

**EROSIVE TOOTH WEAR:  
AN INVESTIGATION INTO KNOWLEDGE AND PREVALENCE**

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## **ABSTRACT**

Kristi Ellen Erickson: Erosive Tooth Wear: An Investigation in Knowledge and Prevalence  
(Under the direction of Dr. Terry Donovan)

The purposes of this study were 1) to determine the knowledge of dental practitioners on the clinical signs, etiology, and treatment of dental erosion, 2) to determine the prevalence of dental erosion in a population of subjects with Gastroesophageal Reflux Disease (GERD) as compared to a control population, and 3) to determine the association of number of acidic challenges, number of medications, age, salivary buffering capacity, initial salivary pH, and salivary flow rate to the erosive tooth wear (ETW) present. Results indicate that 1) while dental practitioners can identify the signs of dental erosion with a 36% accuracy, various etiologies and preventive treatment options are being overlooked, 2) the prevalence of erosion in a population of GERD subjects is 40% as compared to 15% in a control population, and 3) the only association seen is an increase of ETW with an increase in age.

This thesis is dedicated to Stephen Michael Nedzel.

For 18 years you were in my life bringing laughter and music.

You made sure that I always would remember what gingivitis was.

Lemon chills will always be consumed after their alternate use has been told.

Not one musical can I sit through without thinking of you.

The Cubs will someday win the World Series and I will hear you cheering.

Thanks for all the memories.

You are always in my heart.

I will miss you always.

Let the band play on.

Cheers!

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## **LIST OF ABBREVIATIONS**

ACP-CPP	Amorphous Calcium Phosphate
ADA	The American Dental Association
ADR	The 29th Annual Dental Review
BEWE	Basic Erosive Wear Exam
CDA	California Dental Association
CE	Continuing Education
CEJ	Cemento- Enamel Junction
DE	Dental Erosion
ETW	Erosive Tooth Wear
GERD	Gastroesophageal Reflux Disease
GI	Gastro Intestinal
IRB	Institutional Review Board
NC	North Carolina
NCCL	Non Carious Cervical Lesion
NHANES	National Health and Nutrition Examinations Survey
OTC	Over the Counter
RDA	Relative Dentin Abrasivity
STWI	Simplified Tooth Wear Index
TWI	Smith and Knight Tooth Wear Index
UK	The United Kingdom
UNC	The University of North Carolina at Chapel Hill

US

The United States of America

WDU

Weekly Dental Update

## **Introduction**

As the lifespan has been increasing and the caries rate continues decreasing, we as a population have been keeping our teeth longer. Along with a change to the modern diet a resulting increase in non-carious tooth loss has been noted.<sup>1</sup> This non-carious loss of tooth structure may also be called Erosive Tooth Wear (ETW).

### **Erosive Tooth Wear:**

ETW has multiple etiologies, including attrition, abrasion, abfraction and erosion. Rarely is only one of these entities solely responsible.<sup>2-5</sup> The term ETW attempts to encompass this multifactorial origin and the acceleration of the other etiologies by acid.<sup>6-10</sup> Often the terms tooth wear and erosive tooth wear are interchangeable in the literature.<sup>11,12</sup>

Attrition is defined as loss of tooth structure from tooth to tooth wear from normal aging and parafunctional habits, such as bruxing, grinding and clenching.<sup>5,8</sup> The clinical appearance of attrition often shows matching polished wear facets on occlusal or incisal surfaces.<sup>8</sup>

Abrasion is the loss of tooth structure through an abnormal mechanical process.<sup>5</sup> This may be caused by a third source such as a toothbrush and toothpaste, holding nails with ones' teeth or chewing on pens.<sup>5,8</sup> Abrasion may also occur when porcelain opposes natural tooth structure. Clinically, abrasion usually appears as cervical concavities, often on buccally positioned teeth.<sup>8</sup>

Abfraction is often considered more theoretical and results in wedge shaped lesions at the cementoenamel junction (CEJ).<sup>5,8</sup> There are multiple theories to the origin of these lesions, but it is generally believed they originate due to cervical tooth flexure from tensile forces generated from occlusal stresses which cause microfractures to occur at the CEJ that progress with time.<sup>5,8,13</sup> Stress concentrations focused in the cervical region also are thought to weaken the tooth structure in this area making it more susceptible to abrasion and erosion.

Dental erosion is defined as the loss of hard tooth structure due to acid not bacterial in origin. The primary sources of the acid are dietary acids and gastric juice.<sup>14</sup> The concept of dental erosion has been well accepted in Europe but has been slower to gain acceptance in the United States as an etiology of tooth wear.<sup>2,15</sup> The locations of erosive lesions are dependent on the origin of the acid. Dental erosion seems to be increasing in frequency.<sup>16</sup>

### **Dental Erosion:**

Dental erosion is currently estimated to occur in 2-56% of the population, varying depending on the age and location of the sampled population.<sup>17-19</sup> Erosion contributes to dental wear through external and internal source of acids.<sup>4,5,16,20</sup> Initial clinical signs of erosion present as the loss of enamel texture, silky glossy appearance and sometimes a dulling of the surface gloss, also known as the “whipped clay effect”.<sup>16,21</sup> Initial enamel and dentin lesions can be extremely difficult to diagnose, often being difficult to differentiate from abrasive lesions.<sup>4,12,16</sup> Other common signs of erosion are cupping of the cusp tips and incisal edges and restorations “standing proud” above the neighboring tooth structure.<sup>4,8,16,22</sup>

Intrinsic erosion results from endogenous acid, more specifically gastric acid, attacking the tooth surface; rumination, vomiting and regurgitation allow the gastric acid to

reach the oral cavity.<sup>23</sup> Anorexics, bulimics, alcoholics, pregnant women and patients with various GI disorders may be at greatest risk for intrinsic dental erosion.<sup>5</sup>

Extrinsic acids include those from sources such as fruits and fruit juices, sports drinks and sodas, energy drinks, pickled foods, as well as alcoholic drinks and herbal teas.<sup>8,15,24</sup> Ethnic diets also are potential sources of dietary acids. For example, ceviche utilizes lemon and lime juice while Filipino adobo dishes stew meat in vinegar.<sup>25</sup> Environmental factors may also be sources of external erosion; before tighter workplace regulation factory workers in battery plants had high levels of erosion. Competitive swimmers and frequent swimmers, especially when the pH of the pool is incorrectly monitored may also experience erosion.<sup>26</sup> Medications also have the potential to be acidic and cause erosion.<sup>2</sup>

Erosion occurs by the demineralization of hydroxyapatite or fluorapatite crystals in the enamel. The less organized and well formed the apatite crystals are the more prone they are to acid demineralization.<sup>27</sup> Once the dentin is reached, demineralization begins with apatite crystals at the interface between intertubular and peritubular dentin. The rate of demineralization decreases as the amount of collagen increases.<sup>28</sup> Unlike caries which is a slower demineralization-remineralization progression of a subsurface lesion erosion appears to progress more rapidly and as a surface lesion.<sup>27</sup>

High risk populations for erosion are teenage males and females, patients with GERD and the elderly on multiple medications.<sup>8,26</sup> Teenage males are at risk due to their consumption of acid beverages, sports and energy drinks, while teenage females are at risk due to anorexia and bulimia.<sup>8,22,26</sup> Patients with GERD are at particularly high risk due to the possible presence of gastric acid in the oral cavity. Multiple medications and salivary

changes in the elderly may lead to decreased salivary flow allowing the encountered acids to have a greater effect.

Early detection is essential to being able to manage erosion, but is difficult because it rarely presents with symptoms.<sup>2-4,16,21,29</sup> The locations of erosive lesions may help to determine the source of the acid but should not be used as the sole factor in the determination.<sup>14</sup> Erosion from internal sources tends to show signs of tooth loss on the anterior maxillary palatal surfaces, posterior maxillary and mandibular occlusal surfaces, and posterior mandibular buccal surfaces.<sup>5,8,15,26</sup> Extrinsic sources of erosion tend to show tooth wear on the labial surfaces of anterior teeth, the buccal surfaces of posterior teeth and the occlusal surfaces of the posterior mandibular teeth.<sup>8</sup>

If the etiology is determined to be intrinsic due to anorexia or bulimia, psychological counseling is needed. Suspected GERD patients should be referred to primary care physicians for further diagnosis and treatment.

If an extrinsic source of erosion is suspected, a written diet analysis should be conducted. It is recommended that two weekdays and the weekend be recorded and counseling should follow the analysis focusing on diet modifications.<sup>8,16,26</sup> Frequent consumption of acidic foods and drinks, and various oral habits like swishing or holding drinks in the mouth all may exacerbate erosive potentials.<sup>2,5,16,22,23</sup> Diet modifications should involve the manner in which food is consumed (chewed, sucked, dissolved), eliminating certain foods or decreasing contact time (use of a straw); referral to a registered dietitian may also be recommend.<sup>8,25,29</sup>

Determining the erosive potential of a food is not as simple as determining the pH, and the method of contact. The titratable acidity of a food or beverage also must be considered.<sup>2</sup> Additionally the type of the acid, the calcium chelating properties, the calcium, phosphate and fluoride ion concentrations present, the adherence to enamel, the ability to stimulate salivary flow, and the temperature may all impact the erosive potential of an acid in a beverage, food or medicine.<sup>27</sup>

Not everyone who eats an acidic diet or has GERD presents with erosion. There are biological factors that can protect the teeth from erosion. The pellicle and saliva are two protective factors. The pellicle provides a physical layer which the acid must permeate.<sup>26</sup> The pellicle's composition can be influenced by age and degeneration of the salivary glands which may influence its permeability.<sup>27</sup> Saliva impacts the progression of erosion through the salivary flow rate, buffering capacity, composition and volume.<sup>5,27</sup> Decreased salivary flow resulting in dry mouth or xerostomia can be caused as a result of side effects of medications, loss of function of the salivary glands and/or dehydration.<sup>16,30</sup> If a patient consumes more than three medications per day it has been shown that xerostomia is a likely side effect, even if the medications do not have a xerostomatic side effect on their own.<sup>31</sup> In addition to a good flow rate to clear any acidic challenge, the saliva also functions to buffer or neutralize the acid; in 30 seconds with a normal flow rate saliva can buffer an acid with a pH of 3.5 up to 6.1.<sup>27</sup>

Treatment goals for erosion should be to decrease the risk and impact of acids. Acid intake should be reduced, the acidity of the oral environment should be reduced, the salivary flow rate needs to be increased, remineralization of the erosive lesions should occur, a reduction in abrasive challenges, protection of exposed dentin, reduction in parafunctional



habits and restorations as needed.<sup>2,8,21,26,29,32</sup> These goals can be achieved through a variety of techniques and treatments. To reduce the acid intake a diet analysis should be performed and referrals should be made as needed for control of anorexia, bulimia or GERD. The acidity of the oral environment can be decreased by rinsing immediately after an acid challenge with water or sodium bicarbonate.<sup>21,33-35</sup> To increase salivary flow, sugar free or xylitol mints and gums may be used in addition to pilocarpine.<sup>34</sup> Remineralization of erosive lesions should occur by increasing the levels of fluoride present either by the application of fluoride varnish or prescription toothpastes.<sup>2</sup> Decreasing abrasive challenges can be achieved by avoiding brushing for 30 minutes after an acid challenge and using a low abrasive toothpaste.<sup>32,33</sup> Filled dentin bonding agents or sealants should be applied over exposed dentin when the erosive lesion does not compromise the existing tooth structure.<sup>2</sup> The damage caused by parafunctional habits can be reduced through the use of an occlusal guard. Restorations should be conservative and additive in nature especially in mild and moderate erosion.<sup>34</sup> Once erosion has reached a more severe stage, further into dentin, more aggressive treatment may be indicated, perhaps restoring at an increased vertical dimension to replace lost tooth structure.<sup>29</sup> These full mouth rehabilitations are complex and take large amounts of time and money. Prevention and early intervention are much more cost effective.<sup>22</sup>

Monitoring the progression of the wear is important in determining the proper treatment plan and being able to decide when intervention is needed. Photographs and study casts should be taken once erosion is suspected and repeated periodically so progression can be accurately assessed.<sup>2,16,21</sup> Wear indices are available for dentists to screen for erosive wear on their patients and monitor the progression.<sup>2,12</sup> There are various erosive and tooth

wear indices available though most were developed for research. Eccles developed a classification for assessment of dental erosion of non-industrial origin; three classes of lesions are assigned to four tooth surfaces.<sup>4</sup> Table 1 Smith and Knight then introduced the Tooth Wear Index where four visible surfaces of all teeth are scored for wear.<sup>36</sup> Table 2 This was then modified by Bardsley in 2004 to the Simplified Tooth Wear Index.<sup>37</sup> Table 3 Most indices are modified for each specific study they are used in and are not easily comparable in meta-analyses; additionally inter and intra-examiner reliability is an area of concern.<sup>12</sup> Many of these indices are looking for a specific etiology of wear and may lead to confusion as it has been determined tooth wear is multifactorial.<sup>12,38</sup> A weakness of many indices is that in identifying exposed dentin an accurate assessment by percentage often is inconsistent between examiners.<sup>39</sup>

The basic erosive wear exam (BEWE) was developed as a tool for general dentists to quickly screen for ETW and for its progression.<sup>40,41</sup> Table 4 It is a sextant based exam which allows a provider to quickly select the tooth in a sextant with the worst wear and grade it.<sup>41</sup> A cumulative score is calculated which allows a risk for erosive wear to be determined. The etiology of the wear is not assigned during this exam.

While wear indices are often used more modern techniques utilizing scanning and 3D technology are increasing in use.<sup>42</sup> The difficulty in these methods of assessment especially over a longitudinal period is the absence of stable reproducible reference points.<sup>43</sup>

The purpose of this thesis was to assess the knowledge of American dentists regarding erosion and examine the prevalence of ETW in an American adult population.

In Chapter I, the primary aim was to assess the knowledge of American dentists regarding the clinical signs, etiology and treatment of dental erosion. Secondary aims examined the frequency erosion (ETW) as seen in their practice, the frequency of their use of diet analysis and the frequency of referrals to physicians.

In Chapter II, the primary aim was to determine the prevalence of ETW in an adult American population. To accomplish this task a population of subjects diagnosed with GERD were assessed for ETW and compared to a control population. A secondary aim was to evaluate associations between the number of acidic challenges, number of medications, salivary flow rate, salivary buffering capacity, initial salivary pH and the ETW present.

Table 1: Eccles Classification of Dental Erosion

<b>Class I</b>	Superficial lesions- involving enamel only
<b>Class II</b>	Localized lesion—involving dentin for less than one third of the surface
<b>Class III</b>	Generalized lesions – involving dentin for more than one third of the surface <ul style="list-style-type: none"> <li>a. Facial surfaces</li> <li>b. Lingual and palatal surfaces</li> <li>c. Incisal and occlusal surfaces</li> <li>d. Severe multisurface involvement</li> </ul>

Table 2: Smith and Knight Tooth Wear Index

Score	Surface	Criterion
0	B/L/O/I	No loss of enamel surface characteristics
	C	No change of contour
1	B/L/O/I	Loss of enamel surface characteristics
	C	Minimal loss of contour
2	B/L/O	Loss of enamel exposing dentine for less than one-third of the surface
	I	Loss of enamel just exposing dentine
	C	Defect less than 1mm deep
3	B/L/O	Loss of enamel exposing dentine for more than one-third of the surface
	I	Loss of enamel and substantial loss of dentine, but not exposing pulp or secondary dentine
	C	Defect 1-2 mm deep
4	B/L/O	Complete loss of enamel, or 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

Table 3: Simplified Tooth Wear Index – Bardsley

<b>Score</b>	<b>Criteria</b>
0	No wear into dentin
1	Dentin just visible (including cupping) or dentin exposed for less than 1/3 of surface
2	Dentin exposure greater than 1/3 of surface
3	Exposure of pulp or secondary dentin

Table 4: Basic Erosive Wear Exam Scoring Definitions and Risk Levels

<b>Score</b>	
0	No erosive tooth wear
1	Initial loss of surface texture
2	Distinct defect, hard tissue loss, 50% of surface area
3	Hard tissue loss >50% of the surface area

<b>Risk Level</b>	<b>Cumulative score of all sextants</b>
None	Less than or equal to 2
Low	Between 3 and 8
Medium	Between 9 and 13
High	14 and over

## CHAPTER I

### **Introduction:**

Erosive tooth wear (ETW), which includes attrition, abrasion, abfraction and erosion appears to be increasing in incidence. Attrition and abrasion are attributed to be the major etiologies of tooth wear in the United States (US), while in Europe the primary etiology of tooth wear appears to be erosion.<sup>15</sup> Whether this observation is because of the direction of research or in actual differences in etiologies is difficult to determine. The National Health and Nutrition Examinations Survey (NHANES) for 2003-2004 was the first cycle with a measurement of “tooth wear” [erosion] in children ages 13-19 in the United Kingdom (UK).<sup>11</sup> Although the measure of tooth wear is used in conjunction with and interchangeably with dental erosion in NHANES 2003-2004, the best term is actually erosive tooth wear.<sup>17</sup> Differences in the beverages sold in the US and UK were found in Murrell’s 2009 study examining the pH and erosive potentials.<sup>44</sup> While the pH and erosive potentials are different, it does not fully explain the differences in the erosive patterns seen between the two countries.<sup>44</sup> Perhaps, it is not that the ETW patterns are different between the two countries, but that the diagnosis and etiology are attributed differently.<sup>15</sup> This conclusion would then suggest that perhaps the US dental education system is not imparting a good understanding of ETW. A 2010 study conducted in a Brazilian dental school found that the understanding of dental erosion was not good among their students and faculty.<sup>45</sup> Hygiene and dental students are well educated at the University of North Carolina School of Dentistry first in the etiologic factor of Class V lesion being tooth brush abrasion. This viewpoint is reflected in



the second year dental students presenting the majority of Class V lesions to faculty as toothbrush abrasion lesions rather than a more general non carious cervical lesion (NCCL). Once abfraction and erosion are presented to the third year dental students' diagnoses of the etiology of NCCLs begin to diversify.

It is suggested that the difficulty with early diagnosis and management of dental erosion is because the topic is not emphasized in dental curriculums and is not a desirable continuing education topic.<sup>29</sup> Others suggest that dental professionals worldwide are confused by the signs and symptoms of erosion, especially regarding the similarities and differences of it to other sources of ETW due to the complex interaction of the etiologic agents.<sup>1</sup> In April of 2011 the California Dental Association (CDA) dedicated an entire issue of the CDA Journal with the goal of ensuring “that dentists can more effectively recognize this condition[dental erosion], educate patients, and manage dental erosion and tooth wear problems early and in a conservative manner.”<sup>46</sup>

Assessing the knowledge of dentists regarding ETW is rare. In 2003 a survey on erosion was distributed to general dentists and 12 year old children in Leicestershire, UK assessing their awareness of erosion.<sup>18</sup> A survey was sent out to UK and overseas prosthodontists in 2008 to examine the management of tooth wear.<sup>47</sup> In 2010 a Brazilian dental school surveyed their students, faculty and patients regarding their knowledge of erosion.<sup>45</sup> In 2011 a survey on dental erosive wear was sent to all dentists who were part of the Norwegian Public Dental Health Service.<sup>48</sup> These four surveys constitute our basis of what dentists know regarding erosion and only select US prosthodontists represent the knowledge of American dentists.

The assumption exists that American trained dentists do not have a strong understanding of the etiology or clinical signs of dental erosion.<sup>15,29</sup> The purpose of this study was to assess the knowledge of dentists in the United States on the clinical signs, etiology, and treatment of dental erosion. The frequency of erosion seen in patients, use of diet analyses, and referrals to physicians were also examined.

The hypothesis was that American dentists are able to identify the clinical signs and etiologies of erosion and are following the recommend treatments for dental erosion.

## **Materials and Methods:**

In order to assess American dentists' knowledge and treatment of dental erosion a survey was developed. Participants were asked to identify the clinical signs that indicated erosion. Questions addressing the frequency of encounters with erosion (ETW), use of diet analysis, and referrals to physicians were asked. Preventive and restorative treatments for erosion were evaluated as were possible etiologies of erosion. The remaining questions dealt with provider demographics. See Appendix A This study was reviewed by the University of North Carolina (UNC) Biomedical Institutional Review Board of the Office of Human Research Ethics and declared exempt (IRB, study # 12-1103, 12-1801, 12-1802).

**Survey Development.** The survey instrument (Appendix A) was developed with the assistance of The Odum Institute at The University of North Carolina at Chapel Hill and Dr. Ceib Phillips, the University of North Carolina School of Dentistry. The survey was created in Qualtrics Software (Qualtrics, Provo, Utah) and a duplicate paper survey was created using Teleform (Cardiff Software, Vista, CA).

Three sample populations were surveyed as part of this study. A convenience sample was drawn from a continuing education meeting, the 29<sup>th</sup> Annual Dental Review (ADR) in Myrtle Beach, SC. A random sample was obtained from the general dentists in North Carolina. A master list of active dentists was requested from the North Carolina Board of Dental Examiners. A random sample of 1735 active general dentists was created from this list. The final sample was all 1083 active duty US Navy Dentists.

**Survey Distribution:** The survey was distributed in packets given to all registrants at the ADR. Each morning a verbal invitation was issued to complete the survey; the meeting ran three days.

A mixed mode distribution method was used for the distribution of surveys to NC dentists. All NC dentists who provided their email address to the NC Dental Board of Examiners were emailed a letter explaining the survey and an invitation to complete the survey electronically through the Qualtrics system. Three electronic reminders were sent to non-respondents every two weeks after the initial distribution. For those who did not provide an email address, hard copies of the invitation, letter, and survey were mailed with a postage paid return envelope. A final hard copy was sent to all non-respondents, whether they received an initial electronic or hard copy survey. Each mailing contained a cover letter explaining the survey and postage paid return envelope. Six weeks after the final mailing no further surveys were counted.

All US Navy Dentists were invited to participate in the survey via the Weekly Dental Update (WDU), an electronic newsletter sent to US Navy Dental leaders and distributed to the dentists in their command. For six weeks an invitation explaining the survey and

electronic link to the Qualtrics survey ran in the WDU. The Navy Qualtrics survey was shut down after ten weeks.

## **Results**

Respondents were excluded if they did not return a survey, returned an illegible survey or the survey was returned after the cutoff date.

A master data set was formed from the downloaded data from Qualtrics and the Teleform responses.

**Statistical Analysis.** All three distributions of this study were combined into one data pool for analysis. Descriptive statistics were conducted on all questions. Weighted values were assigned to determine the ability of providers to correctly identify the clinical signs of erosion.

**Response Rate.** A total of 69 surveys were received during the ADR, 180 participants were registered resulting a response rate of 38.3%. A total of 744 out of 1735 surveys were returned from NC general dentists, a response rate of 42.9%. Five surveys were returned by the post office as undeliverable. One hundred forth five out of 1153 Navy dentists (70 retirees plus 1083 active duty dentists) responded to the survey invitation for a response rate of 12.6%. A total of 958 surveys were returned for analysis.

Demographic data is shown in Table 5.

Results of the surveyed dentists over 70.3% saw a patient with erosion or ETW once a week, 41.2% reported encountering a patient with erosion daily. Seven and a half percent of the surveyed dentists do not encounter erosion more frequently than once every 6 months.

Figure 1

Forty three and seven tenths of a percent of the survey dentists have not used a diet analysis in their practice in the last year. Figure 2

Fifty eight percent of the surveyed dentists have not referred any patients to their primary care physicians in the past year. Figure 3

Only 30.5% of the surveyed dentists could correctly identify all the clinical signs of erosion. Figure 4

Eighty six percent of the surveyed dentists feel competent in recognizing the clinical signs of dental erosion and discussing erosion with their patients. Eighty one percent of the dentists feel competent discussing the etiology of erosion with their patients, while only 76.8% feel competent treating patients who have tooth loss due to erosion. Table 6

The preventive treatments utilized for patients with mild erosion were most frequently hygiene instruction (75.8%) and prescription toothpaste (72.1%). Figure5 shows the frequency of other preventive measures for mild erosion.

Restorative treatments utilized by the surveyed dentists are shown in Table 7. Full coverage restorations in patients with severe erosion were the most common treatment at 58%. Occlusal guards were the next most common treatment. Fifty one and one tenth percent of the surveyed dentists use occlusal guards for those with moderate erosion and 45.9% for those with severe erosion.

Identification of the etiologic factors of erosion was highly variable. Figure 6 reflects those that may be considered etiologic factors while Figure7 shows identified agents that are not etiologic factors for erosion. The highest positively identified etiologic agents were Anorexia/Bulimia and GERD.

## **Discussion:**

The aim of this study was to determine the knowledge of dentists in the US on the etiology, clinical signs and treatment of dental erosion. Surveys regarding erosion are fairly infrequent. Four studies were found on erosion and all but one looked only at dentists outside of the US.<sup>18,45,47,48</sup> The majority of dentists who participated in this study were general dentists from the state of North Carolina and are not necessarily a representation of the knowledge of dentists across the US. The inclusion of the US Navy dentists widens the geographic range and includes more than general dentists.

The low rate, 38%, of response at the CE meeting may be from self-exclusion. Offices may have brought hygienists, assistants and office staff to the meeting and the auxiliaries would have been counted as one of the 180 registered attendees. As the survey targeted dentists, the auxiliaries most likely did not complete or turn in the survey. Additionally, as the meeting is sponsored by the UNC Department of Operative Dentistry, faculty and staff were registered and counted among the 180 attendees but did not respond as they were a biased sample. A response rate of 43% from the random sampling of NC general dentists is lower than the other comparable studies on erosion but is an average response rate for a mixed mode survey.<sup>18,45,47,48</sup> The 12.6% response rate from the electronically distributed survey to US Navy dentists may be due to operational issues that will not allow them to complete the web based survey due to limited band width or blocked access to the Qualtrics website. The topic of erosion may also not have been applicable to some of the specialists such as oral surgeons and endodontists.

No definitions of erosion were provided nor any definition for what is considered mild, moderate or severe erosion. While this was done to allow the knowledge of the dentists

to be assessed it may also mean a variety of definitions and levels of erosion exist among the surveyed dentists.

### ***Frequency***

Dentists were asked to recall their frequency of encounters with patients with erosion and their treatments utilized. Forty one and nine tenth percent of the providers saw erosion or ETW on a daily basis, higher than Dugmore's 2003 survey of general dentists in Leicestershire where 36% saw erosion often or very frequently.<sup>18</sup> Dugmore did not define what is often or frequent and in both studies the memory of the providers is being relied on rather than tracking patients seen with erosion. Additionally, if it is considered that only 30% of the surveyed providers could correctly identify all the signs of erosion perhaps a high frequency of erosion is not being seen but a higher frequency of ETW in general.

### ***Referral***

Fifty eight percent of the surveyed dentists did not refer their patients to their primary care physician due to their erosion. Referral to a physician would most likely be due to the ETW etiology being GERD, anorexia or bulimia. Such a high non referral rate may be due to patients already having a diagnosis of GERD, anorexia or bulimia and already being under a physician's care. Studies find a prevalence of erosion in the range of 18-58% for patients with GERD.<sup>49-51</sup>

### ***Identification of Clinical Signs***

Only 30.4% of the surveyed dentists were able to correctly identify the signs of erosion, but 86% feel confident that they can recognize the clinical signs of erosion. Perhaps if they saw the erosion they would be able to identify the signs but in this survey no clinical examples or photographs of erosion were given, only written descriptions of the clinical signs

of erosion were given. The two additional clinical signs listed were specific to attrition and normal physiologic wear. The misidentification of the signs could be because of the difficulty in separating ETW, multifactorial tooth wear, from erosion specifically. Forty nine and nine tenths percent of the surveyed dentists included at least one clinical sign other than those characteristic of erosion in their answer. It seems dentists can identify ETW but not necessarily the primary etiology of the wear. This inability to correctly identify the etiology of the ETW may lead to improper prevention and treatment of the lesion as it is dependent on determining the etiology.

### ***Confidence***

Over 80% of the surveyed dentists report they feel confident in discussing and treating erosion. This finding is similar to that found in Hermont's study at a Brazilian dental school (50-80%) which included dental students and faculty.<sup>45,48</sup> In truth we see in this study the majority (70%) of dentists were not able to identify the clinical signs for erosion, so evidently their confidence is misplaced.

### ***Diet Analysis***

Diet analysis is underutilized, though providers seem to realize food and beverages can lead to erosion. Only 14.1% use a diet analysis more than once a month and 42.8% see an erosion or ETW patient daily. In Mulic's study only half of the dentists occasionally recorded the diet history of their erosion patients.<sup>48</sup> The recommend technique for a diet analysis is a four day consecutive record including at least one weekend day; patients should be instructed to record all food, drink and medications consumed along with the time of consumption and quantity.<sup>34,52</sup> A Cochrane review of one to one dietary interventions in a dental setting, shows that fruit, vegetable and alcohol consumption can be altered through



direct dietary counseling such as found when doing a detailed diet analysis.<sup>53</sup> When reviewing a patient's diet analysis it is important to discuss the manner in which foods or drinks are consumed, sucking on citrus fruits or swishing drinks can increase the erosive potential of foods.<sup>8,25</sup> Bartlett et al calculated the odds ratios of foods and beverages risk of causing erosion and saw the frequency and method of consumption seems to increase the amount of ETW seen.<sup>19</sup>

### ***Preventive Techniques***

Though diet counseling is used by 62% of the surveyed dentists as a preventive measure for erosion it could be the hygienist providing this information not the dentist and is not the same as conducting a diet analysis. The American Dental Association (ADA) code D1310 for nutritional counseling is defined as "counseling on food selection and dietary habits as part of treatment and control of periodontal disease and caries" with no mention of erosion. Diet counseling for erosion should specifically address the frequency and manner of consumption of food and beverages which have an erosive potential.

Remineralization either by various techniques is advocated to slow the progression of erosion.<sup>8,10,34,54</sup> The lower use of the surveyed providers of amorphous calcium phosphate (ACP-CPP) (28.7%) than fluoride varnish (62.3%) appears to be supported by the studies on reduction of ETW. Fluoroapatite is more difficult to erode than hydroxyapatite, so the application of fluoride varnish is recommended.<sup>54</sup> In *in vitro* studies Ranjitkar et al demonstrated that ACP-CPP reduces ETW.<sup>55,56</sup> Wegehaupt et al though have shown in another *in vitro* study that ACP-CPP provides no significant protection against ETW; two fluoride gels in the same study did reduce ETW.<sup>57</sup>

Over the counter (OTC) toothpaste, while advertised highly in the media for the treatment of erosion, *in vitro* studies are inconclusive if they are effective at preventing ETW.<sup>58</sup> As prescription toothpastes are more frequently (72%) recommended by the surveyed providers than OTC toothpastes (38%), perhaps providers are focusing on increasing the fluoride and fluoroapatite concentration rather than the lower relative dentin abrasivity (RDA) that some toothpastes targeting erosion may offer. OTC toothpastes' abrasive particle size may or may not play a direct role. Some studies show lower RDA is relative to the amount of dentin loss seen as related to how soon after an acid exposure the brushing occurs.<sup>59</sup> OTC toothpastes were not specified in the survey so dentists may also recommended OTC toothpastes focusing on desensitization, sometimes a symptom of ETW.

OTC mouthwashes such as ACT (Chattem, Chattanooga, TN) can be utilized as part of a protocol to neutralize acid exposure and then shift the balance to remineralization, but are not frequently recommended by the surveyed population.<sup>34</sup> As specifics were not given regarding the OTC mouthwashes, Biotene (GlaxoSmithKline, RTP, NC) or Boost (Oral BioTech, Albany, OR), mouth lubricating mouthwashes may also be options that were recommend to patients. They help to fight xerostomia which may exacerbate ETW.

Bonding agents, especially filled dentin adhesives should be an effective short term dentin protection and can be reapplied as needed.<sup>34,43,54</sup> Forty six and one tenth percent of the surveyed dentists utilize bonding agents as a preventive method but it decreases as a desired treatment as the severity of erosion increases. Sabahipour's survey of prosthodontists in the UK and overseas showed prosthodontists are most likely to cover erosive lesions with bonding agents and prescribe a fluoride mouthwash as a preventive treatment.<sup>47</sup>

Hygiene instructions, which over 75% of the surveyed providers report they use for the prevention of erosion, need to be specific and not the basic instructions given on frequency and technique of brushing and flossing. It is impossible to determine from this survey if dentists are giving the appropriate hygiene instructions regarding erosion. Specifically, patients should be instructed to rinse immediately with water or sodium bicarbonate after an acid challenge, delay brushing until 30 minutes after an acid challenge, and utilize a fluoride mouthwash.<sup>34,54</sup>

About 40% of the surveyed providers recommend xylitol gum to their patients to help prevent erosion. While xylitol gum or any chewing gum as a method to increase salivary flow to clear the acid is suggested by some authors, others do not recommend chewing gum as a preventive technique. There may exist an increased risk of abrasion to the acid challenged tooth surface from the tongue and buccal tissues during the gum chewing.<sup>8 10,54</sup> If enamel is still present then recommending xylitol gum may not be a bad preventive technique, but should be used with caution as dentin exposure increases.

Sixty three percent of the surveyed dentists use an occlusal guard as a preventive measure for erosion. This method should be used if signs of parafunctional wear are present not solely erosion.<sup>34,54</sup> ETW is multifactorial and the presence of acid can potentiate abrasion and attrition.<sup>10,29</sup> The use of an occlusal guard as a preventive treatment for erosion again returns to the realization that while the surveyed population is poor at identifying erosion but better at identifying ETW. As ETW is multifactorial, treating ETW with an occlusal guard to reduce abrasion and abfraction is not wrong but is not specifically targeting the erosive etiology.

Preventive techniques, while theoretically good have not been proven effective at stopping ETW *in vivo*. The key to prevention of ETW is early diagnosis and identification of the etiologic agent.<sup>20,29,54</sup> In a review of the literature Holbrook et al found that clinicians have a hard time classifying erosion severity especially when looking at exposed dentin so catching erosion early can be difficult.<sup>39</sup> The goal of preventive treatment for ETW should be the reduction in acid exposure, the reduction of abrasion, and the increase in remineralization.<sup>29,34,54,60</sup>

### ***Restorative Treatment***

With the high use of occlusal guards (27% mild, 51% moderate, 46% severe) as a restorative treatment it can be inferred that providers either are treating erosion as parafunctional wear or they are recognizing the multifactorial nature of erosive tooth wear and are trying to address various possible etiologies. Due to the lack of use of diet analyses, the former would be indicated. Additionally, the inability to correctly identify the clinical signs of erosion leads to the belief that providers are attributing the ETW to attrition specifically parafunction. Dental erosion does weaken the teeth through demineralization and then permits greater damage to occur when parafunctional habits such as bruxing or clenching occur or when abrasion is present through tooth brushing or opposing porcelain surfaces.<sup>9</sup> It seems that the confusion over the multifactorial nature of erosion is not unique to the surveyed providers. In Dugmore's study a hard toothbrush was attributed as a cause of erosion in 9% of the surveyed dentists.<sup>18</sup> While occlusal guards may be a reasonable treatment for some erosive tooth wear, their frequent use as a preventive and treatment measure gives support to Bartlett's theory that US dentists attribute ETW to attrition and parafunctional habits.<sup>15</sup>

Restorative treatments need to be focused on additive techniques and early conservative intervention. Composite resins, glass ionomers or resin modified glass ionomers are best indicated for mild to moderate ETW.<sup>29</sup>

Onlays, in particular ceramic bonded onlays, should be considered more than they are used by the surveyed providers; 53% do not use onlays as a restorative treatment option. Onlays are a conservative method to add to a tooth without destroying as much of the remaining healthy tooth structure. Providers may be hesitant to treat patient with onlays, only 16.7% use in the case of severe erosion, because it is not a commonly taught procedure in dental school and may be more technically involved than a full crown preparation.

Full coverage restorations may do more harm than good depending on how much tooth structure is removed. In severe cases of ETW, the occlusal vertical dimension may need to be increased and full coverage may be the only treatment available, though again onlays may be a reasonable alternative or even direct composite restorations.<sup>29,61</sup> Full coverage is used by over 58% of the surveyed dentists when severe erosion is identified possibly due to the loss of vertical dimension and due to familiarity with the needed preparation.

### ***Etiologic Factors***

Etiologic factors contributing to erosion were not narrowly defined in this survey. A wide range of erosive potential can exist for several of them. Tea for example can be neutral such as in the case of chamomile or highly acidic and having a high erosive potential when citrus fruits are part of it.<sup>62-64</sup> An increased risk of erosion is different than a low or acidic pH; coffee and beer while acidic do not seem to have an increased erosive potential.<sup>63,65</sup>

Also, it must be remembered that the presence of an etiologic risk factor alone does not mean erosion will occur.

Diet soda (75.7%) was selected less than regular soda (83%) as an etiologic in this study. Diet sodas are just as likely to cause erosion as regular sodas.<sup>66</sup> While patients switch to diet beverages believing they are making a positive change for their teeth and diet, their frequency of consumption may be greater leading to an increased risk of erosion. Jarvinen saw an increased risk of erosion if more than 4-6 soft drinks were consumed weekly.<sup>30</sup>

Unlike dentists in Dugmore's study, in this study GERD (87%), anorexia and bulimia (88.3%) are well recognized by study participants as etiologic factors of erosion.<sup>18,20</sup> Dugmore's providers, while also general dentists, were asked to consider erosion specifically in their 12 year old patients. Mulic's survey of Norwegian dentists showed that GERD, anorexia and bulimia were considered uncommon (8%) causes of erosion, while consumption carbonated beverages [sodas] were the most common cause.<sup>48</sup> Mulic's patient population was 18-30 year olds. This is the population usually considered at risk for anorexia and bulimia, especially in females. Jarvinen et al showed an increased risk of erosion from 10 times greater if heartburn and other gastric symptoms occurred at least weekly and if vomiting occurred at least weekly there was a 31 times greater risk of erosion.<sup>30</sup> These differences in opinions seem to support the differences that Bartlett spoke of between European and American dentists as to the cause of ETW. Even when considering erosion specifically the surveyed dentists were more certain of the intrinsic sources of erosion while their European counterparts more often identify extrinsic sources.

Frequent consumption of sports drinks are a possible etiologic agent of erosion due to them containing citric acid.<sup>24,67</sup> Only 65% of the surveyed dentists considered sports drinks

an etiologic risk for erosion. Jarvinen determined weekly consumption of sports drinks to increase the risk of erosion.<sup>30</sup> Teenage boys are the most common population effected by erosion due to high sport drink consumption and should be counseled on the risk of frequent consumption.<sup>34</sup>

Seventy four percent of the surveyed dentists agreed fruit juice is an erosive etiologic factor. Multiple studies agree with this as a risk factor.<sup>4,20,63,68-70</sup> Fruit juice consumption was shown by Okunseri et al to increase the risk for ETW.<sup>71</sup> Frequency of apple juice gave the highest risk of ETW.<sup>71</sup>

A vegetarian diet may possibly cause erosion. Linkosalo found vegetarians to have a significantly higher prevalence of erosion than non-vegetarians.<sup>72</sup> Herman et al observed a slight increase in the ETW of those following a vegetarian diet but it was not statistically significant.<sup>73</sup> Al-Dlaigan et al saw no difference in the prevalence of erosion between vegetarian and non-vegetarian teenagers.<sup>74</sup>

Fruits were only considered by the study population to be possible etiologic agents of erosion 60% of the time. This observation may be due to a definition of fruits that is too broad and inclusive. Citrus fruits are much more likely to be considered erosive due to the presence of citric acid, but apples, pears and plums may be forgotten.<sup>25</sup> Consumption of citrus fruits more frequently than twice a day was found by Jarvinen to increase the risk of erosion.<sup>30</sup> The frequency of consumption is not the sole risk factor, but the method of consumption, mulling or sucking of fruits and frequency can also increase the erosive potential.<sup>20,25</sup>

White wine has a greater erosive potential than red wine though the surveyed population finds them to be equally likely (34%) to be a cause of erosion.<sup>75,76</sup> Case studies

with wine tasters show severe erosion, especially because they swish the wine as part of their job.<sup>77</sup> Beer, while acidic has a low erosive potential so is not considered an etiologic factor for erosion.<sup>65</sup> The surveyed 16% who consider beer a risk factor may be considering the addition of citrus fruits to beers like an orange slice to Blue Moon (Coors, Golden, CO) or a lime wedge to Corona (Amheuser-Busch inBev, Leuvenm, Belgium).

Hard candies and mints do not necessarily cause erosion but there is an increased popularity in sour candies such as jaw breakers which are erosive.<sup>78,79</sup> This fact may account for the 34% of surveyed dentists who consider hard candies and mints a possible etiologic agent of erosion.

Unflavored carbonated water does not seem to have an erosive impact on the dentition, but again if flavors are added especially with citric acid the erosive potential of the beverage increases.<sup>63,70,80,81</sup> This may be what the 32.8% are considering.

Dehydration (28%) and xerostomia (50%) increase the risk of erosion by two methods, by decreasing the salivary flow rate and allowing whatever beverages and food that are consumed to have a greater impact on the dentition. Jarvinen et al found that if subjects had a low unstimulated salivary flow rate they had a higher risk of erosion even if they do not have a high number of acidic challenges.<sup>30</sup>

In general it is not enough to just assume a food or drink will be erosive due to its pH. It is a good starting place but does not accurately reflect the damage that it may inflict on tooth structure.<sup>63</sup> Yogurt, though acidic does not have a high erosive potential attributed to its high calcium and phosphate content.<sup>63,82</sup> Lussi et al conducted a study on the erosive effects of various foods, drinks and medications; they showed that pH, buffering capacity, fluoride concentration, calcium concentration and the level of hydroxyapatite and



fluoroapatite all contribute to the erosive potential.<sup>63</sup> The frequency and method of consumption of food or beverage must also be considered as it can impact the erosive potential too.<sup>19,67</sup> It is also important to remember as Bartlett points out that most studies linking dietary acids and erosion are laboratory or associative epidemiological studies, causal relationships are much harder to prove.<sup>14</sup> Most studies on dietary acids also rely on the subjects self-reporting and recollection of what food and drinks they have consumed.

Competitive or frequent swimming may cause erosion though only 38% of the surveyed population considered this a possible etiologic agent. This is often seen in case reports of patients who undergo rapid loss of tooth structure.<sup>83,84</sup> The frequency and duration of the swimming and the pH of the swimming pool are the main factors determining if dental erosion is seen in the patient.

Further surveys could address a more representative geographical sample of the American dentist population, or could see if providers record the progression of erosion and even what is taught in the North American Dental School curriculums.

## **Conclusions:**

- Dentists do not appear to know the signs of erosion but think they do.
- Reported erosion (ETW) is frequent.
- Dietary analysis is underutilized.
- American dentists do appear to treat erosion as a parafunctional wear with occlusal guards and full coverage restorations.

Table 5: Survey Respondent Demographics

	<b>Annual Dental Review n= 69</b>	<b>North Carolina n=744</b>	<b>US Navy n=145</b>	<b>Total n=958 (%)</b>
<b>Years of Practice</b>				
<i>0-10</i>	10	154	73	237 (24.7)
<i>11-20</i>	17	157	24	198 (20.7)
<i>21-30</i>	15	192	23	230 (24.0)
<i>&gt;30</i>	26	228	18	272 (28.4)
<i>No answer</i>	1	13	7	21 (2.2)
<b>Currently practicing dentistry</b>				
<i>yes</i>	66	702	126	894 (93.3)
<i>no</i>	3	16	15	34 (3.5)
<i>No answer</i>	0	26	4	30 (3.1)
<b>Specialty</b>				
<i>General Dentistry</i>	64	724	99	887 (92.6)
<i>Orthodontics</i>	0	3	2	5 (.5)
<i>Periodontics</i>	1	1	4	6 (.6)
<i>Prosthodontics</i>	2	2	15	19 (2.0)
<i>Other</i>	2	5	16	23 (2.4)
<i>No answer</i>	0	9	9	18 (1.9)
<b>Gender</b>				
<i>Female</i>	13	183	34	230 (24.0)
<i>Male</i>	54	543	103	700 (73.1)
<i>No answer</i>	2	18	8	28 (2.9)
<b>Age</b>				
<i>25-35</i>	6	103	55	164 (17.1)
<i>36-45</i>	15	169	33	217 (22.7)
<i>46-55</i>	16	163	24	203 (21.2)
<i>&gt;55</i>	30	300	25	355 (37.1)
<i>&lt;25</i>	1	0	0	1 (.1)
<i>No answer</i>	1	9	8	18 (1.9)

Figure 1: Frequency of Dental Erosion (Erosive Tooth Wear)

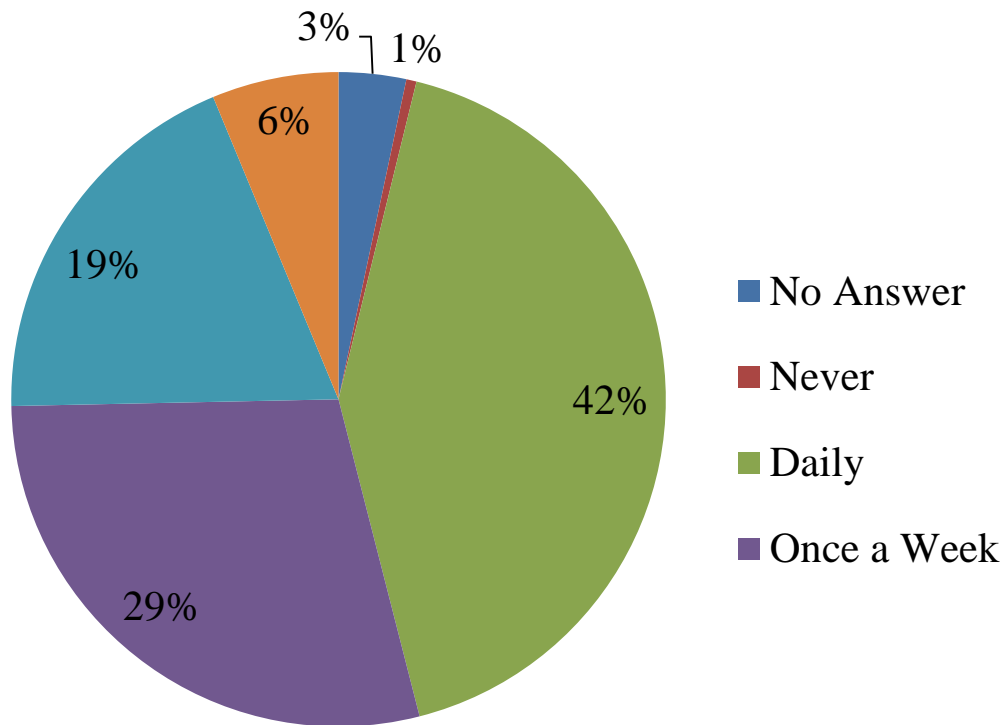


Figure 2: Diet Analysis Usage Frequency

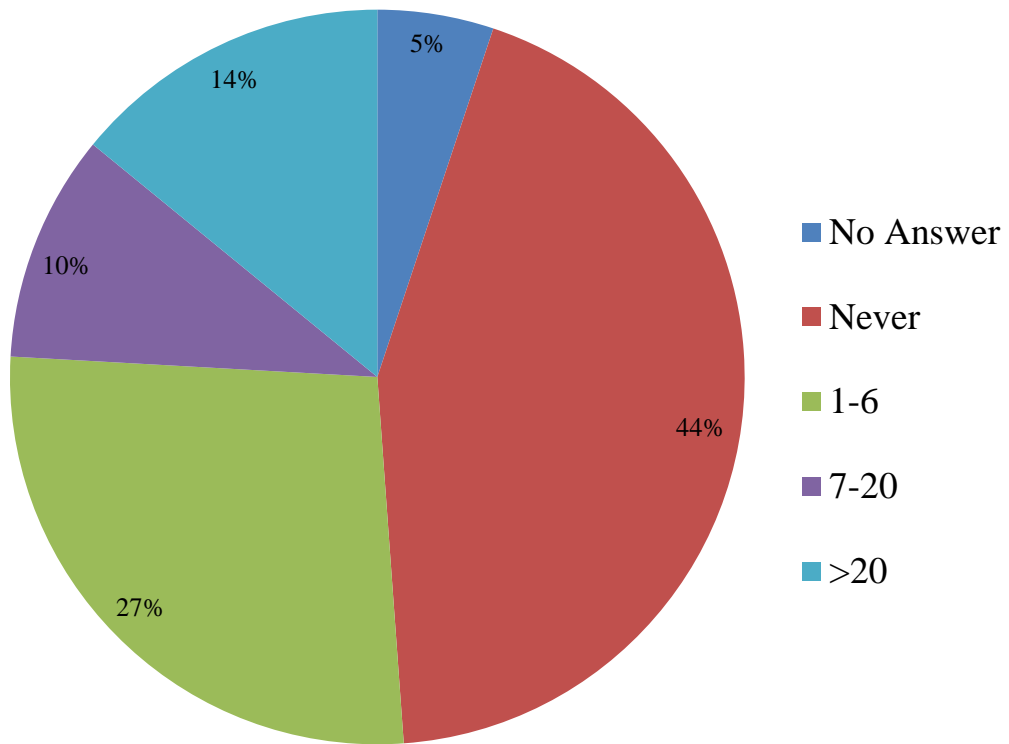


Figure 3: Primary Care Physician Referral

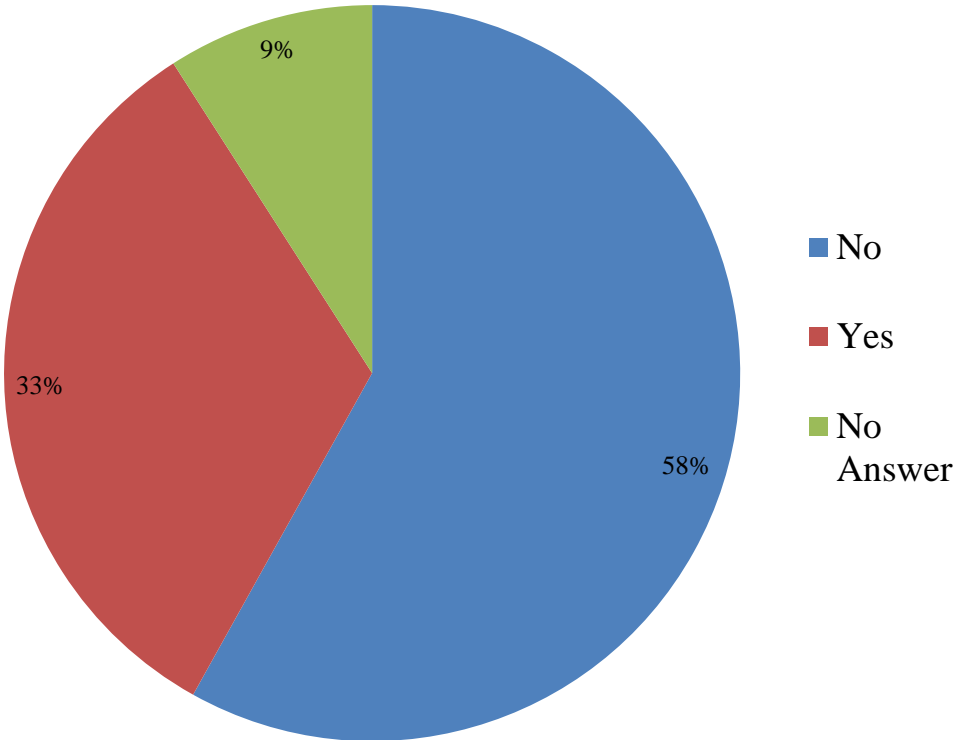


Figure 4: Correct Identification of Erosion as Respondents Needed to Select

11. Do you believe each of the following is an indicator of erosion?	<u>Yes</u>	<u>No</u>
a. Loss of enamel on the palatal of maxillary teeth	<input checked="" type="radio"/>	<input type="radio"/>
b. Wear of incisal edges of maxillary anterior teeth only	<input type="radio"/>	<input checked="" type="radio"/>
c. Wear of incisal edges of mandibular anterior teeth only	<input type="radio"/>	<input checked="" type="radio"/>
d. Restorations appearing higher than the level of the teeth	<input checked="" type="radio"/>	<input type="radio"/>
e. Loss of enamel characteristics, dull enamel surfaces	<input checked="" type="radio"/>	<input type="radio"/>
f. Cupping of incisal edges on incisors or cusp tips	<input checked="" type="radio"/>	<input type="radio"/>

Table 6: Confidence Level Discussing Erosion

<b>Please evaluate your agreement on the following statements</b>	<b>Yes (n=958)</b>	<b>%</b>
<i>I feel competent to recognize the clinical signs of dental erosion</i>	824	86
<i>I feel competent to treat patients whose loss of tooth structure has occurred from dental erosion</i>	736	76.8
<i>I feel competent discussing the dental erosion with my patients</i>	830	86.6
<i>I feel competent discussing the etiology of dental erosion with my patients</i>	776	81

Figure 5: Frequency of Preventive Measures for Mild Erosion

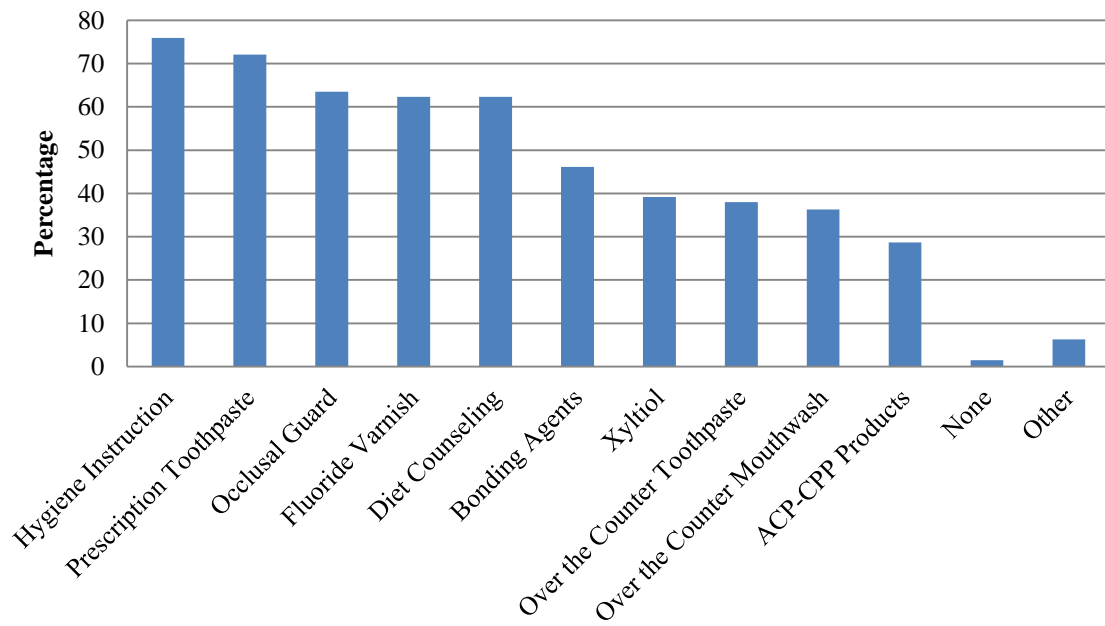




Table 7: Restorative Treatments Utilized by Respondents

	Bonding Agent %	Flowable Composite %	Glass Ionomer %	Resin Modified Glass Ionomer %	Onlay %	Full Coverage %	Occlusal Guard %
<i>Mild Erosion</i>	35.7	25.7	9.3	10.3	2.2	2.4	26.9
<i>Moderate Erosion</i>	23.6	40.9	24.1	28.9	6.7	12.2	51.1
<i>Severe Erosion</i>	11.6	19.1	17.2	22.9	16.7	58.2	45.8
<i>Do Not Use</i>	25.8	21.3	38.8	33.4	53.1	19.5	14.1

Figure 6: Positive Etiologic Agents Selected by Respondents as Positive Agents

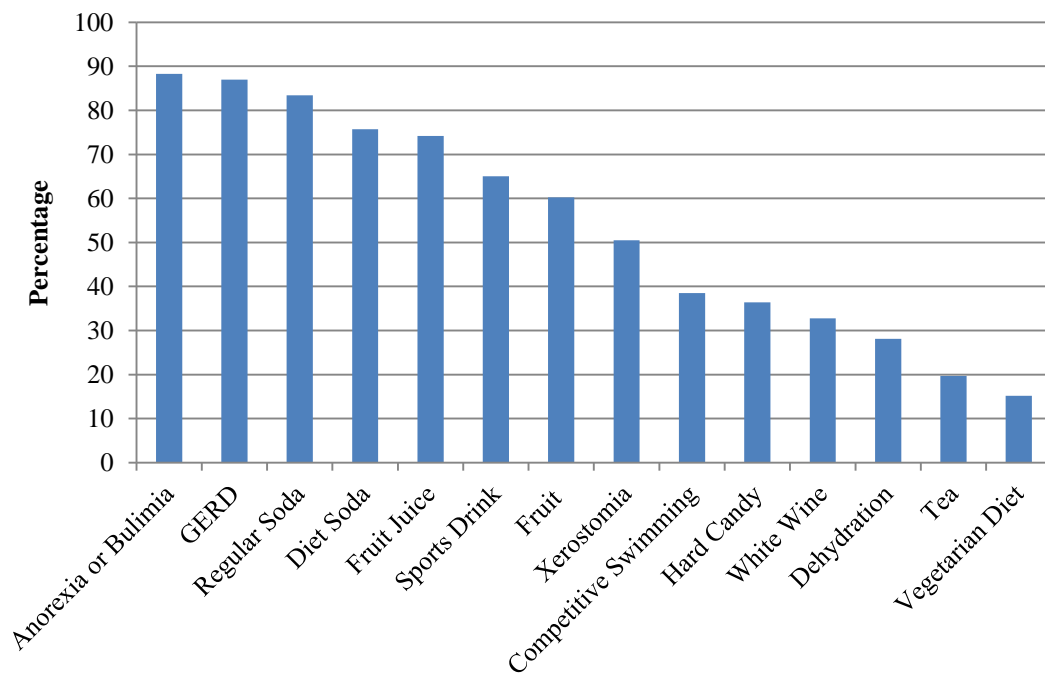
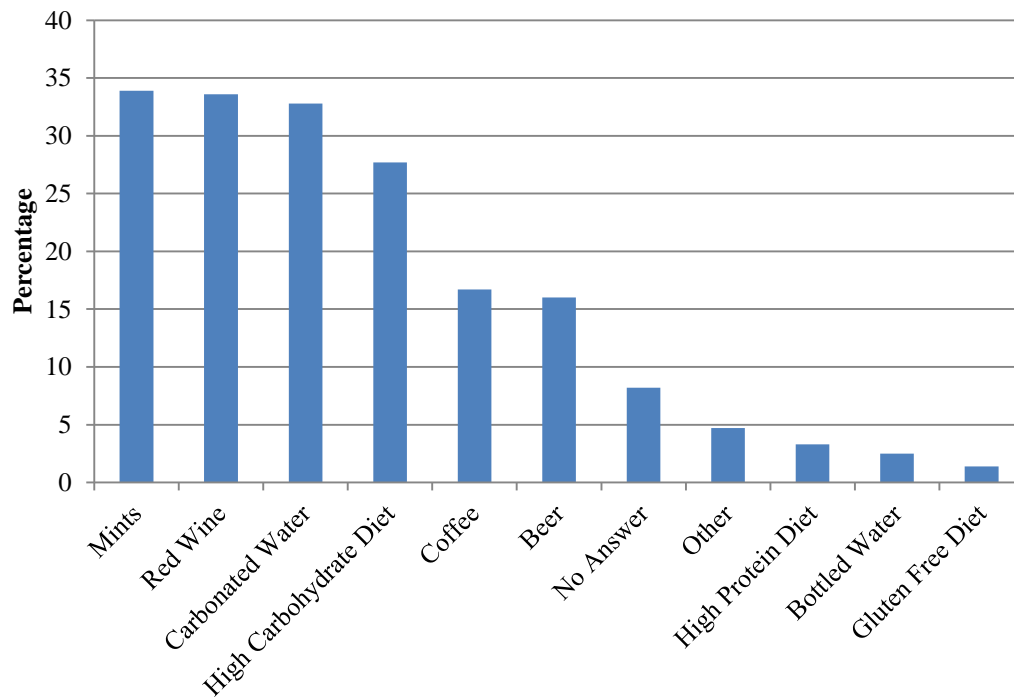


Figure 7: Negative Etiologic Agents Selected by Respondents as Positive Agents



## **Chapter II**

### **Gastroesophageal Reflux Disease and Erosive Tooth Wear**

#### **Introduction**

As seen in the previous chapter 95% of dental practitioners surveyed feel that gastroesophageal reflux disease (GERD) is an etiology for dental erosion. Studies show that erosion does not always occur in a patient though they may have a risk factor for it. There is a variable range in the prevalence/ frequency of erosion in the population. Seven to fifty-six percent of the population have been shown to have dental erosion in the UK depending on an array of variables being used.<sup>11</sup> While the association between GERD and dental erosion has been shown to be plausible, the strength of the association is not clear.<sup>85,86</sup>

Pace et al conducted a systematic review “to assess the relationship between DE [dental erosion] and GERD.”<sup>49</sup> Their results showed a median prevalence of 24% erosion in GERD patients but with a range in prevalence from 5-47.5%. When looking at adult subjects with erosion there was a median prevalence of 32.5% of GERD. Pace et al concluded there was a strong association between GERD and dental erosion. The range of prevalence and strength of association between GERD and dental erosion can be attributed to a number of variables. First, the diagnostic method used to determine if a subject has GERD may vary. Symptoms, endoscopy or 24-hour pH manometry all may be used. Second, the tooth wear index being used to measure the erosion or erosive tooth wear (ETW) present may vary. Also to be considered is the age of the study population; many erosion studies are conducted on children or adolescents which may not accurately reflect the prevalence of erosion in an adult population.

The majority of studies on erosion have been conducted outside of North America. As discussed in the previous chapter studies on tooth wear in the US have focused on attrition and abrasion.<sup>15</sup> Prevalence studies on erosion are beginning to be seen in the US but as the US covers such a large geography and diverse population, variations in the prevalence of erosion may be greater within the US.

### ***Gastroesophageal Reflux Disease***

GERD as defined by the Montreal consensus is “a condition which develops when the reflux of stomach contents causes troublesome symptoms and/or complications.”<sup>87</sup> While symptoms and complications from GERD such as heartburn, esophageal stricture, bleeding, and Barrett’s esophagus are commonly cited, less likely to be mentioned is dental erosion.<sup>88</sup> Silent GERD is the absence of heartburn symptoms in a patient who actually has reflux. In silent GERD atypical symptoms can present such as hoarseness, throat problems, respiratory issues and dental erosion, all of which may not lead to diagnosis of the disease.<sup>89,90</sup>

Over 15 million Americans experience heartburn symptoms each day and 10-20% of the US adult population is affected by GERD.<sup>91</sup> Dental erosion due to GERD is an etiology that seems likely but is still relatively unknown to the general medical and dental practitioner.<sup>88,92</sup>

The purpose of this study was to determine the prevalence of ETW in GERD subjects compared to that in a control population. The association between the number of acidic challenges, number of medications, age, salivary flow rate, initial salivary pH and salivary buffering capacity and the erosive wear present will also be examined.

The null hypotheses tested in this study were that (1) there was no difference in prevalence of ETW as measured by the Basic Erosive Wear Exam (BEWE) between the

GERD subjects and the control and (2) there was no association between the selected factors and the ETW present.

## **MATERIALS AND METHODS:**

This cross sectional study was to determine the prevalence of dental erosion in a population diagnosed with GERD and a control population. Subjects' dentition's were examined using the BEWE. They provided a stimulated salivary sample and took home a diet diary to complete.

The research protocol was reviewed and approved by the University of North Carolina (UNC) Biomedical Institutional Review Board (IRB, study #11-2327).

### ***Subject Selection***

Subjects were recruited from the Center for Esophageal Disease and Swallowing, University of North Carolina Hospital Division of Gastroenterology and Hepatology and the University of North Carolina at Chapel Hill School of Dentistry Operative Dentistry Clinic. Subjects were asked to participate in the study if they were positively diagnosed with GERD or no had history of GERD (control).

### ***Inclusion Criteria***

- Adults (18 – 85 years old)
- Two natural teeth per sextant (12 teeth total)
- Diagnosis of GERD or no history of GERD (control)

### ***Exclusion Criteria***

- Inability to speak or understand English

-History of anorexia or bulimia

-Greater than 85 years old

A total of 22 subjects with GERD and 22 control subjects were desired in the study.

Sample size calculations were calculated with  $\alpha=.05$  and power= 0.8, assuming the proportion of dental erosion in the GERD population to be 0.4 and the proportion of dental erosion in the control group to be 0.05.

Descriptions of the specific tests follow.

### ***Basic Erosive Wear Exam (BEWE)***

Each patient was examined by the primary investigator (KEE) using the BEWE. The BEWE was developed by Bartlett et al.<sup>41</sup> It was developed to be a quick screening method to determine the erosive wear present on the dentition. The mouth is divided into sextants and the tooth with the greatest wear is rated in each sextant. Scoring is from 0-3. A cumulative score is calculated and the subject is assigned a risk category for erosive wear.

See Table 4: Basic Erosive Wear Exam Scoring Definitions and Risk Levels

### ***Stimulated Salivary Sample***

Subjects were asked to chew on a paraffin wax tablet for 5 minutes. Rather than swallowing the generated saliva it was expectorated and collected in a sterile container. The samples were labeled with the subject's unique numerical identifier and stored on ice for transportation to the Oral Microbiology Lab at the UNC School of Dentistry. Initial pH, salivary buffering capacity and salivary flow rate were determined by the lab. Salivary buffering capacity was determined by the saliva being diluted four-fold in 0.0005N HCl and the final pH recorded after ten minutes. A pH value of 5.0 or greater was considered normal,

4.1-4.9 is moderate risk, and less than 4.0 is high risk. All samples were destroyed after testing. See Table 8: Salivary Risk Categories

### ***Dietary Analysis***

Subjects were given a diet diary to take home and record all food, drink and medications consumed during the next Thursday through Sunday period. Instructions were reviewed with the subjects and a sample sheet was included on their diet diary; a stamped addressed envelope was given to the subjects to return the diaries to the primary investigator (KEE). The subject's unique numerical identifier was placed on the diet diary. If the diary was returned with the subject's name on it the sheet was removed and shredded. Daily acidic challenges were counted. If the subject was ambiguous to the specifics of a potential acidic food or drink (eg tea v chamomile tea) the decision was made to assume it was acidic. The average daily number of acidic challenges was calculated for each subject. If subjects had not returned the diet diary after 3 weeks, a reminder letter, new diet diary and postage paid return envelope was sent to the participant. If still after an additional 3 weeks no diet diary was received a final reminder, diet diary and envelope were sent.

### ***Statistical Analysis***

Frequency and bivariate analysis were performed. A logistic regression was performed to identify significant explanatory variables for the outcome of BEWE adjusting for group. A forward selection was used with an entry at a significant level .05. All analyses were performed using SAS 9.2 software (SAS Institute, Cary, NC).



## Results

A total of 67 subjects were recruited to participate in the study. Eleven subjects did not follow through with any portion of the exam. The remaining 56 completed the exam and salivary sample. Forty nine out of the 56 returned their diet analysis (25 GERD and 24 controls). Table 9: Bivariate Results

The prevalence of ETW in GERD subjects is not statistically different from the prevalence of erosion in the control subjects. 40% of the GERD subjects were at medium risk for ETW as compared to 15.4% of the control subjects. 50% of the GERD subjects were at low risk as compared to 73.1% of the control subjects.

The association of selected factors and ETW was only statistically significant for age. Table 10 Logistic Regression

## Discussion

The prevalence rate found 40% of the GERD subjects to be at moderate risk of ETW versus 15.4% of the control subjects. This difference is not statistically significant. The sample size of this study was small and may contribute to the prevalence rate not being statistically significant.

This prevalence is only truly applicable to the region studied; subjects came from North Carolina, South Carolina and Virginia and were all adults. Children prevalence studies exhibit a great range in prevalence 14-87% in Pace's systematic review but this 40% prevalence falls into Pace's range of prevalence in adult studies.<sup>49</sup>

Table 11 Prevalence of dental erosions in adults with GERD

Differences in the observed prevalence and prevalence in previous studies may be due to the difference in methods being utilized to diagnosis GERD. This study used subjects who had been diagnosed with GERD through either a positive endoscopy or positive 24 hr pH manometry (monitoring).

Differences in the observed prevalence and in previous studies may also be due to the different wear indices being used. Though all have similar methods of evaluating wear, the differences between them may increase the difficulty of comparing the results. The BEWE is a newer exam and while its validity and sensitivity and specificity have been tested, there exist very few published studies using it as a tooth wear index.<sup>38,40,93</sup>

Only one examiner (KEE) performed the BEWE so in addition to possible bias from this and not being blinded to the subject populations that were being examined there was also a learning curve on the exam. As tooth surface area increased such as from recession, more surface area is exposed, such as the root surfaces, so the amount of tooth loss may decrease overall. The BEWE is based on the percentage of surface area worn and molar cervical wear may give a higher score than localized incisal wear. The exam was also performed under less than ideal conditions on the most of the GERD subjects. There was no air/ water syringe, only drying of the teeth with gauze, and the patients were in office chairs not dental exam chairs so lighting was not ideal. This may have led to difficulty assessing enamel versus dentin wear and could have led to underestimating the ETW present.

Some subjects only posterior uncrowned teeth were second or third molars, which can be difficult to assess when not in a dental chair. High numbers of full coverage restorations were seen in the GERD population on some subjects. This suggests they may have had ETW

in the past but have already had those teeth restored, leading to an underestimation of the ETW present, as the healthiest least damaged teeth remain unrestored in the mouth.

A higher prevalence of ETW may have been seen in the control population perhaps due to the fact this population was recruited from patients in a restorative dental clinic in a dental school. These patients have active treatment needs, so may overestimate the ETW actually seen in the general population.

The number of medications was significantly higher in the GERD population. This may be because the subjects were recruited from a GI clinic so they may have more medical issues than simply GERD.

The number of acidic challenges was significantly higher in the control population. Accuracy in self-reporting of diets is always questionable especially as patients knew the purpose of the study so they may have adjusted their diet during the days they recorded. Though the differences in acidic diets can also be attributed to the fact that many foods that may be acidic are eliminated from the diet of subjects with GERD because they may trigger reflux episodes and they have already adjusted their diets. An acidic challenge does not equal a food or beverage having a high erosive potential. Beer, coffee and yogurt are all acidic but do not high have a high erosive potential, so while they were counted in this study as an acidic challenge they should not increase the ETW present.<sup>22,65</sup> The method of consumption is also key to increasing the erosive potential of acidic food and from the diet diary it cannot be assessed, a detailed in person review of a diet diary is required to determine any consumption habits.

The buffering capacity of saliva shows how quickly acid in the mouth can be neutralized. There were no statistically significant differences between GERD and control

subjects buffering capacity in this study. In other studies no statistically significant difference was found but a lower median buffering capacity was found by Moazzez et al in the UK and Meurman in Finland.<sup>94,95</sup> Buffering capacity statistically differed though with subjects with GERD in Iceland.<sup>96</sup>

Stimulated salivary flow rate did not differ significantly between GERD subjects and control subjects. Similar results were found by Schroeder et al in Alabama, Meurman in Finland, and Gudmundsson in Iceland.<sup>95-97</sup> Yoshikawa though found low salivary flow in GERD patients with ETW.<sup>98</sup> Jarvinen also found an increased risk of ETW when a subject had a low salivary flow rate but he was looking at the unstimulated salivary flow rate.<sup>30</sup> Stimulated saliva controls the clearance of acid from the mouth and can be standardized more easily than unstimulated salivary tests. Food and beverage consumption within hours of a salivary test may alter the flow rate of an unstimulated sample, as will the time of day the sample is collected.

Initial salivary pH did not fall below 6.7, the critical pH of cementum and root dentin. This indicates that the subjects are not at a risk for their saliva to cause damage to the tooth unless an acid is added.

The only association seen between variables and BEWE score was age; as age increased so did the BEWE. Van't Spijker's systematic review of the prevalence of tooth wear concluded the same; tooth wear increases with age.<sup>99</sup> The most likely etiology of this ETW related to age is attrition due to tooth to tooth wear of the dentition.

## **Conclusion**

- GERD patients have a higher prevalence of ETW though not statistically significant.
- The influence of other factors on this increased risk is unclear, and further studies are still needed to determine which factors increase a GERD patient's risk of erosion.

Table 4: Basic Erosive Wear Exam Scoring Definitions and Risk Levels

<b>Score</b>	
0	No erosive tooth wear
1	Initial loss of surface texture
2	Distinct defect, hard tissue loss, 50% of surface area
3	Hard tissue loss >50% of the surface area
<b>Risk Level</b>	
<b>Cumulative score of all sextants</b>	
None	Less than or equal to 2
Low	Between 3 and 8
Medium	Between 9 and 13
High	14 and over

Table 8: Salivary Risk Categories

	<b>Normal</b>	<b>Intermediate Risk</b>	<b>High Risk</b>
Flow Rate per Minute	1-2 mL	<b>0.7 mL or less</b>	0.1mL or less= Xerostomia
Buffering Capacity – Final pH	5.0-7.0	4.0-4.9	Below 4.0

Table 9: Bivariate Results

	GERD ( N=30)	CONTROL (N=26)	p
Female	19 (63.3%)	13 (50%)	
Male	11 (36.7%)	13 (50%)	
Mean age (std) missing = 3	52.4 ± 12.8	47.2 ± 15.2	0.17
Medications missing= 5	5 (16.7%)	11 (42.3%)	0.01*
0	8 (26.7%)	11 (42.3%)	
1-3	12 (40%)	4 (15.4%)	
>3			
BEWE Risk			0.11
None	3 (10%)	3 (11.5%)	
Low	15 (50%)	19 (73.1%)	
Medium	12 (40%)	4 (15.4%)	
Acidic challenges missing = 7	5 (20%)	1 (4.2%)	0.01*
<2	5 (20%)	1 (4.2%)	
2-3	15 (15%)	22 (91.7%)	
≥3			
Buffering capacity risk missing = 2	14 (50%)	12 (46.2%)	0.73
Normal	3 (10.7%)	7 (26.9%)	
Medium Risk	11 (39.3%)	7 (26.9%)	
High Risk			
Salivary flow rate risk	24 (80%)	23 (88.5%)	0.39
	6 (20%)	3 (11.5%)	
Normal			
Medium or			
High			

\* &lt;.05 statistically significant



Table 10: Logistic Regression

	<b>Variable</b>	<b>OR</b>	<b>95% C.I.</b>	<b>X<sup>2</sup>statistic</b>	<b>DF</b>	<b>p</b>
Group	GERD v Control	2.51	(0.57, 11.15)	1.46	1	0.22
(centered)	Age	1.08	(1.02, 1.12)	6.01	1	<0.01*

\* <.05 statistically significant

Table 11: Prevalence of Dental Erosion in Adults with GERD

<b>Study</b>	<b># of patients with GERD</b>	<b>GERD diagnostic method</b>	<b>Index</b>	<b>Location</b>	<b>Prevalence (%)</b>
Meurman	117	Endoscopy and or 24 pH monitoring	Eccles and Jenkins	Finland	24
Jarvinen	20	Endoscopy	Eccles and Jenkins	Finland	20
Moazzez	144	Manometry and 24h pH tests	Smith and Knight TWI	UK	?
Munoz	181	Endoscopy and or 24 pH monitoring	Modified Eccles and Jenkins	Spain	47.5
Oginni	125	Symptoms	Smith and Knight TWI	Nigeria	16
Schroeder	30	24h pH monitoring	Eccles and Jenkins	US (Alabama)	40
Yoshikawa	40	Symptoms and endoscopy	Modified Smith and Knight TWI	Japan	24.3

# Appendix A

**UNC SCHOOL OF DENTISTRY**  
**Department of Operative Dentistry**

## DENTAL EROSION SURVEY

ID #:

**INSTRUCTIONS:** Fill in circles completely using a **BLACK BALLPOINT PEN**. Choose only ONE response per question unless otherwise directed. Thank you for your participation.

1. Did you attend the Annual Dental Review, June 14-16, 2012 in Myrtle Beach, SC? ☐ Yes ☐ No

2. Are you a practicing dentist? ☐ Yes ☐ No

3. How many years have you been practicing dentistry? ☐ 0 to 10 ☐ 11 to 20 ☐ 21 to 30 ☐ more than 30

4. What is your gender? ☐ Female ☐ Male

5. How old are you? ☐ 26 to 35 ☐ 36 to 45 ☐ 46 to 55 ☐ over 55

6. What is your specialty in the dental field?

- ☐ General dentistry ☐ Orthodontics ☐ Periodontics ☐ Prosthodontics  
☐ Other (please specify) \_\_\_\_\_

7. How often in the past year have you encountered a patient with dental erosion (erosive tooth wear) in your practice?

- ☐ Never ☐ Daily ☐ Once a week ☐ Once a month ☐ Once every 6 months ☐ Once a year

8. For approximately how many patients have you done a diet analysis in the past year?

- ☐ Never ☐ 1-6 times / year ☐ 7-20 times / year ☐ More than 20 times / year

9. Which of the following preventive measures have you used in the past 12 months on patients with mild dental erosion? Select **ALL** that apply.

- ☐ Xylitol (Gum or Candy) ☐ Fluoride Varnish ☐ Over the Counter Toothpaste ☐ Prescription Fluoride Toothpaste  
☐ Over the Counter Mouthwash ☐ ACP-CPP Products ☐ Bonding Agents ☐ Occlusal Guard  
☐ Hygiene Instruction ☐ Diet Counseling ☐ None  
☐ Other (please specify) \_\_\_\_\_

10. In the past year have you referred a patient to their primary care physician due to the erosion (erosive tooth wear) you saw on their dentition?

- ☐ Yes ☐ No

11. Which of the following materials have you used for patients with dental erosion in the past 12 months?

	Mild Erosion	Moderate Erosion	Severe Erosion	Not Used
a. Bonding agent	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Flowable Composite	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Glass Ionomer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Resin Modified Glass Ionomer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Onlays	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Full Coverage Restoration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Occlusal Guard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Other (please specify) _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Revised 08/2012

## 12. Do you believe each of the following is an indicator of erosion?

Yes

No

a. Loss of enamel on the palatal of maxillary teeth

☐☐

b. Wear of incisal edges of maxillary anterior teeth only

☐☐

c. Wear of incisal edges of mandibular anterior teeth only

☐☐

d. Restorations appearing higher than the level of the teeth

☐☐

e. Loss of enamel characteristics, dull enamel surfaces

☐☐

f. Cupping of incisal edges on incisors or cusp tips

☐☐

## 13. Please evaluate your agreement on the following statements.

Agree

Disagree

a. I feel competent to recognize the clinical signs of dental erosion.

☐☐

b. I feel competent to treat patients whose loss of tooth structure has occurred from dental erosion.

☐☐

c. I feel competent discussing the dental erosion with my patients.

☐☐

d. I feel competent discussing the etiology of dental erosion with my patients.

☐☐14. Which of the following do you consider to be etiologic agents for erosion? Select **ALL** that apply.☐ Regular soda☐ Fruit juice☐ Sport drinks☐ Bottled water☐ White wine☐ Diet soda☐ Red wine☐ Beer☐ Carbonated water☐ Tea☐ Coffee☐ High carbohydrate diet☐ Vegetarian diet☐ High protein diet☐ Gluten free diet☐ Hard candies☐ Fruit☐ Mints☐ Dehydration☐ Xerostomia☐ Anorexia or Bulimia☐ Gastroesophageal Reflux Disease (GERD)☐ Competitive swimming☐ Other (please specify) \_\_\_\_\_

Any comments:

THANK YOU FOR YOUR PARTICIPATION!

## Appendix B

ID \_\_\_\_\_

Department of Operative Dentistry  
UNC School of Dentistry at Chapel Hill  
4-Day Diet Analysis

### Instructions

Please write down everything you ingest (foods, snacks, beverages, medications), and the approximate amount in the appropriate time slot. Please see the last page for an example.

Record this information for 4 consecutive days from Thursday to Sunday.

Please complete and return this diet analysis to Dr. Kristi Erickson. A pre-addressed postage paid envelope has been provided for your convenience.





Thursday

TIME	FOOD ITEM	AMOUNT
Breakfast		
Morning		
Lunch		
Afternoon		
Dinner		
Evening		



Friday

TIME	FOOD ITEM	AMOUNT
Breakfast		
Morning		
Lunch		
Afternoon		
Dinner		
Evening		



Saturday

TIME	FOOD ITEM	AMOUNT
Breakfast		
Morning		
Lunch		
Afternoon		
Dinner		
Evening		





Sunday

TIME	FOOD ITEM	AMOUNT
Breakfast		
Morning		
Lunch		
Afternoon		
Dinner		
Evening		



### Example

TIME	FOOD ITEM	AMOUNT
Breakfast	Baby aspirin Orange juice Black coffee Toast and jam	1 pill 1 glass 2 cups 2 slices
Morning	Diet coke	12 oz. can
Lunch	Diet coke Cheezies Chocolate cake	12 oz. can Single bag 1 small piece
Afternoon	Water Candies	2 glasses 2 mints
Dinner	Steak Baked potato/butter & sour Cream Cream corn White Wine	12 oz. rib-eye 1  1 helping 1 glass
Evening	Rum & diet coke Popcorn/butter	1 glass 1 microwave pack

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