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The ability of 1.23% acidulated phosphate fluoride gel to inhibit simulated endogenous erosion in tooth roots

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Abstract

Background: Endogenous dental erosion is that produced by contact of gastric acids with tooth structure. It may affect exposed root cementum/dentine as well as coronal enamel, causing marked loss of mineral. The aim of this study was to determine whether 1.23 per cent acidulated phosphate fluoride gel, if applied to the surface cementum at certain intervals during an erosive acid challenge, could provide any protection against demineralization.

Materials and methods: Roots of preserved extracted human teeth were painted with a water and acid resistant varnish, leaving two windows (3x1mm) of exposed dentine. These were placed in a solution containing 0.06MHCl and 2.2mMCaHPO$_4$, which has been shown to simulate gastric acid when it meets the tooth surface. The roots were placed in the erosive solution unprotected (controls), or subject to APF application for four minutes prior to and every 10, 30 or 120 minutes during the erosive challenge. Roots were removed at either 6 or 12 hours, washed thoroughly and cut into 120µm thick sections. Depths of demineralization were measured using an optical graticule under polarized light microscopy.

Results: A high level of protection was provided when the roots were coated with APF gel every 10 or 30 minutes.

Conclusions: APF gel will partially inhibit endogenous erosion of roots for up to 30 minutes if applied, for example, the night before a morning reflux episode. This should be considered along with other erosion control or reduction procedures for patients suffering from the effects of endogenous erosion.

Key words: Root cementum/dentine, acidulated phosphate fluoride gel, erosion, protection.

Abbreviations and acronyms: APF = acidulated phosphate fluoride; DDW = deionized distilled water.

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INTRODUCTION

Endogenous erosion is a commonly experienced form of dental erosion, and can occur in all age groups. It results when gastric acids come in contact with the teeth for prolonged lengths of time through gastric reflux, regurgitation or emesis resulting from a variety of medical or psychological conditions.[1] As such, it may be difficult or impossible for the patient to control, even with medical help. This leaves the dental professional with the task of helping protect the teeth from erosive demineralization, or at least advising the patient on methods of reducing its destructive effects.

Most commonly it is the tooth enamel which is affected by endogenous erosion. However, particularly in the elderly, exposed root cementum or dentine can also be seriously affected. White *et al.*[2] have demonstrated the potential results of erosion from many sources of erosive acids in the mouth on roots. Endogenous erosion was shown to demineralize the tooth mineral, leaving collagen relatively intact so long as it remains well hydrated and undamaged by physical factors like tooth brushing, coarse food or dental instrumentation. As such, root erosion often appears similar to root surface caries, with tactile detection the only reliable indicator of the degree of demineralization.

Jones *et al.*[3] have recently demonstrated that concentrated fluoride gels are able to provide some degree of protection to enamel against simulated endogenous erosion, and Mok *et al.*[4] have demonstrated that these gels can provide a high level of protection against exogenous erosion of both enamel and cementum/dentine in wine assessors when applied at certain intervals. In both cases, 1.23 per cent acidulated phosphate fluoride (APF) gel provided the highest level of protection.

The aim in this study was to determine whether 1.23 per cent APF gel can provide protection of tooth roots against simulated endogenous erosion.

MATERIALS AND METHODS

Root specimens

Roots were removed from sound extracted teeth of unknown origin, which had been cleaned of debris and

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Fig 1. Tooth root with exposed windows (present on both facial and lingual surfaces prior to vertical sectioning of the root).

stored in a 0.1 per cent Thymol – deionized distilled water (DDW) solution at 4ºC. Extracted teeth had been collected following the guidelines laid down by the Committee for the Ethics of Human Experimentation, The University of Adelaide.The roots were hemi-sectioned vertically and painted with an acid and water resistant nail varnish, except for two windows of size 3x1mm of exposed cementum on the root surfaces (Fig 1). The pairs of root sections were stored together individually in vials of Thymol DDW to control fungal infection. Test and control specimens were from the same tooth root to ensure differences in erosion susceptibility between teeth did not affect the results.

Erosive acid

The erosive acid used was that found by Jones *et al*.[3] and White *et al*.[4] to simulate regurgitated gastric acid most closely in terms of its erosive effect on enamel and root cementum/dentine. This was 0.06MHCl, with $CaHPO_4$ added to result in a final concentration of 2.2mM. The latter was to simulate the saliva/acid mix.

Fluoride source

APF gel (1.23 per cent; Colgate Oral Care Australia Pty Ltd) was used as the test protective agent.

Method

Nine pairs of roots were adhered by strong wax to narrow wooden rods and the rods placed in lengths of polystyrene foam so as to have sets of nine roots as controls matched by their paired sections as test roots in separate lengths of polystyrene (Fig 2). All root sections were stored temporarily in DDW. The test teeth were coated with excess APF gel for four minutes and then washed copiously in DDW. Both control and test series were lightly dried and then placed in baths of excess erosive acid solution in a rotatory incubator at 37ºC.

Fig 2. Roots undergoing experimental erosion in a rotary incubator.

Experiment 1

In Experiment 1, the roots were all removed at two hours and washed with copious DDW. The test roots were again coated with APF gel for four minutes, washed and all roots lightly dried before being returned to the erosive acid bath. This was repeated for up to 12 hours. At six hours, three pairs of roots (control and test) were removed, washed in DDW and stored in Thymol/DDW until prepared for examination. The remaining three pairs were removed at 12 hours.

Experiments 2 and 3

The protocol was similar as for Experiment 1, except that for Experiment 2, the roots were removed at 30 minute intervals and APF gel applied to the test roots. For Experiment 3, the roots were removed at 10 minute intervals for APF coating of test roots.

Analysis of depths of erosion

Following the tests, all the roots were sectioned vertically using a diamond sectioning blade on the Gillings Hamco Sectioning machine. Sections approximately 150µm thick were examined under a HB2 Olympus light microscope with polarized light attachments. Depths of erosion were estimated using an eyepiece graticule, which had been calibrated against a standard mm microscope slide scale marked into 50 sections. The statistical difference between results for test and control pairs were assessed using Student paired *t*-tests.

RESULTS

The mean depths of erosion resulting from six and 12 hours of erosion for controls and paired test specimens, coated with APF prior to, and following every 120 minutes (Experiment 1), 30 minutes (Experiment 2), and 10 minutes (Experiment 3) of acid exposure are recorded in Table 1. Each point is the mean of six data readings. As controls and test specimens were from the same roots, and the aim was to compare test with control data, it was not considered necessary to measure background levels of fluoride in each root. The statistical significance of differences between test and control results are also recorded in Table 1. The reductions in erosion depth at six and 12 hours between test and control groups in each category are recorded in Fig 3.

DISCUSSION

These data indicate that APF gel can significantly reduce the depth of erosion caused by simulated gastric acid *in vitro*, the degree of inhibition being dependent

Table 1. Depths of erosion at 6 and 12 hours in µm, following coating of roots with APF gel prior to, and following every 120 (Expt 1), 30 (Expt 2) and 10 (Expt 3) minutes of exposure to acid

Expt 1	Control		Experimental		T-Test		
Time	Mean	SD	Mean	SD	t-value	df	Sig: p<0.05
6 h	304.4	53.0	246.9	31.2	4,57	5	Sig – 0.006
12 h	403.8	80.1	352.8	124.1	0.84	5	N Sig
Expt 2							
6 h	363.2	78.3	186.8	56.9	3.59	5	Sig – 0.015
12 h	436.4	88.1	239.1	55.8	5,04	5	Sig – 0.004
Expt 3							
6 h	338.4	67.5	165.9	36.2	4,57	5	Sig – 0.006
12 h	490.0	76.3	211.7	55.7	5.93	5	Sig – 0.002

on frequency of exposure of the cementum/dentine to APF gel and time. When the APF gel was applied for four minutes prior to, and after every two hours exposure to acids, the reduction in depth of erosion was only in the order of 16 per cent, even after 12 hours of continuing erosion, compared with the controls.

However, when it was applied prior to every 30 minutes of acid exposure, the reduction was around 50 per cent compared with controls. The reduction when applied at 10 minute intervals was not greater than from 30 minute intervals of coating after six hours of experimentation, though it had increased to around 58 per cent by 12 hours of experimentation.

How relevant are these findings to clinical practice? In practice, endogenous erosion does not occur in a prolonged continuous sequence of acid contact with the teeth. It usually occurs in 1-2 minute episodes, and the bitter taste resulting usually generates a rapid rush of stimulated saliva with its very effective bicarbonate buffering system. Where hypo-salivation problems exist, neutralization of the refluxed acid will take much longer, and thus immediate rinsing with water, milk, bicarbonate or a fluoride mouthrinse is necessary. In severe cases, there may be multiple episodes of acid present for 1-2 minutes duration in random succession at a particular time of day. These episodes often occur over two to three week periods, though in some cases it can be much longer, e.g., prolonged nausea during pregnancy.[1]

Previous tests in our laboratory have shown multiple increments of erosive challenge produce a similar depth of erosion of enamel as occurs when it is exposed to a continuous exposure for a similar accumulated time period. Hence, applying APF gel before every 10 minutes of erosive challenge might be considered as equivalent to applying the gel prior to five 2 minute episodes of gastric acid exposure.

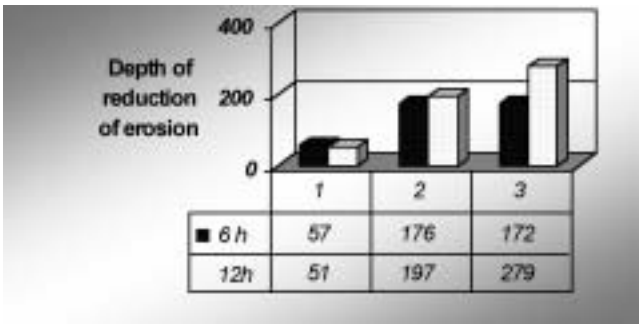

Fig 3. Reductions in depth of erosion at 6 and 12 hours, following exposure of roots to APF Gel every 120, 30 and 10 minutes.

Hence, any patient who suffers from periodic bouts of endogenous erosion might be instructed to self apply either an APF gel (where no glass-based restorative materials are in place) or neutral NaF gel each night before bed, or in severe cases, both night and morning. This can be achieved by toothbrush application or using customized trays. Only a light coating of APF gel is needed, not the 5mL previously used in topical fluoride therapy. All excess should be expectorated and not swallowed. This should result in a significant level of reduction of any erosion occurring within at least the next 12 hours. Whilst the protective effect of NaF gel has not been tested in this study, it was found in the studies by Jones *et al.*[3] and Mok *et al.*[4] to have an effect approximately half to two-thirds of APF gel. Fluoride varnishes were found by Mok *et al.*[4] to also provide a high level of control of exogenous erosion, though these are for professional application only, and not as convenient as the 'self application' gels for patients experiencing unpredictable, intermittent gastric reflux problems.

Even though these results are from *in vitro* studies, such schedules appeared to have a discernible inhibiting effect on endogenous erosion in the 'High Wear Risk Clinic' at the Adelaide Dental Hospital, provided salivary protection is normal.

Another aspect of the results which needs comment is the variation in depths of erosion in the different groups of control root surface specimens. This level of variation has been found in all such tests conducted in this laboratory, and for this reason, each test specimen is matched with the other half of the sectioned root. This guarantees that those factors affecting the rate of demineralization will be similar for test and control specimens. It is presumed this variability in susceptibility to acidic demineralization relates to the previous exposure of the original teeth to fluorides, or to other demineralization inhibiting trace elements or minerals. Such factors were noted as early as the 1970s by Hals and Selvig,[5] to account for these differences in root surfaces.

Protection by fluoride gels should be only one component of the assistance offered by the dental

professional to patients experiencing endogenous erosion. Initially, where the erosion is considered serious and enduring, recommending to the patient that he/she seek referral to a gasterontology practice is important to determine whether medical treatments are able to control the cause of the acid reflux. In the mean time, it will be necessary to help the patient control the cause of the erosion by helping the patient learn erosion control behaviours. These include: (1) learning to rinse with water or fluoride rinse as soon as the bitterness of any acid is experience in the mouth; (2) not brushing the teeth for some time following an acid attack; (3) using antacid rinses regularly around the time of an attack; and (4) in more severe cases, providing physical protection of the vulnerable areas of the teeth.

CONCLUSION

It is concluded that 1.23 per cent APF gel is able to significantly reduce the depth of erosive damage of root cementum/dentine caused by gastric reflux lasting for up to 30 minutes, for up to at least 12 hours following its application. This should be only one of many approaches aimed both at helping control the cause of endogenous erosion and in helping the patient learn erosion reduction behaviours.

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