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Dental erosion, gastro-oesophageal reflux disease and saliva: how are they related?

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KEYWORDS
Tooth wear; Gastro-oesophageal reflux disease; Saliva; Hoarseness

Summary *Aims*. The purpose of this study was to assess the prevalence of tooth wear, symptoms of reflux and salivary parameters in a group of patients referred for investigation of gastro-oesophageal reflux disease (GORD) compared with a group of control subjects.

Materials and methods. Tooth wear, stimulated salivary flow rate and buffering capacity and symptoms of GORD were assessed in patients attending an Oesophageal Laboratory. Patients had manometry and 24-h pH tests, which are the gold standard for the diagnosis of GORD. Tooth wear was assessed using a modification of the Smith and Knight tooth wear index. The results were compared to those obtained from a group of controls with no symptoms of GORD.

Results. Patients with symptoms of GORD and those subsequently diagnosed with GORD had higher total and palatal tooth wear ($p < 0.05$). The buffering capacity of the stimulated saliva from the control subjects was greater than patients with symptoms of GORD ($p < 0.001$). Patients with hoarseness had a lower salivary flow rate compared with those with no hoarseness.

Conclusions. Tooth wear involving dentine was more prevalent in patients complaining of symptoms of GORD and those diagnosed as having GORD following 24-h pH monitoring than controls. Patients had poorer salivary buffering capacity than control subjects. Patients complaining of hoarseness had lower salivary flow rate than controls.

Aim

This study was designed to assess the prevalence and hence the extent of the problem of tooth wear in a group of patients presenting with symptoms of gastro-oesophageal reflux disease (GORD) to an Oesophageal Laboratory in the UK. Following 24-h pH measurement, tooth wear was assessed in patients that had pathological reflux according to the internationally recognised normals[1,2] and compared with a group of matched controls with no symptoms of GORD. Stimulated salivary flow rate and buffering capacity of these patients were compared to those of the controls.

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Introduction

Tooth wear and GORD are two conditions that have been reported to be related[3,4] GORD is a common condition affecting approximately 60% of the population and is caused by the retrograde movement of gastric juice into the oesophagus.[5] Saliva has an important role in the clearance of acid in the oesophagus. This is true both for healthy individuals and patients with GORD. Oesophageal acid clearance occurs in a two-step procedure, peristalsis clearing the volume, followed by saliva neutralising the acid. Oesophageal emptying must be complete by peristalsis before acid neutralisation by swallowed saliva occurs.[6] Bouchoucha et al. (1997) reported improved buffering capacity of saliva in 17 patients with symptoms of GORD compared to 20 healthy volunteers.[7] Sonnenberg et al. (1982) on the other hand found no difference in resting saliva volume and bicarbonate content between patients and controls.[8]

It has been shown that stimulation of saliva by means of oral lozenges decreases oesophageal clearance time by 50% and conversely acid clearance times are prolonged by aspiration of saliva.[9] Most patients with reflux oesophagitis experience heartburn after perfusion of the oesophagus with acid.[6] Upper gastrointestinal mucosal irritation has long been thought to stimulate salivation by a phenomenon termed 'oesophago-salivary reflex'.

Sarosiek et al. (1996) assessed the flow rate and buffering capacity of resting and paraffin wax stimulated saliva in 36 patients diagnosed at endoscopy with reflux oesophagitis and a group of 31 asymptomatic controls.[10] Endoscopy diagnoses oesophageal inflammation whereas ambulatory pH measurement assesses the exposure of the oesophagus to acid. Some patients can have exposure to acid, but without significant inflammation of the oesophageal mucosa. The authors reported that stimulation of saliva significantly increased the salivary flow rate and bicarbonate content in both the patient and the control groups.

Manifestations of GORD are wide and varied. An extra-oesophageal manifestation is chronic hoarseness with no discernible cause. Wiener et al. (1989) reported 26 out of 33 (79%) of patients with chronic hoarseness and laryngeal lesions had evidence of severe GORD on pH monitoring.[11] Other extra-oesophageal manifestations include: asthma, chronic cough and globus (feeling of a lump in the throat).

There appears to be evidence that severe tooth wear is caused by reflux disease. Bartlett et al. in a controlled study of 40 patients presenting with pathological tooth wear, observed that 60% of these patients had pathological levels of reflux assessed from ambulatory pH monitoring.[3] This study supported the findings of Schroeder et al. (1995) in a small study of 12 patients with tooth wear. The authors investigated reflux using 24-h pH monitoring.[12] Ten of the 12 dental patients were diagnosed with reflux disease, but no relationship was reported between saliva and tooth wear. Schroeder et al. also assessed the presence of dental erosion in a separate group of 30 patients with reflux disease as assessed by 24-h pH measurement. Twelve out of these 30 patients had tooth wear. Meurman et al. (1994) assessed the dental status and salivary characteristics of 117 Finnish patients presenting with reflux disease, rather than presenting with dental erosion, and reported that tooth wear and reflux disease were inter-related, but no statistical relationship was observed between salivary parameters and tooth wear.[13] Different countries are recognised as assessing tooth wear differently and so the relationships observed between saliva, tooth wear and reflux might vary.[14]

Method and materials

Patients were recruited from those attending the Oesophageal Laboratory of St Thomas' Hospital who had been referred for investigation of GORD by manometry and 24-h oesophageal pH tests from a variety of medical sources. All patients selected had both procedures carried out. The presence or absence of oesophageal (heartburn, dysphagia, regurgitation, retrosternal chest pain) and/or extra-oesophageal (non-cardiac chest pain, hoarseness, laryngitis, globus and dental erosion) symptoms were recorded for each patient. Patients were excluded if they had less than 10 teeth, were outside the age range 18–75 years and suffered any other medical conditions that would interfere with the study. Control subjects with a similar age range, but without symptoms of GORD were also recruited. Oesophageal tests were not carried out for control subjects and they were included if there was no history of any symptoms of GORD. Control subjects were partners of patients attending for the tests, colleagues and dental students. Tooth wear was not assessed prior to selection of any subject. Ethical approval was obtained prior to the study.

Assessment of tooth wear

The distribution and severity of tooth wear was determined using a modified version of the Smith

and Knight tooth wear index.[15] Briefly, this consisted of recording a score between 0 and 5 for, cervical buccal/labial, occlusal/incisal and palatal/lingual surfaces of all teeth. A modification was made to the original index described by Smith and Knight, where restored surfaces resulting from tooth wear were included and were recorded as a score 5. All other restored surfaces where excluded. A score 5 was only recorded if the author had managed to trace the original models of the teeth before restoration and if the presence of tooth wear and the reason for the restoration could be determined accurately. All assessments were carried out by the first author under ideal lighting. All teeth were thoroughly cleaned and dried using cotton wool buds. The cervical, buccal/labial, occlusal/ incisal and lingual/palatal surfaces of each tooth were examined in the same order for each patient and data were recorded by the author. Ten patients were scored twice on separate occasions to test reproducibility and agreement between scores on two occasions. Intraclass correlation coefficients were 0.996, 0.999 0.998 for each of the calculated scores, respectively.

Ambulatory pH monitoring

Patients referred for the assessment of GORD underwent 24 h ambulatory pH monitoring. Data from the pH in the oesophagus were digitally stored and compared to symptoms recorded by an event marker in the equipment. Patients recorded consumption of foods and drinks and were asked to avoid citrus fruits, black tea/coffee and all other drinks known to provoke reflux except for milk and water. Subjects also recorded on the data logger the time of food and drink consumption and periods of supine or prone position. The results of the manometry and 24-h pH tests were used to diagnose GORD. These tests are recognised as the gold standard for diagnosis of GORD.

Analysis of diet and symptoms

A detailed record of each subject's dietary intake was taken by written questionnaire. The dietary history was used to exclude subjects with high consumption of acidic foods and drinks. A standard questionnaire was delivered by a trained medical specialist to assess the symptoms (oesophageal and extra-oasophageal), expanding the questions where necessary, and included the length of time and changes in the pattern or severity of the symptoms.

Salivary flow rate and buffering capacity

The salivary flow rate and buffering capacity were assessed on patients attending the clinic midmorning. The patients were asked to sit comfortably and undisturbed for at least 15 min prior to the collection of saliva and then asked to chew a piece of paraffin wax for 2 min, changing the chewing side every 15 s and swallowing the saliva. They then continued to chew and change sides every 15 s, but drooled the saliva into a plastic container until 2 ml of saliva was collected. Salivary flow rate was calculated as time taken to collect 2 ml of stimulated saliva.[16,17] One millilitre of saliva was then mixed with 2 ml of fluid comprising 1.46 ml 0.005N hydrochloric acid, 500 μl 0.02% Bromocresole purple and 40 μl BDH '4.5' indicator (Merck Ltd, Leics, UK) and, after 2 min, the colour compared with a standard colour chart to determine the final pH of the solution.[16,17] All salivary tests were carried out midmorning and patients were asked to fast for at least 4 h prior to the test to avoid vomiting during intubation of the pH probes.

Controls

Control subjects were interviewed by the principal investigator. A dietary intake assessment was carried out using an identical method to that used on the study patients. Salivary flow rate and buffering capacity were assessed using the standard protocol used in patients. Tooth wear assessment was carried out using the modified index.

Statistical analysis

Data were described and analysed using non-parametric methods. Tooth wear was analysed as score 2 and above, score 3 and above, score 4 and score 5 for the total number of teeth and the palatal and occlusal surfaces separately. Median and interquartile range were calculated in addition to mean and standard deviation, and the Mann–Whitney *U*-test used for comparisons between groups. p values less than 0.05 were regarded as indicating statistical significance.

Results

One hundred and four patients with a mean age of 44 (standard deviation (SD) = 14.4, 60 males and 44 females) and 31 controls with a mean age 42 (SD = 16.2, 13 males and 18 females) were recruited. Saliva was assessed in all control subjects

Table 1 Median (interquartile range) total percentage time that pH fell below four during the 24-h pH recording in patients with and without GORD, together with percentage time whilst patient was either upright or supine.

	Patients with GORD	Patients without GORD
Total reflux	11.6 (8.1–16.2)	1.4 (0.3–2.6)
Upright reflux	12.1 (9.3–17.4)	1.5 (0.2–3.7)
Supine reflux	5.6 (0.9–19.2)	0.1 (0–0.6)

and 41 of the patients with the mean age of 46 (SD = 13.2, 20 males and 21 females). The most common oesophageal symptoms were heartburn (72%), regurgitation (44%), dysphagia (36%) and the extra-oesophageal symptoms were asthma (16%), hoarsness (13%) and globus (5%). There were no statistically significant differences in age or gender between the groups ($p = 0.138$ and 0.378, respectively). The results from the questionnaire were used to ensure that the dietary intake in both groups did not have a high acidic content.

The pH data is summarised for patients with and without GORD in Table 1. The total percentage time during which the patient experienced reflux was higher for patients with GORD compared with those without GORD (not controls), as was the percentage time for reflux in the upright or supine position.

Patients with symptoms of GORD had a higher frequency/proportion of the Smith and Knight score of 2 and above (median 14.5) and score 3 and above (median 23.8) on all surfaces of their teeth than the controls (median 8.2 and 0.2, respectively) ($p < 0.001$ and 0.005, Table 2). A similar pattern was observed on the palatal surfaces of the upper anterior teeth (Table 3). The proportion of all the scores were higher on the occlusal surfaces of the posterior teeth for the patient compared to control group, but the difference did not reach statistical significance. Those patients diagnosed with GORD from the results of the manometry and 24-h tests were analysed separately. The 59 patients who were diagnosed with GORD had a higher frequency of the Smith and Knight score of 2 and above and 3 and above on all surfaces of their teeth than the 31 controls ($p < 0.001$ and $p = 0.018$). The difference between these groups was also statistically significant for these scores on palatal surfaces of the upper anterior teeth ($p < 0.001$ and $p = 0.023$, respectively). The proportion of all the scores were again higher on the occlusal surfaces of the posterior teeth for the patient compared to control group, but the difference did not reach statistical significance.

The results of the salivary tests showed that the buffering capacity of patients complaining of symptoms of GORD had a lower median (interquartile range) final pH of 5.5 (5–6) compared to 6 (5.5–6.5) for the controls ($p < 0.001$). The results were similar in the sub-group of 30 patients with confirmed GORD who had the salivary tests (total number of patients with confirmed GORD was 59, Table 4) when compared with the group of controls ($p < 0.001$). There were no statistical significant differences for the stimulated salivary flow rate (median 1.3 ml/min, IQR 1.14–2 for patients compared with median 1.14, IQR 1.07–1.6 for the controls). The 13 patients who complained of hoarseness had a lower stimulated salivary flow rate (median 0.66 ml/min, IQR 0.4–1.1) compared with those with no hoarseness (median 1.60 ml/min, IQR 1.1–2.6). The difference was statistically significant ($p = 0.011$).

Discussion

The level and assessment of tooth wear is interpreted differently around the world. Subtle differences in the diagnosis and the assessment mean that the prevalence data may not be entirely comparable across different countries.[14] This difference would have clinical significance, especially if some countries diagnose cervical wear as erosion and others diagnose the same lesion as abrasion or abfraction. Therefore, comparing data from reflux patients with or without tooth wear may present conflicting results. The results from the present study indicate that patients in the UK with symptoms of GORD have more tooth wear than subjects without symptoms. This difference was also observed separately for the palatal surfaces of the upper anterior teeth. Palatal tooth wear has been associated with dental erosion

Table 2 Mean (standard deviation) and median (interquartile range) frequencies/proportions of score 2 and above, score 3 and above, score 4 and above on all tooth surfaces.

	Patients	Controls	*p* value
Score 2 and above	23.8 (53.4), 14.5 (8.8–25.9)	8.2 (8.6), 7.4 (0–13.3)	<0.001
Score 3 and above	5.4 (18.5), 0 (0–2.3)	0.2 (0.9), 0 (0–0)	0.005
Score 4 and above	3.4 (15.6), 0 (0-0)	0 (0), 0 (0–0)	0.107

Table 3 Mean (standard deviation) and median (interquartile range) frequencies/proportions of score 2 and above, score 3 and above, score 4 and above on palatal surfaces.

	Patients	Controls	*p* value
Score 2 and above	29.8 (70.5), 0 (0-0)	0 (0), 0 (0-0)	<0.001
Score 3 and above	15.4 (65.8), 0 (0-0)	0 (0), 0 (0-0)	0.039
Score 4 and above	10.4 (63.7), 0 (0-0)	0 (0), 0 (0-0)	0.194

caused by GORD and therefore these results indicate that tooth wear in this group of patients was caused by regurgitated gastric acid.

The tooth wear index used in this study has been shown to be reasonably reproducible in large studies, but can be less predicable in smaller studies, where judgement differences may be over emphasised. The problem with the index is that judging dentine exposure on levels 2 (less than a third of the surface), 3 (greater than a third of the surface) and 4 (secondary dentine or pulpal exposure) can be difficult. To overcome this problem the author underwent intensive training prior to the investigation and the assessment of reproducibility indicated a high level of repeatability. Another complication of using tooth wear scores is that some emphasise the multifactorial nature of the condition[15] whilst others focus on erosion.[18] Whilst erosion is the most important factor in the tooth wear of patients with reflux, attrition and abrasion cannot be ignored and were therefore included. For this reason, the palatal surfaces of the upper anterior teeth, where erosion is the most likely reason for tooth wear, were reported separately.

The role of reflux in erosion has been recognised for some time, but the medical symptoms associated with reflux are the most important reason for patients seeking medical advice.[3,4] This is the first study to report that patients presenting with hoarseness (an atypical symptom of reflux disease) had reduced salivary flow rate compared to those without this symptom. Some workers have suggested that direct contact with acid is necessary for symptoms such as cough or hoarseness to develop, whereas others believe that the symptoms are a vagally mediated reflex to the presence of acid in the lower oesophagus.[19] This mechanism is suggested because of the common embryological origins of the oesophagus and the tracheo-bronchial tree. Prolonged contact of the mucosal lining of the larynx with refluxed gastric acid could produce inflammation. Within the laryngeal mucosal lining there is a reduced number of minor salivary glands, compared to the mouth and the oesophagus, and slight reductions in salivary flow would have an exaggerated effect.

Table 4 Age (standard deviation) and gender of patients and control subjects investigated in the study.

Group	N	Age	Male/female
Patients with symptoms of GORD	104	44 (14.4)	60/44
Patients with symptoms of GORD and saliva analysis	41	46 (13.2)	20/21
Patients diagnosed with GORD	59	45 (13.2)	38/21
Control subjects	31	42 (16.2)	13/18

The clearance of acid regurgitated in the oesophagus occurs by primary peristalsis initially followed by the chemical clearance by saliva. Any swallowed saliva in turn initiates secondary peristalsis clearing the remaining acid further. This would imply that a decrease in salivary flow rate and buffering capacity would have a reduced potential for chemical clearance as well as secondary peristalsis thus increasing the contact time between the acid and the oesophageal lining. Oesophagitis is the inflammation of the lining of the oesophagus which occurs in most patients with GORD. Symptoms of GORD such as heartburn would then be expected if acid is not cleared by the saliva, hence increasing the contact time with the oesophageal lining. Other extra-oesophageal symptoms are also likely.

The study was carried out during the morning and afternoon. It was not feasible within the confines of the study to assess salivary flow rate and buffering capacity in all patients. Patients were only recruited for salivary assessment if their appointment was midmorning to reduce circadian variation and the influence of gustatory intakes. The buffering capacity of the saliva of control subjects was observed to be higher than patients with GORD. This in turn could provide some insight into the presence of symptoms of GORD in the patients.

Once acid has passed the lower oesophageal sphincter, and enters the oesophagus it may or may not progress along the proximal oesophagus into the mouth. Dental erosion occurs once the acid comes in contact with the teeth. The clearance of acid by saliva would then be important in the development of dental erosion. The poor buffering capacity of saliva in patients with GORD in conjunction with the higher prevalence of tooth wear in this group of people might suggest that saliva may play an important role in tooth wear. Further studies are needed to assess the important role that saliva

may have in tooth wear and GORD. There is no doubt that tooth wear and GORD are related and good collaboration between the dental profession and gastroenterologists is of utmost importance for the diagnosis and prevention of both conditions.

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