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THE IMPACT OF GERD ON ORAL AND DENTAL HEALTH

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Abstract

Introduction: Gastroesophageal reflux disease (GERD) is a chronic disorder which is defined by backflow of stomach acid content into the oesophagus and oral cavity. GERD might occur due to intrinsic or extrinsic factors. "Typical" manifestations of GERD are heartburn and regurgitation; however, it has some atypical and less known manifestations such as oral complications, particularly dental erosion (DE).

Objective: Main purpose of this project was to further understanding of GERD and its oral complications particularly dental erosion and providing deep insights into the biological factors which may modify dental erosion. Moreover evaluation of possible association between GERD and dental caries, periodontal disease and inflammatory mucosa along with assessment of salivary parameters alterations in GERD was conducted and at the end ideas regarding dental management in GERD was proposed.

Material and method: Medline and PubMed databases literature search was conducted to specify articles associated with GERD and oral manifestations, accompanied by searching and selecting relevant medical books.

Discussion: Almost all authors agree on the association between GERD and dental erosion. Reduced salivary flow and buffer capacity in GERD are recognised as the main contributor of dental erosion in majority of publications. There are a few disagreements on other oral manifestations such as periodontal disease, inflammatory oral mucosa and their possible link with GERD and far less agreements about dental caries.

Conclusion: Dental erosion is the main oral manifestation of GERD influenced by salivary deficiency and reduced buffer capacity. Periodontal disease and mucosal inflammation are less common complications. However, it is dentist's responsibility to early diagnose and treat the GERD patients, to prevent further damage.

Resumen

Introducción: La enfermedad por reflujo gastroesofágico (ERGE) es un trastorno crónico que se define por el reflujo de ácido del estómago hacia el esófago y la cavidad oral. La ERGE puede ocurrir debido a factores intrínsecos o extrínsecos. Las manifestaciones "típicas" de la ERGE son pirosis y regurgitación; sin embargo, presenta algunas manifestaciones atípicas menos conocidas como complicaciones bucales, en particular, la erosión dental (ED).

Objetivo: El objetivo principal de este proyecto fue profundizar en la comprensión de la ERGE y sus complicaciones orales, en particular, la erosión dental, y proporcionar conocimientos sobre los factores biológicos que pueden modificar la erosión dental. Además, se evaluó la posible asociación entre la ERGE y la caries dental, la enfermedad periodontal y la mucosa inflamatoria junto con la evaluación de las alteraciones de los parámetros salivales. Finalmente se propusieron ideas sobre el manejo dental en la ERGE.

Material y método: Se realizó una búsqueda bibliográfica en Medline y PubMed para especificar artículos asociados con ERGE y manifestaciones orales, acompañadas de búsqueda y selección de libros médicos relevantes.

Discusión: Casi todos los autores coinciden en la asociación entre ERGE y erosión dental. La reducción del flujo salival y la capacidad amortiguadora en la ERGE se reconocen como el principal contribuyente de la erosión dental en la mayoría de las publicaciones. Hay algunos desacuerdos sobre otras manifestaciones orales como la enfermedad periodontal, la mucosa oral inflamatoria y su posible vínculo con la ERGE y mucho menos acuerdos sobre la caries dental.

Conclusión: La erosión dental es la principal manifestación oral de la ERGE influenciada por la deficiencia salival y la reducción de la capacidad amortiguadora. La enfermedad periodontal y la inflamación de las mucosas son complicaciones menos frecuentes. Sin embargo, es la responsabilidad del dentista diagnosticar y tratar a tiempo al paciente con ERGE para evitar daños mayores.

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Introduction :

Gastroesophageal reflux disease (GERD)

GERD is a spontaneous muscle relaxing of the lower esophageal sphincter, which lets the stomach content to move towards the oesophagus or ends up in the oral cavity.

GERD is a common medical condition, with a prevalence ranging from 21% to 56% in the world.(1),(2)

Between common precipitating factors for Gastro-oesophageal reflux we can mention to smoking, excessive alcohol drinking, obesity and heavy meals. If irritation to oesophageal lining continues it may result in the tissue damage. (3)

The Montreal definition of GERD refers to this condition as a cause of irritating symptoms and complications(4),(5).

GERD has been classified by Montreal consensus as a disorder with oesophageal and extraesophageal symptoms(5),(6)

Apart from oesophageal symptoms the stomach acid regurgitation into oesophagus or oral cavity is a causal factor in presenting many extraesophageal symptoms(7) such as heartburn, chest pain, pyrosis, hoarseness, asthma(1)(8), sore throat, globus sensation(8) and oral manifestations including dental erosion, non-specific burning sensation, ulcers in mucosa, erythema of the soft/hard palate, uvula, and xerostomia (9),(10). Among them dental erosion is the most prevalent oral complication.(11),(5)

Symptoms of GERD are categorised into two main groups typical and atypical ones.

Heartburn, regurgitation, dysphagia and retrosternal pain are typical symptoms of GERD while some others such as asthma, chronic cough, hoarseness, oral

complication and dental erosion are between atypical ones(1) which latter will be discussed about in this study.

Oral complications in GERD

Dental erosion (DE) is characterised as a loss of dental hard structure by a nonbacterial chemical agent (12). It is manifested by rounded and smoothly glazed tooth surface(13) it starts with slight changes in the surface of enamel. This alteration can progress to a more advanced situation leading to an irreversible loss of tooth substance, (8) However, if dental erosion is detected in the early stages this alteration could be reversible. The enamel structure might be remineralized by preventative measurements in diet, or medicaments.(1)

Any acid with a PH lower than 5.5 which is critical PH of the enamel can cause dissolution of hydroxyapatite structure and causes erosion of the tooth(14).

Dental erosion might originate from extrinsic source such as dietary and medicinal substances, or intrinsic source which refers to acid reflux and regurgitated gastric juice with a PH lower than 2.0 in GERD (15)(16)(17)

These two types of erosions are seen in different surfaces of the teeth.

Extrinsic dental erosion is caused by intake of acidic foods or drinks or various medications(1)(14) also excessive exposure to gas-chlorinated water of the swimming pool, occupational contact and other industrial chemical substances are reported as less common extrinsic origins. (14)This type of erosion is observed mainly on the labial surface of anterior teeth and buccal and occlusal surface of posterior teeth(1),(10),(14) ,while dental erosion might occur due to intrinsic origin such as bulimia, rumination, chronic vomiting and GERD(14). This type of erosion is mainly seen in palatal surface of maxillary teeth and occlusal surface of mandibular molars.(1),(10),(14)

Since 1937, gastroesophageal reflux disease has been linked to dental erosion, first by Borgen and Austin(18)

The main mechanism of this action is due to direct contact of acid with the teeth and oral mucosa. Repeated or continuing exposure of oral cavity to the acidic gastric content may lead to create an ongoing erosive acidic environment(8) which ends to dissolution of the tooth surfaces and other alterations such as hypersensitivity, functional impairment, even fracture of the teeth .(1)

However acid reflux to the oral cavity is considered as the etiological factor for dental erosion, the severity of DE in GERD patients is proportional to other factors such as the duration and frequency of reflux, the pH, the quality and volume of saliva. It also depends on whether patients rinse or not right after the regurgitation episodes .(1)

Between mentioned factor, saliva plays a significant role as a dental erosion modifier(19).

Saliva has a significant role in protecting oral tissue and dental structures as well as other homeostasis functions(8). Deficiency of saliva may lead to speech difficulties, swallowing problems, dysphagia, dysgeusia, higher risk of harm or trauma, ulcers, candidiasis, burning mucosa, and dental erosion.(20)

Saliva buffer system acts as an important factor to control the PH of the oral environment to neutralise the acid which is produced by bacterial plaque and oral microorganisms.(1)(20). Saliva also has a contributing role in remineralisation of eroded tooth and its softened structure by deposition of salivary calcium and phosphate. Many studies suggest that decreasing salivary flow and its buffering capacity are contributing factors in dental erosion.(20) On the other hand hyposalivation in GERD patients has been reported by some authors(21).

Moreover, hyposalivation in GERD is suggested as the strongest reason for considering GERD as a predisposing factor for chronic *periodontitis*(21) and *gingivitis*(11)

Dental caries and its possible link to GERD is another disorder which is studied in this paper. Demineralisation of dental structure in both cases of caries and dental erosion occurs when saliva PH drops to lower than critical PH(5.5). Below this PH dental structure dissolution begins.(20) . That's why some authors try to find a correlation between gastroesophageal reflux disease and dental caries. However, as we discuss later, initiation of dental caries is dependant to other factors.

It is important for us to recognise possible oral complications of GERD, diagnose them correctly and try to mitigate its detrimental effect as soon as possible.

Objectives:

Main objectives

- To further understanding of GERD and its oral complications particularly dental erosion
- To identify whether there is any association between GERD and dental erosion
- To determine the biological factors which modify DE and other complications in GERD.

Secondary objectives

- To evaluate whether GERD is a predisposing factor for other oral complications including dental caries, periodontal disease and inflammatory oral mucosa.
- To find out the possible link between GERD and alteration of salivary parameters including salivary flow rate and buffer capacity.

- Last objective of this paper is about dental management in the GERD patients by preventive treatment and mitigating its adverse effect on the teeth and oral cavity.

Material and Methods:

Search strategy

Several procedures were implemented to ensure a high quality literature review .

First a comprehensive search of academic publications was completed based on a wide range of key terms including: *GERD; oral complications; dental erosion(DE) ; Saliva*. These terms were combined in various ways with “AND” commands in order to obtain the most narrowly defined result in the relevant articles. Each of the search terms were selected due to their relevance regarding the purpose of this literature review.

Electronic database

To supply sources for this literature review multiple databases were used including PubMed and Medline.

The search for publications with the mentioned keywords with different combination was performed in PubMed as well as Medline with a subset of publications in Dentistry between 1995 and 2021. A total of 114 articles were found. Between them 26 studies which were relevant to GERD affecting oral and dental health, and related to our objectives were retained for analysis based on full text and the rest were excluded. Also an additional review through cross references added 4 more references to the list of retained articles.

In this project also 2 medical books were consulted. One of them about dental erosion and its clinical management and the other one which was a reference medical book about oral pathology and medicine containing a chapter about gastroesophageal disease which along with other articles shed light on evaluating better GERD and its oral complications.

Inclusion and exclusion criteria

Articles about GERD which were dealing with oral manifestations including dental erosion, dental caries, periodontal disease, soft tissue alteration, change of salivary flow and other oral changes relevant to GERD as well as oral management in these patients were selected. Articles about GERD in children, GERD in animals or those articles which were not addressing oral complications were excluded. Also no case report was selected as a reference.

in terms of language only articles and books written in English and Spanish were selected and the rest were excluded.

Studies older than 1995 were excluded except for one of the references which was dated back to 1984 (Smith and Knight index) . This index was commonly used in the selected researches and It was important to mention about. Electronic copy of this article was provided through British dental association library.

A range of Descriptive (cross sectional), systematic review and analytical studies including cohort and retrospective case control studies were used.

Data collection

in order to retrieve data from available sources a table was designed including Author's name, year of publication, study design, sample size, evaluated oral complications and their conclusion.

Discussion

Due to widespread nature of GERD, many researchers have conducted studies about this disease and its oral manifestations. Different findings relevant to GERD were proposed, such as dental erosion as the main complication, dental caries, periodontal disease, inflammatory oral mucosa such as gingival and palatal erythema and ulcers as well as some alterations such as hyposalivation and reduced buffer capacity which we compare and analyse them here in following.

Risk of dental erosion

According to many studies dental erosion is a common complication of GERD(22),(20),(23)(24).

DE is characterised as irreversible loss of dental hard tissue by a chemical and non-bacterial procedure. (22),(12),(25),(17) Demineralization of tooth structure occurs due to exposure to acids that are introduced into the oral cavity either by intrinsic(endogenous) in case of GERD or extrinsic (exogenous) sources. (22).

On the basis of many studies continuous stomach acid contact with oral cavity (PH <4) has a positive association with dental erosion in GERD patient.(23) PH of gastric acid is about 1.2; however, regurgitated gastric content is not as acidic as gastric acid itself, as it is composed of digested foods and pepsin with different proportion. Enamel starts to demineralise when the PH of oral cavity falls below 5.5 . Hence the severity of dental erosion might vary according to composition of regurgitated gastric content or its PH and frequency of the reflux(17)(14)

DE is not easy to detect in early stages(12). In this alteration firstly the enamel surface is dissolved and continues until the underlying dentin layer with its yellow colour is shown through the thin layer of remaining enamel. Affected teeth present sensitivity to

temperature changes (10),(25),(12). The lesions we observe in dental erosion are hard and smooth in contrast with soft and dark lesions which are typically seen in tooth caries. (25)

A worn tooth has a glazed or “silky” appearance which looks very clean because of removal of acquired pellicle and plaque from the tooth surface by acid .(17). Eroded tooth looks like a tooth which has been lightly prepared for full coverage restoration with a chamfer margin. (14),(1). It has been hypothesized that intact enamel around gingival margin might be due to plaque remnants which performs as the protective barrier against acid.(1) or it could be due to sulcular fluid and its antacid effect by basic PH of 7.5-8.(1)

In more severe cases of DE, due to morphological changes, “cupping” or concavity in enamel and dentin appears along with further occlusal erosion in posterior teeth, by rounding the cusps and restoration standing above the tooth surface. In more advanced cases this destruction is up to the extent that entire enamel and dentine are eroded and pulp is exposed.(1)

Worn enamel and dentin structure are in higher risk of attrition and abrasion. In pure erosion lesions normally cannot be seen in occlusal contacts unlike attrition.(25)

Early stages of dental erosion is slower in progress as it is involved with enamel as a hard substitute. On the contrary once dentin is exposed, progression of DE would be much faster due to dentin softer composition and its higher level of susceptibility, while some dental materials such as amalgam restoration are very resistant to erosion.

Dental amalgam in eroded tooth will “stand above” the tooth surface(1), (14)

Tooth sensitivity to cold, hot, sweet would be a definite consequence of dentinal tubule exposure. In more advanced cases in which pulp is exposed, endodontic treatment

would be the only option. Another consequence of dental erosion would be compensatory eruption of the tooth in order to maintain the functional bite, and some other alterations such as tipping of the tooth, diastema, decreasing overjet, loss of vertical dimension, change of facial feature and bite collapse of the patient. (14)

DE is going to be aggravated when GERD is accompanied by bruxism or exogenous stimulus such as alcohol.(14)

In 2006, In a world congress of gastroenterology of Montreal consensus, 44 physicians confirmed that prevalence of dental erosion is higher in GERD patients based on 96% consensus including 42% of the votes “agreed strongly” with the mentioned correlation, 35% and 19% of the votes agreed with “minor “and “major” reservation.(17),(26)

In this section we investigate and analyse the result of some retrospective studies which were conducted in GERD cases and control groups, in order to identify whether the prevalence of dental erosion is higher in GERD patients or not.

Yoshikawa et al. (22) studied DE in 40 GERD patients vs 30 healthy controls (15 younger and 15 older). Severity of dental erosion was studied by modified Smith and knight tooth wear index (Annex 1).(27) This index ranges between 0 to 4 ,in which 0 is the score assigned to no erosion and 4 is the score when pulp is exposed. In the modified version score 5 is added which is representing any tooth surface which has been restored due to dental wear.(22)

According to their study the prevalence of dental erosion was 24.3% in the GERD group (vs 0% in the control groups).(22)

According to their research dental erosion was observed mainly in anterior teeth and only one patient was presenting tooth wear in posterior teeth(first premolar). In general scores of 1 and 2 were distributed between 21 and 6 patients respectively. In superior

dental arch, erosion only was observed in palatal while in the inferior dental arch only in the labial surface. They proposed that susceptibility of palatal surface of upper teeth to dental erosion is attributed to the force of reflux which directs the acid from the pharynx into the oral cavity toward anterior teeth, while lingual surface of lower teeth is not considerably affected by dental erosion. The most reasonable explanation of lower teeth being less susceptible to erosion, could be due to mechanical protection of the tongue as well as protective layer of serous saliva provided by submandibular gland .(22)

Similar result was achieved by Correa et al.(20) proposing that prevalence of erosion in patients with gastroesophageal reflux was greater than in controls. Mean number of eroded teeth in GERD group constitutes 5.22 ± 2.52 , and in healthy group, it shows 0.06 ± 0.36 .(20) This result was in agreement with Alavi et al.(26) who reported a higher prevalence of dental erosion again in GERD patients (22.6%) compared to control group accounting for 7%.

Association between GERD and dental erosion was also confirmed by another study by Sîmpălean et al.(24) indicating higher prevalence of dental erosion in GERD compared to control group(24)

Muñoz et al.(23) implemented a research on not only the prevalence and possible link between GERD and dental erosion, but also degree and severity of tooth wear in patients with gastroesophageal reflux vs healthy group. They evaluated dental erosion by Eccles and Jenkins index (Annex 2).(14) The obtained figure was significantly higher in the GERD group . According to their study Dental erosion was reported in 47.5% of GERD patients while it only constituted 12.5% of the Control group. They also concluded that the degree of dental erosion in GERD patients was more severe

than in control group by stating that all subjects with DE in control group had a mild degree of severity with less than 5 teeth affected, whereas between 86 cases of dental erosion in GERD patients, 35 of them (40.6%) had at least five teeth affected and more than a third of them represented sever degree of erosion.(23)

They also proposed that dental erosion is modified by another factor which is age. They stated that risk of dental erosion increases by age. Hence a positive association was reported between age and existence of dental erosion in patients with GERD. They justified their proposal by indicating that over a period of years oral cavity would be exposed to acid for a longer time in older patients.(23)

Evaluating different studies clarifies that prevalence of dental erosion in all GERD patients is not the same(22). This difference could be influenced by either individual factors such as having different defence mechanisms to acid including saliva flow rate(22),(23) PH and its buffering capacity, or presence of external contributing factors such as taking acidic foods or drinks(23).

Between mentioned modifier agents saliva plays an important role in dental erosion. According to studies acquired pellicle of saliva has been indicated as a tooth erosion inhibitory factor(17),(28). Salivary acquired pellicle acts as a diffusion barrier on the surface of the teeth and performs like a source of calcium, phosphate and fluoride ions and with reducing this layer, the teeth would be more susceptible to demineralisation and dental erosion.(28)

Since the acidic stomach content alters the protective function of saliva and saliva is constantly removed and displaced by acid In GERD, this ends up to elimination of acquired pellicle covering the tooth surface. By removal of this protective layer tooth

will be more prone to dissolution of hydroxyapatite followed by demineralisation of the tooth structure and dental erosion.(17)

Dental erosion is a multi-factorial alteration which is affected by overcome buffer capacity either for decreasing salivary flow or increased volume of acid in GERD(7)

Although numerous studies report GERD as a predisposing factor for dental erosion, there are very few studies which fail to find any significant association between GERD and DE.(29) According to some authors, there is a significant association between DE and gastroesophageal reflux disease to an extent , they reported dental erosion as an indicator which reveals silent GERD (2)(30).

Risk of Dental caries

Dental caries is an infectious incurable disease originated by bacterial acid. The three necessary factors for initiation of caries are the host, microbiota and cariogenic foods such as carbohydrates. In this process the organic acids which is produced through fermentation of carbohydrates by the action of microorganism, cause demineralisation of dental structure leading to dental caries.(20) According to many evidences *Streptococcus Mutans* are essential for initiation of dental caries(3),(20), and *Lactobacillus* proliferation produces acid. Through this acid production oral PH drops down to below critical PH (5.5) and demineralisation of enamel structure begins. (20). According to what mentioned above to find a link between dental caries and GERD, one hypothesis is whether the microbiota changes in the GERD patients or not.

In the study conducted by correa et al.(20) prevalence of dental caries were evaluated in the two groups in which 41 carious teeth were found in GERD group vs 156 in control group .

In this study a bacterial count of Streptococcus Mutans and lactobacillus of the saliva was performed in two groups. According to the result obtained by their study the number of cariogenic bacteria found in the GERD group was lower than in the control group, Both for the count of Streptococcus Mutans as well as Lactobacillus.(20)

They concluded that decreased number of caries in GERD group could be explained by low amount of bacteria (Streptococci and lactobacilli) in this group.

According to their study neither through the clinical exploration nor by the bacterial count a link could be found between GERD and risk of dental caries.

Another researcher also conducted the same bacterial count on GERD patients and they obtained lower count of Streptococcus mutans . Two explanations were proposed. Firstly, this bacteria is able to metabolise up to PH degree 4.2 and not lower than that, While PH test of the GERD patients indicated below 4.2, making an unsuitable ambient for proliferation of that bacteria. Second explanation is that gastric HCL hydrolyses the plaque and removes majority of bacteria (28)

In another study Yoshikawa et al.(22) used DMF indexes including specific scores for the decayed, missing, filled to evaluate dental caries in 2 groups of GERD patients and control.

As per their study DMF index was higher in the patients with gastroesophageal reflux compared to other 2 control groups (older and younger)(22). Fig.1

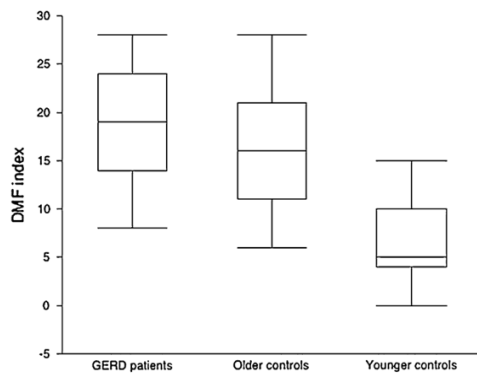


Fig. 1 (DMF) index scores between GERD patients and control groups (22)

Whereas in another study by Watanabe et al. (11) the DMF index for dental caries in the GERD patients were much higher than in the younger controls and smaller than in the older controls. Proposing the hypothesis that the higher the age the higher the risk of caries. Watanabe's study indicated no correlation between GERD and dental caries. Fig.2.

They insisted on a correlation between dental caries and age.

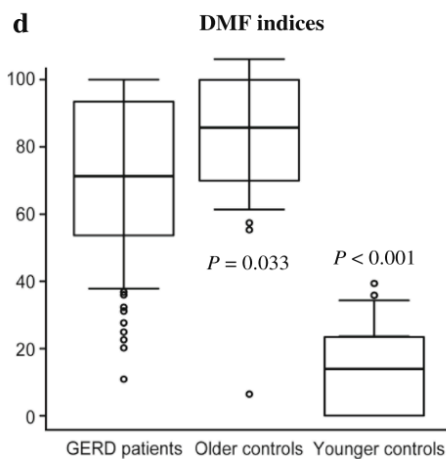


Fig.2 DMF index. The GERD patients had significantly higher levels than the younger controls, but lower levels than the older controls. (11)

Conversely, Muñoz et al.(23) proposed in his study that the presence of caries evaluated by DMF index is almost the same in patients with gastroesophageal reflux and healthy subjects (median 28.57 vs 26.78) respectively.

Similar result was obtained in a study by Simpălean et al. (24) who proposed that no statistical difference was found between DMFT of GERD and control groups.

Comparing different DMF indexes results, or bacterial count of saliva, could not contribute to find a strong evidence about a link between GERD and dental caries.

Risk of periodontal disease

Periodontal disease as an inflammatory condition affecting the gum and tissues surrounding the teeth is another possible complication in GERD which has been investigated by some researchers and authors. Presence of both gingivitis and periodontitis have been evaluated and analysed in different publications.

In the study conducted by Watanabe et al.(11) presence of gingivitis was evaluated in the GERD and control group. In order to do this investigation two indexes were used . (PMA)Papillary, marginal, and attached gingival index to assess gingival inflammation and (OHI-S)Simplified oral hygiene index to assess oral hygiene condition.(11) In the scores representing PMA index , 0: corresponds to no inflammation, and 1: representing inflammation of papillary, marginal and attached gingiva for all dentition. Regarding oral hygiene index, scores were ranging between 0-3 considering two sub scores for debris and calculus (11) According to their analysis PMA gingival index in patients with gastroesophageal reflux, was higher compared to control groups (both younger and older). Also OHI index which is composed of Debris index and calculus index was notably higher in GERD patients than in both control groups. To defend their

hypothesis they mention to the protective role of saliva in cleaning oral cavity and its antimicrobial effect, and they refer to reduced *salivary flow* as the main reasonable explanation for periodontal disease, which will be discussed later in this manuscript(11) Song et al.(21) proposed that GERD was an independent predisposing factor for chronic periodontitis and there is a link between chronic inflammatory periodontal disease and gastroesophageal acid reflux. They compared two different groups with and without chronic periodontitis(n=280 each group). They reported that the number of cases of GERD in chronic periodontitis group were much higher than GERD in cases with no periodontal disorder(80 cases vs 28 cases) . They indicated reduced salivary flow in GERD patients as the contributory factor for chronic periodontitis (21)

According to their study reduced amount of salivary flow in GERD would provide a proper ambient for bacterial growth which is a causal factor for the formation of plaque on the teeth and gingival tissue which ends to *periodontal disease*. (21)

A specific group of gram negative anaerobic bacteria, including *Actinobacillus actinomycetemcomitans* and *Porphyromonas gingivalis* are often found in association with chronic periodontitis(21) These bacteria have the more chance to live in the absence of saliva and its antimicrobial effect. Saliva is composed of various antimicrobial agents between them Chemokine ligand 28 (CCL28) has the main role in destroying bacteria involved in periodontal disease.

This finding was in agreement with Vinesh et al.(30) who suggested periodontitis as the second most common oral findings in GERD patients(25.5%) after dental erosion(44.6%).

Although most of authors found an evidence about an association between GERD and periodontal disease Muñoz et al. (23) failed to find this link. They evaluated Plaque index, haemorrhage index, and gingival recession, between the GERD and control group. Prevalence of periodontal lesions was the same in control as in the GERD group. However gingival recession was higher in the group with gastroesophageal disease.

Risk of Inflammatory oral mucosa

Inflammation of oral mucosa such as redness, erosion and ulcer in different regions of oral cavity in GERD patients are evaluated in different publications.

In the study conducted by Watanabe et al.(11) 16 cases (15.2%) of GERD group(out of 105 patients) represented inflammation of oral mucosa in areas such as tongue, hard and soft palate as well as buccal mucosa; whereas , no inflammatory region were found in control group. Severity of inflammation observed in GERD were classified into 3 categories as “Normal” without any alteration, “Mild” corresponding to redness, and “Severe” inflammation which corresponds to erosion or ulcer. Severe inflammations in GERD patients are mainly reported in tongue, buccal mucosa and soft palate. Floor of the mouth was the only area which was intact even in GERD patients.(11)

It is suggested that GERD might provoke oral mucosal lesions, by either direct acid contact or vapor of the acid to the oral cavity(17). Ranjitkar et al.(17) proposed that there is a correlation between GERD and erythema of palatal mucosa and uvula. Also histological evaluation of palatal mucosa showed an epithelial atrophy and greater number of fibroblasts. However naked eyes were unable to recognise these

alterations. According to their study acid refluxate accompanied by contributing factor of hyposalivation causes oral mucosa alteration (17).

In another study by Vinesh et al.(30), association between GERD and palatal erythema was observed. however the association was subtle(2.8% of GERD patients). Same result was confirmed by Fede et al.(29)who found a link between GERD and soft/hard palate and uvula mucosal erythema. In this study erythematous lesions were found in 21.5% of GERD patients in comparison with only 5% in control groups.(29)

This finding was in agreement by the study of Baxter et al.(31) which stated that 48.6% of GERD patients present oral alteration, such as erythematous lesions in 35.1% and burning sensation in 40.5% of them.

[Analysis of salivary parameters](#)

Alteration of salivary parameters including salivary flow rate, buffering capacity and PH has been assessed in GERD patients by many authors and researchers. Considering protective function of saliva and its important role in neutralising acids and its buffering system, is of paramount importance to know about its possible changes in GERD patients.

More recent studies suggest a significant association between GERD and reduced salivary flow and buffering capacity (29). Hyposalivation and dry mouth (Xerostomia) which is often linked to oral burning sensation as well as other common symptoms such as impaired swallowing function, trouble in mastication, speech difficulty, pain and discomfort in mouth and throat, dryness of lips and angular cheilitis are reported as complications of GERD in some studies (17).

In the study implemented by Fede et al.(29) xerostomia was reported in GERD patient accounting for 54.5%, almost double of what was found in control group(29.0%)as well as higher prevalence of burning sensation in GERD patients (43.2%) vs 21% in control group (29).

Changes in pH, buffer capacity and salivary flow rate are observed in patients with GERD according to several studies (20), (21)

Yoshikawa et al.(22) continued their study by measurement of flow rate of saliva and swallowing function, by the Saxon test . They also evaluated frequency of swallowing .As per their study salivary flow rate, and frequency of swallowing was remarkably reduced in GERD patients compared with both control groups(22)

According to their study reduced salivary flow or impaired swallowing function is considered as the more important associated factor of oral complications in patient with GERD (22)

This finding was confirmed by Watanabe et al.(11) who by using Saxon test proposed that salivary flow rate in the GERD patients was remarkably lower compared to both younger and older control groups. Also As per their study, oral dryness is a common complication observed in GERD patients. They proposed that according to performed medical interview with GERD patients oral dryness is the most common complaint among them (56.2%).They attributed that complaint to the consequences of reduced salivary flow.(11) Fig.3

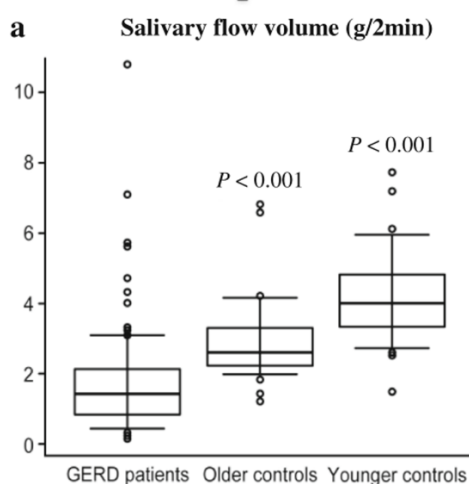


Fig 3. Salivary flow volume, Saxon test(11)

Some other studies not only confirmed hyposalivation in GERD patients but also took further steps to establish an understanding of the etiology behind this alteration. Song et al.(21) has stated the esophago- salivary reflex as a key mechanism, which controls secretion of saliva in response to presence of acid in oesophageal lumen. In which the acid and its low PH stimulates oesophageal mechano-chemoreceptors.

Following that afferent fibres would be activated, and parasympathetic efferent fibres induce secretion of saliva in salivary gland. This mechanism means that in a physiologic situation the more oesophageal refluxate the more saliva will be secreted. However this esophago-salivary reflex mechanism is impaired in GERD patients meaning a reduced salivary secretion and hyposalivation despite higher amount of oesophageal refluxate. This is a proposed hypothesis which needs further research to prove it (21) It has been stated that mixed saliva covers the whole oral cavity and creates a protective barrier against mechanical, thermal, chemical, and infectious damage. It is obvious that by removal of this protecting barrier oral cavity is susceptible to many disorders such as periodontal disease.(21)

Same result was achieved by another study in which the author has reported xerostomia, ulceration, angular cheilitis and gingivitis with the highest correlation with GERD and DE (6)and emphasizes again on saliva protecting role in the oral cavity.

In another study carried out by Filip et al. (28)they stated that salivary flow rate in patient with GERD is lower than normal(Basal flow rate). They also indicated that in the study of GERD patients, low buffering capacity was observed in 54.2% of them , whereas high buffering capacity was detected only in 8.3% . As per their study decreased buffer capacity is much more important than reduced salivary flow in the occurrence of dental erosion and oral disease. (28)

While most of selected studies indicated hyposalivation and reduced buffering capacity as the association factor for oral complications in GERD, Some others conversely proposed that no significant difference was observed in the salivary flow of GERD and control group.

According to Correa et al.(20) No significant changes in salivary flow was observed in the GERD and control groups. Neither in stimulated nor in non-stimulated saliva differences were reported. According to the author, their obtained result was in contrast with many other articles which all agree upon reduced salivary flow in GERD patients. As per their statistical analysis no difference was observed in saliva PH between the two case and control groups. In GERD group salivary PH was between 6.45 and 7.86 with a slight difference with PH values of control groups (6.47- 8.69).However, they realised that buffering capacity of saliva was smaller in GERD than in control group (3.2 ± 0.7 units vs 3.7 ± 0.9) They concluded that higher prevalence of dental erosion observed in GERD patients could be due to reduced salivary buffering system.(20)

Although the last study failed to find any evidence reporting reduced salivary flow, they confirmed on reduced buffer capacity of saliva and the rest of studies agreed on the decrease of salivary flow rate and reduced buffering capacity as the common complication of GERD.

Dental Management in GERD

Early diagnosis of GERD is very important in order to impede irreversible destruction of the tooth. In order to diagnose and differentiate characteristics of erosion compared to other types of tooth wear, expertise and ample knowledge is required (1). Regarding management of oral complications in GERD, first it needs to be correctly diagnosed, following required protocols including patient's medical and dental history, detailed intraoral and extraoral examination is needed. If the dentist is suspicious about GERD and the patient is unaware of it, questions about presence of other typical symptoms of GERD such as heartburn or acid taste in the mouth should be asked by the dentist. In order to confirm diagnosis dentist should refer the patient to gastroenterologist for further medical evaluation.(1)

Patients with GERD, are more susceptible to oral complications and need to follow a specific and appropriate oral hygiene including brushing at least twice a day. As they normally complain about sensitive teeth and gums using soft bristled toothbrush and fluoridated toothpaste for sensitive teeth are recommended. Mouthwash and dental floss also improve their oral hygiene.(24) Taking into account that dental brushing immediately after the acid backflow should be avoided. They can brush approximately after 60 min which is the time required by saliva to neutralise acid .(24) However, It is highly recommended that Immediately after acidic reflux the patient rinses with water, sodium bicarbonate and a fluoride mouthwash. Water is to eliminate acid, sodium

bicarbonate is to neutralise the demineralising acid and fluoride is to remineralise dental structure .(1)(24)

Fluoride therapy is important as this substance inhibits demineralisation of the teeth.(24) The role that fluoride plays is by precipitation of calcium fluoride like material, on the eroded tooth surfaces. Use of fluorine is proposed in many articles to improve the tooth surface integrity.(17) Mouth wash, gels, varnishes which are highly concentrated with fluoride are strongly recommended to lower the risk of enamel and dentin erosion and increase of tooth resistance.(1)

Fluoride varnish is a preventive measurements that should be taken every 3 months in dental office for GERD patients.(1). Successful remineralisation of dental erosion also depends on having a controlled diet of less sugary as well as less acidic foods.(14). It is highly recommended to GERD patients to reduce consuming acidic foods or beverages such as alcohol, lemon juice or coffee. Patients with hyposalivation who ingest acidic products to stimulate saliva production, should be advised to avoid these products(17)(24) and replace them by chewing of antacid-sugar free medications instead, which contributes to increasing PH level.

Also xylitol chewing gum which improves salivary secretion and increases tooth remineralization is recommended (1). In a severe xerostomia a consultation with patient's doctor might be required to prescribe Pilocarpine to improve salivary flow rate.(1)

Restorative treatment is required when :(1)

- the structural integrity of the tooth is altered
- the teeth are hypersensitive
- The teeth are with loss of anatomical structure, vertical dimension or function

- The teeth aesthetically disapproved by the patient
- Risk of pulpal exposure

In early stages of erosion with enamel loss (BEWE 3-8) restoration might be done in order to prevent progression of disorder and /or aesthetic needs. In these cases treatment of choice would be the minimal invasive treatment which is direct composite veneer(1),(12) in medium stages when dentin is exposed (BEWE 9-13) direct or indirect porcelain veneer or crown could be the treatment option.(1),(12) When it comes to sever loss of tooth structure with more than 50% destruction of dental surface (BEWE14-18) or loss of vertical dimension, indirect prosthetic reconstruction such as ceramic crown would be our only treatment of choice.(1),(12)

BEWE(Basic Erosive Wear Examination) grading criteria and risk level grouping in (Annex 3, 4)(32)

Conclusion:

Taking into account the results of our different selected studies and analysing them, we came to the conclusion that:

- Dental erosion is the most prevalent oral complication of GERD.
- Saliva is the most important biological factor, influencing dental erosion by alteration of its quality and quantity.
- There is a strong association between reduced salivary flow and buffering capacity in GERD and oral complications.

- There is a correlation between GERD and other oral manifestations including periodontal disease and oral inflammatory mucosa, however prevalence of them are much less than DE.
- Possible link between GERD and Dental caries has not been proved and authors have different ideas upon. Further study is required in this field.
- Precise evaluation of oral cavity along with ample knowledge, discloses many of oral disorders associated with GERD, and contributes to early diagnosis, in order to prevent further damage to the teeth and oral cavity.

Responsibility of the study

This project provides background knowledge about GERD which is a very common disease with various troublesome symptoms. The project has the social responsibility as by broadening the knowledge about GERD and its oral complications, early diagnosis would be possible and the progress of disease would be halted. Moreover through correct treatment of GERD, possible pain or discomfort would be relieved and quality of life of the patient will be improved.

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Annexes

Annex 1.

Smith and Knight tooth wear index (27)

| score | surface | criterion |
|-------|---------|--|
| 0 | B/L/O/I | -No loss of enamel surface |
| | C | -No change of contour |
| 1 | B/L/O/I | -Loss of enamel surface |
| | C | -Minimal loss of contour |
| 2 | B/L/O | -Loss of enamel surface with dentin exposure less than one-third of the surface |
| | I | -loss of enamel just exposing dentin |
| | C | -Defect less than 1mm deep |
| 3 | B/L/O | -Loss of enamel surface with dentin exposure less than one-third of the surface |
| | I | -Loss of enamel and substantial loss of dentine, with intact pulp or secondary dentine |
| | C | -Defect 1-2 mm deep |
| 4 | B/L/O | -Complete loss of enamel along with pulp exposure or exposure of secondary dentine |
| | I | -Pulp exposure or exposure of secondary dentine |
| | C | -Defect more than 2 mm deep or pulp exposure or exposure of secondary dentine |

*Lower score is assigned when there is a doubt

B= buccal or labial; L= lingual or palatal; O=occlusal ; I=incisal ; C=cervical(27)

Annex 2.

Erosion grading scale of Eccles and Jerkins (14)

| Grade | Description |
|-------|---|
| 0 | No Erosion |
| 1 | Loss of surface detail ; limited to enamel |
| 2 | Exposure of dentin less than 1/3 crown affected |
| 3 | Exposure of dentin 1/3 of the crown or bigger is affected |

Annex 3.

Grading tooth erosion BEWE criteria(32)

| Grade | Description |
|-------|---|
| 0 | No erosion |
| 1 | Initial loss of surface texture |
| 2 | Distinct defect, hard tissue loss less than 50% of surface area |
| 3 | Hard tissue loss, more than 50% of the surface area |

Annex 4.

BEWE risk level grouping (32)

| Risk level | BEWE score |
|-------------|------------|
| No risk | 0-2 |
| Low risk | 3-8 |
| Medium risk | 9-13 |
| High risk | 14-18 |

Annexes 5.

References

1.

Dental approach to erosive tooth wear in gastroesophageal reflux disease

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Abstract

Background: The duration of gastro-esophageal reflux disease (GERD), the frequency of reflux, the pH and type of acid, and the quality and quantity of saliva affect the severity of dental erosion due to GERD.

Objective: To summarize the diagnostic protocol and treatment of dental erosion due to GERD.

Methods: A Medline literature search was performed to identify articles associated with a dental approach to GERD.

Results: The dental professional must carry out a diagnostic protocol, which includes collecting data on the patient's medical and dietary history, occupational/recreational history, dental history, and oral hygiene methods. Intraoral, head and neck, and salivary function examinations should be performed to expose the dental implications of GERD symptoms.

Conclusion: Diagnosing the cause of erosive tooth wear can help prevent further damage. Patients must be informed about how to prevent GERD.

Keywords: Dental erosion, gastro-esophageal reflux disease

African Health Sciences 2014; 14(2):481-486

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Introduction

Dentists are often the first health care professionals to diagnose a systemic disease through observation of its oral manifestations. One such disease is gastro-esophageal reflux disease (GERD), which may be evidenced by dental erosion. GERD is defined as involuntary muscle relaxing of the lower esophageal sphincter, which allows refluxed acid to move upward through the esophagus into the oral cavity.¹ It is a relatively common condition worldwide, with prevalence rates in adults ranging from 21% to 56% in different countries.²

In healthy individuals, most gastric fluid is returned to the stomach by peristalsis stimulated by swallowing. The remaining fluid is cleared by secondary peristalsis stimulated by direct contact of the juice with the esophageal mucosa.³ In contrast, patients with GERD have delayed acid clearance,⁴ and the gastric acid and contents are involuntarily passed through the esophagus and into the oral cavity.⁵

The typical manifestations of GERD are heartburn, regurgitation, dysphagia, and retrosternal pain.⁶ Atypical manifestations, such as asthma, chronic cough, hoarseness, noncardiac chest pain, and dental erosion, are often underappreciated and poorly understood.⁷ Dentists are commonly the first to diagnose GERD through erosion of teeth because most people are not aware of the presence of the disease.

Dental erosion is defined as the loss of tooth substance by chemical processes (acid exposure) not involving bacteria.⁸ Repeated or prolonged exposure of teeth to acid leads to selective dissolution of specific components of the tooth surface, with eventual loss of tooth substance, hypersensitivity, functional impairment, and even tooth fracture. The severity of dental erosion due to GERD is related to the duration of the disease frequency of reflux, the pH and type of acid, and the quality and quantity of saliva.⁹ However, if enamel demineralization is detected sufficiently early before the damage becomes irreversible,^{10,11} the enamel framework can be remineralized using oral regimes and preventative modifications in diet, behavior, or medication.

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Evidence linking gastroesophageal reflux disease and dental erosion is not strong

A critical summary of Pace F, Pallotta S, Tonini M, Vakil N, Bianchi Porro G. Systematic review: gastro-oesophageal reflux disease and dental lesions. *Aliment Pharmacol Ther* 2008;27(12):1179-1186.

Judy Fan-Hsu, DDS

Systematic review conclusion. The review claims a strong association between gastroesophageal reflux disease (GERD) and dental erosion (DE).
Critical summary assessment. Qualitative assessments of multiple weak trials suggest but do not demonstrate a link between GERD and DE.
Evidence quality rating. Limited.

Clinical questions. Do patients with gastroesophageal reflux disease (GERD) have a higher prevalence of dental erosion (DE)? Do patients with DE have a higher prevalence of GERD?

Review methods. The authors searched two databases for studies of humans published in English from January 1966 through September 2007: MEDLINE and the Cochrane Controlled Trials Register. They identified 19 studies in which investigators compared GERD with DE, 17 of which met their inclusion criteria: seven observational studies, six case-control

studies, two cross-sectional studies, one retrospective study and one questionnaire-based study.

Main results. In their systematic review, the authors identified trials that involved patients who had either GERD or DE. The diagnostic criteria, trial designs and reported prevalences of the trials varied considerably. In adult patients, the reported prevalence of DE among patients with GERD ranged from 5 to 48 percent. Conversely, the reported prevalence of GERD among adults with DE ranged from 21 to 83 percent. In children, the reported

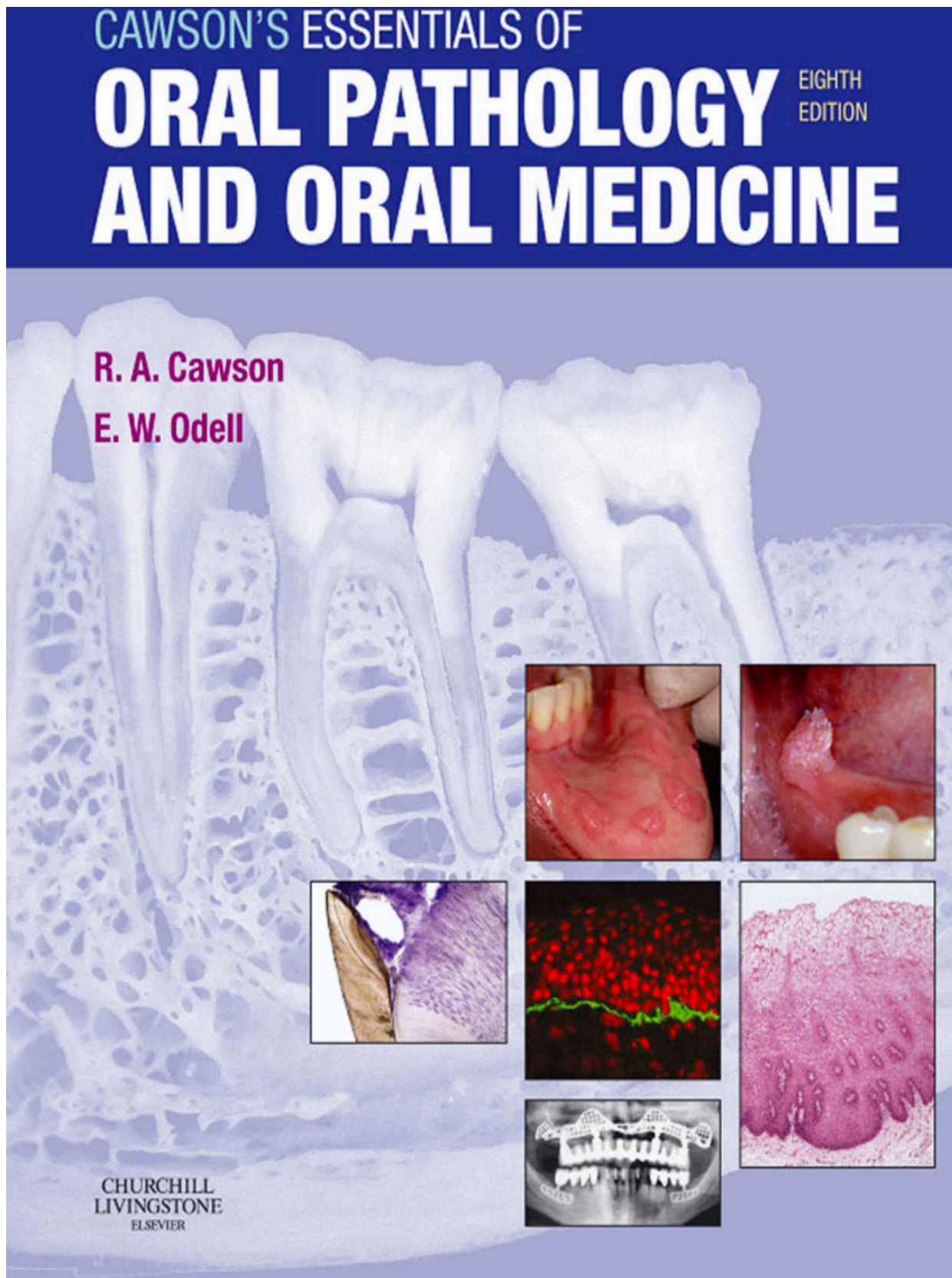
prevalence of DE among patients with GERD ranged from 17 to 87 percent.

Conclusions. The authors of this systematic review suggested a strong association between GERD and DE. They also suggested that the severity of DE correlates with the presence of GERD. These associations were based on multiple diagnostic measures, trial types, patient identification schemes and outcomes. The rationale provided for these multiple assessments was that GERD has a variety of manifestations and presentations and is subject to some uncertainty in terms of classification. To address this uncertainty, the authors looked for GERD in patients with DE. Again, they identified an association.

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3.



Influence of Intrinsic Factors on Erosive Tooth Wear in a Large-Scale Epidemiological Study

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Key Words

Adult · Erosive wear · Intrinsic acid · Risk indicator

Abstract

Objective: To assess the influence of self-reported intrinsic factors [gastroesophageal reflux disease (GERD), long-term alcoholism, long-term heavy use of alcohol and multiple pregnancies] on erosive tooth wear in a middle-aged cohort sample. **Materials and Methods:** Of the total Northern Finland Birth Cohort (NFBC 1966), a convenience sample (n = 3,181) was invited for an oral health examination in 2012–2013, of which 1,962 participated, comprising the final study group. Erosive tooth wear was assessed by sextants using the Basic Erosive Wear Examination Index (BEWE, 0–18). Clinical data were supplemented by questionnaires conducted in 1997/1998 and 2012/2013. The participants were divided into severe (BEWE sum ≥ 9) and no-to-moderate (BEWE sum 0–8) erosive wear groups, and the logistic regression model was applied. **Results:** Selected intrinsic factors were quite rare in this cohort sample and explained only 5.9% of the difference in the prevalence and severity of erosive wear. Daily symptoms of GERD [odds ratio (OR) 3.8, confidence interval

(CI) 1.2–12.0] and hyposalivation (OR 3.8, CI 1.2–11.8) were the strongest risk indicators for severe erosive wear. Additionally, variables associated with an elevated risk for severe erosive wear were diagnosed alcoholism at any point (OR 2.5, CI 0.7–9.7) and self-reported heavy use of alcohol in both questionnaires (OR 2.0, CI 0.6–6.2). Even low-dose long-term consumption of alcohol was associated with erosive wear. **Conclusions:** In this cohort sample, intrinsic factors such as GERD or alcoholism alone are relatively uncommon causes of erosive tooth wear. The role of long-term use of alcohol in the erosion process may be bigger than presumed.

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The chemical properties of intrinsic or extrinsic acids and the frequency of acidic challenges play an important role in the erosive tooth wear process [Lussi and Hellwig, 2014]. The most common general health condition, in which intrinsic acids may enter into the oral cavity, is gastroesophageal reflux disease (GERD); the prevalence in Europe has been reported to range between 12 and 24% [Ronkainen and Agreus, 2013]. The Montreal definition of GERD describes it as a condition that develops when

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CME

The Montreal Definition and Classification of Gastroesophageal Reflux Disease: A Global Evidence-Based Consensus

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- OBJECTIVES:** A globally acceptable definition and classification of gastroesophageal reflux disease (GERD) is desirable for research and clinical practice. The aim of this initiative was to develop a consensus definition and classification that would be useful for patients, physicians, and regulatory agencies.
- METHODS:** A modified Delphi process was employed to reach consensus using repeated iterative voting. A series of statements was developed by a working group of five experts after a systematic review of the literature in three databases (Embase, Cochrane trials register, Medline). Over a period of 2 yr, the statements were developed, modified, and approved through four rounds of voting. The voting group consisted of 44 experts from 18 countries. The final vote was conducted on a 6-point scale and consensus was defined *a priori* as agreement by two-thirds of the participants.
- RESULTS:** The level of agreement strengthened throughout the process with two-thirds of the participants agreeing with 86%, 88%, 94%, and 100% of statements at each vote, respectively. At the final vote, 94% of the final 51 statements were approved by 90% of the Consensus Group, and 90% of statements were accepted with strong agreement or minor reservation. GERD was defined as a condition that develops when the reflux of stomach contents causes troublesome symptoms and/or complications. The disease was subclassified into esophageal and extraesophageal syndromes. Novel aspects of the new definition include a patient-centered approach that is independent of endoscopic findings, subclassification of the disease into discrete syndromes, and the recognition of laryngitis, cough, asthma, and dental erosions as possible GERD syndromes. It also proposes a new definition for suspected and proven Barrett's esophagus.
- CONCLUSIONS:** Evidence-based global consensus definitions are possible despite differences in terminology and language, prevalence, and manifestations of the disease in different countries. A global consensus definition for GERD may simplify disease management, allow collaborative research, and make studies more generalizable, assisting patients, physicians, and regulatory agencies.

(Am J Gastroenterol 2006;101:1900-1920)

INTRODUCTION

A number of guidelines and recommendations for the diagnosis and management of gastroesophageal reflux disease (GERD) have been published in different countries, but a universally accepted definition of GERD and its various symptoms and complications is lacking (1-9). Reflux symptoms are common in primary care and GERD is frequently diagnosed based on symptoms alone, but there is no consensus on the distinction of GERD from dyspepsia, so that these terms may lead to confusion in primary care settings. This

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has led some authorities to combine these entities in primary care management strategies (10). There is also uncertainty about the extraesophageal manifestations of GERD, coupled with an expanding list of putative extraesophageal disorders, resulting in both over- and underdiagnosis of the disease. Finally, the definition of Barrett's esophagus varies in different regions of the world, causing confusion in the assessment of risk and the appropriate use of surveillance.

The aim of this international Consensus Group was to develop a global definition and classification of GERD, using rigorous methodology, that could be used clinically by primary care physicians and that embraces the needs of

BMJ Open Risk factors associated with oral manifestations and oral health impact of gastro-oesophageal reflux disease: a multicentre, cross-sectional study in Pakistan

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ABSTRACT

Objective Gastro-oesophageal reflux disease (GORD) is a relatively common disorder and manifests with extraoesophageal symptoms, such as dental erosions (DE), cough, laryngitis, asthma, and oral soft- and hard-tissue pathologies. This study aimed (1) to identify oral soft and hard-tissue changes in patients with GORD and (2) to evaluate these oral changes as indices for assessing GORD and its severity.

Setting This cross-sectional study was conducted at four major tertiary care government hospitals, in two metropolitan cities of Pakistan.

Participants In total, 187 of 700 patients who underwent oesophago-gastro-duodenoscopy and having GORD were included in the study. Patients with GORD were divided according to the presence of DE into group A (with DE, chronic/severe GORD) and group B (without DE, mild GORD). Patients who were unconscious and had extremely limited mouth opening were excluded.

Primary and secondary outcome measures Abnormal conditions and lesions of the oral mucosa were recorded. The impact of oral hard and soft-tissue changes on the oral health-related quality of life was assessed using the Pakistani (Urdu) version of the validated Oral Health Impact Profile-14 (OHIP-14) instrument.

Results Oral submucous fibrosis (66.3%), ulceration (59.4%) and xerostomia (47.6%) were significantly more common in group A ($p < 0.05$). The prevalence of GORD was 26.7%, within which the prevalence of DE was 35.3%. Unhealthy dietary pattern, nausea/vomiting, oesophagitis, xerostomia, ulceration, gingivitis and angular cheilitis showed a statistically significant association with chronic GORD and DE. All subscales of OHIP-14 were positively correlated ($p < 0.05$) in patients with GORD and DE, with notable impact on psychological discomfort ($rs = 0.30$), physical disability ($rs = 0.29$), psychological disability ($rs = 0.27$) and functional limitation ($rs = 0.20$).

Conclusion Patients with GORD and DE presented with more severe oral manifestations than did those with GORD and no DE. We recommend timely dental check-ups to assess the severity of both systemic and oral disease.

Strengths and limitations of this study

- This study is the first of its kind to bridge the gap created by either lacking evidence or controversial literature on the effect of gastro-oesophageal reflux disorder (GORD) on oral soft-tissues.
- This study assessed oral health-related quality of life using Oral Health Impact Profile-14 instrument, the results of which highlight how oral health and systemic health are interlinked from a psychological and general well-being perspective.
- General practitioners and gastroenterologists are often the primary healthcare providers for patients with GORD, but while addressing their main gastroenterological concerns, the oral manifestations of these systemic conditions are often overlooked. This study highlights the need for dental referral in patients with upper gastrointestinal disorders (in this case GORD), which can have a marked effect on both systemic and oral health.
- Cross-sectional design of this study limits the ability to rule out confounders and establish causal-inference relationships. Hence, the study results are limited to correlation extent only. We recommend future researchers to assess the reported risk factors in a prospective study design, in order to understand the evolution of oral morbidities linked with the pathogenesis of GORD.

INTRODUCTION

Gastro-oesophageal reflux disease (GORD) is a common disorder, affecting approximately 10%–20% of the general population.¹ The Montreal consensus classifies GORD as an entity manifesting as oesophageal and extraoesophageal symptoms.² The oesophageal symptomatology includes regurgitation or burning retrosternal chest pain, reflux oesophagitis, strictures, Barrett's oesophagus and adenocarcinoma, and the extraoesophageal symptomatology comprises reflux,

INVITED REVIEW

Extra-esophageal manifestations of gastroesophageal reflux

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Gastroesophageal reflux disease (GERD) is a common medical condition affecting approximately 35–40% of the adult population in the western world. The role of GERD in causing extra-esophageal symptoms including laryngitis, asthma, cough, chest pain, and dental erosions is increasingly recognized with renewed interest among gastroenterologists and other specialists. Direct injury by mucosal contact, and vagally mediated reflex from distal esophageal acid exposure are the two possible mechanisms by which reflux-related extra-esophageal tissue injuries may occur. Several investigational techniques may be used to diagnose gastroesophageal reflux; however, because of the poor sensitivity of endoscopy and pH monitoring, and the poor specificity of laryngoscopy, empiric therapy with proton-pump inhibitors (PPI) is now considered the initial diagnostic step in patients suspected of having GERD-related symptoms. In those who improve with such therapy, it is likely that GERD may be the cause of the extra-esophageal presentation. In those who are unresponsive to such therapy, other diagnostic testing such as impedance/pH monitoring may be reasonable in order to exclude continued acid or weakly acid reflux. However, PPI-unresponsive patients usually have causes other than GERD for the extra-esophageal symptoms and signs.

Oral Diseases (2007) 13, 349–359

Keywords: extra-esophageal; gastroesophageal; reflux laryngitis

Introduction

Gastroesophageal reflux disease (GERD) is implicated to play the causative role in the development of many extra-esophageal symptoms (Rodriguez-Tellez, 2005; Vaezi, 2005). GERD is a common medical condition affecting approximately 35–40% of the adult population

in the western world (Spechler, 1992; Vaezi, 2005) with 36% having at least once-monthly symptoms (Nebel *et al.*, 1976). The role of GERD in causing extra-esophageal symptoms including laryngitis, asthma, cough, chest pain, and dental erosions is increasingly being recognized (Jonaitis *et al.*, 2006). The association between GERD and laryngeal disorders has been recognized since the late 1960s (Young *et al.*, 1996). Chronic laryngeal signs and symptoms associated with GERD are often referred to as reflux laryngitis or laryngopharyngeal reflux (LPR) (Richardson *et al.*, 2004). It is estimated that nearly 10% of ear, nose, and throat (ENT) patient visits are caused by GERD-related laryngeal complaints (Vaezi, 2005). These patients often complain of sore throat, hoarseness, throat-clearing as well as dysphagia and cough. Classic reflux symptoms (heartburn and regurgitation) which are referred to as 'typical GERD' may be absent in more than half the patients presenting with extra-esophageal symptoms (Koufman, 1991; Koufman, 2002; Vaezi, 2003a).

Studies since the early 1970s (Howden, 1971) have highlighted the injurious role of gastroduodenal contents in oral soft-tissue pathology as well as dental erosions (Table 1). For example, although the prevalence of dental erosions in the general population is estimated to be as high as 5–16% (Jarvinen *et al.*, 1991; Lussi *et al.*, 1991), it can reach 40% in GERD patients (Schroeder *et al.*, 1995). Given the increasing prevalence of typical GERD and its association with oropharyngeal, laryngeal, and pulmonary conditions, there has been renewed interest among gastroenterologists and specialists in other areas such as otolaryngology, pulmonology, allergy, cardiology as well as dentistry in understanding this relationship better. In this article, we review the literature on the association between GERD and extra-esophageal symptoms by highlighting the pathophysiologic mechanisms, the role of diagnostic testing, as well as therapeutic options for this important group of patients.

Pathophysiology

Potential agents involved in GERD-related extra-esophageal injuries usually include a mixture of both gastric

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Oral pH in gastroesophageal reflux disease

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Abstract

Aims and Objectives The aim of this study is to compare surface pH in various parts of the oral cavity between patients with gastroesophageal reflux disease (GERD) and healthy controls.

Methods Using a flat pH meter sensor, fixed electrode pen type digital pH meter, oral pH levels were assessed at different mucosal sites among 34 GERD patients and 32 healthy controls. Salivary flow rates and buffering capacity were also assessed in them. A thorough oral examination was performed to screen for any oral and dental changes.

Result A significantly lower pH of 6.65 ± 0.13 (mean \pm SD) was found in the GERD group compared to control group 7.23 ± 0.12 ($p < 0.05$). Least pH was found in the floor of the mouth 6.594 ± 0.17 and highest in the lower labial mucosa among the GERD patients. Salivary flow rate and buffering capacity were low in these patients. Significant changes were noticed in the hard and soft tissues of the oral cavity among the GERD group.

Conclusion Oral mucosal pH is altered in GERD patients and may contribute to effects on the oral cavity.

Keywords Buffering capacity · GERD · Oral pH · Salivary flow rate

Introduction

Gastroesophageal reflux disease (GERD) is a condition where there is involuntary passage of gastric contents into the esophagus leading to symptoms like heartburn, chest pain, pyrosis, hoarseness, asthma, sore throat, globus sensation and dental erosion (DE) [1]. Repeated presence of gastric contents, which has a pH below 1, in the oral cavity may lead to a persistently acidic environment which can be detrimental to the hard and soft tissues of the oral cavity. Adequate quantity and quality of salivary secretions are essential for the protection of the teeth and oropharyngeal and esophageal mucosa. Salivary flow rates and pH not only exert an important influence on the occurrence and severity of DE and caries but are also potentially destructive to oral soft tissue structures [2, 3]. Dental erosion, which begins with subtle changes in the surface enamel and can progress to severe, irreversible loss of tooth substance, is considered to be a predominant extra oral manifestation of GERD [4]. Though acid regurgitation has been implicated as the etiological factor for DE, stimulated salivary flow rate, buffering capacity of stimulated saliva, duration for clearance from the mouth and whether patients brush the effected tooth surfaces immediately after the regurgitation episodes play an important role. Though the association between GERD and various salivary parameters are extensively studied, there is no data available about its impact on hard and soft tissues of the oral cavity. In the present study, we have evaluated various salivary parameters like stimulated salivary flow rate, pH, and salivary buffering capacity and determined its effects on the oral hard and soft tissues among individuals with GERD.

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RESEARCH

Gastroesophageal Reflux Disease Symptom Screening in a Dental Setting

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Abstract

Purpose: Gastroesophageal Reflux Disease (GERD) is a chronic health condition in which the symptoms often go unnoticed. Oral problems accompanying GERD may include non-specific burning sensation, mucosa ulceration and erosion, erythema of the soft/hard palate mucosa and uvula, loss of taste and either xerostomia or increased salivary flow with potential long-term complications such as difficulty swallowing, trouble breathing, esophagitis and potential development of esophageal adenocarcinoma (EAC). The purpose of this study was to assess the feasibility of using a GERD screening in the dental clinic setting to identify and refer patients.

Methods: This was a descriptive survey design utilizing a convenience sample of patients (n=227) from two dental hygiene clinics. Students and faculty were calibrated to administer a previously validated, GERD diagnostic screening questionnaire.

Results: The prevalence of GERD in the study population was 8.7%; with 10.1% of female reporting symptoms versus 7.0% of male. There were no statistically significant differences in the study population demographics and GERD prevalence.

Conclusion: Screening for GERD symptoms should be a routine procedure for oral health care providers, as is oral cancer screening. GERD screening has the potential to identify those at risk and enable referral to medical care in order to decrease the serious complications associated with GERD.

Keywords: GERD, screening, heartburn, complications, cancer, oral health

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Introduction

The prevalence of GERD in the United States is estimated to be 18.1%-27.8% accounting for over 8.9 million primary care visits annually.^{1,2} GERD is a chronic or longer lasting form of gastroesophageal reflux.³ GERD occurs when the lower esophageal sphincter (LES), a group of muscles at the lower end of the esophagus, relaxes and allows the stomach's contents to flow up into the esophagus or beyond, into the oral cavity (including larynx) or lung.^{3,4} Gastric acid has a pH of 1.2 which can damage the tissue lining of the esophagus with repeated exposures.¹ A diagnosis of GERD is made using a combination of indicators including self-report of heartburn and regurgitation; endoscopy, or monitoring of reflux in an outpatient setting.³

GERD is common in a number of conditions including post-bariatric surgery, obesity, irritable bowel syndrome, developmental disorders, asthma, sleep apnea, obesity and pregnancy.^{5,6} Heartburn and regurgitation are typical symptoms of GERD, although some adults with GERD are asymptomatic.⁴

GERD symptoms may differ from person to person and range from mild to severe and can include a chronic dry cough, wheezing, asthma, recurrent pneumonia, sinusitis, nausea, vomiting, sore throat, chronic hoarseness or laryngitis, difficulty or painful swallowing, pain in the chest or the upper abdomen, dental erosion and oral malodor.^{3,4}

The symptoms are influenced by daily activities including diet, stressors and drugs, which can make the assessment of GERD symptoms at one point in time challenging.⁷ For individuals with disruptive GERD (daily symptoms) sleep may be disturbed and quality of life may be impacted resulting in missed work and/or reduced work productivity.³

Oral symptoms and complications associated with GERD may include non-specific burning sensation, mucosa ulceration and erosion, erythema of the soft/hard palate mucosa and uvula, loss of taste and either xerostomia or increased salivary flow.^{1,8} Untreated or unmanaged GERD is capable of long-term complications such as dysphagia, difficulty breathing and esophagitis.⁴ Esophagitis is an irritation of the

Oral Manifestations of Systemic Disease

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Careful examination of the oral cavity may reveal findings indicative of an underlying systemic condition, and allow for early diagnosis and treatment. Examination should include evaluation for mucosal changes, periodontal inflammation and bleeding, and general condition of the teeth. Oral findings of anemia may include mucosal pallor, atrophic glossitis, and candidiasis. Oral ulceration may be found in patients with lupus erythematosus, pemphigus vulgaris, or Crohn disease. Additional oral manifestations of lupus erythematosus may include honeycomb plaques (silvery white, scarred plaques); raised keratotic plaques (verrucous lupus erythematosus); and nonspecific erythema, purpura, petechiae, and cheilitis. Additional oral findings in patients with Crohn disease may include diffuse mucosal swelling, cobblestone mucosa, and localized mucogingivitis. Diffuse melanin pigmentation may be an early manifestation of Addison disease. Severe periodontal inflammation or bleeding should prompt investigation of conditions such as diabetes mellitus, human immunodeficiency virus infection, thrombocytopenia, and leukemia. In patients with gastroesophageal reflux disease, bulimia, or anorexia, exposure of tooth enamel to acidic gastric contents may cause irreversible dental erosion. Severe erosion may require dental restorative treatment. In patients with pemphigus vulgaris, thrombocytopenia, or Crohn disease, oral changes may be the first sign of disease. (*Am Fam Physician*. 2010;82(11):1381-1388. Copyright © 2010 American Academy of Family Physicians.)

In 2000, the U.S. Surgeon General's report *Oral Health in America* highlighted numerous ways in which oral and general health are linked.¹ Oral examination can reveal signs and symptoms of immunologic diseases, endocrinopathies, hematologic conditions, systemic infections, and nutritional disorders. In addition, several studies have reported associations between periodontal disease and diabetes mellitus, heart disease, stroke, and adverse pregnancy outcomes.²⁻⁴ Identifying these oral findings may allow for early diagnosis and treatment. Family physicians should be familiar with the relationship between systemic and oral health, and be prepared to coordinate care with dental or medical subspecialists as indicated.

This article provides a guide for recognizing the oral manifestations of select systemic diseases. A number of oral manifestations of systemic disease have been covered previously^{5,6}; therefore, a detailed discussion of these findings is not provided here. However, for comprehensiveness, salient features of these findings are included in *Table 1*, with a summary of the conditions and associated

oral manifestations discussed in this article. For each category of oral finding, the conditions are presented in order of the frequency in which oral manifestations are encountered, from the most to least common.

Mucosal Changes

MUCOSAL PALLOR AND ATROPHY

Oral findings in patients with anemia may include mucosal pallor, atrophic glossitis, and candidiasis. Oral mucosal pallor may be difficult to appreciate.⁷ Atrophic glossitis appears as complete or patchy baldness of the tongue caused by atrophy of the lingual papillae (*Figure 1*). Atrophic glossitis is a nonspecific finding that can occur in association with iron deficiency anemia, pernicious anemia/vitamin B complex deficiencies, and various other conditions. Atrophy can be observed most easily on the dorsal tongue, although other sites may be affected. Burning, pain, tenderness, and erythema also may be present. Candidiasis may be a concurrent finding or an alternative cause of erythema, burning, and atrophy. In addition, some patients may present with angular cheilitis (a lip infection

RESEARCH ARTICLE

Open Access



Oral soft tissue disorders are associated with gastroesophageal reflux disease: retrospective study

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Abstract

Background: Dental erosion (DE), one of oral hard tissue diseases, is one of the extraesophageal symptoms defined as the Montreal Definition and Classification of gastroesophageal reflux disease (GERD). However, no study evaluated the relationship between GERD and oral soft tissues. We hypothesized that oral soft tissue disorders (OSTDs) would be related to GERD. The study aimed to investigate the association OSTDs and GERD.

Methods: GERD patients (105 cases), older and younger controls (25 cases each) were retrospectively examined for oral symptoms, salivary flow volume (Saxon test), swallowing function (repetitive saliva swallowing test [RSST]), teeth (decayed, missing, and filled [DMF] indices), and soft tissues (as evaluation of OSTDs, gingivitis; papillary, marginal, and attached [PMA] gingival indexes, simplified oral hygiene indices [OHI-S], and inflammatory oral mucosal regions). Clinical histories, which included body mass index [BMI], the existence of alcohol and tobacco use, and bruxism, were also investigated. A *P* value of <0.05 was defined as statistically significant.

Results: GERD patients, older and younger controls participated and aged 66.4 ± 13.0 , 68.3 ± 8.2 and 28.7 ± 2.6 years old, respectively. The most common oral symptom in the GERD patients was oral dryness. Salivary flow volume and swallowing function in the GERD patients were significantly lower than in either of the controls (all *P* < 0.05). Inflammatory oral mucosal regions were found only in the GERD patients. The DMF indices, as a measure of dental caries, in the GERD patients were higher than in the younger controls (*P* < 0.001), but lower than in the older controls (*P* = 0.033). The PMA gingival indexes, as a measurement for gingival inflammation, and OHI-S, as a measure for oral hygiene, in the GERD patients were significantly higher than in either of the controls (all *P* < 0.05). Though no significant differences in BMI, the existence of alcohol and tobacco use were found, bruxism, as an exacerbation factor of periodontal disease, in the GERD patients was significantly more frequent than in either control group (*P* = 0.041).

Conclusions: OSTDs were associated with GERD, which was similar to the association between DE and GERD.

Keywords: Dental erosion, Gastroesophageal reflux disease, Gingivitis, Inflammatory oral mucosal regions, Oral soft tissue disorders, Salivary flow volume, Swallowing function

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DENTAL EROSION IN GASTRO-ESOPHAGEAL REFLUX DISEASE. A SYSTEMATIC REVIEW

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Abstract

The growing interest reflected in the studies on dental erosion is justified by the severe health problems it entails, i.e. esthetic, phonetic, masticatory disturbances and pulp complications. Most studies investigate the prevalence of dental erosion in adults and children, the severity of lesions and etiopathogenetic factors.

Background and aim. Dental erosions (DE) are one of the extraesophageal complications of gastroesophageal reflux disease (GERD). An increasing amount of papers shed light on this topic. We carried out a systematic review on the association between GERD and DE.

Methods. We studied the association between DE and GERD in adults and children. The search for published studies was performed in PubMed using search terms "dental erosion" and "gastro-esophageal reflux disease". References published since 2007 were included and a systematic review was carried out. Articles not assessing DE in GERD patients were excluded, and also case presentations and articles in languages of limited circulation. The prevalence of DE in patients with GERD, extrinsic and intrinsic etiological factors of DE and the severity of dental erosion lesions were analyzed.

Results. A total of 273 articles were found, 10 studies being retained for analysis. Correlations between DE and GERD, namely the prevalence and severity of dental erosion in GERD patients, were investigated. DE prevalence was between 10.6% - 42%, median 25.5%. Mean values of DE prevalence were 48.81% in GERD patients, compared to 20.48% in non-GERD controls. Comparative values of DE frequency in adults with GERD was 38.96%, compared to 98.1% in children with GERD.

Conclusions. DE is a condition associated with GERD. DE prevalence is higher in GERD patients. Intrinsic pathogenetic factors with direct action on the hard dental tissues are GERD, while extrinsic factors are represented by diet. Among the patients diagnosed with GERD, youth under the age of 18 had a higher frequency compared to adults.

Keywords: dental erosion, gastroesophageal reflux, GERD, prevalence, intrinsic factors

Introduction

Dental erosion is defined as a loss of hard dental tissue by a chemical process without bacterial involvement [1]. In the last years this mechanism has been recognized as a major cause of tooth decay (TD) both in children and adults [2]. Differential diagnosis with other TD mechanisms

is difficult given the intricacy with attrition, abfraction, abrasion, and it is established based on the specific aspect of injury locations [3].

Early injuries may be barely visible to the dentist or patient when located in the enamel, being no major alterations in color or morphology; a detailed patient history, questions about diet, medication, diseases, is important for etiopathogenesis; medium and advanced lesions are recognized by the exposure of dentin as yellowish round islets at a lower level than the thin surrounding

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RESEARCH |

Quantitative analysis of tooth surface loss associated with gastroesophageal reflux disease

A longitudinal clinical study

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The oral cavity is the gateway to the gastrointestinal tract. Although usually viewed independently, they are connected. A Global Consensus Group defined gastroesophageal reflux disease (GERD) as a “condition that develops when the reflux of stomach contents causes troublesome symptoms and/or complications.”¹ The group recognized dental erosion as a possible GERD syndrome.¹ Gastro-

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At the time this study was conducted, Dr. Versluis was a research assistant professor, Department of Restorative Sciences, School of Dentistry, University of Minnesota, Minneapolis. He currently is a professor and director of biomaterials research, Department of Bio-science Research, College of Dentistry, University of Tennessee Health Science Center, Memphis.

Ms. Dunn is a clinical research coordinator, Oral Health Clinical Research Center, School of Dentistry, University of Minnesota, Minneapolis.

Dr. Delong is a professor and chair, Department of Restorative Sciences, School of Dentistry, University of Minnesota, Minneapolis.

ABSTRACT

Background. Acid regurgitation resulting from gastroesophageal reflux disease (GERD) causes dissolution of tooth structure. The authors conducted a longitudinal clinical study to measure tooth surface loss associated with GERD.

Methods. The authors made replicas of dental impressions obtained from 12 participants with GERD and six control participants at baseline and six months. Using an optical scanner, they digitized the tooth surfaces of these replicas. They then analyzed the volume of tooth surface loss and characterized it as noncontact erosion or erosion/attrition.

Results. Mean (standard deviation) volume loss per tooth in participants with GERD (0.18 [0.12] cubic millimeter) was significantly higher than that in control participants (0.06 [0.03] mm³; *t* test; *P* < .013). Nine participants with GERD exhibited tooth surface loss with characteristics of erosion (noncontact erosion in three participants, erosion/attrition in eight participants).

Conclusions. Tooth surface loss in participants with GERD was significantly greater than that in control participants. The pattern of surface loss was characteristic of erosion in noncontact areas and around contact areas.

Clinical Implications. Anterior and posterior teeth of participants with GERD were affected by erosive tooth wear. In addition, the amount of erosive tooth wear on occlusal surfaces was twice as high when there was evidence of attrition.

Key Words. Tooth wear; erosion; gastroesophageal reflux disease; acid reflux; optical scan.

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Dental Erosion in Gastroesophageal Reflux Disease

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Abstract

Dentists are often the first health care professionals to diagnose dental erosion in patients with gastroesophageal reflux disease (GERD). Gastroesophageal reflux (GER) is the passage of gastric contents into the esophagus, and GERD is defined as symptoms or complications of GER. Twenty-four-hour monitoring of esophageal pH is helpful in diagnosing GERD. Treatment of dental erosion resulting from GERD involves a multidisciplinary approach among family physician, dentist, prosthodontist, orthodontist and gastroenterologist. When possible, dental erosion should be treated with minimal intervention, and such treatment should include control of microflora, remineralization, adhesive restorations and use of biomimetic materials.

MeSH Key Words: dental enamel/pathology; gastroesophageal reflux/complications; tooth erosion/etiology

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This article has been peer reviewed.

Dentists are often the first health care professionals to diagnose a systemic disease through observation of its oral manifestations. One such condition is gastroesophageal reflux disease (GERD), which may be evidenced by dental erosion. Dental erosion is defined as the progressive loss of hard dental tissues caused by a chemical process not involving bacterial action.¹ It has been associated with ingestion of acidic foods,² bulimia,³ rumination and GERD.⁴ In addition to causing dental erosion, undiagnosed and untreated GERD may also result in esophagitis, Barrett's epithelium, esophageal adenocarcinoma and aspiration pneumonitis of various degrees. It is therefore important that dentists recognize GERD so that timely preventive and treatment measures can be instituted. This paper discusses the relationship between dental erosion and GERD, the prevalence and causes of these conditions, diagnostic approaches and treatments.

Dental Erosion

Prevalence

In a 5-year longitudinal study,⁵ 71% of children had erosive lesions of at least grade 1 affecting their primary dentition, and 26% had grade 2 erosions (Table 1). By

16 years of age, 12% had at least one permanent tooth with grade 1 erosion, and up to 0.2% of patients had at least one permanent tooth with grade 2 erosion.⁵ Other studies have reported a similar prevalence of erosion in adults (between 5% and 16%).^{6,7} It has been our observation, working in the dental department of a tertiary care facility with a catchment area of 10 million people, that many causes of dental erosion go unnoticed or undiagnosed in adolescence, and the problems are not identified until early adulthood, when the damage is much more severe and much more difficult to treat.

Causes

Erosion begins as superficial demineralization of the enamel, which can cause dissolution of the subsurface layers and eventual loss of tooth structure. Any acid with a pH below the critical pH of dental enamel (5.5) can dissolve the hydroxyapatite crystals in enamel. Gastric refluxate has a pH of less than 2.0 and thus has the potential to cause dental erosion.⁸ In vitro experimental erosion has been shown to occur at an oral pH of less than 3.7.

Causes of dental erosion are classified as extrinsic or intrinsic. Extrinsic causes include carbonated or acidic

RESEARCH REPORTS

Clinical

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ABSTRACT

Dental erosion is caused by dietary or gastric acid. This study aimed to examine the location and severity of tooth erosion with respect to causative factors, and to determine whether the clinical pattern of erosion reflected the dominant etiological factor. The study involved 249 Icelandic individuals and included: a detailed medical history; clinical oral examination; salivary sampling, and analysis for flow rate, pH, and buffering capacity. Reflux was assessed in 91 individuals by gastroscopy, esophageal manometry, and 24-hour esophageal-pH monitoring. Reflux symptoms were reported by 36.5% individuals. Manometry results were abnormal in 8% of study participants, abnormal esophageal pH in 17.7%, and a pathological 24-hour pH recording in 21.3%. 3.6% were positive for *Helicobacter pylori*. Normal salivary flow was found in 92%, but low salivary buffering (10.4%) was associated with erosion into dentin ($P < 0.05$). Significant associations were found between erosion and diagnosed reflux disease (OR 2.772; $P < 0.005$) and daily consumption of acidic drinks (OR 2.232; $P < 0.005$).

KEY WORDS: Dental erosion, location, risk factors, saliva, gastro-esophageal reflux.

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Gastric Reflux is a Significant Causative Factor of Tooth Erosion

INTRODUCTION

Erosion is an increasingly common type of tooth wear, defined as the loss of tooth substance by a chemical process not involving bacteria (Pindborg, 1970). It is caused by acid that may be extrinsic, usually in the form of soft drinks, or intrinsic, in the form of refluxed gastric acid (Järvinen *et al.*, 1988; Meurman *et al.*, 1994). The etiology is complex, with an interplay of extrinsic and intrinsic factors together with other types of tooth wear, such as attrition or abrasion. Epidemiological studies of erosion suggest that either the prevalence of erosion is rising (Nunn *et al.*, 2003), or there is an increasing awareness of the disease, for example, in young adults and adolescents (Lussi *et al.*, 1991; Jaeggi and Lussi, 2006) and young children (Downer, 1995). Mild degrees of dental erosion have been reported as affecting over 20% of teenage and young-adult population groups, with severe erosion extending well into dentin in several teeth being seen in about 5% (Árnadóttir *et al.*, 2003). Erosion is usually linked to a high consumption of soft drinks in European studies, but the problem has received less attention in the American literature (Bartlett *et al.*, 1999).

An initial study (Holbrook, unpublished observations) of 150 consecutive Icelandic individuals was used for the assessment of erosion and the planning of further investigations. Persons with erosion were predominantly male. Some had only incisor erosion, while others showed involvement of molars and incisors. Severity of erosion varied from being limited to enamel through to severe dentinal erosion of several adjacent teeth, typically 4-6 maxillary anterior teeth. Concern about the possible role that gastro-esophageal reflux might play in causing tooth erosion in Iceland had been raised in 2001 by one of the authors (Theodórs, unpublished observations), who found the prevalence of reflux symptoms occurring once a month to be 26%. This supported the possibility that intrinsic acid attack might play a role in causing erosion. *In situ* pH electrodes had previously failed to demonstrate acid reflux into the mouth in persons with a history of reflux disease (Gudmundsson *et al.*, 1995). While erosion was clearly caused by acid attack from either intrinsic and extrinsic sources, or both, there is no evidence in the literature that the clinical manifestations of observed erosion might differ depending on the causative factor. Wide variation in the prevalence of tooth erosion has been reported among persons with reflux, even from the same research group (Järvinen *et al.*, 1988; Meurman *et al.*, 1994). Thus, the purpose of the present study was to investigate a larger group of referred individuals in a standardized manner to determine the interplay of possible causative and reparative factors in tooth erosion. Furthermore, the aim was to record erosion with respect to location and severity, to determine if the clinical picture might give a clue to the dominant etiological factor of the erosion.

Dental Erosion and Its Clinical Management

Bennett T. Amaechi
Editor

 Springer

REVIEW

Oral manifestations of gastroesophageal reflux disease

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Key words

collaborative management, dental erosion, gastroesophageal reflux disease, prevention.

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Conflict of interest: None.

Abstract

Numerous case-control and other studies involving confirmation of gastroesophageal reflux disease (GERD) by esophageal pH-metry and the assessment of dental erosions have shown significant associations between the two conditions in both adults and children. By contrast, when asked to vote on whether GERD may cause dental erosions, only 42% of physicians strongly agreed that such an association existed in adults, and just 12.5% strongly agreed for children, respectively in two global consensus reports. Part of this divergence between the perceptions of physicians and the findings of research publications may reflect a general lack of oral health education during medical training, and cursory oral examinations being made under less-than-ideal conditions. Adequate salivary secretions are essential for the protection of the teeth and the oropharyngeal and esophageal mucosa. The quantity and quality of the saliva require monitoring as many drugs, including several of the proton pump inhibitors (PPIs), can cause hyposalivation. In addition, PPIs do not always result in adequate acid suppression. Therefore, collaboration between physicians and dentists is strongly advocated to prevent or ameliorate possible adverse oral effects from both endogenous and exogenous acids, and to promote adequate saliva production in patients with GERD.

Introduction

There is relatively little information in general medical and gastroenterology literature regarding tooth erosion that may be associated with gastroesophageal reflux disease (GERD). This association is commonly observed by dentists, but is given very cursory mention or omitted entirely when describing extra-esophageal (supra-esophageal) manifestations of GERD.¹⁻⁷

When 44 medical experts and family physicians from 18 countries voted in the World Congress of Gastroenterology presentation in Montreal on the statement that "The prevalence of dental erosions, especially on the lingual and palatal tooth surfaces, is increased in patients with GERD" (Extra-esophageal Syndromes: Established Associations, Statement #48), the result was a high-grade consensus agreement of 96%.⁸ However, only 42% of the consensus votes "agreed strongly" with the above statement, 35% "agreed with minor reservations," and 19% "agreed with major reservations." Just three selected clinical studies were quoted to support the statement.⁹⁻¹¹

Subsequently, when eight pediatric gastroenterologists using a revision of the original Montreal presentation protocol voted on the statement that "GERD may cause dental erosions in pediatric patients" (Extraesophageal Syndromes: Definite Associations, Statement #53), the result was a low-grade consensus agreement of 100%.¹² But, only 12.5% of the votes "agreed strongly," 37.5% "agreed moderately," and 50% "just agreed." One systematic

review article¹³ and four other selected clinical articles¹⁴⁻¹⁷ were quoted to support the above statement. Dental erosion was only one of two extra-esophageal conditions considered to be definitely associated with GERD in pediatric patients, the other being Sandifer's syndrome (torticollis).¹²

In the two previous global consensus reports,^{8,12} the relatively low percentages of physicians' votes agreeing strongly that GERD may cause tooth erosion in both adults and children is possibly a reflection of a lack of oral health training. One random survey involving 611 graduating pediatric residents found that most received either no training or less than 3 h of oral health training, with only 14% spending clinical observation time with a dentist.¹⁸ A national survey of pediatricians also found that only 54% examined the teeth of more than half of their 0-3-year-old patients. Fewer than 25% of these pediatricians had received any oral health education at all during their career.¹⁹ In both surveys, most of the pediatricians stated that they should be trained to undertake basic oral health screenings. Compounding this problem, another questionnaire survey found that only three of 104 pediatricians were aware of tooth erosion caused by acidic pediatric medications.²⁰ A recent review article concluded that, "the primary care physician and the gastroenterologist need to pay more attention to the often neglected oral examination."¹³

Tooth erosion is usually a slow process occurring over many years, and its subtle appearance is often not adequately observed during a cursory examination under less-than-ideal conditions. It is

Annals of Internal Medicine

Dental Erosion and Acid Reflux Disease

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■ **Objective:** To determine the relation between gastroesophageal reflux disease and dental erosion using ambulatory 24-hour esophageal pH testing.

■ **Design:** Cross-sectional observational study.

■ **Setting:** Tertiary referral center.

■ **Patients:** The dental group consisted of 12 patients with idiopathic dental erosion who were identified by dentists and screened for gastroesophageal reflux disease using 24-hour pH testing. The gastroenterology group consisted of 30 patients who had 24-hour pH testing in the esophageal laboratory and who were referred for dental evaluation (10 did not have reflux, 10 had distal reflux, and 10 had proximal reflux).

■ **Measurements:** 24-hour esophageal pH monitoring using a pH probe in the distal and proximal esophagus. Complete dental examination with particular attention to the presence and severity of dental erosion; plaque; gingival damage; and decayed, missing, and filled teeth. Analysis of saliva for pH, flow rates, buffering capacity, and calcium and phosphorus levels. Standardized questionnaire to ascertain possible causes of dental erosion and presence of reflux symptoms.

■ **Results:** Ten of the 12 patients in the dental group (83% [95% CI, 52% to 98%]) had gastroesophageal reflux on esophageal pH monitoring. Nine had distal and 7 had proximal reflux. Seven had reflux in the upright position only, 1 had reflux in the supine position only, and 2 had both upright and supine reflux. No saliva abnormalities were found. Ten patients had typical symptoms of gastroesophageal reflux, but dietary or mechanical problems that may have been causing dental erosion were not identified. In the gastroenterology group, upright reflux was seen in 5 of the 10 patients with distal reflux and in all 10 patients with proximal reflux. In addition, 40% of patients in the gastroenterology group (12 of 30) had dental erosion (4 of the 10 with distal reflux [40%], 7 of the 10 with proximal reflux [70%], and only 1 of the 10 without reflux [10%]; $P = 0.02$ for those with reflux compared with those without reflux). The cumulative dental erosion score correlated with proximal upright reflux when all 24 study patients with erosion were analyzed ($r = 0.55$ [$P < 0.01$]); this correlation was even stronger in the subgroup of 12 patients with abnormal amounts of proximal upright reflux ($r = 0.84$ [$P = 0.001$]).

■ **Conclusion:** Dental erosion is a common finding in patients with gastroesophageal reflux disease and should be considered an atypical manifestation of this disease.

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Dental erosion is defined as the loss of tooth substance by a chemical process that does not involve bacteria (1, 2). It is an irreversible lesion leading to altered appearance and function and eventually to tooth loss. Dental erosion is characterized as a hard, "dished-out" area with a smooth, glistening base (Figure 1, top, and Figure 2); it can involve any tooth surface but is most often seen on the facial, occlusal, and lingual surfaces. It differs clinically and microscopically from dental caries, which is initiated by bacterial degradation of dietary sugars within dental plaque. In carious teeth, the occlusal and interproximal surfaces are most commonly involved; the affected surfaces have a soft, discolored appearance and are densely populated with microorganisms (Figure 1, bottom).

Both extrinsic and intrinsic factors contribute to dental erosion. Extrinsic factors include acidic foodstuffs, beverages, and snacks and exposure to acidic contaminants in the workplace (3-7). The pattern of damage depends on the exposure. For example, frequent ingestion of citrus fruits such as lemons has been associated with erosion of the facial surface of the anterior teeth. Exposure to aerosolized industrial acids in the workplace (as in lead battery factories) may result in the erosion of surfaces exposed to the atmosphere (8, 9). There have also been anecdotal reports of swimmers developing dental erosion from improperly maintained water in gas-chlorinated swimming pools (10).

Intrinsic factors that have been recognized to contribute to dental erosion include impaired salivary production (11, 12), altered buffering capacity (13), and frequent vomiting of gastric contents (14-19). Bulimia nervosa is a common problem that affects between 4% and 10% of adolescent and college-aged women (20, 21). Jones and Cleaton-Jones (22) found dental erosion in 69% of bulimic patients and postulated that it was caused by the exposure of enamel and dentin to acidic gastric contents. Erosions were seen on the lingual surfaces of maxillary teeth in 50% of their patients and on the facial surfaces of the central incisors and canines in 70% of their patients. A similar pattern of tooth loss has been reported in healthy patients with radiographic evidence of hiatal hernia (23-25). This has been anecdotally attributed to gastroesophageal reflux disease; however, physiologic studies evaluating the relation between gastroesophageal reflux and dental erosion are lacking. Because of the frequency with which gastroesophageal reflux occurs in the general population (7% have it daily and 36% have it at least once monthly [26]) and the potentially detrimen-



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Gastroesophageal reflux disease: New oral findings

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Objective. The objective of this study was to investigate the effects of gastroesophageal reflux disease (GERD) on dentition, salivary function, and oral mucosa.

Study design. Thirty-one patients with esophagitis underwent medical evaluation, which included taking their medical history, performing both an esophagogastroduodenoscopy and esophagus biopsy, and conducting a stomatologic examination. The latter consisted of an extraoral and intraoral physical examination, saliva tests (flow, buffer capacity, and pH), and biopsy and morphometry of the palatal mucosa, as well as taking a history of the patients' habits. Fourteen healthy volunteers from the same population were used as a control group.

Results. No relationship between GERD and changes in the oral cavity was shown by saliva tests, oral clinical examination, or histopathologic examination of the palatal mucosa. However, morphometric analysis of the palatal epithelium showed a statistically significant difference between the patients with GERD and the control group.

Conclusions. GERD is associated with microscopic alterations in the palatal mucosa (epithelial atrophy and increased fibroblast number), which are only detected by morphometry.

(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91:301-10)

Gastroesophageal reflux has been defined as the movement of gastric content into the esophagus.¹ This content, composed of acid, pepsin, bile salts, and trypsin, could cause damage to tissues not adapted to its harmful potential.¹⁻³ According to Deschner and Benjamin,⁴ the reflux can be classified as physiologic

(occurring in every individual at some point in their lives), symptomatic (when there is sensitivity but no evidence of disease), or as gastroesophageal reflux disease (GERD). Pope⁵ defined GERD as several clinical manifestations of the reflux of gastric and duodenal contents into the esophagus. The typical symptoms of GERD are pyrosis and regurgitation associated with an acid or bitter taste in the mouth. Among the atypical symptoms are chest pain, hoarseness, asthma, recurrent pneumonia, chronic cough, otitis media, reflux laryngitis, chronic hiccup, sore throat, globus sensation, and dental erosion.^{4,6} The association between dental erosion and GERD has been observed and studied in case reports⁷⁻¹⁰ and scientific investigations.¹¹⁻¹⁶ However, doubts remain about the possibility of a direct influence of the gastric acids in the mouth, as well as about their relationship with salivary flow and its buffer capacity.

Dental erosion was defined by Pindborg¹⁷ as "the superficial loss of the hard tissues of the teeth by a chemical process that does not involve the action of bacteria." The relationship between dental erosion and gastrointestinal changes, such as vomiting, regurgita-

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This study was part of the requirements to fulfill the PhD program at Bauru Dental School, University of São Paulo.

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SALIVARY PARAMETERS AND TEETH EROSIONS IN PATIENTS WITH GASTROESOPHAGEAL REFLUX DISEASE

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ABSTRACT – Context - In the gastroesophageal reflux disease (GERD), a highly prevalent digestive disorder, gastric content may return to the esophagus and reach the mouth, thus leading to a small number of carious lesions and high incidence of dental erosion. Since saliva plays a major role in oral homeostasis, evaluating salivary parameters is necessary in attempting to explain such outcome. **Objectives** - This study aimed at analyzing salivary parameters (salivary flow, pH and buffering capacity), bacterial count, caries index and dental erosion in patients with GERD. **Materials** - Sixty patients were studied, and of these, 30 had GERD (group 1), and 30 were controls (group 2). Gastroesophageal reflux disease diagnosis confirmation was achieved by means of endoscopy, manometry and pH metric esophageal monitoring. The above mentioned salivary parameters were evaluated in patients from groups 1 and 2. **Results** - The number of erosions in patients with GERD (group 1) was larger than in controls ($P < 0.001$). The number of carious teeth was smaller in group 1 than in group 2 ($P < 0.001$). Salivary flow (non-stimulated and stimulated) and pH did not show differences between the 2 groups ($P = 0.49$; $P = 0.80$ and $P = 0.85$, respectively). Salivary buffering capacity in patients with GERD showed lower values in controls ($P = 0.018$). The number of bacteria (Lactobacilli and Streptococci) was smaller in patients with gastroesophageal reflux disease than in controls ($P = 0.0067$ and $P = 0.0017$, respectively). **Conclusion** - It was concluded that the large number of erosions must be a result of GERD patients reduced salivary buffering capacity. The reduced number of caries of patients in group 1 can be explained by the low prevalence of bacteria (Lactobacilli and Streptococci), observed in the saliva of patients with chronic reflux.

HEADINGS – Saliva. Tooth erosion. Dental caries. Gastroesophageal reflux.

INTRODUCTION

The gastroesophageal reflux disease (GERD) is a condition that develops when gastric content passes to the esophagus and causes the onset of annoying symptoms and/or complications⁽¹⁷⁾. It is a disease of great medical and social importance due to its increasing incidence and long-lasting symptoms, which hinder patients quality of life^(5, 20).

The oral lesions resulting from GERD are not usually noticed by patients, physicians or dentists until they cause significant damage. They may range from pruritus and burning on the oral mucosa, tooth sensitivity, aphthae, sour taste, decrease in the vertical dimension of occlusion to irreversible damage such as dental erosion, which can be increased by friction or abrasion⁽¹⁹⁾.

Studies on the oral health of patients with chronic reflux have shown a prevalence of dental erosion and a small number of caries in individuals with GERD as compared to control groups^(3, 4, 10).

Silva et al.⁽²³⁾ studied patients with GERD and reported that saliva is an important dental erosion modifier. However, they did not relate the reflux disease to the presence of carious lesions, but only to microscopic alterations on the palatal mucosa.

Saliva is one of the major elements responsible for homeostasis in the oral cavity and in the digestive tract. Alterations in both pH and salivary volume were found in patients with GERD⁽⁹⁾. In addition to playing a vital role in maintaining healthy mouth tissues, saliva has several other functions in the oral cavity; therefore, its reduction may cause difficulties in speaking and eating, dysphagia, dysgeusia, oral hygiene deficiency, traumas,

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The Relationship between Gastroesophageal Reflux Disease and Chronic Periodontitis

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Background/Aims: The most common cause of chronic periodontitis is poor oral hygiene. Gastroesophageal reflux disease (GERD) enhances the proximal migration of gastric contents and may cause poor oral hygiene. We hypothesized that GERD may increase the risk of chronic periodontitis and investigated this potential relationship. **Methods:** A retrospective cross-sectional study was conducted in outpatients between January 1, 2010, and April 30, 2012. GERD was defined as being present based on at least two of the following criteria: etiologic agent(s), identifiable signs and symptoms, and consistent anatomic alterations. A total of 280 patients with chronic periodontitis and 280 controls were analyzed. Information regarding patient demographics and other potential confounding factors for chronic periodontitis were collected through individual medical records. **Results:** GERD was revealed to be independently associated with an increased incidence of chronic periodontitis (odds ratio [OR], 2.883; 95% confidence interval [CI], 1.775 to 4.682). The other three variables of dental caries (OR, 1.531; 95% CI, 1.042 to 2.249), tobacco use (OR, 2.335; 95% CI, 1.461 to 3.730), and history of medication (calcium channel blocker, cyclosporine, or phenytoin) (OR, 2.114; 95% CI, 1.160 to 3.854) were also determined to be independent risk factors. **Conclusions:** The present study supported our hypothesis that GERD can be a risk factor for chronic periodontitis. (*Gut Liver* 2014;8:35-40)

Key Words: Gastroesophageal reflux; Chronic periodontitis; Oral hygiene

INTRODUCTION

Chronic inflammatory disorders of the structures surrounding

the teeth lead to chronic periodontitis, which is characterized by the irreversible loss of supporting connective tissue, alveolar bone, and periodontal ligament.¹ Chronic periodontitis is common and severe in the American adult population, with at least 35% of dentate adults having periodontitis and 10% to 15% having the severe forms of periodontitis.² The presence and progression of untreated chronic periodontitis jeopardizes the intact dentition, leading to tooth loss and compromised patient-based outcomes such as esthetics, impaired oral functioning, and other domains of oral-health-related quality of life.^{3,4} Patients with chronic periodontitis require management such as supportive periodontal care and surgery, including replacement of their dentition. These patients may perceive such treatments to be costly maintenance requirements over their lifetime. Consequently, the active prevention of chronic periodontitis is important, and the investigation of the potential risk factors of chronic periodontitis is imperative.

Based on the Montreal Definition and Classification agreement, gastroesophageal reflux disease (GERD) is defined as a condition that develops when the reflux of stomach contents causes troublesome symptoms and/or complications.⁵ The prevalence of GERD in Western countries is higher than in Eastern countries, and is estimated to be about 10% to 20%.⁶ Extraesophageal manifestations resulting from GERD include laryngeal (reflux laryngitis, hoarseness, chronic cough, vocal cord ulcers, and granulomas), pharyngeal (mucositis), respiratory (asthma, bronchitis, chronic cough, and aspiration pneumonia), sinus (sinusitis), middle ear (otitis media), and oral conditions (tooth erosion, sour taste, and mucositis).⁷⁻⁹

We speculated that GERD may be one of the causes of chronic periodontitis since it can induce poor oral conditions, which can easily result in chronic periodontitis through poor salivary function or microbial colonization in GERD patients.¹⁰⁻¹³ Despite

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Oral symptoms including dental erosion in gastroesophageal reflux disease are associated with decreased salivary flow volume and swallowing function

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Abstract

Background This preliminary clinical study aimed to evaluate the effects of salivary flow volume and swallowing function on oral symptoms including dental erosion in gastroesophageal reflux disease (GERD).

Methods The subjects were 40 GERD patients and 30 (15 younger, 15 older) healthy controls. Detailed medical, dietary, and dental histories were obtained to identify individual behavioral habits potentially associated with dental erosion. Oral examination evaluated dental erosion and determined scores for the decayed, missing, filled (DMF) index, the papillary, marginal, attached (PMA) index for gingivitis, and the Simplified Oral Hygiene Index (OHI-S). Salivary flow volume and swallowing function were evaluated by the Saxon test and repetitive saliva swallowing test, respectively.

Results The DMF index and OHI-S scores differed significantly between all 3 groups. The PMA index was significantly different between the GERD group and the two control groups. The prevalence of dental erosion was 24.3% in the GERD group (0% in the control groups). No specific relationship was found between the incidence of

dental erosion and dietary history or behavioral habits. The Saxon test results were significantly lower in the GERD group than in both the control groups. Frequency of swallowing was significantly lower and time to first swallow was significantly longer in the GERD group than in the two control groups.

Conclusions Oral symptoms in GERD are likely to be associated with impaired salivary flow volume or swallowing function. Treatment for the oral dryness induced by reduced salivary flow volume and rehabilitation for swallowing function could be indicated in patients with GERD.

Keywords Dental erosion · Gastroesophageal reflux disease · Salivary flow volume · Swallowing function · Age

Introduction

The global consensus definition and classification of gastroesophageal reflux disease (GERD) that was proposed by Vakil et al. [1] in 2006 brought about a conceptual change in the classification of GERD-related disease manifestations, presenting it as a set of syndromes. The manifestations of GERD were divided into esophageal and extraesophageal syndromes, with extraesophageal syndromes subclassified into established and proposed associations. One of the oral symptoms that can be caused by GERD is dental erosion, with reflux dental erosion syndrome being classed as an established association by Vakil et al. [1].

Dental erosion is defined as irreversible loss of dental hard tissue by a chemical process that does not involve bacteria [2, 3]. Dissolution of the mineralized tooth structure occurs upon contact with acids that are introduced into the oral cavity from intrinsic or extrinsic sources. Dental

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Alimentary Tract

Dental and periodontal lesions in patients with gastro-oesophageal reflux disease

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Abstract

Objective. Dental erosion has been considered an extraesophageal manifestation of gastro-oesophageal reflux disease, but few reports have studied the relationship between this disease and other periodontal or dental lesions. The aim of this study was to investigate the prevalence of dental and periodontal lesions in patients with gastro-oesophageal reflux disease.

Patients and methods. A total of 253 subjects were prospectively studied between April 1998 and May 2000. Two study groups were established: 181 patients with gastro-oesophageal reflux disease and 72 healthy volunteers. Clinical assessment, including body mass index and consumption of tobacco and alcohol, was performed in all subjects, as well as a dental and periodontal examination performed by a dentist physician, blind as to the diagnosis of subjects. Parameters evaluated were: (a) presence and number of dental erosion, location and severity, according to the Eccles and Jenkins index [Prosthet Dent 1979;42:649–53], modified by Hattab [Int J Prosthesis 2000;13:101–7]; (b) assessment of dental condition by means of the CAO index; and (c) periodontal status analysed by the plaque index, the haemorrhage index, and gingival recessions.

Results. Clinical parameters were similar in both groups ($p > 0.05$). Age was statistically associated with the CAO index, presence of dental erosion, and gingival recession ($p < 0.001$, Student's *t*-test). Compared with the control group, the percentage of dental erosion was significantly higher in the gastro-oesophageal reflux disease group (12.5 vs. 47.5%, $p < 0.001$, χ^2 -test), as was the number and severity of dental erosions ($p < 0.001$, Student's *t*-test). Location of dental erosion was significantly different between groups. Age was not statistically related to either the amount or severity of dental erosion. CAO and periodontal indices were similarly distributed between groups.

Conclusions. Dental erosion may even be considered as an extraesophageal manifestation of gastro-oesophageal reflux disease. The fact that the prevalence of caries and periodontal lesions is similar in patients with gastro-oesophageal reflux disease and in healthy volunteers suggests a lack of relationship with gastro-oesophageal reflux disease.

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Keywords: Dental erosions; Gastro-oesophageal reflux disease

1. Introduction

Gastro-oesophageal reflux disease (GORD) refers to the varied clinical manifestations of reflux of stomach and duodenal contents into the oesophagus, although the clear demarcation between abnormal and 'physiological' reflux is not well defined [1]. GORD is a disease with a high prevalence (more than 40% of American adults have reflux

symptoms on a monthly basis) [2]. Over the last three decades, many reports have implicated refluxed gastric acid as a cause or contributory factor in the development of a variety of acute/chronic extraesophageal disorders ('atypical' symptoms related to GORD) [3–6]. Extraesophageal reflux symptoms occur in up to one third of patients with classic symptoms of GORD (heartburn and/or acid regurgitation) and in a similar percentage of patients without classic symptoms [7]. GORD has been associated with a great variety of disorders, such as pulmonary diseases (asthma, bronchitis, fibrosis), ear, nose,

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RESEARCH ARTICLE

The frequency of dental caries in adult patients with gastroesophageal reflux disease

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Introduction. The aim of the study was to evaluate the frequency of dental caries in adults patients with gastroesophageal reflux disease. **Material and method.** A cross-sectional study was performed between November 2013 and October 2014. All subjects who agreed to participate to the study were asked to complete a questionnaire regarding personal information, oral hygiene and dental evaluation. The individuals with complete false teeth (superior and inferior removable prosthetic devices) were excluded from the study. The study included 134 people divided in two groups, based on upper gastrointestinal endoscopy: a group with gastroesophageal reflux disease (71), and a control group (63). Dental evaluation was performed by a dentist blind to the diagnosis of the subjects. Dental caries were evaluated by applying the decayed, missing, and filled teeth index (DMFT index). The statistical significance was defined as $p < 0.05$. **Results.** From 71 subjects included in GERD group, 33 (46.48%) were males and 38 females (53.52%) with a mean age of 44.99 ± 11.19 (42, 59.15% from urban area and 29, 40.85%, from rural area). In the control group we included 28 (44.44%) males and 35 (55.56%) females (mean age 43.84 ± 9.48) and 29 (46.03%) subjects were from urban area and 34 (53.97%) from rural area. DMFT index in GERD group was 19.49 ± 4.28 and in control group 18.16 ± 4.54 ($p < 0.05$). **Conclusions.** The present study showed that there is no difference between GERD and control group, regarding the frequency of dental caries.

Key words: oral manifestations, dental caries, gastroesophageal reflux

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Introduction

Gastroesophageal reflux is a physiological process, which consists in an effortless retrograde movement of the gastric contents to the esophagus (1). The gastroesophageal reflux disease (GERD) is a common chronic disease (2,3), with a high prevalence (4) and an increasing incidence (5). GERD occurs when the amount of gastric reflux into the esophagus is above the normal range, causing various symptoms, which can involve esophageal mucosal injury (esophagitis) (5,6). Regurgitation, pyrosis (heartburn), which can be reported in the presence or absence of regurgitation, retrosternal pain, dysphagia, sour taste and odynophagia, are considered typical manifestation of GERD (7, 8). Oral manifestations that may occur in patients with gastroesophageal reflux disease include periodic hypersalivation, xerostomia (dry mouth syndrome), burning sensation, halitosis, and dental erosions. A certain pattern of erosion was observed in patients affected by this disease: they appeared more frequently on the occlusal surfaces of posterior mandibular teeth and lingual surfaces of the anterior maxillary teeth (10).

Dental caries are represented by tooth hard tissue demineralization and destruction, caused by bacteria and acid. During a day, the enamel demineralizes and remineralizes many times. When this balance is disrupted and demineralization exceeds remineralization, the caries progress. In our country, dental caries occur frequently from an early

age. The pathogenesis implies both internal and external factors.

Dental caries can have serious and long term complications, which is why they have to be treated properly, but most important they should be prevented.

The aim of the study was to evaluate the frequency of dental caries, in adult patients with gastroesophageal reflux disease.

Material and method

A cross-sectional study was performed, conducted between November 2013 and October 2014. During the study period all individuals with ages between 20 and 80 years old, who were hospitalized to the Gastroenterology clinic of the Emergency County Clinical Hospital, were evaluated. All subjects who agreed to participate in the study were asked to fill in a questionnaire regarding personal information, oral hygiene and dental evaluation.

Besides personal information, the questionnaire contained 7 questions, 5 questions concerning oral hygiene (fig. 1) and 2 questions referring to dental evaluation (Fig. 2). Regarding oral hygiene, we obtained information on the frequency of teeth brushing, the oral care products used and how often the respondent visits a dentist.

Concerning dental evaluation, we were interested if the respondent complained regarding the dental status and dental treatments.

After filling in the questionnaire, there were excluded from the study the individuals with complete false teeth (superior and inferior removable prosthetic devices). We

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Effects of Gastroesophageal Reflux on the Oral Cavity

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The effects of chronic exposure of the oral cavity to gastric acid can be many and varied. Soft tissue symptoms (nonspecific burning and sensitivity) have been mentioned in the literature, but pathognomonic soft tissue lesions have not been documented. Dental erosion can be considered to be the predominant oral manifestation of gastroesophageal reflux disease. Erosion begins with subtle changes in the surface enamel and can progress to severe loss of tooth substance. Because the causes of such tooth lesions may be multifactorial, combining the effects of erosion, attrition, and abrasion and because of the subtle changes present in the beginning stages of such lesions, diagnosis may be difficult. Although the basic mechanism of erosion in gastroesophageal reflux patients is the dissolution of enamel and dentin due to acid exposure, a multitude of other factors can modify the effects of gastric acid. Salivary parameters, in particular, may play an important role in affecting oral pH after reflux episodes. Once dental erosion is diagnosed, thorough evaluation is necessary to document the extent of damage and to detect a cause, which may have both intrinsic and extrinsic components. Treatment goals include eliminating the causes of acid exposure, preventing the effects of acid exposure when it is not controllable, treating symptoms of soft tissue irritation and dental erosion, and restoring the dentition to an esthetically and functionally acceptable level. *Am J Med.* 1997;103(5A):107S-113S. © 1997 by Excerpta Medica, Inc.

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One of the first reports of the effects of gastric acid reflux on oral tissues was that of Howden,¹ which documented dental erosion in a patient suffering from hiatus hernia. Other gastrointestinal disorders have been linked to damage of oral hard tissues, including chronic vomiting during pregnancy, voluntary reflux phenomenon (rumination),² sub-clinical regurgitation due to chronic gastritis associated with alcoholism,³ and dieting disorders, such as anorexia nervosa and bulimia.⁴ Effects of gastric acid on the oral mucosa and on the periodontium (soft and hard tissues supporting and investing the teeth) might also be expected, but these have not been extensively documented. The objective of this article is to describe briefly the oral manifestations of gastroesophageal reflux disease. Additionally, methods for preventing tooth demineralization caused by acid exposure and restoring damaged dentition are discussed.

ORAL SOFT TISSUE LESIONS

The effects of gastric acid reflux on oral tissues can be profound, ranging from minor soft tissue irritations to severe tooth destruction resulting in masticatory dysfunction and requiring extensive restorative treatment (Table I). Although reflux of gastric acid and pepsins into the lower esophagus can cause mucosal damage leading to erosive esophagitis and development of strictures,⁵ extension of tissue injury to oral mucosa has not been shown but might be expected. No correlation between oral mucosal lesions or symptoms and gastroesophageal reflux disease has been documented, and only a few studies even mention such lesions. Reflux patients have complained of burning mouth sensation, tongue sensitivity, nonspecific itching and burning sensations of the mouth and pharynx, and/or painful oral ulcers, but pathognomonic oral mucosal lesions have not been noted, and subjective symptoms have not correlated with either the presence or severity of gastroesophageal reflux disease.^{6,7} The most prevalent adult dental disease, periodontal disease, has not been studied in reflux patients, but one study of patients suffering from anorexia nervosa and bulimia noted a higher incidence of gingivitis (despite lower plaque levels) but no difference in periodontitis.⁸

DENTAL EROSION

In contrast to oral soft tissue lesions, the hard tissue lesion termed dental erosion has been associated

Original Article**Dental Erosion in Patients with Gastroesophageal Reflux Disease (GERD) in a Sample of Patients Referred to the Motahari Clinic, Shiraz, Iran**Alavi G.^a, Alavi AA.^b, Saberfiroozi M.^c, Sarbazi AH.^d, Motamedi M.^e, Hamedani Sh.^f^a Post Graduate Student, Department of Oral and Maxillofacial Pathology, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, IRAN^b Biomaterial Research Center, Dept. of Operative Dentistry, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran^c Gastroenterology Research Center, Nemazee Hospital, School of Medicine, Shiraz University of Medical Sciences, Shiraz, IRAN^d Dept. of Prosthodontics, School of Dentistry, Aja University of Medical Sciences, Tehran, IRAN^e Dept. of Operative Dentistry, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, IRAN^f Dental Research Development Center (DRDC), School of Dentistry, Shiraz University of Medical Sciences, Shiraz, IRAN**KEY WORDS**Dental erosion;
Gastroesophageal reflux disease;
Risk factorReceived June 2013;
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Accepted Oct. 2013.**ABSTRACT****Statement of Problem:** Systematic reviews of the literature show that the dental erosion is associated with the gastroesophageal reflux disease (GERD). The prevalence of the problem may not be exclusively similar in different countries.**Purpose:** The purpose of this study was to investigate the association of gastroesophageal reflux disease (GERD) with dental erosion in a sample of Iranian population regarding the standing difference in the Iranian oral hygiene and diet.**Materials and Method:** 140 patients with the average age of 30 to 50 years old comprised the study group. The participants were already eligible for the endoscopic examination, diagnosed by their gastroenterologist. All patients completed a detailed questionnaire regarding the medical and dental situations. After completing the questionnaire and before endoscopy, dental examination was performed by two blinded dentists. The endoscopy was then performed by a gastroenterologist and the patients were divided into three groups of healthy, suspected to GERD, and positive GERD. Data were collected and analyzed by Chi-Square test. The cross tabulation test was performed to compare the qualitative variants and discover the correlations. The statistical significance was adopted as: $p < 0.05$.**Results:** The prevalence of dental erosion in GERD patients (22.6%) was found to be higher than the suspected (5.3%) and the healthy (7%) individuals.**Conclusion:** This study declared the GERD patients are at higher risk of developing dental erosion compared to the healthy individuals in a sample of Iranian population.**Corresponding Author:** Alavi AA., Biomaterial Research Center, Dept. of Operative Dentistry, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran Address: School of Dentistry, Ghasrodash Ave, Shiraz-Iran, P.O Box: 71345-1836 Tel and Fax: +98-711-6280458 Email: alavia@sums.ac.ir

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Introduction

Gastroesophageal reflux disease (GERD) depicts a condition that involves all the individuals who are prone to the physical complications of gastroesophageal reflux or otherwise, their health and life quality is significantly impaired by problems associated with the symptoms of this disease [1].

Retrograde movement of the acid from the stom-

ach into the esophagus is normally controlled by lower esophageal sphincter through an anti-reflux mechanism. The failure of this coordination may lead to the chronic condition recognized as gastroesophageal reflux disease (GERD) [1-2]. GERD manifestations in the oral cavity are reported as dental erosions, mal-odour, burning sensation, mucosal ulceration, loss of taste, xerostomia and sometimes increased salivary flow [3].

An Index for Measuring the Wear of Teeth

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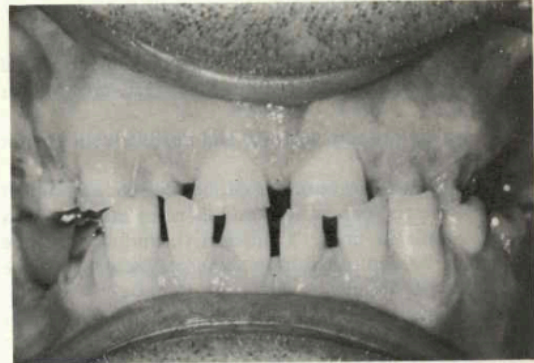
A new tooth wear index is proposed. It is designed for use in research into the aetiology, prevention and management of tooth wear problems, in epidemiological studies, and in the long-term monitoring of tooth wear in individual patients. The degree of damage to teeth caused by erosion, attrition, abrasion and combinations of these conditions is recorded, and the method is applicable whether or not the cause can be determined. Data from a sample of 100 randomly selected 'normal' patients were used to set maximum levels of acceptable tooth wear for each age-group. Beyond these levels the condition is regarded as pathological. Studies to establish the reproducibility of the index are described.

There is ample evidence that the average age at which patients become edentulous is rising sharply, and there is optimism that the problems of extensive caries in young people and periodontal disease may be declining.¹ As patients keep their teeth longer and have them restored less, the problems associated with the dentition wearing out will assume greater importance. General dental practitioners are increasingly being faced with the restorative problems illustrated by the example shown in fig. 1. In these cases it is necessary to make the difficult choice between multiple extractions, multiple crowns, or doing nothing other than to observe the condition.

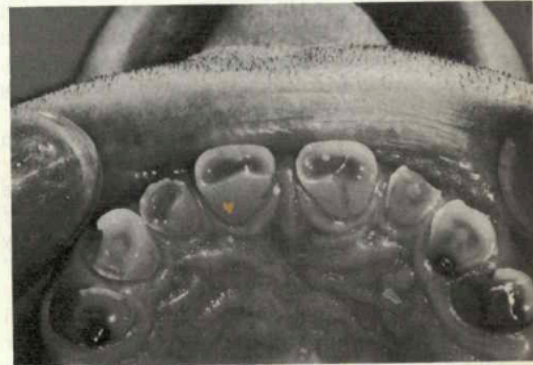
With less advanced cases, identifying and eliminating the cause may be all that is necessary to prevent further deterioration. Here again there are difficulties. Determining the aetiology may not be easy, and often it is simply assumed on the basis of the clinical appearance. Wear of the occlusal surfaces is often diagnosed as being due to attrition, yet in many cases further detailed investigation reveals an erosive component to the aetiology as well.² However, even an extensive history and examination often fails to unearth the cause of the tooth wear, demonstrating the need for much more clinical research into the causes of tooth wear and the mechanisms by which it occurs.

This difficulty in making reliable diagnoses, together with the fact that there is often a combined cause, brings to light a gap in current terminology. The simple term 'tooth wear' is proposed to embrace all three conditions plus their combinations, whether or not the cause is known.

One obstacle to systematic study of the aetiology of tooth wear is the absence of a simple, reliable index to measure it. Similarly, the extent and severity of pathological levels of tooth wear in the population are not known, again partly because of the lack of an index



(a)



(b)

Fig. 1. (a), (b) Patient aged 43 years with extensive tooth wear of unknown aetiology.

suitable for epidemiological studies.

The clinician recognises the fact that teeth wear with age but has no established criteria to guide him in drawing a line between 'normal' and pathological wear for a given age. The proposed tooth wear index (TWI) provides this guidance together with a method of monitoring any progressive changes in a patient over a period of time.

Existing indices

A number of indices that record the extent of tooth tissue destruction arising from erosion, abrasion or attrition have been described.³⁻¹¹ To use them, a diagnosis of the aetiology of the damage must first be made, and in all but one⁶ the index is used when only one of the conditions exists.

The proposed tooth wear index

The proposed index has the following features:

- (1) It is based upon some aspects of previous indices and owes much to them.

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Oral health status, salivary factors and microbial analysis in patients with active gastro-oesophageal reflux disease

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Aim: To present a complex oral health status including salivary factors, microbial analysis and periodontal and hygiene indices in patients with active gastro-oesophageal reflux disease (GORD). Return of stomach contents is quite common in cases of gastro-oesophageal reflux. Pathological acid movement from the stomach into the oesophagus and oral cavity may lead to a development of dental erosion. Long-lasting untreated GORD may damage hard dental and periodontal tissues and alter the oral microbial environment. The quality and amount of the saliva play an important role in hard and soft oral tissues changes. **Method:** Fifty patients with diagnosed GORD using 24-hour pH manometry underwent dental examination; 24 patients had active GORD and had been waiting for surgical therapy. In this patient group oral health status and salivary analysis were evaluated. **Results:** Indicated low salivary flow rates and buffering capacity with a low caries risk but a high risk for dental erosion progression.

Key words: Dental erosion, gastro-oesophageal reflux disease, salivary flow rates, caries risk

Dental erosion is a chemical dissolution of tooth substances by non-cariogenic acids with multi-factorial aetiology^{1,2}. The consequences of premature loss of tooth tissues may result in dentine hypersensitivity, pulpal irritation, and the need for long and expensive restorative treatment.

The aetiology of dental erosion is a complex combination of extrinsic and intrinsic factors. The extrinsic factors include demineralising acidic foods and acidic beverages, sports drinks, some medicines, e.g. effervescent vitamin C preparations and chewable vitamin C tablets^{3–5}.

The prevalence of soft drink consumption, predominantly carbonated drinks, is an increasing problem worldwide^{3,4,6–9}. Intrinsic causes of tooth erosion include recurrent vomiting as a result of psychological disorders, like anorexia, and bulimia, alcoholism, or regurgitation of gastric contents because of some abnormality in the gastrointestinal tract^{10,11}. Acid movement from the stomach into the oesophagus is usually controlled by an anti-reflux mechanism involving the lower oesophageal sphincter. A failure of this system may result in the chronic condition known as gastro-oesophageal reflux disease^{12–16}. Gastro-oesophageal reflux disease (GORD) is defined as a pathological passage of gastric contents into the oesophagus which

may also reach the oral cavity. The acidity of gastric fluid may be below pH 1. Symptoms are acid regurgitation, heartburn, chest pain, chronic respiratory complications, and asthma bronchiale. Undiagnosed and untreated GORD may also result in oesophagitis, Barrett's epithelium and oesophageal adenocarcinoma¹⁷.

Dental erosion is the main intraoral manifestation of gastro-oesophageal reflux disease^{12–16}. Erosion is commonly associated with other types of tooth wear, such as attrition or abrasion^{1,16}. Tooth surface loss begins as superficial demineralisation of the enamel, which can cause dissolution of the subsurface layers and eventual loss of tooth structure. The critical pH for enamel dissolution is 5.5¹⁸. Dental caries and dental erosion both lead to a loss of mineral components of the teeth. Dental caries involves hard dental tissues as a result of exposure to weak acids from cariogenic plaque. Dental erosion, as opposed to dental caries, occurs in plaque-free surfaces when acids have direct access to the surfaces^{19,20}.

Protective functions of the saliva and its components dilute acids in the mouth, neutralising and buffering them. Salivary ions calcium, phosphate and fluoride can stop demineralisation and help remineralisation of hard dental tissues. Salivary factors such as flow rates, pH,

Oral manifestations in patients with gastro-oesophageal reflux disease: a single-center case–control study

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OBJECTIVE: To assess the occurrence of oral pathological changes and symptoms in patients affected by gastro-oesophageal reflux disease (GERD).

PATIENTS AND METHODS: 200 patients with GERD and 100 matched healthy controls were studied. Thorough visual examination of the dental and oral mucosal tissues was performed and medical history relevant to oral symptoms was collected. The primary outcome was defined as a statistically significant difference, between the study group and controls, in the presence of the following indicators: soft/hard palate and uvula erythema, tooth wear, xerostomia, oral acid/burning sensation, subjective halitosis and dental sensitivity. Statistical analysis included chi-squared test, and crude odds ratio with 95% CI.

RESULTS: Univariate analysis showed that xerostomia, oral acid/burning sensation, subjective halitosis, and soft and hard palate mucosa and uvula erythema were more common in patients with GERD than matched controls ($P < 0.05$).

CONCLUSIONS: This study failed to find any significant association between GERD and dental erosions, whereas some symptoms and other objective oral mucosal changes were found to be significantly associated with GERD.

J Oral Pathol Med (2008) 37: 336–340

Keywords: dental erosion; gastro-oesophageal reflux disease; oral manifestations; oral mucosa lesions

Introduction

Gastro-oesophageal reflux disease (GERD) refers to reflux of gastric contents into the oesophagus leading to oesophagitis, reflux symptoms capable to impair quality

of life, or long-term complications (1, 2). Heartburn and regurgitation are the typical clinical manifestations of GERD; in addition, several pulmonary, ear, nose and throat and oral cavity manifestations have been linked to GERD. These have been termed extra-oesophageal manifestations of GERD (3) and include symptoms such as dysphagia, odynophagia, globus (lump in the throat), sore throat, laryngitis, water brash (increased salivary flow) and cough, among many others (2, 3). With regard to GERD-associated manifestations in the oral cavity, dental erosions, halitosis, non-specific burning sensation, mucosal ulceration/erosion, loss of taste and both xerostomia and increased salivary flow have been reported (4). However, most studies focused on dental involvement only (5–43), whereas pathological changes of the soft oral tissues and salivary flow have been less frequently investigated (7, 44–48). The aim of this study was to assess the occurrence of oral manifestations in a population of patients affected by GERD.

Patients and methods

This case–control study was conducted at the Departments of Oral Medicine and Gastroenterology of Palermo University Hospital, Italy. The study group (S) consisted of 200 patients with GERD. Eighty-nine (44.5%) were men (mean age: 46.9; range: 19–78) and 111 (55.5%) were women (mean age: 49.3; range: 19–78). The control group (C) included 100 healthy subjects, without any symptoms or medical history of GERD or other gastrointestinal diseases. They were recruited from teachers of secondary schools, and from medical students. Forty-six (46.0%) were men (mean age: 43.5; range: 20–78) and 54 (54.0%) were women (mean age: 49.1; range: 20–78). S and C groups were matched for demographic variables ($P > 0.2$ by Student's *t*-test); in addition, diet, particularly in relation to weekly acidic beverages/foods consumption, was comparable between the two groups, as found by history

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ORIGINAL RESEARCH



A Clinicopathologic Study of Oral Changes in Gastroesophageal Reflux Disease, Gastritis, and Ulcerative Colitis

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ABSTRACT

Objectives: The aim and objectives of this study are to identify oral changes in certain gastrointestinal (GI) diseases, namely gastroesophageal reflux disease (GERD), ulcerative colitis, gastritis, and to evaluate these oral symptoms as indicators for assessing GI disorders.

Materials and methods: In this study, the oral manifestations of various GI disorders were assessed in a varying age group of 250 patients in Government Stanley Medical College and Hospital, Chennai. Out of 250 patients, 142 were affected by GERD, 99 were affected by gastritis, and 9 patients were affected by ulcerative colitis. Of these patients, 177 were males and 73 were females.

Results: Evaluation of patients with gastritis revealed that 66.7% affected with gingivitis, 19.2% with dental erosion on the palatal and lingual aspects of maxillary and mandibular teeth predominantly in the anterior region, 10.1% with periodontitis, 2% with gingival erythema. Among the patients with GERD, 44% of the cases showed dental erosion, 25.5% periodontitis, 9.9% gingivitis, 5.7% gingival erythema, 2.8% palatal erythema, 2.1% gingival ulcers, glossitis 2%, 1.4% floor of the mouth erythema, and 0.7% erythema of the tongue. Patients with ulcerative colitis showed 44.4% of gingival erythema, 33.3% of dental erosions, and 22.2% of gingival ulcers and periodontitis.

Conclusion: In our study of 250 patients, oral manifestations were observed in 88% of the patients. Both soft tissue and hard tissue changes were evident. There was a high correlation

between various GI disease and dental erosion, erythema at various sites of the oral cavity, oral ulcers, gingivitis, periodontitis, and glossitis. Careful evaluation of oral cavity may unveil many GI disorders and help the patient by providing early diagnosis, which further facilitates the prognosis.

Keywords: Gastritis, Gastroesophageal reflux disease, Oral manifestations of gastrointestinal disorders, Ulcerative colitis.

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INTRODUCTION

The oral cavity, lined by stratified squamous epithelium, is the portal of entry to the gastrointestinal (GI) tract, and as a consequence, it is often involved in conditions that affect the GI tract.¹

Gastrointestinal diseases manifest as lesions within the jaws, oral mucosa, or perioral tissues. These lesions are directly caused by GI diseases or at times, by systemic alterations secondary to GI diseases.²

Gastroesophageal reflux disease (GERD) is defined as a "condition that develops when the reflux of stomach contents causes troublesome symptoms and/or complications."³ The common symptoms of GERD include heartburn, regurgitation, and dysphagia.⁴ Oral manifestations of GERD include dental erosion, dental caries, xerostomia, burning sensation, halitosis, and erythema of the palatal mucosa and uvula.⁵

Ulcerative colitis is a type of inflammatory bowel disease that primarily affects the colonic mucosa. Initial symptoms include diarrhea with blood and mucus, fever, and weight loss.⁶ Oral manifestations include aphthous ulceration and pyostomatitis vegetans.⁷

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Alteraciones bucales asociadas a la enfermedad por reflujo gastroesofágico

Oral alterations associated to gastroesophageal reflux disease

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RESUMEN

Introducción: La enfermedad por reflujo gastroesofágico es un trastorno funcional, multifactorial, del tracto gastrointestinal superior. Las alteraciones bucales han sido consideradas como parte de sus manifestaciones extraesofágicas. **Objetivo:** Determinar las alteraciones bucales encontradas en pacientes con enfermedad por reflujo gastroesofágico. **Métodos:** Se realizó un estudio observacional descriptivo en 37 pacientes con diagnóstico de enfermedad por reflujo gastroesofágico. Las variables analizadas fueron: edad, sexo, presencia de alteración, signos y síntomas, y localización. Se confeccionó base de datos con registros, se calcularon las frecuencias absolutas y porcentajes. **Resultados:** El 48,6 % de los pacientes presentó alguna alteración bucal, como sensación de ardor o urente (40,5 %) y eritema (35,1 %). Entre las regiones afectadas se encontraron paladar blando/úvula (72,2 %) y lengua (61,1 %). **Conclusiones:** Casi la mitad de los pacientes afectados por reflujo gastroesofágico presentó alguna manifestación bucal. Las más frecuentemente encontradas fueron: la sensación de ardor o urente, eritema, sensación de boca seca y ulceraciones. Las localizaciones más frecuentes fueron paladar blando/úvula y lengua.

Palabras clave: enfermedad por reflujo gastroesofágico; reflujo ácido; manifestaciones bucales.

ABSTRACT

Introduction: Gastroesophageal reflux disease is a functional multifactorial disorder of the upper gastrointestinal tract. Oral alterations are considered to be extraesophageal manifestations of this disease. **Objective:** Determine the oral alterations found in patients with gastroesophageal reflux disease. **Methods:** An observational descriptive study was conducted of 37 patients diagnosed with

The Basic Erosive Wear Examination (BEWE) applied retrospectively to two studies

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 E. Arnarsdóttir · S. H. Jónsson · S. R. Sæmundsson

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Abstract

Objectives A scoring method for tooth erosion is needed to enable community-based assessments. The aim of this study was to evaluate the Basic Erosive Wear Examination (BEWE) scoring method, using data previously collected from two studies.

Materials and methods In a national survey of erosion in children and adolescents, a representative, 20 % nationwide sample of 2,251 children, aged 6, 12 and 15 years, was examined. Erosion, recorded for all surfaces of permanent teeth, was converted to a BEWE score. For a group of referred patients, erosion was scored for 351 patients and then converted to a BEWE score.

Results From the national survey, no erosion was seen in permanent teeth of 6 years old, but was present in 12 years old (19.9 % boys, mean BEWE of 0.22; 11.0 % girls, mean BEWE of 0.079; $p < 0.001$). Among 15 years old, erosion was seen in 30.7 % of subjects (38.3 % boys, mean BEWE of 1.00; 22.7 % girls, mean BEWE of 0.42; $p < 0.001$). For the referred patients, the BEWE score was 9.4 for subjects with gastric reflux symptoms but 6.0 for those without symptoms ($p < 0.001$).

Conclusions The value of scoring with the BEWE methodology was clearly demonstrated, showing increasing severity of erosion between 12 and 15 years and gender differences in erosion severity. Intrinsic acid erosion clearly caused an increased BEWE score.

Clinical relevance The BEWE scoring methodology appears valuable for assessing erosion in populations.

Keywords Tooth erosion · Tooth wear · Epidemiology · Gastro-oesophageal reflux disease · Iceland · Gender difference

Introduction

Tooth erosion is an increasingly recognised clinical problem in many countries [1, 2, 5, 6, 10, 11, 18]. Extrinsic acids, usually dietary, as well as intrinsic acids in subjects with gastric reflux cause a decalcification and softening of enamel that is then more readily subject to physical wear forces such as abrasion and attrition that result in an alteration in the tooth surface that has been termed “erosive tooth wear” or “ETW” [15]. Although numerous indices have been described for assessing tooth erosion/erosive tooth wear (see review by [7]), none have yet attained the level of acceptance of well-known scoring methods that are used for scoring caries (DMFT/DMFS) or periodontal disease (PSR or CPITN). This has resulted in a failure to monitor erosion in both cross-sectional and longitudinal studies and, within communities, between groups with perceived differences in erosion prevalence or risk. An attempt to solve this problem was to produce a new scoring system termed the Basic Erosive Wear Examination (BEWE) system [8, 9, 20]. The aim of producing this index was to provide dental research and community dentistry with an index that could help increase in understanding the clinical perspective of tooth erosion and assist in its management. The BEWE system scores the most affected tooth surface in each sextant of the mouth, and the sum of the scores provides the total BEWE score. The perceived high prevalence of tooth erosion in Iceland has led to several studies including: (1) epidemiology [5, 6], (2) the association

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