Chewing gum as a medium for the delivery of anticariogenic therapeutic agents: a review

ABSTRACT

Objectives. To consider the effects of chewing gum on dental plaque and saliva, and to discuss the value of chewing gum as a means of delivering anticariogenic agents.

Methods. Literature and data from 1940 to 2007 related to chewing gum and anticariogenic therapeutic agents were sourced using PubMed and hand searches.

Results. Chewing of gum increases salivary production and salivary flow rate. With the increase in salivary flow, the concentration of bicarbonate and phosphate is higher in stimulated saliva. The resultant increase in plaque pH and salivary buffering capacity prevents demineralization of tooth structure. The chewing action also results in the physical removal of plaque and food debris, which assists in cleansing the occlusal surfaces of the teeth. Because gum is repetitively chewed it has a longer period of exposure to the surfaces of teeth than a dentifrice or mouthrinse; thus, it can be a useful adjunct in maintaining oral health, especially if it contains a therapeutic agent that is effective topically. Agents that have been added to chewing gum to specifically prevent dental caries include: polyols such as xylitol and sorbitol, fluoride, calcium phosphate, carbamide (urea), enzymes, and granules.

Conclusions. There is insufficient published evidence, especially for carbamide, enzymes, and granules, to support the notion that these additives have a therapeutic role when added to chewing gum. Further investigations are required to justify the anticariogenic claims when chewing gum is the medium of delivery.

Key words: Chewing gum; Dental caries; Saliva

Introduction

Chewing gum probably has its origins in ancient Egypt and in Mayan Indian times as these peoples are known to have chewed the resin of trees. Basically, chewing gum is composed of 20 to 60% sweeteners, 18 to 35% chewing gum base, 3 to 20% glycerol, 1 to 2% coloring and flavoring agents, and 0.3 to 3.0% softeners. Chewing gum did not become a commercially available product in the US until the mid-1800s, with the first patent being issued to Dr. William F. Semple, who was a dentist.

In 50 A.D., when the Greeks sweetened their breath and cleansed their teeth with a resin called mastiche, which was obtained from the bark of the mastic tree, chewing gum first became an aid to maintaining oral health. In the belief that it would aid digestion, pepsin powder was added to gum in the late 19th century. Since then, a number of
anticariogenic, topical and systemic therapeutic agents have been added to modern chewing gums.

In 2006, the annual market worldwide for chewing gum was about 1.3 million tons and worth approximately US$1.9 billion [1]. Therefore, the use of chewing gum as a vehicle for the delivery of therapeutics has great potential. Although nicotine-containing chewing gum is widely used to assist people in breaking the habit of smoking tobacco, to date relatively few other drugs have been administered via this route. Controlling the release of the drug is a major concern because it is dependent on several variables such as chewing time, aqueous solubility, and the gum’s composition [2].

As a vehicle for the delivery of anticariogenic agents could well be beneficial because chewing gum comes into direct contact with the teeth, is pleasant and convenient to use, and a high level of user compliance can be expected. Aside from the physical removal of plaque and food debris, which assists in the cleansing of dental occlusal surfaces [3,4], the use of chewing gum also increases salivary flow rate and enhances the protective properties of saliva. This is because the concentration of bicarbonate and phosphate is higher in stimulated saliva, and the resultant increase in plaque pH and salivary buffering capacity prevents demineralization of tooth structure. Moreover, the higher concentration of calcium, phosphate, and hydroxy ions in such saliva also enhances remineralization [5,6]. It was observed that the artificial lesions in enamel slabs exposed to saliva stimulated by gum chewing remineralized almost twice as much as those exposed to the unstimulated saliva [6]. During gum chewing, the initial stimulated flow rate of saliva was 10 to 12 times greater than the unstimulated rate (0.47 mL/min), and 2.7 times greater after 20 minutes of chewing, with very little difference among the various flavored gums, whether sugar-containing or sugar-free [7]. Chewing of both sugar-containing and sugar-free gums for 20 minutes increased plaque pH to the original resting values when this had been depressed (the mean [±standard deviation] minimum pH was 3.69±0.12) following consumption of five different kinds of meals [8]. However, plaque pH reversals cannot be related directly to reductions in dental caries, and higher caries increments were found in children who consumed sugar-containing chewing gums compared to matched controls who had not chewed any gums [9,10].

This selective literature review set out to consider the effects of chewing gum on dental plaque and saliva, and discuss its value as a delivery system for anticariogenic agents. The anticariogenic therapeutic agents that have been used as additives in chewing gums are provided to practitioner audiences for reference. To achieve this, electronic and manual methods were used as means of searching. For the electronic method, PubMed searches were conducted and limited to articles in English, in dental journals, with human subjects, and published from 1940 to 2007. The key words used were ‘chewing gum’ combined with ‘caries’, ‘saliva’, ‘plaque’, or ‘drug delivery’. Articles not concerned with the use of chewing gum or anticariogenic therapeutic agents were excluded. Additional articles were searched manually. Reference lists of articles retrieved from the electronic database were hand-searched for any other articles that might provide information relevant to the objectives of this paper.

**Chewing gum as a vehicle for topical and systemic therapeutic agents**

To date, the use of chewing gum as a vehicle for the delivery of drugs has been limited. Being able to control the release of the drugs, and hence the dose, is a major concern which is related to the chewing time, and the drug’s aqueous solubility of its compatibility with other constituents of the gum [1].

During the late 19th century, Dr. Edward Beeman incorporated pepsin powder into chewing gum, arguing that people bought pepsin powder to enhance their digestion, yet they bought and used chewing gum for no reason [1]. Then, in 1924, chewing gum containing aspirin was introduced in the US [1]. Later in 1945, Burill et al. [11] experimented with chewing gum containing vitamin K in an attempt to prevent the drop in the pH of dental plaque.

There are several advantages to using chewing gum to administer drugs. It is non-invasive, readily accepted, and can be given at almost anytime and everywhere. Stability of the therapeutic agent is easily maintained during storage because of packaging that keeps it away from oxygen, light, and water.

Gum chewing can have local effects in the mouth and also systemic effects after the active agents have been
swallowed, or absorbed through the oral mucosa. The latter route results in better bioavailability, as drug metabolism in the gut and liver (first-pass effect) is avoided; it is directly transported into the vena cava 1.

Topical therapeutic agents

Chewing gum has been used for the delivery of topical therapeutic agents such as sulfonamides and neomycin, and the topically effective gramicidin to resolve infections in the oral cavity 7. Miconazole and nystatin have also been delivered by chewing gum to control oral candidiasis. A clinical study 12 comparing the effect of miconazole gel and chewing gum to treat oral candidosis in HIV-positive patients revealed no reduction in the efficacy of the drug, and the patients reportedly found chewing gum to be a more pleasant way of taking the medication.

Another use of chewing gum as a delivery system for topical therapeutic purposes was the addition of chlorhexidine gluconate. An in-vivo study 13 to assess the antiplaque effect of chlorhexidine gum showed that it is effective in preventing plaque growth and accumulation. Its plaque-inhibiting properties were also found to be significantly better than those of chewing gum containing sorbitol and xylitol 14. Aside from better plaque-preventive properties, chewing chlorhexidine gum can also result in decreased gingival inflammation 15. In elderly patients, compared to xylitol chewing gum, chlorhexidine gum significantly reduced the numbers of mutant streptococci, lactobacilli, and yeasts 16.

Systemic therapeutic agents

Nicotine is used in chewing gum as a therapeutic agent which can be absorbed via the oral mucosa, so that it can have a rapid systemic effect and help patients break the smoking habit 17. Thus, it relieves tobacco withdrawal symptoms by the slow release of low levels of nicotine, allowing time for the development of tolerance 18. In a hospital-based program where nicotine gum was used as an adjunct to behavioral group therapy, its success rate was from 40 to 47% over a 1-year period 19.

Other drugs that have been incorporated into chewing gum for systemic delivery include: aspirin, dimenhydrinate, vitamin C, verapamil, and methadone. Medicinal roots and herbs such as ginseng, ginkgo, propolis, guarana, and many others have also been added to chewing gum 1.

Oral microbiota

Before reviewing how incorporation of therapeutic agents into chewing gum can have a topical effect on dental caries, the role of oral microbes and saliva in the development of dental caries should be appreciated.

In the presence of fermentable carbohydrates, bacteria such as Streptococcus mutans on the surface of teeth produce extracellular polysaccharides, resulting in bacterial aggregation 20. With growth in the number of microorganisms, there is an increase in plaque formation. Furthermore, carbohydrates such as sucrose initiate a decrease in plaque pH, through the formation of bacterial lactic acid. The demineralization of teeth enamel by inorganic acids formed by bacterial plaque constitutes the initial stage of dental caries 21.

Saliva maintains ecological balance in the oral cavity through mechanical, immunological, and non-immunological clearance of microorganisms 22. While the flow of saliva in the oral cavity prevents plaque aggregation on the surface of teeth 5, the presence of lysozyme, lactoferrin, and lactoperoxidase interfere with the growth and reproduction of microorganisms 22. In addition, saliva maintains a neutral pH in the oral cavity including within the bacterial plaque, owing to the presence of bicarbonates, phosphates, and histidine-rich peptides, which act as buffers 23. Furthermore, saliva maintains the integrity of the teeth, because ions such as calcium, phosphate, magnesium, and fluoride can diffuse into enamel 21, thus establishing a natural remineralization process.

Chewing gum as a vehicle for anticariogenic agents

Chewing gum use has a longer period of exposure to the surface of teeth than a dentifrice or mouthrinse; therefore it can be a useful adjunct for maintaining oral health, especially if it contains a therapeutic agent that is effective topically. Agents that have been added to chewing gum to specifically prevent dental caries include: polyols such as
xylitol and sorbitol, fluoride, calcium phosphate, carbamide (urea), enzymes, and granules.

**Polyols**

Currently, more that 50% of chewing gums available in the market are sweetened with sugar substitutes such as sugar alcohols (polyols), the most common of which are sorbitol and xylitol \(^1\). This is because sorbitol is less cariogenic than sucrose, glucose, and fructose \(^2\). While sorbitol prevents the formation of glucan and dental plaque, it has only a minimal capacity to decrease plaque pH \(^25\). Xylitol is a non-fermentable sweetener that reduces the growth and metabolism of *S. mutans*, thus creating a less cariogenic oral environment \(^26\).

Clinical research has been conducted to assess the caries-preventive effect of xylitol. In a 40-month double-blind cohort study \(^10\) performed in caries-active 10-year-old children, those who chewed xylitol gums 3 or 5 times a day developed 52 to 73% fewer carious lesions than those consuming no gums. After 2 years of a school prevention program, a decayed, missing, and filled tooth surfaces (DMFS) increment of 2.24 surfaces was found in the xylitol gum group compared to 6.06 surfaces in the non-gum group \(^27\). Moreover, during a 3-year field study \(^28\), 35 to 60% reduction in caries increment was found in two experimental groups of children who chewed xylitol gum and sucked xylitol candy respectively, after comparison with children in the control group. However, all of these studies failed to prove that the caries-preventive effects of xylitol-containing gum and candy were due to the xylitol itself rather than the stimulation of salivary flow, because none of the control groups were chewing gum or sucking candy. To claim that the caries-preventive effects of chewing sugar-free gum was only related to the chewing process rather than gum sweeteners or additives, Machiulskiene et al. \(^29\) used a ‘control gum’. Their 3-year community intervention trial found that control gum was as effective as xylitol-containing gum, though other sweeteners (acesulfame potassium and saccharin) and a softener (glycerin) were added to the former gum.

Interestingly, xylitol chewing gum and fissure sealants were found to be equally effective in caries prevention \(^30\). The use of xylitol chewing gum was considered to be more cost-effective because it did not require professional application, clinical visits and treatment, special equipment for application, and multiple individual visits, as is the case with fissure sealants. By contrast, the results of studies attempting to compare the caries-preventive effect of xylitol and sorbitol remain equivocal. In a study \(^31\) with a small sample size (seven adults in each group), the amount of plaque and the plaque and saliva levels of *S. mutans* were higher in the sorbitol than in the xylitol gum group. The plaque of the xylitol gum chewers even showed a significantly better ability to resist pH reductions induced by the sucrose rinse than the plaque in the sorbitol gum chewers \(^31\). The results of a study \(^10\) in which more than 1000 children participated also indicated that xylitol was superior to sorbitol in reducing the onset of caries, though a higher dropout rate in the xylitol than sorbitol gum group (49 vs 12%) may be the explanation. Other clinical trials \(^29\) have shown that sorbitol and xylitol in chewing gums were equally effective as caries-preventive agents.

In the studies described above, dosages of xylitol for caries prevention ranged from 4.3 to 10.9 grams per day. The doses were divided throughout the day, usually after meals \(^10\) \(^27\). Although diarrhea has been reported in patients consuming 3 to 60 grams of xylitol per day, it is generally believed to be safe for children, pregnant women, and child-rearing mothers. Use of xylitol by expectant and child-rearing mothers was shown to reduce the level of *S. mutans* in their children \(^33\)\(^34\).

Sugar-containing chewing gum increases plaque formation, growth of cariogenic microorganisms, and caries incidence \(^1\) \(^9\) \(^10\). Thus, sugar substitutes such as polyols in chewing gum can be a useful adjunct to any preventive regimen. The caries-preventive effects of polyol-containing gums seem to be based on the chewing process, although an antimicrobial effect cannot be excluded. Polyol-sweetened gums available in the Hong Kong markets are shown in the Table.

**Fluoride**

Chewing gum would seem to be an alternative to mouthrinses and tablets for the delivery of fluoride to children with rampant caries as a preventive measure, because it is more economical and less time-consuming to
Apply 1, 35, besides being more readily accepted.

As fluoride is known to play a role in remineralization of enamel, adding it to chewing gum should be beneficial. One experiment on the remineralization of subsurface enamel lesions compared the effects of chewing a fluoride-free gum, a fluoride-containing gum, and no chewing gum on subjects who brushed their teeth 3 times a day with a non-fluoridated dentifrice. The use of fluoride-containing chewing gum resulted in significantly greater remineralization and fluoride uptake 38. Another study 39 showed that using fluoride-

<table>
<thead>
<tr>
<th>Manufacturer (in alphabetical order)/ name of product</th>
<th>Ingredients of polyol</th>
<th>Xylitol per piece (g)</th>
<th>No. of pieces for 4 g xylitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail products</td>
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<tr>
<td>Cadbury/Clorets XP Gum</td>
<td>Menthol, xylitol</td>
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<tr>
<td>Cadbury/Whiteen Chewing Gum</td>
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<td>Lotte/ACUO Gum</td>
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<tr>
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<td>NC</td>
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<tr>
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<tr>
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<tr>
<td>Xlear/Spry Sugar Free Gum with Xylitol</td>
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<tr>
<td>Zellies/Xylitol Gum</td>
<td>Xylitol</td>
<td>0.70</td>
<td>6</td>
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</tbody>
</table>

* NC Not certain as information cannot be derived from Internet, vendor, or market packaging
containing chewing gum resulted in a reduction in the size of natural carious lesions and an increase in salivary fluoride concentration. In older patients, chewing fluoride-containing gum 5 times a day for 21 days induced remineralization of root surface lesions in situ 40.

Thus, it may be inferred that fluoride-containing chewing gum could be of benefit to children living in fluoride-deficient areas, as well as in older children and adults at high risk from caries who have low salivary flow rates, and patients suffering from enamel erosion 1,37. However, caution is necessary to prevent fluoride overdoses, especially in children. Examples of marketed fluoride-containing chewing gums are Fludent/Flux and Fluorette (Fertin Pharma A/S, Denmark).

**Calcium phosphate**

Stimulated saliva is known to promote remineralization of early carious lesions due to its mineral supersaturation with respect to dental hard tissue 1. It is therefore logical that mineral salts such as calcium and phosphate that are known to help strengthen tooth surface enamel could be used to enhance this effect.

Finn and Jamison 41 examined the effect of a sugar-containing gum, a sugar-free gum, and a dicalcium phosphate gum. After two and a half years, the use of the chewing gum with dicalcium phosphate resulted in lower caries increments than sugar-containing gum. However, its effects did not differ significantly from those of the sugar-free gum. A subsequent study 42 showed that a gum with dicalcium phosphate can significantly decrease caries increments on the approximal surfaces of teeth, although the total reduction of caries did not differ significantly from that associated with using the sugar-containing and sugar-free gums, when all surfaces of the teeth were considered. Richardson et al. 43 compared the use of a sugar-containing gum and a dicalcium phosphate gum with a no-chewing gum group as the controls; their results revealed no significant difference in the total caries increments among all groups. The differing results of these experiments can probably be attributed to the low solubility of dicalcium phosphate, which is therefore considered unsuitable for use in a chewing gum.

Monocalcium phosphate, which is more soluble than dicalcium phosphate, was evaluated to determine whether it would result in greater increases in salivary calcium and phosphate concentrations. A study 44 comparing the effects of chewing gums containing monocalcium phosphate, tetracalcium phosphate, or dicalcium phosphate on the mineral concentration of saliva revealed a greater salivary flow and mineral supersaturation with the two former compounds than with dicalcium phosphate.

Amorphous calcium phosphate (ACP), approximate formula Ca₅(PO₄)₂·3H₂O, is a postulated precursor in the formation of hydroxyapatite (compositional formula Ca₁₀(PO₄)₆·(OH)₂). The ACPS exhibit very high solubility and are readily converted to hydroxyapatite, which makes them suitable mineralizing agents 23. Addition of ACP to chewing gum can significantly increase calcium and phosphate concentrations in saliva, and raise the pH of saliva during in vivo acid challenges 45.

Casein phosphopeptides (CPP) containing the cluster sequence -Ser(P)-Ser(P)-Ser(P)-Glu-Glu- have the ability to stabilize ACP in a metastable solution. Through the multiple phosphoseryl residues, the CPP bind to nanoclusters of ACPS that are forming. This prevents their growth to the critical size required for nucleation and phase transformation, which leads to a highly water-soluble calcium phosphate phase 46. More recently, CPP-ACP nanocomplexes have been added to sugar-free chewing gums and tested in double-blind, cross-over, human in-situ studies 47-49. A dose-related increase in enamel remineralization was reported when CPP-ACP were added to sorbitol- and xylitol-based gums 47. A xylitol-containing gum with CPP-ACP was shown to produce higher levels of enamel remineralization than chewing gums containing other forms of calcium (CaHPO₄/ CaCO₃ or only CaCO₃) 48. Moreover, the addition of CPP-ACP to citric acid–flavored gum negated the effect of the citric acid and produced a remineralizing effect greater than that of neutral sugar-free gum without citric acid 49.

The release of ions such as calcium, phosphate, and hydroxide from calcium phosphates is very favorable to the remineralization process 50. Thus, incorporation of these ions into chewing gum could be of benefit in preventing the initiation and progression of dental caries. Commercial examples of calcium phosphate-containing gums are Xylitol Supercool (Lotte) and Xylish Mint (Meiji); Recaldent...
Chewing gum to deliver anticariogenic agents

(Cadbury) contains CPP-ACP.

Carbamide (urea)

Urea, which is present in blood and saliva, is an organic substance synthesized from amino acids and carbon dioxide. Some oral microbes hydrolize salivary and dietary urea via the enzyme urease to produce ammonia and carbon dioxide, which result in an increase in plaque pH. A mathematical model of the influence of salivary urea on dental plaque was constructed to demonstrate the effect it can have on unstimulated saliva. Data from a study indicated that urea present in unstimulated saliva has a significant effect on plaque pH by elevating and counteracting the fall of plaque pH in the fasting state.

Several studies have sought to determine the effect of urea in chewing gum. The study by Lmfeld et al. involved the use of sugar-free gum with urea. The number of chewing gums and the concentration of urea were increased at different stages during the experiment. They found that higher concentrations of urea resulted in greater pH recovery after a sucrose rinse. Another study which compared the effect of sugar-free chewing gum with and without urea on pH, calculus formation, amount of saliva, and prevalence of cariogenic microorganisms, involved a period of chewing five pieces of sugar-free gum with urea, then a period of chewing sugar-free gum without urea, and finally a no-gum-chewing stage. Although there was a general increase in the plaque pH and buffering capacity of saliva throughout the whole study, the resting plaque pH was greater after gum chewing with urea compared to the other stages. However, there was no difference in the amount of saliva and prevalence of acidogenic microorganisms during the entire study period. Also, chewing sugar-free gum, with or without urea, did not inhibit calculus formation.

Hitherto, only two clinical trials have attempted to test the caries inhibitory effect of adding carbamide to sugarless chewing gum. The test groups of grade 1 and grade 4 schoolchildren in a community trial in Madagascar used chewing gum which contained 55.5% sorbitol, 4.3% xylitol, and 2.0% carbamide. The gums were chewed 3 or 5 times a day in different test groups, but there were no significant reductions in dental caries when compared to the controls, except for the extent of occlusal caries in grade 1 students who chewed the gum 3 times a day. Another community intervention trial conducted in Lithuanian secondary schools, used sorbitol/carbamide gum, sorbitol gum, xylitol gum, control gum, and no gum. The finding of the study was intriguing because children in the sorbitol/carbamide group had higher DMFS increments than those in the sorbitol gum, xylitol gum, and control gum groups. Moreover, the DMFS increments in the sorbitol/carbamide group were similar to those observed in the no-gum group. Nevertheless, there are no data lending support to the claim that carbamide and sorbitol acting together in chewing gum have a negative effect.

It was concluded by many researchers that the use of carbamide-containing chewing gum may be beneficial for patients with high caries activity because of its ability to significantly increase plaque pH, however such effects do not necessarily translate into clinically measurable caries reduction. Carbamide-containing chewing gums are marketed under the trade names V6 (Fertin Pharma A/S, Denmark) and Dirol (Cadbury, UK).

Other agents

A variety of other agents such as egg white lysozyme, lactoperoxidase, glucose oxidase, and the proteolytic enzyme papain are all being used as anticariogenic agents in chewing gums.

Chewing gum containing lactoperoxidase and glucose oxidase are available in Switzerland, Belgium, and the US, and claimed to have an antibacterial action that prevents gingival bleeding, halitosis, and plaque formation. However, to date no clinical studies to support this assertion have been published in the dental literature. Consequently, it appears that their use in chewing gum and claims of their efficacy are merely speculations based on observational data on their use with various enzymes in dentifrices, gels, and mouthrinses.

A mouthrinse containing lactoperoxidase, aminoglucoisidase, and glucose oxidase was shown, in vivo, to decrease the incidence of carious lesions during the test period. Another enzyme incorporated into chewing gum is papain. This is believed to act as a debriding agent used in chewing gum as a tooth-whitening agent. So far, most enzyme-containing chewing gums have not been subjected...
to critical clinical testing.

Although chewing sugar-free gum can significantly decrease plaque formation and completely remove plaque from the occlusal surfaces of the teeth, there is no effect on plaque in the cervical region of the crown. Furthermore, the addition of granules to sugar-free gum decreases the amount of plaque formation by a further 15%.

**Chewing gum usage**

During the early 1900s, gum chewing was deemed to be just slightly less contemptible than tobacco chewing, only because it did not involve expectoration. Later, gum chewing acquired a degree of cultural acceptance (especially in the US), possibly because of its association with baseball players, and worldwide because of its use by top sporting personalities.

But even with the development of sugar-free chewing gum, parents and teachers are continue to be wary of its use by young children. Indiscriminate disposal can result in the gum being found in children's hair, under desks, tables, and chairs. A study on the acceptance and compliance of chewing gum use by preschool children and teachers showed that although there was excellent acceptance by the children, acceptance by teachers was low as it was believed to disturb classroom routine.

The possibility of allergic gingivostomatitis due to the use of chewing gum warrants consideration, because of reported gingival and vestibular mucosal hyperemia and edema, loss of the filiform papillae, and angular cheilitis. Although the patients were given nutritional supplements and topical antifungal cream, symptoms only resolved completely after cessation of chewing gum use. The hypersensitivity reaction was subsequently attributed to one of the constituents in the chewing gum.

There have also been concerns regarding the link between gum chewing and temporomandibular joint dysfunction. A recent study investigated the effects of prolonged gum chewing on pain, fatigue, and pressure tenderness of masticatory muscles, in which female subjects chewed very hard gum, soft gum, and performed empty chewing. The perceived pain and pressure pain threshold were tested before, during, and after chewing of the gum. Pain scores were higher when chewing hard gum, but quickly recovered 10 minutes after cessation of the exercise. There was no difference in the threshold for pressure-induced pain after chewing hard or soft gum. The authors concluded that the muscles of mastication, in healthy subjects, recover quickly from prolonged chewing and that chewing gum does not contribute to masticatory muscle tenderness.

Even with the benefits of chewing gum and the therapeutic agents incorporated in them, there have been questions regarding their efficacy. Most clinical studies on the efficacy of sugar-free gum were evaluated in comparison to control groups that did not use chewing gum. There have also been questions regarding compliance, which was found to decrease over time. Such decline in compliance is hardly surprising, as the gum has to be chewed 3 to 5 times a day to be effective. If the duration of the study was long, gum chewing might not be perceived as necessarily beneficial by the children or the teacher reinforcing gum use. Nevertheless, chewing gum would appear to have great potential as a vehicle for topically effective therapeutic agents, especially those that can prevent or reverse demineralization of enamel.

**Conclusions**

Aside from effects on the amount and quality of saliva, and salivary and plaque pH, other factors which make chewing gum a good vehicle for the delivery of anticariogenic agents include: ease of administration and direct contact with the teeth. Agents that have been incorporated in chewing gum to promote dental health are polyols (xylitol, sorbitol), fluoride, calcium phosphate, carbamide (urea), enzymes (lactoperoxidase, glucose oxidase, papain), and granules.

Numerous studies have been performed on chewing gum alone and with therapeutic agents. However, questions remain about their efficacy. Further investigations are therefore required to fully understand the effects of the various topical anticariogenic agents, particularly to ensure that they cause no adverse systemic reactions. Only then would it be appropriate to routinely advocate commercially produced chewing gums containing topical anticariogenic therapeutic agents.
References


