

SUGAR-FREE CHEWING GUM AND DENTAL CARIES – A SYSTEMATIC REVIEW

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Received: March 27, 2007 - Accepted: April 16, 2007

ABSTRACT

Objective: To appraise existing evidence for a therapeutic / anti-cariogenic effect of sugar-free chewing gum for patients. Method: 9 English and 2 Portuguese databases were searched using English and Portuguese keywords. Relevant articles in English, German, Portuguese and Spanish were included for review. Trials were excluded on lack of randomisation, control group, blinding and baseline data, drop out rate >33%, no statistical adjustment of baseline differences and no assessment of clinically important outcomes. Reviews were excluded on lack of information, article selection criteria, search strategy followed, search keywords, searched databases or lack of study-by-study critique tables. In cases of multiple reports from the same study, the report covering the longest period was included. Two reviewers independently reviewed and assessed the quality of accepted articles.

Results: Thirty-nine articles were included for review. Thirty were excluded and 9 accepted. Of the 9 accepted, 2 trials of reasonable and good evidence value did not demonstrate any anti-cariogenic effect of sugar-free chewing gum. However, 7 articles, with 1 of strong, and 6 of good evidence value, demonstrated anti-cariogenic effects of chewing Sorbitol, Xylitol or Sorbitol/Xylitol gum. This effect can be ascribed to saliva stimulation through the chewing process, particularly when gum is used immediately after meals; the lack of sucrose and the inability of bacteria to metabolize polyols into acids. Conclusion: The evidence suggests that sugar-free chewing gum has a caries-reducing effect. Further well-designed randomised trials are needed to confirm these findings.

Uniterms: Sugar free; Chewing gum; Caries; Xylitol; Sorbitol; Remineralisation.

INTRODUCTION

Several publications have suggested that sugar-free chewing gum has an anti-cariogenic effect^{1,5,8,16,35,41}. Such effect is ascribed to the action of 2 factors: saliva stimulation through the chewing process and integration of dietary polyols⁸.

An increase in stimulated saliva flow has been associated with an increase in plaque pH¹⁹ and a higher salivary buffer capacity⁸. Manning and Edgar²⁵ (1993) reported that chewing sugar-free chewing gum directly after meals reduced the immediate plaque pH response and thus enhanced the potential of enamel remineralisation. Edgar and Geddes⁹ (1990) suggest further that the anti-cariogenic saliva effect may be further attributed to increased salivary bicarbonate, leading to higher buffer strength, as well as to an increased supply of alkaline substrates to the plaque. Furthermore, an

increased salivary flow rate may significantly contribute to oral health through optimized cleansing of the tooth surface and to accelerated clearance of dietary sugars and plaque acids away from the tooth surface^{9,27}.

The most common dietary polyols used in sugar-free chewing gum are Xylitol and Sorbitol⁸. Most oral bacteria do not metabolise Xylitol and Sorbitol to form acid⁸. Xylitol is a sugar alcohol derived from pentose sugar xylose and Sorbitol is a sugar alcohol derived from glucose⁸. Both elicit a gustatory reflex which, together with the chewing process, enhances saliva stimulation⁸. Unlike Sorbitol, Xylitol has been observed to exhibit a dose-related inhibition of *S.mutans*' growth in vitro².

Based on these findings, a caries reduction in patients who chew sugar-free chewing gum is expected. The objective of this systematic literature review was to appraise existing evidence concerning a possible therapeutic / anti-cariogenic

effect of sugar-free chewing gum for patients.

MATERIAL AND METHODS

Search strategy

The literature search included 9 English databases: BIOMED CENTRAL, COCHRANE ORAL HEALTH REVIEWS, COCHRANE LIBRARY, DIRECTORY OF OPEN ACCESS JOURNALS, EXPANDED ACADEMIC ASAP PLUS, META REGISTER OF CONTROLLED TRIALS - mRCT, PUBMED, SCIENCE-DIRECT, RESEARCH FINDINGS ELECTRONIC REGISTER – ReFeR and 2 Portuguese databases: BIBLIOGRAFIA BRASILEIRA EM ODONTOLOGIA – BBO, LITERATURA LATINO-AMERICANA E CARIBENHA EM CIÊNCIAS DA SAÚDE – LILACS.

The English keywords “(chewing gum) AND (caries OR tooth decay) and (chewing gum) AND (caries risk)” and Portuguese keywords “(Goma mascar AND cári\$) and (Goma mascar) AND (risco cári\$)” were used to search the English and Portuguese databases, respectively. The keywords were standardised in both languages for equivalent weight during the literature search. The time-search for publications in all databases was retrospectively unlimited until 09 June 2005. Publications were selected from the search results on the basis that their titles and abstracts were in accordance with the inclusion criteria: (i) relevance to the review objective; (ii) publication in English, German, Portuguese or Spanish. Where only a relevant title without a listed abstract was available, a full copy of the publication was assessed for inclusion. To be selected for review, publications had to fulfill all inclusion criteria.

Publication review

The review followed published guidelines³⁹. All included

publications were assessed independently by two reviewers. Disagreements between the reviewers were solved through discussion, until final consent. Only in-vivo and in-situ trials were included. In-vitro studies were judged as providing insufficient evidence for therapy, since they carried the potential error of extrapolation of laboratory results to physiological effects in humans. For that reason they were not included. In cases of multiple reports from the same study, only the report covering the longest period was included. Published trials and literature reviews were assessed according to the exclusion criteria listed in Table 1. Publications were accepted as evidence only if they passed all exclusion criteria.

Criteria for evidence value

The evidence value of accepted articles was rated by application of a structured scoring system^{3,45} (Table 2). Following a similar validation system used by Zero, et al.⁴⁵ (2001), included articles were rated as having ‘strong’, ‘good’ or ‘reasonable’ evidence value. The value of evidence depends on the amount of information provided by authors in their articles, to support the methodology used to obtain their results⁴⁵. Accepted reviews were automatically rated as having strong evidence value. Since publications needed to pass all exclusion criteria in order to be accepted, accepted articles with lowest value ratings were still considered as offering reasonable evidence value.

RESULTS

After the literature search, 39 articles were found to be in accordance with the inclusion criteria and were selected for review. Of these, 14 were literature reviews and 25 were articles reporting on clinical trials.

TABLE 1- Exclusion criteria for trials and literature reviews

| Trials | Literature reviews |
|--|---|
| Lack of randomisation Drop-out rate >33% | Focus on population or intervention not clearly stated in title and abstract |
| Patients and clinicians not ‘blinded’ where possible and appropriate | Article methodology describes no clear inclusion and exclusion criteria for reviewed publications |
| No baseline data provided for both the control and the study group | Article methodology describes no clear search strategy, key words and databases used and includes no study-by-study critique table or discussion of study qualities |
| Baseline differences not statistically adjusted | |
| Clinically important outcomes for patients not assessed. | |

Excluded articles

After review, 14 literature reviews and 16 trials were excluded. Most of the excluded reviews^{1,4,7-9,11,14,29,35,36,38,41,44} were narrative in nature, lacking a stated literature search strategy and lacking stated inclusion and exclusion criteria for literature selection. Most reviews^{1,4,7,9,11,14,29,36,38,44} also lacked study-by-study critique tables. Five of the reviews^{7,11,14,36,38} had been published as editorials or short communications and one was a review of 1 single trial⁴². Five of the 14 reviews only discussed sugar-free chewing gum as part of an overall review theme; such as general chewing gum^{9,35}, dental caries management^{1,4} and preventive dentistry⁴⁴.

Of the 16 excluded trials, 11 were not randomised^{13,15,18,19,21-24,33,37,43}; 3 trials^{5,16,17} had a loss to follow up of more than 33% and 2 trials lacked operator blinding as part of their methodology^{10,30}.

Accepted articles

A total of 9 articles reporting on trials were accepted. The data concerning the accepted articles are shown in Table 3. Two articles^{20,26} reported on results of 2 trials, each conducted with chewing gum of different polyol content, thus raising the number of accepted individual trials to 11. From these, 8 trials followed in-vivo, and 3 in-situ study designs. The trials reported on the effects of using sugar-free chewing gum with Sorbitol (6 trials), Xylitol (2 trials) and Sorbitol/Xylitol combined (3 trials). The in-situ trials investigated the anti-cariogenic effect of enamel

remineralisation on artificial carious lesions and in-vivo trials reported on caries reduction, mainly in permanent teeth (Table 3). The reported use of chewing gum in the accepted trials varied in frequency per day (3 – 7 times) and duration (5-20 min). Five trials reported gum use immediately after meals^{6,20,28,31,40}.

The results of the in-situ trials were conflicting. Two trials of good evidence value²⁶, 1 with Sorbitol and 1 with Sorbitol/Xylitol chewing gum, reported statistically significant ($p < 0.05$) enamel remineralisation after 21 days, while 1 trial with Sorbitol chewing gum of reasonable evidence value⁶ showed no significant remineralisation ($p = 0.07$) after 7 weeks. One in-vivo trial of good evidence value did not demonstrate any significant caries reduction with Sorbitol chewing gum¹². All other in-vivo trials, 1 of strong evidence⁴⁰ and 6 of good evidence value^{20,28,31,32,34}, were able to demonstrate significant caries reduction after chewing of Sorbitol, Xylitol and Sorbitol/Xylitol chewing gum, as compared to no gum use. However, of these trials, 1 trial³² reported such reduction for the occlusal tooth surfaces, only.

DISCUSSION

This systematic review was the first to include English as well as Portuguese databases in its literature search and to review articles in the 4 publication languages: English, German, Portuguese and Spanish, relating to the topic of

TABLE 2- Criteria for evidence values

| Quality aspect | Criteria | Points |
|----------------------------------|--|--------|
| Study setting: | In - situ | 1 |
| | In - vivo | 2 |
| Article provides information on: | How the sample were collected | 1 |
| | How examiners/patients were blinded | 1 |
| | How operators were trained or calibrated | 1 |
| | Examiners' reliability | 1 |
| Sample drop-out rate: | 33-20% | 0 |
| | 10-19% | 2 |
| | <10% | 3 |
| Followed up period: | <1 year | 0 |
| | 1 year | 1 |
| | >1 year | 2 |

Quality scores (Total number of points):

'Strong evidence' = 10-11

'Good evidence' = 6-9

'Reasonable evidence' = 0-5

TABLE 3- Main characteristics of the 11 accepted trials

| Article/ 1 st Author | Trial Nr | Study design | Dental chewing gum | Application Regime | Control | Caries /Dentition | Follow-up period | Result | | Value as evidence |
|--|----------|--------------|--------------------------------|--|-------------------------------|-----------------------|------------------|------------------------------------|-----------------------------------|-------------------|
| | | | | | | | | Anti-cariogenic effect | Reported statistical significance | |
| Creanor, et al. ⁶ (1992) | 1 | In-situ | Sorbitol (2.7 g stick) | 5x per day, 20 min chewing after meals | Baseline before chewing | Artificial lesion | 7 weeks | Enamel remineralisation | (p = 0.07) | Reasonable |
| Glass ¹² (1983) | 2 | In-vivo | Sorbitol | Daily chewing gum distribution | No gum | Deciduous | 2 yrs | Caries increment reduction | (p>0.05) | Good |
| Machiulskiene, et al. ²⁰ (2001) | 3 | In-vivo | Sorbitol | 5x per day, 10 min chewing after meals | No gum | Permanent | 3 yrs | DMFS increment reduction | (p<0.05) | Good |
| | 4 | In-vivo | Xylitol | | No gum | Permanent | 3 yrs | DMFS increment reduction | (p<0.05) | Good |
| Manning, et al. ²⁶ (1992) | 5 | In-situ | Sorbitol (100%) | After meals for 20 min | Baseline before chewing | Artificial lesion | 21 days | Enamel remineralisation | (p<0.05) | Good |
| | 6 | In-situ | Sorbitol/ Xylitol (25%/75%) | | Baseline before chewing | Artificial lesion | 21 days | Enamel remineralisation | (p<0.05) | Good |
| Möller and Poulsen ²⁸ (1973) | 7 | In-vivo | Sorbitol (1.2 g) | 3x per day, after meals | No gum | Permanent | 2 yrs | Cariou decay progression reduction | (p<0.05) | Good |
| Peng, et al. ³¹ (2004) | 8 | In-vivo | Sorbitol/ Xylitol (55.5%/4.3%) | 4x per day, after meals | No gum | Permanent | 2 yrs | DMFS increment reduction | (p<0.05) | Good |
| Petersen, et al. ³² (1999) | 9 | In-vivo | Sorbitol/ Xylitol (55.5%/4.3%) | 3 and 5 x per day | No gum/ oral health education | Permanent & deciduous | 3 yrs | Occlusal DMFS increment reduction | (p<0.01) | Good |
| Scheinin, et al. ³⁴ (1975) | 10 | In-vivo | Xylitol | 3-7 x per day | Sucrose gum | Permanent | 1 yr | Caries incident reduction | (p<0.05) | Good |
| Szöke, et al. ⁴⁰ (2001) | 11 | In-vivo | Sorbitol (65%) | After meals | No gum | Permanent | 2 yrs | DMFS increment reduction | (p<0.05) | Strong |

sugar-free chewing gum and caries. Moreover, the literature search was extended to cover multiple English databases. However, despite this broader approach, some limitations may have affected its results: (i) no hand-searching method was used; thus relevant studies may not have been identified; (ii) used search keywords might not have been broad enough in order to capture all articles listed in the databases. No meta-analysis was undertaken, owing to differences in the methodologies of the accepted trials.

One in-situ⁶ and 1 in-vivo trial¹² out of the 11 separate trials accepted in this review did not report any anti-cariogenic effect of sugar free chewing gum. The reason for not achieving any significant remineralisation ($p = 0.07$) in-situ after chewing Sorbitol gum 5 times per day for 20 min, as compared to no gum use⁶, remains unclear. After 7 weeks, remineralisation in the test group was 18.2% and in the control group, 12.1%. Remineralisation in the latter may have been aided by the use of an 1100-ppm-F (NaF) dentifrice given to both groups, thus reducing the effect of Sorbitol gum alone. The in-vivo study by Glass¹² (1983) confirmed that Sorbitol chewing gum does not promote tooth decay. However, the results did not confirm any anti-cariogenic effect.

Two in-situ, and 7 in-vivo trials demonstrated significant enamel remineralisation and caries reduction, respectively. In contradiction to the in-situ trial of Creanor, et al.⁶ (1992), both in-situ trials by Manning, et al.²⁶ (1992), with Sorbitol and Sorbitol/Xylitol chewing gum showed significant remineralisation of enamel. The contradicting outcome of these trials may be due to differences in technical aspects of the investigated artificial lesions. Such aspects may include lesion depth due to length of enamel placement in demineralising solution, as well as differences in enamel composition and structure, which vary between tooth sites. For this reason, the evidence found in our systematic literature review with regard to any significant remineralising effect of sugar-free chewing gum use on carious lesions is inconclusive.

Most of the accepted in-vivo trials showed significant caries reduction. Such reduction appeared to be independent of polyol-type, polyol-composition and concentration and chewing regimes. Machiulskiene, et al.²⁰ (2001) observed no difference between polyol gum and a sugar-free control gum without polyol but a caries-reducing effect of the control gum when compared to no gum use. Petersen, et al.³² (1999) found a caries-reducing effect only for occlusal surfaces and Scheinin, et al.³⁴ (1975) suggested that the anti-cariogenic effects of polyol were due to the lack of its suitability for micro biotic metabolism. Szöke, et al.⁴⁰ (2001) observed an anti-cariogenic effect after 20 min of chewing sugar-free chewing gum, especially immediately after meals: thus long after all soluble ingredients, such as polyols had been dissolved. It can therefore be concluded that the caries-reducing effect was not due to any therapeutic action of polyol but rather, to the chewing process itself and subsequent saliva stimulation.

According to our criteria, the evidence value of 9 accepted trials was good, while 1 trial was of strong, and 1

of reasonable evidence value. Of these 9 trials, 5 trials^{6,12,26,28,34} did not elaborate on examiner calibration and reliability in their methodologies. Such lack of information reduced the value of evidence found in this review. The quality and quantity of the found evidence suggests a further need for well-designed randomised trials to further confirm the caries-reducing effect of sugar-free chewing gum, as well as its underlying mechanisms. Further trials should provide data on any remineralising effect of polyol chewing gum and clarify whether specific polyols, such as Xylitol, have any anti-cariogenic, therapeutic effect.

CONCLUSION

The evidence suggests that chewing sugar-free chewing gum, used immediately after meals, reduces caries. The observed caries reduction can be ascribed to saliva stimulation throughout the chewing process, the lack of sucrose and the inability of bacteria to metabolise polyols into acids. No evidence for a direct therapeutic effect caused by Sorbitol or Xylitol was found. Further well-designed randomised trials are needed to confirm these findings.

ACKNOWLEDGMENT

This review was supported by GC Asia and Midentistry.com

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