of numerous needle-like, prismatic crystals ranging from 3 to 5 µm in diameter, which are bundled in an orderly manner to ensure the mechanical strength and biological protection (Figure 2) [19,20]. The degree of saturation of oral fluids in relation to apatite minerals, influences the process of de- and Remineralization [21]. Demineralization occurs when the pH value falls below the critical value and the endogenous bacteria in the dental plaque produce weak organic acids, which creates an imbalance of calcium and phosphate ions from the tooth enamel, as minerals are lost [22,23]. On the other hand, remineralization occurs when dental plaque pH is restored by saliva through uptake of calcium, phosphate and fluoride on the demineralized area (Figure 3,4) [24].

Paradigm shift of pediatric dental caries prevention and treatment

Paradigm has been defined as "a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline" [25]. Caries can progress if pathological factors are

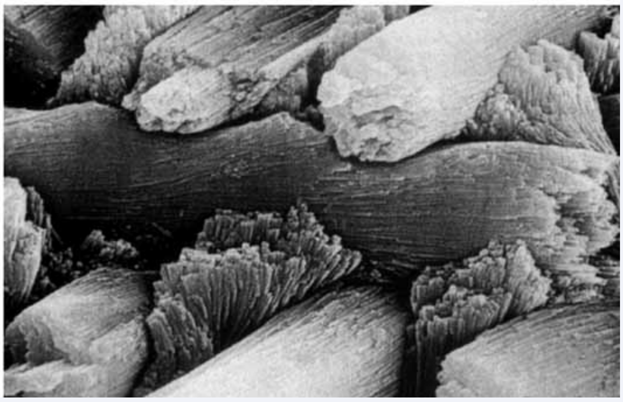

Figure 2 Scanning Electron Microscopy enamel images of needle like HA crystallites [67].

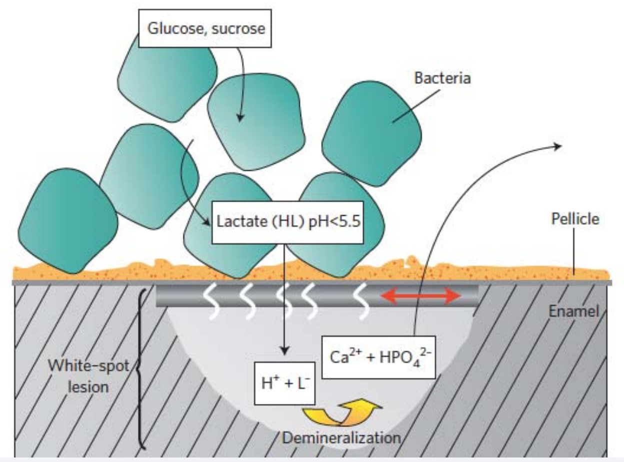

Figure 3 Early stages of tooth decay caused by bacterial biofilm [68].

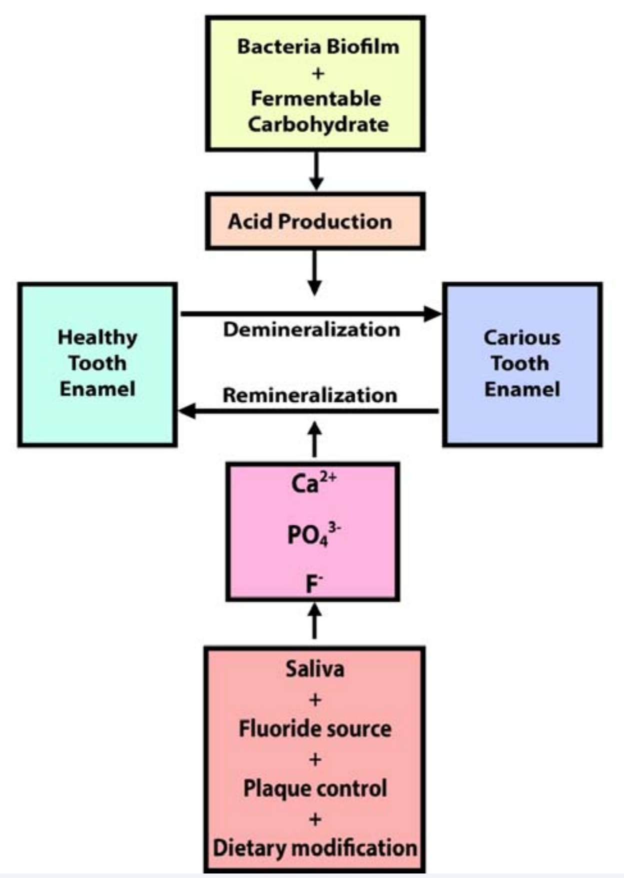

Figure 4 Diagram of the caries process as regular flux of demineralization and remineralization [69].

dominant and can reverse if protective factors become superior [5]. Through appropriate treatment, early lesions can be arrested and be remineralized. Though there is a present variability in caries detection, caries activity and risk assessment, treatment options, and decision-making on when and how to treat teeth and what is the best method for monitoring disease. Recognition of patients who are at high-risk of developing dental caries will allow dentists to develop strategies for prevention and treatment of the disease. Early detection of caries lesions and assessment of disease activity is critical and widely recognized in limiting the extent of demineralization [26]. First popularized in Thomas Kuhn's classic work, "*The Structure of Scientific Revolution"*, a true paradigm shift may consider as changing emphasis from surgical model of corrective and reparative interventions to more focused on diagnosis, early intervention, and prevention. Prevention has become a foundational principle of modern dentistry practice, where non-operative treatment is given emphasis and minimal intervention dentistry has been widely accepted [27,28]. Evidence-based dentistry provides dental practitioners the current best scientific evidence and incorporates into their clinical decision-making, however it is yet to be successfully disseminated and fully implemented [27].

International caries detection and assessment system – ICDAS: ICDAS concept is used to provide information to plan, manage and improve long-term caries outcomes. The system has been designed for education, research, clinical practice and public health [29]. The goal of the caries management system is to improve oral health through implementation of new paradigms in managing dental caries [29,30].

Seven caries categories of visual criteria have been designed and designated by numbers 0-6 based on the histological extent of lesions. They are as follows:

0. Sound tooth surface

1. First visual change in dried enamel

2. Distinct visual changes in wet enamel

3. Localized enamel breakdown due to caries with no visible dentin

4. Underlying dark shadows from dentin (with or without enamel breakdown)

5. Distinct cavity with visible dentin

6. Extensive distinct cavity with visible dentin

International caries classification and management system – ICCMS™: The ICCMS™ is a system developed based on the best biological and clinical evidence. ICCMS™ in a holistic approach provides a standardized method for caries assessment and individualized caries management. Designed to accommodate the needs of different users across the ICDAS domains. Preservation of tooth structure and restoration only when indicated is the central and fundamental guidance on operative intervention of ICCMS™, which is evidence-based and patient-centered. Following the principles of ICCMS™, four elements are involved. The first element is collecting the patient's past and present dental and medical history, and caries assessment level of risk factors. The second element is the caries classification stage, which starts with plaque assessment followed by clinical examination, and then caries stage determination, assessment and evaluation of each tooth. The third element is decision-making, diagnosis of each caries lesion, and risk of acquiring new lesions. The fourth element includes the individualized caries prevention and caries control management care (Figure 5) [30].

Management of each lesion will depend on the caries classification of the surface. For sound teeth, risk-based prevention is recommended and aims to lower the risk of the patient, addresses homecare, and clinical approaches adjusted to status of patient. During primary dentition of the active initial caries lesion, non-operative care is recommended includes application of topical fluoride, dental sealants on pit and fissures, oral hygiene instruction, and supervision until the age of 8 years while in initial inactive lesion, no lesion specific treatment. In moderate and extensive active or inactive lesion, non-operative care and tooth-preserving operative care is suggested. The same management is recommended for permanent dentition [30]. The implementation of ICCMS™ will increase the comfort level among dentists with the introduction of decision tools and education programs. This will also help the dentistry in management of early childhood caries that can result in positive outcomes [30].

Minimal intervention

Minimal intervention dentistry has been introduced into the management of caries, and has evolved from caries removal methods to early prevention and intervention of disease; all are integrated into the patient caries management. From a biological standpoint, restorations are not the 'final solution', and the major benefit of minimal intervention is the prevention of the inevitable failure of restorations because of unending cycles of recurrent caries [31]. Minimum intervention aims to decrease the unnecessary destruction of tooth structure and gives emphasis on prevention of the disease to continue the caries process [17]. It is important to note, while there is an urgent need to address current disease, the long-term of outcomes should be expected [31].

Remineralizing agents: Remineralization is the delivery of minerals into the caries lesion, mostly calcium and phosphate to reverse or arrest caries progression [32]. In addition, changing the chemistry of tooth surface and reducing tooth susceptibility to acid attack makes it less vulnerable to demineralization [5]. There has been an increased interest in emphasizing prevention and intervention in high caries risk individuals, enhancing the remineralizing agents to arrest caries progression, and improving the reversal of the condition [33].

Fluoride is the best-established remineralization strategy compared to the other remineralization system [34]. Fluoride being the main active ingredient of remineralizing agent is most effective in reversing early lesion at the tooth surface [35,36]. In forming one-unit of fluorapatite ($Ca_{10}(PO_4)_6F_2$), every 2 fluoride ions, 10 calcium ions and 6 phosphate ions are required to consequently limiting the net remineralization to occur due to the availability of calcium and phosphate [37]. The remineralization effect of topical fluorides only attempt to reduce apatite dissolution than to promote mineralization of lost minerals and apatite crystals [20]. Moreover, the fluoride dosage in children still raises a concern in the occurrence of dental fluorosis due to fluoride ingestion, which may exceed the maximum allowable dosage and intake recommended for children under the six years of age [34].

CPP-ACP technology also demonstrates its anti-cariogenic potential and enhances Remineralization [37, 38]. The high concentrations of calcium and phosphate ions will maintain the concentration gradient during the remineralization, and diffusion of the ions into lesions [39]. ACP precipitates from a highly supersaturated calcium phosphate solution [40]. It has been widely used in biomedical field due to the excellent bioactivity, adjustable biodegradation rate, high cell adhesion and good osteoconductivity [41]. CPP through multiple phosphoseryl residues has the ability to stabilize ACP into CPP-ACP complex. The product is primarily used as abrasive paste and a treatment

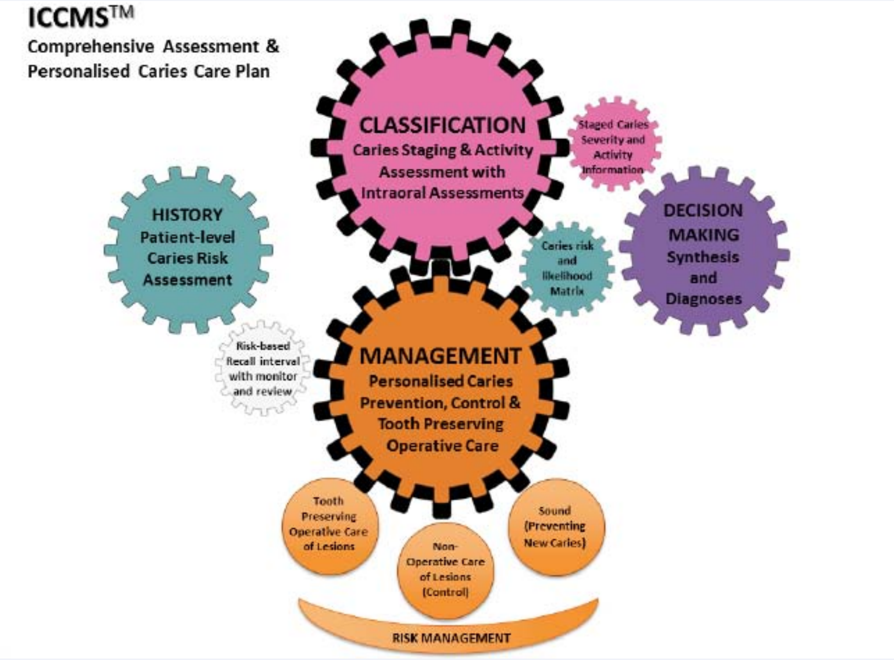

Figure 5 Detailed overview of ICCMS™ elements and their components [30].

for tooth sensitivity. CPP-ACP binds well to plaque, provides a large calcium reservoir and diffuses free calcium slowly [40]. Similar with fluoride, CPP-ACP has shown additive effects in reducing dental caries experience [42].

Tricalcium Phosphate (TCP) also enhances remineralization with better formulations, in addition of calcium to complement fluoride. When TCP reaches the tooth surface, the saliva will activate the calcium complex, which is carried by TCP and protected by fluoride ions. When released at the tooth surface, high fluoride and calcium levels concentrates on the lesion, thus promote Remineralization [43].

Arginine is a semi-essential amino acid found in salivary peptides and proteins, demonstrates inhibiting caries in children to have significant effects [44]. The arginine technology produces ammonia and has highly alkaline that causes a rise in pH, presenting an ideal condition for Remineralization [45]. Arginine is found free in saliva in micromolar concentrations [46]. Using arginine formulations, modulating the alkali-generating potential of dental plaque may promote an ecologically healthy oral environment, which could have a potential to suppress the emergence of acid-tolerant, caries-associated pathogenic organisms [47].

Silver Diamine Fluoride (SDF) is used in dentistry when a child is too young for the carious teeth to be restored by conventional methods [48]. It allows to kill cariogenic bacteria, precipitates on carious dentine and provides instant caries arrest, and does not require an injection and drilling. On the other hand, the disadvantage of using SDF is that the lesions were stained black, results from the impermeable layer on the tooth surface resistant to caries [49].

Most recently, theobromine is added as an active ingredient to toothpaste, which is from the xanthine family. It is an alkaloid available in cocoa and chocolate discovered to enhance crystallinity and the resistance of the remineralized surface to subsequent acid challenge. It is attributed to the crystallite size increase, as it is one of the major factors that control the rate of apatite dissolution [50].

Nano-hydroxyapatite

Hydroxyapatite (HA) the main inorganic component of enamel is 95% by weight of the total weight of enamel. The enamel's basic building block is generally composed of 20 to 40 nm particles of HA [19]. However, when the maturation of enamel is reached, proteins are removed in which controls the crystallization and contains no cell, hence the enamel cannot be biologically remodeled [19,20,51]. Thus, the use of synthetic apatite or HA is found to be beneficial in remineralizing enamel minerals. Hydroxyapatite is able to absorb glucan, produced by *S. mutans* in combination of the salivary proteins which will inhibit plaque formation, and an important source of calcium and phosphate responsible for the remineralization of demineralized enamel area [20,52].

Improving the repairing effect of enamel, the dimensions of enamel are reduced to nano-scale, where the smaller dimension exhibit a larger surface area; A smaller HA is found to be closer to a biological apatite compared to a larger HA particle [19,51]. Moreover, the recent increased interest in nanotechnology introduced the nano-hydroxyapatite (nano-HA) been widely used in medicine and dentistry [53]. It is used in Japan as toothpaste since 1980 and tested the apatite-containing dentifrices in a clinical trial in Japanese schoolchildren, and found to be significant in inhibiting new caries [52,54]. Synthetic nano-HA has the same chemical-physical properties of apatite found on enamel. Although the structure of the enamel is too complex to be remodeled, it is suggested that a biomimetic technique can be used to repair enamel surface and possess a strong affinity to the tooth [19,51,55]. A 20 nm size HA layer revealed similar to the subunits of a biological apatite and is resistant to acidic solution [19]. The nano-HA due to its higher pH value increased its remineralizing effect compared to amine fluoride. It was observed in the latter a hyper mineralization of the surface layer that may have obstructed the diffusion of ions into deeper lesion depth, thus inhibit the Remineralization process [21]. Nano-HA while may have observed minor toxicity in human cells, it is also found to be non-allergenic, non-mutagenic, non-carcinogenic [56,57], and has no accumulative toxicity found in animal cell [58]. Its non-toxicity and non-inflammatory property makes it ideal to be used as bone substitute and dental implant [59].

Mechanism of action: Nano-hydroxyapatite can repair and can prevent initial lesions in enamel due to its size and high availability of calcium and phosphate ions that plays a key role in demineralization and remineralization process [60,61]. The concentration of calcium is observed to have greater effect than the phosphate concentration in inhibiting demineralization. Low levels of calcium in plaque are found to be an indicative of caries incidence while none for the phosphate ions [62]. The pH level affects the concentration of calcium and phosphate in nano-HA pH study where highest degree of remineralization is observed at pH 4.0 than at pH 7.0, and as pH the value decreases, the concentration of calcium and phosphate increases. More minerals are also deposited in the body of the lesion, and depth was significantly reduced as pH value of nano-HA decreased. Under acidic conditions, nano-HA can significantly accelerate the rate, depth of penetration and extent of Remineralization [61]. In SEM analysis, nano-HA is observed to adhere to pores created by demineralization, and aggregate into micro clusters then form a uniform apatite layer on demineralized surface covering the prismatic and interprismatic enamel structure. Furthermore, the analysis of Ca/P ratio showed nano-HA significant increase in mineral content compared to 2% sodium fluoride [55].

Clinical applications of nano-HA: In recent years, a considerable attention is received on application of nano-HA in repair of early caries lesion. In search for alternatives to fluoride, nano-HA with high concentrations of calcium and phosphate ions has been incorporated to toothpaste. A 10% Nano-HA toothpaste was able to reduce the demineralization and enhance the remineralization of the artificial caries lesion and produce similar results like in fluoride containing toothpaste [63]. In a similar study, the effects of daily treatment with different nano-HA toothpastes evaluate the remineralization of bovine enamel and dentine subsurface compared amine fluoride toothpaste. A hypermineralization accompanied by increased lesion depth was observed in amine fluoride whereas, no hypermineralization observed on nano-HA toothpastes. Furthermore, higher remineralization on the dentin surface was also achieved with nano-HA or $ZnCO_3$/n-HA toothpaste when compared to amine fluoride dentifrice [21].

However, a different result was obtained in another study on remineralization potential of nano-HA. The nano-HA would only promote preferential remineralization on the surface unable to achieve full remineralization. This restriction leads to an idea that to combine nano-HA with another effective anti-caries agent-like fluoride or other elements. This may enhance the remineralization effect and possible to achieve the full remineralization effect [64]. Nano-HA found to achieve higher surface area due to its size, and provide dental enamel a good mechanical strength that can assist in improving the remineralization of NaF. Different concentrations of nano-HA (0%, 1%, 5% and 10%) were added to NaF and distilled water for comparison. The results showed a higher degree of remineralization obtained in NaF than in the distilled water group. In addition, increasing remineralization was observed as the concentration of nano-HA increased [59].

A possible combination of other elements with nano-HA can also be accomplished. The addition of natural products may have a potential in enhancing nano-HA remineralization effect [64]. In search for new bioactive anti-caries compound, a Chinese herbal medicine called Galla chinensis (GCE) showed an ability to inhibit demineralization and enhance remineralization *in vitro* [65-69]. In addition, GCE has been proven to possess antibacterial properties, which would supplement the nano-HA deficiency on its bacteriostatic ability and may have better effects in anti-caries [64]. The combination of Nano-HA and GCE showed a shallower lesion depth and comparable to the NaF group. Also the combination showed higher volume percent mineral at surface layer and deposited at depth 40 to 140 µm indicating more mineral is deposited in the body of the lesion [64].

DISCUSSION

Modern approaches to early childhood caries have been advocated in the shift from surgical to early intervention and preventive measures and showed increased interest in recent years. Minimal intervention dentistry has been widely accepted and through appropriate treatment, early lesions can be arrested or remineralized. Different types of remineralizing agents such as fluoride, casein phosphopeptide amorphous calcium phosphate, tricalcium phosphate, arginine, silver diamine fluoride, and theobromine which are only of the few studied agents available in the market that have been proven to either arrest caries progression or reduce the tooth susceptibility to demineralization.

Nanotechnology has been widely used in the field of medicine and showed potential improvement in the field of dentistry in the use on dental implants, restorative materials, and dental materials yet not much studied its potential as a remineralizing agent. The application of nanotechnology on remineralization could provide an alternative and superior approach particularly in the treatment intervention of dental caries in children. The production of synthetic hydroxyapatite on a nano-scale have shown from previous studies have the potential and more effective to repair enamel surface due to the same chemical-physical properties of the apatite found on the enamel. Nano-hydroxyapatite due to its size and high availability of calcium and phosphate ions plays a role in the demineralization and Remineralization process. Numerous studies presented the benefits and effects on the use of nano-hydroxyapatite however there are still barriers and challenges in the establishing nano-hydroxyapatite as effective remineralizing agent.

CONCLUSION

It has been suggested that extensive research be performed to prove a modern approach to pediatric dental caries prevention and treatment in a clinical setting, which has a great potential to improve oral health for children in providing effective preventive, diagnostic and therapeutic measures. In addition, the clinical application of nanotechnology can bring advancement into the practice of pediatric dentistry.

CONFLICT OF INTEREST

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REFERENCES

1. Dye BA, Thornton-Evans G, Li X, Iafolla TJ. Dental caries and sealant prevalence in children and adolescents in the United States. 2011-2012. NCHS Data Brief. 2015; 191: 1-8.
2. Demirci M, Tuncer S, Yuceokur AA. Prevalence of caries on individual tooth surfaces and its distribution by age and gender in university clinic patients. Eur J Dent. 2010; 4: 270-279.
3. Krol DM. Dental caries, oral health, and pediatricians. Curr Probl Pediatr Adolesc Health Care. 2003; 33: 253-270.
4. Anderson M. Risk assessment and epidemiology of dental caries: review of the literature. Pediatr Dent. 2002; 24: 377-385.
5. Cummins D. Dental caries: a disease which remains a public health concern in the 21st century--the exploration of a breakthrough technology for caries prevention. J Clin Dent. 2013; 24: 1-14.
6. Edwardsson S. Characteristics of caries-inducing human streptococci resembling Streptococcus mutans. Arch Oral Biol. 1968; 13: 637-646.
7. Spatafora G, Rohrer K, Barnard D, Michalek S. A Streptococcus mutans mutant that synthesizes elevated levels of intracellular polysaccharide is hypercariogenic *in vivo*. Infect Immun. 1995; 63: 2556-2563.
8. Berkowitz RJ, Jones P. Mouth-to-mouth transmission of the bacterium Streptococcus mutans between mother and child. Arch Oral Biol. 1985; 30: 377-979.
9. Grönroos L1, Saarela M, Mättö J, Tanner-Salo U, Vuorela A, Alaluusua S. Mutacin production by Streptococcus mutans may promote transmission of bacteria from mother to child. Infect Immun. 1998; 66: 2595-2600.
10. Kuramitsu HK. Virulence factors of mutans streptococci: role of molecular genetics. Crit Rev Oral Biol Med. 1993; 4: 159-176.
11. Li SH, Kingman A, Forthofer R, Swango P. Comparison of tooth surface-specific dental caries attack patterns in US schoolchildren from two national surveys. J Dent Res. 1993; 72: 1398-1405.
12. Staat RH, Gawronski TH, Cressey DE, Harris RS, Folke LE. Effects of dietary sucrose levels on the quantity and microbial composition of human dental plaque. J Dent Res. 1975; 54: 872-880.
13. Peretz B, Sarit F, Eidelman E, Steinberg D. Mutans streptococcus counts following treatment for early childhood caries. J Dent Child (Chic). 2003; 70: 111-114.

14. Sheiham A, James WP. Diet and Dental Caries: The Pivotal Role of Free Sugars Reemphasized. J Dent Res. 2015; 94: 1341-1347.

15. Bowen WH, Eastoe JE, Cock DJ. The effect of sugar solutions on the pH of plaque in caries-active monkeys (macaca irus). Arch Oral Biol. 1966; 11: 833-838.

16. Paes Leme AF, Koo H, Bellato CM, Bedi G, Cury JA. The role of sucrose in cariogenic dental biofilm formation--new insight. J Dent Res. 2006; 85: 878-87.

17. Fejerskov O, Kidd EAM. Dental caries: the disease and its clinical management. Oxford Ames, Iowa: Blackwell Munksgaard. 2008; 616.

18. Lagerlöf F, Lindqvist L. A method for determining concentrations of calcium complexes in human parotid saliva by gel filtration. Arch Oral Biol. 1982; 27: 735-738.

19. Li Li, Haihua Pan, Jinhui Tao, Xurong Xu, Caiyun Mao, Xinhua Gu. et al. Repair of enamel by using hydroxyapatite nanoparticles as the building blocks. J Mater Chem. 2008; 18: 4079-4084.

20. Norberto Roveri, Elisabetta Foresti, Marco Lelli, Isidoro G. Lesci, et al. Recent Advancements in Preventing Teeth Health Hazard: The Daily Use of Hydroxyapatite Instead of Fluoride. Recent Patents on Biomedical Engineering. 2009; 2: 197-215.

21. Tschoppe P, Zandim DL, Martus P, Kielbassa AM. Enamel and dentine remineralization by nano-hydroxyapatite toothpastes. J Dent. 2011; 39: 430-437.

22. Bowen WH. Do we need to be concerned about dental caries in the coming millennium? Crit Rev Oral Biol Med. 2002; 13: 126-131.

23. Kleinberg I. The other side of confection use and dental caries. J Can Dent Assoc. 1989; 55: 837-838.

24. Selwitz RH, Ismail AI, Pitts NB. Dental caries. Lancet. 2007; 369: 51-59.

25. American Heritage Dictionary. 5th ed. 2013, New York: Houghton Miffin Harcourt Publishing Company.

26. Anusavice KJ. Present and future approaches for the control of caries. J Dent Educ. 2005; 69: 538-54.

27. Garcia RI, Sohn W. The paradigm shift to prevention and its relationship to dental education. J Dent Educ. 2012; 76: 36-45.

28. Kidd E. The implications of the new paradigm of dental caries. J Dent. 2011; 39: 3-8.

29. Pitts NB, Ekstrand KR, ICDAS Foundation. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS) - methods for staging of the caries process and enabling dentists to manage caries. Community Dent Oral Epidemiol. 2013; 41: 41-52.

30. Amid I. Ismail, Nigel B. Pitts, Marisol Tellez, et al. The International Caries Classification and Management System (ICCMS) Guide for Practitioners and Educators. BMC Oral Health. 2015; 15: 9.

31. Walsh LJ, Brostek AM. Minimum intervention dentistry principles and objectives. Aust Dent J. 2013; 58: 3-16.

32. Amaechi BT, Mathews SM, Ramalingam K, Mensinkai PK. Evaluation of nanohydroxyapatite-containing toothpaste for occluding dentin tubules. Am J Dent. 2015; 28: 33-39.

33. Featherstone JD, Doméjean S. The role of remineralizing and anticaries agents in caries management. Adv Dent Res. 2012; 24: 28-31.

34. Zero DT. Dentifrices, mouthwashes, and remineralization/caries arrestment strategies. BMC Oral Health. 2006; 6 : 9.

35. Biesbrock AR, Faller RV, Bartizek RD, Court LK, McClanahan SF. Reversal of incipient and radiographic caries through the use of sodium and stannous fluoride dentifrices in a clinical trial. J Clin Dent. 1998; 9: 5-10.

36. ten Cate JM, Arends J. Remineralization of artificial enamel lesions in vitro: III. A study of the deposition mechanism. Caries Res. 1980; 14: 351-358.

37. Reynolds EC. Calcium phosphate-based remineralization systems: scientific evidence? Aust Dent J. 2008; 53: 268-273.

38. Ruchi Vashisht, Rajamani Indira, Ramachandran S, Anil Kumar, Manali Ramakrishnan Srinivasan, et al. Role of casein phosphopeptide amorphous calcium phosphate in remineralization of white spot lesions and inhibition of Streptococcus mutans? J Conserv Dent. 2013; 16: 342-346.

39. Yamaguchi K, Miyazaki M, Takamizawa T, Inage H, Moore BK. Effect of CPP-ACP paste on mechanical properties of bovine enamel as determined by an ultrasonic device. J Dent. 2006; 34: 230-236.

40. Zhao J, Liu Y, Sun WB, Zhang H. Amorphous calcium phosphate and its application in dentistry. Chem Cent J. 2011; 5: 40.

41. Li Y, Li D, Weng W. Amorphous calcium phosphates and its biomedical application. J Inorgan Mater. 2007; 22: 775-782.

42. Reynolds E. Dairy products and dental health. Proc Nutr Soc. 1995; 19: 95-102.

43. Amaechi BT. Remineralization Theraphies for Initial Caries Lesions. Curr Oral Health Rep. 2015; 2: 95-101.

44. Acevedo AM, Montero M, Rojas-Sanchez F, Machado C, Rivera LE, Wolff M, et al. Clinical evaluation of the ability of CaviStat in a mint confection to inhibit the development of dental caries in children. J Clin Dent. 2008; 19: 1-8.

45. ten Cate JM, Cummins D. Fluoride toothpaste containing 1.5% arginine and insoluble calcium as a new standard of care in caries prevention. J Clin Dent. 2013; 24: 79-87.

46. Van Wuyckhuyse BC, Perinpanayagam HE, Bevacqua D, Raubertas RF, Billings RJ, Bowen WH , et al. Association of free arginine and lysine concentrations in human parotid saliva with caries experience. J Dent Res. 1995; 74: 686-690.

47. Nascimento MM, Browngardt C, Xiaohui X, Klepac-Ceraj V, Paster BJ, Burne RA. The effect of arginine on oral biofilm communities. Mol Oral Microbiol. 2014; 29: 45-54.

48. Yee R, Holmgren C, Mulder J, Lama D, Walker D, van Palenstein Helderman W. Efficacy of silver diamine fluoride for Arresting Caries Treatment. J Dent Res. 2009; 88: 644-647.

49. Chu CH, Lo EC. Promoting caries arrest in children with silver diamine fluoride: a review. Oral Health Prev Dent. 2008; 6: 315-321.

50. Amaechi BT, Porteous N, Ramalingam K, Mensinkai PK, Ccahuana Vasquez RA, Sadeghpour A , et al. Remineralization of artificial enamel lesions by theobromine. Caries Res. 2013; 47: 399-405.

51. Roveri N, et al. Surface enamel remineralization: biomimetic apatite noncrystals and fluoride ions different effects. J Nanometer. 2009.

52. Kani T, et al. Effect to Apatite-containing Dentifrices on Dental Caries in School Children. Journal of Dental Health. 1989; 39: 104-109.

53. Richards R, KJ K. Introduction to nanoscale materials in chemistry, in Nanoscale materials in chemistry. 2009; 3-14.

54. Najibfard K, Ramalingam K, Chedjieu I, Amaechi BT. Remineralization of early caries by a nano-hydroxyapatite dentifrice. J Clin Dent. 2011; 22: 139-143.

55. Swarup JS, Rao A. Enamel surface remineralization: Using synthetic nanohydroxyapatite. Contemp Clin Dent. 2012; 3: 433-436.

56. Pang XF. The properties of Nanohydroxyapatite Materials and its

Biological Effects. Materials Sciences and Applications. 2010; 1: 81-90.

57. Pang XF, Zhou HW, Liu JL. Investigation of biological property of nanohydroxyapatite materials. J Nanosci Nanotechnol. 2012; 12: 894-901.
58. Liu LP, Xiao YB, Xiao ZW, Wang ZB, Li C, Gong X. [Toxicity of hydroxyapatite nanoparticles on rabbits]. Wei Sheng Yan Jiu. 2005; 34: 474-476.
59. Choi C, Kim BI. Combined Effects of Nano-Hydroxyapatite and NaF on Remineralization of Early Caries Lesion. Key Engineering Materials. 2007; 330-332: 1347-1350.
60. Min JH, Kwon HK, Kim BI. The addition of nano-sized hydroxyapatite to a sports drink to inhibit dental erosion: in vitro study using bovine enamel. J Dent. 2011; 39: 629-635.
61. Huang S, Gao S, Cheng L, Yu H. Remineralization potential of nano-hydroxyapatite on initial enamel lesions: an in vitro study. Caries Res. 2011; 45: 460-468.
62. Li X, Wang J, Joiner A, Chang J. The remineralisation of enamel: a review of the literature. J Dent. 2014; 42: 12-20.
63. Itthagarun A, King NM, Cheung Y. The effect of nano-hydroxyapatite toothpaste on artificial enamel carious lesion progression: an in-vitro pH-cycling study. Hong Kong Dent J. 2010; 7: 61-66.
64. Huang S, Gao S, Cheng L, Yu H. Combined effects of nano-hydroxyapatite and Galla chinensis on remineralisation of initial enamel lesion in vitro. J Dent. 2010; 38: 811-819.
65. Chu JP, Li JY, Hao YQ, Zhou XD. Effect of compounds of Galla chinensis on remineralisation of initial enamel carious lesions in vitro. J Dent. 2007; 35: 383-387.
66. Brambilla E, García-Godoy F, Strohmenger L. Principles of diagnosis and treatment of high-caries-risk subjects. Dent Clin North Am. 2000; 44: 507-540.
67. Weiner S, Traub W. Crystal size and organization in bone. Connect Tissue Res. 1989; 21: 259-265.
68. Hannig M, Hannig C. Nanomaterials in preventive dentistry. Nat Nanotechnol. 2010; 5: 565-569.
69. Kidd E JBS. Essentials of dental caries: The disease and its management. 1997.

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