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ORAL HEALTH IN UNITED STATES MILITARY POPULATION DIAGNOSED
WITH GASTROESOPHAGEAL REFLUX DISEASE (GERD)

by

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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ABSTRACT

ORAL HEALTH IN UNITED STATES MILITARY POPULATION DIAGNOSED WITH GASTROESOPHAGEAL REFLUX DISEASE (GERD)

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Introduction: Gastroesophageal reflux disease (GERD), affecting 20% of adults in the United States (US), is a chronic disorder caused by retrograde movement of gastric acid into the esophagus and oral cavity. Following chronic exposure to gastric refluxate, dental erosion (DE) and changes in gingival health (GH) can occur. Currently, there are no studies evaluating DE and GH in a US military population diagnosed with GERD. The aim of this collaborative study was to perform a comprehensive medical and dental evaluation of active duty and retired US service members with GERD.

Methods: Six human subjects diagnosed with GERD were enrolled (IRB: WRNMMC-2019-0252). A questionnaire was used to obtain the subjects' date of GERD diagnosis, frequency of dental visits, and oral, dietary, and social habits. Dental examination was performed to record DE and GH, and gingival crevicular fluid (GCF) and saliva were collected for pH analysis.

Results: Utilizing the Eccles and Jenkins erosion scale, 50 teeth (65%) were Grade 0, 25 teeth (32.5%) were Grade 1, 2 teeth (2.5%) were Grade 2, and no teeth met criteria for Grade 3. Gingival Index scoring revealed 50 teeth (65%) as Grade 0, 16 teeth (20.7%) as Grade 1, 11 teeth (14.3%) as Grade 2, and no teeth as Grade 3. The average pH of GCF from teeth with DE was 6.82 ± 0.16 , and the average pH of unstimulated saliva from GERD subjects was 5.09 ± 0.55 .

Maxillary incisors and maxillary posterior teeth were the most common sites for DE and gingivitis, respectively.

Conclusion: Data suggests that our study population has comparable GH, marginally higher DE grading, and lower salivary pH when compared with a civilian population. Although the clinical impact deserves more exploration, our study is the first to report the pH of GCF in a GERD population.

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LIST OF ABBREVIATIONS

DE: Dental Erosion

GCF: Gingival Crevicular Fluid

GERD: Gastroesophageal Reflux Disease

GH: Gingival Health

CHAPTER 1: REVIEW OF THE LITERATURE

Gastroesophageal reflux disease (GERD) is a chronic disorder caused by the retrograde flow of gastric acid into the esophagus. The prevalence of GERD in the Western world population has been reported as a range of 10-20%.^(1,2) A systematic review reported prevalence estimates in specific areas of the world as follows: 18.1%-27.8% in North America, 23.0% in South America, 8.8%-25.9% in Europe, 8.7%-33.1% in the Middle East, 2.5%-7.8% in East Asia, and 11.6% in Australia.⁽³⁾

Recent literature has pointed out that teeth and oral structures continuously exposed to gastric refluxate are more likely to demonstrate dental erosion (DE) and changes in gingival health (GH).^(4,5) Mild to moderate oral complications associated with GERD include xerostomia, loss of taste, non-specific burning sensation, and erythema of the palatal mucosa. Less common, but more severe symptoms include mucosal ulceration and erosion, esophagitis, and the development of esophageal adenocarcinoma.⁽⁶⁾ The link between GERD and DE is related to the impact of reflux on oral pH. The critical pH of dental enamel is 5.5, as dissolution of hydroxyapatite crystals occurs more readily in an environment of sustained acidity.⁽⁷⁾ Gastric refluxate has a pH of less than 2; hence, demineralization of tooth structure and subsequent erosion is a possible consequence of chronic regurgitation.⁽⁸⁾ DE is defined as tooth surface loss as a result of a chemical process--not a bacteria-associated process.⁽⁹⁾ Chronic exposure to regurgitated acid can dissolve dental hard tissues, primarily affecting the palatal surfaces of maxillary teeth.⁽¹⁰⁾ Due to the lack of protection by major salivary glands and the tongue, palatal surfaces of maxillary teeth are first to be attacked by regurgitated acid. As the acid exposure time increases, DE on mandibular teeth, along with occlusal and buccal surfaces of all teeth, is more likely to manifest.⁽¹¹⁾

DE has a high frequency in patients with GERD and many studies with diverse populations suggest that the magnitude of erosion is linked to the severity of GERD. In a study comparing 60 GERD subjects to 60 healthy subjects, 78.7% of GERD subjects presented with DE, while DE was only present in 3.3% of healthy controls. The severity of DE was highly correlated with the severity of reflux.⁽¹²⁾ Additionally, a systematic review of 12 studies with 854 adult subjects showed a strong association between GERD and DE. The prevalence of DE in GERD patients ranged from 5-47.5%, while the prevalence of GERD in DE patients ranged from 21-83%. The magnitude of DE was proportional to severity of GERD symptoms and duration of exposure to gastric acid. The author suggested that an oral assessment for the presence of DE should be a part of the routine screening of GERD patients.⁽¹³⁾ In further support of the GERD-DE linkage, a cross-sectional study of 101 subjects evaluated the association between GERD and DE in a Chinese population. 31 of 51 (60.8%) participants with GERD had DE and 14 of 50 (28%) participants without GERD had DE. In addition to the significant association between GERD and DE, consumption of carbonated beverages was identified as an additional risk factor.⁽¹⁴⁾ In a study of a Nigerian population, the prevalence of DE was three times higher in GERD subjects (16%) as compared to non-GERD subjects (5%).⁽¹⁵⁾ An American longitudinal study measured tooth surface loss in 12 GERD subjects and 6 control subjects over six months, showing that the volume of tooth surface loss in subjects with GERD ($0.18 \text{ mm}^3/\text{tooth}$) was three times greater than control subjects ($0.06 \text{ mm}^3/\text{tooth}$).⁽¹⁶⁾ Given the volume and quality of publications from extremely diverse populations, there is indisputable evidence supporting the gastric refluxate of GERD as a contributing factor to the multifactorial etiology of DE.

While the evidence for the association between GERD and DE is strong, the link between GERD and GH is controversial. In a Korean cross-sectional study comparing 280 patients with chronic periodontitis to 280 healthy subjects, the authors declared that GERD may be an independent risk factor for periodontitis. GERD was also more prevalent in patients with chronic periodontitis (28.6%) than non-periodontitis patients (10%).⁽¹⁷⁾ However, other researchers have reported a lack of an association between GERD and periodontal health based upon findings of similar health between GERD and non-GERD subjects.⁽¹⁸⁾ Similarly, a Japanese study of 280 subjects found no significant difference in disease among GERD subjects with and without periodontitis (8.6% vs. 8.0% respectively).⁽¹⁹⁾ In addition to the competing reports on GERD and periodontal disease, other studies have reported a significant association between GERD and gingivitis in adult subjects.^(13,20)

The number of active duty service members in the United States was estimated at 1.3 million in 2017.⁽²¹⁾ According to data from the Department of Veterans Affairs in 2016, there were approximately 20.4 million veterans, representing 8% of the total US adult population.⁽²²⁾ There is an absence of research exploring the association of GERD with DE and GH in US military and veteran populations. In an effort to expand the body of literature, the aim of this study was to evaluate DE and GH in active duty service members and retirees diagnosed with GERD.

CHAPTER II: MATERIALS AND METHODS

This was a descriptive pilot study of US service members and retirees diagnosed with GERD at the Walter Reed National Military Medical Center by the Gastroenterology Department. (Institutional Review Board approved for human subject study - IIRB: WRNMMC-2019-0252). Data collection involved a one-time visit, approximately 60 minutes in duration, with no subsequent examinations or contact with the subject. Study subjects were GERD patients at the Gastroenterology Department clinic who were evaluated and referred to the Periodontics Department at the Naval Postgraduate Dental School dental screening and possible study enrollment.

A total of six subjects (5 men and 1 woman with the mean age of 54.7) were enrolled in the study over a period of six months. Inclusion criteria for study subjects were active duty or retired military status and an age range of 18-80 years. Additional inclusion criteria involved a minimum of eight maxillary teeth, to include four anterior and four posterior teeth.⁽²³⁾ Exclusion criteria was limited to severely medically compromised patients and those individuals who were unable to attend a one-hour dental screening appointment.

After the subjects provided written informed consent, they were asked to complete a Navy Standard Health Questionnaire form and survey to include the subjects' date of GERD diagnosis, occupation, frequency of dental visits, oral hygiene, dietary, and social habits. One individual examined all of the subjects and clinical examinations were completed with the aid of a light source, intraoral mirror, dental explorer and periodontal probe.

Oral examination for DE.

Oral examinations were carried out to quantify any loss of tooth structure using the Eccles and Jenkins erosion scale. Only palatal surfaces of maxillary teeth were examined. Maxillary teeth were scored between 0 and 3, where 0 represented no erosion and 3 represented

involvement of the dentin, with an exposure area more than one-third of the tooth surface.⁽²⁴⁾

Third molars, teeth with prosthetic crowns, onlays and/or implant restorations were excluded from the examination.⁽²³⁾

Oral examination for GH.

Gingival Index assessment included all teeth in both arches (with focus on maxillary teeth with DE). The Gingival Index was used as a tool for assessing gingival health. The index was scored between 0 and 3, where 0 represented normal, healthy gingiva and 3 represented severe gingival inflammation with spontaneous bleeding.⁽²⁵⁾

Table 1. Eccles and Jenkins Erosion Scale and Gingival Index.

System	Grade	Definition
Eccles and Jenkins erosion scale ⁽²⁴⁾	0	No involvement
	1	Loss of enamel surface. No involvement of the dentin
	2	Dentin exposure of less than one third of the tooth surface
	3	Dentin exposure of more than one third of the tooth surface
<hr/>		
Gingival Index ⁽²⁵⁾	0	Normal, healthy gingiva
	1	Mild gingival inflammation. No bleeding on probing.
	2	Moderate gingival inflammation. Bleeding on probing.
	3	Severe gingival inflammation. Spontaneous gingival bleeding.

Evaluation of pH for periodontal pockets and saliva.

Gingival crevicular fluid (GCF) and saliva were collected using GCF collecting paper tips (Periopaper®) from the surfaces of the maxillary teeth with erosion. Whole saliva was collected from submandibular ducts with GCF collecting paper tips. The paper tips were transferred to 1.8 ml Eppendorf tubes and placed in an icebox while in transit to the laboratory. The sample tubes were centrifuged to extract GCF and saliva from the GCF collecting paper tips. Micro pH electrodes (Orion 9810BN) were used to measure pH of GCF and saliva.

Data Collection and Statistical Analysis.

Data were recorded on a data collection form. Parameters recorded were: Eccles and Jenkins erosion grade, Gingival Index grade, and pH of saliva and GCF. Dental examination scores for erosion and Gingival Index were calculated by dividing the cumulative score of each category by the number of existing maxillary teeth in each subject. The averages for each of the two categories were calculated for assessment of a possible correlation.

CHAPTER III: RESULTS

The study population consisted of six GERD patients (5 males and 1 female with a mean age of 54.7). The patient demographics included two active duty service members and four retirees (1 Asian, 1 African American, and 4 Caucasians).

Table 2.

Subject Demographics					
Subject #	Age	Years with GERD	Gender	Race	Military Status
1	48	1	M	Asian	Active Duty
2	49	1	M	Caucasian	Active Duty
3	52	15	F	African American	Retired
4	60	1	M	Caucasian	Retired
5	51	11	M	Caucasian	Retired
6	68	25	M	Caucasian	Retired
Averages	54.7	9	--	--	--

All study subjects were diagnosed and undergoing treatment for GERD at the time of the evaluation (average year of treatment: 9 years, range 1-25 years). Review of the subjects' dental and social histories did not indicate any unusual social habits or occupational exposures associated with erosion. All patients were non-smokers, and some denied the consumption of carbonated or alcoholic beverages. Interestingly, dietary history assessment revealed an average daily citrus fruit consumption rate of 1.7 servings per subject.

Table 3.

Social and Dietary Habits				
Subject #	Smoking	Carbonated Beverages/month	Alcohol Beverages/month	Citrus Servings/day
1	No	<1	<1	3
2	No	None	None	3
3	No	None	None	3
4	No	None	<1	1
5	No	None	<1	0
6	No	None	<1	0
Averages	--	<1	<1	1.7

A total of 77 teeth from 6 subjects were evaluated and the erosion scores for all maxillary teeth were recorded. Based on the Eccles and Jenkins erosion scale, 50 teeth (65%) were grade 0, 25 teeth (32.5%) were grade 1, 2 teeth (2.5%) were grade 2, and no teeth met criteria for grade 3. The most severe but less frequent DE sites were seen on maxillary molars, while less severe but more frequent DE sites were seen on maxillary incisors.

Table 4.

Dental Erosion					
Subject #	# of maxillary teeth examined	Eccles and Jenkins Erosion Grade 0	Eccles and Jenkins Erosion Grade 1	Eccles and Jenkins Erosion Grade 2	Eccles and Jenkins Erosion Grade 3
1	13	8	3	2	0
2	14	10	4	0	0
3	14	9	5	0	0
4	12	10	2	0	0
5	12	5	7	0	0
6	12	8	4	0	0
Total	77 (100%)	50 (65.0%)	25 (32.5%)	2 (2.5%)	0 (0%)

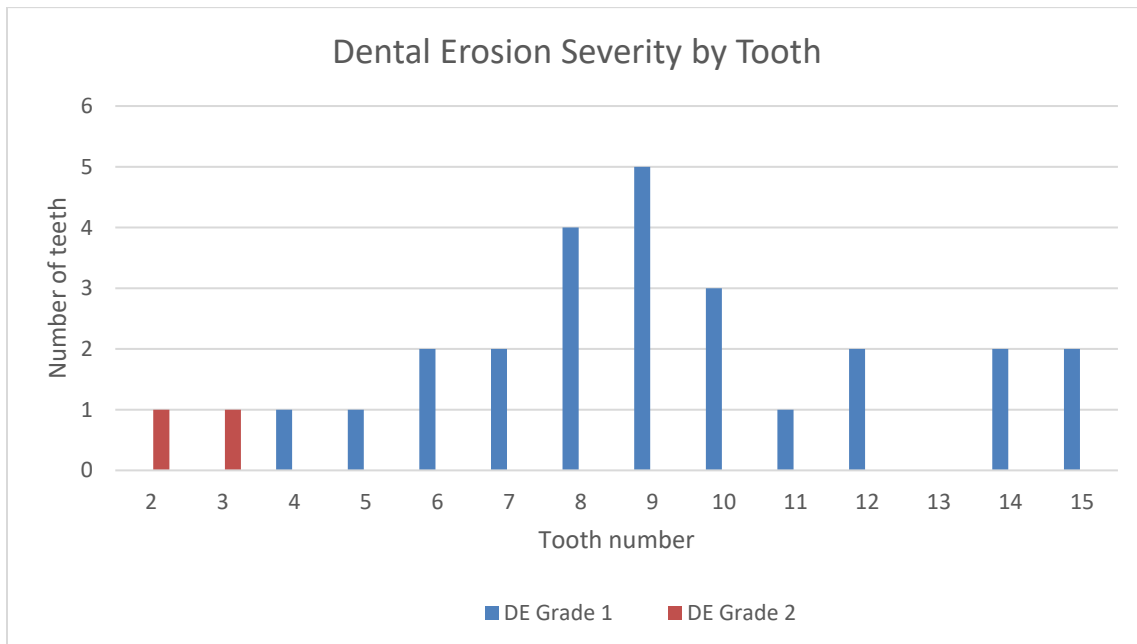


Figure 1. Dental Erosion Severity by Tooth. Anterior teeth were observed to have more DE Grade 1, and two posterior right teeth have DE Grade 2.

Screening evaluations showed good oral hygiene overall, and no subjects demonstrated significant pocketing, clinical attachment loss, or severe bleeding on probing. Based on the Gingival Index scale, 50 teeth (65%) were Grade 0, 16 teeth (20.7%) were Grade 1, 11 teeth (14.3%) were Grade 2, and no tooth was scored as Grade 3. No patient demonstrated erythema or ulceration of the oral mucosa.

Table 5.

Gingival health						
Subject #	# of maxillary teeth examined	Gingival Index Grade 0	Gingival Index Grade 1	Gingival Index Grade 2	Gingival Index Grade 3	Oral hygiene (good,fair,poor)
1	13	6	5	2	0	Good
2	14	10	0	4	0	Fair
3	14	10	0	4	0	Fair
4	12	4	7	1	0	Good
5	12	9	3	0	0	Good
6	12	11	1	0	0	Good
Total	77 (100%)	50 (65.0%)	16 (20.8%)	11 (14.2%)	0 (0%)	--

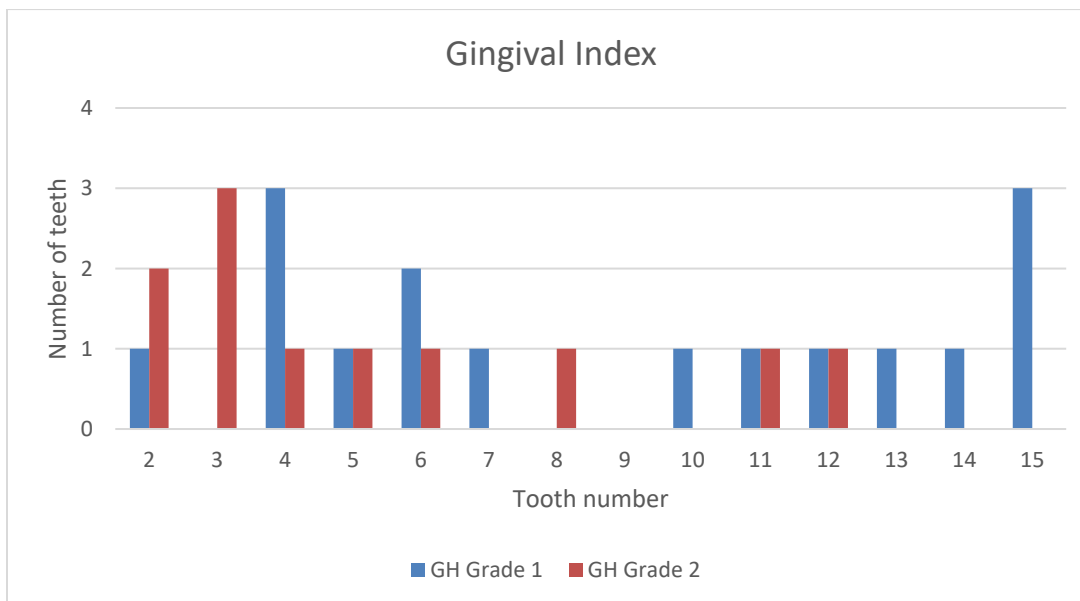


Figure 2. Gingival Health Index. Gingival inflammation and bleeding on probing were observed more frequently on posterior teeth than anterior teeth. Particularly posterior right teeth.

Due to technical issues, data analysis for GCF and salivary pH was completed for only 3 of the 6 subjects. The mean GCF pH from teeth with DE was 6.82 +/- 0.16, and mean submandibular duct pH was 5.09 +/- 0.55.

Table 6.

Oral pH		
Subject #	Average GCF pH	Average Submandibular Ducts pH
1	--	--
2	--	--
3	--	--
4	6.66	4.86
5	7.04	5.85
6	6.76	4.56
Total Averages	6.82	5.09

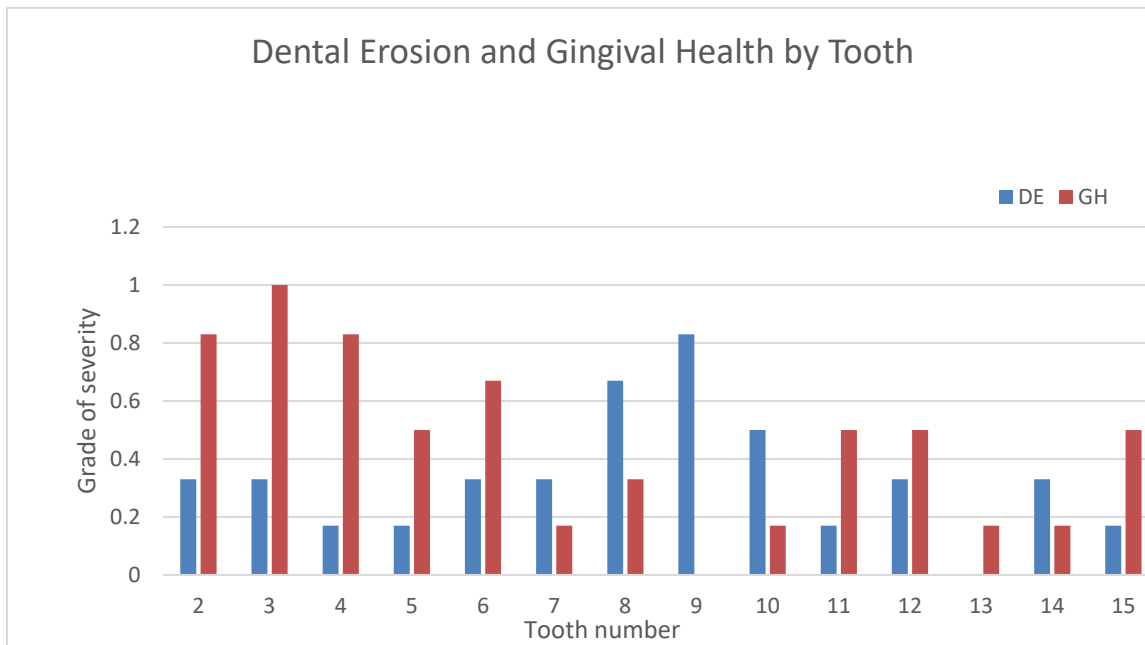


Figure 3. Dental Erosion and Gingival Health by Tooth. DE was observed more frequently on anterior teeth, while gingival inflammation and bleeding on probing were observed more frequently on posterior teeth.

DE grade 1 and 2 were present on 35% of the teeth evaluated and 4 of 6 subjects had gingival inflammation. The most severe but less frequent DE sites were seen on maxillary

molars, while less severe but more frequent DE sites were seen on maxillary incisors. More severe DE and inflammation was observed in one subject with a reported daily citrus fruit consumption of three servings per day. Minimal DE and gingival health were observed in one subject with meticulous oral hygiene.

CHAPTER IV: DISCUSSION

Previous studies have reported the range of prevalence of GERD and DE in adult patients to be 24-33% and suggested a significant association of GERD and gingivitis.^(13,20) The current study was the first to examine a relationship between gastroesophageal reflux disease and dental erosion and gingival health in a US military population.

Due to the fact that all study subjects received regular medical and dental care at a Military Treatment Facility, they were knowledgeable of their conditions and maintained good physical and dental health. The collected data revealed that oral health in all study subjects was stable and only 4 of 6 patients showed signs of mild gingivitis. The remaining subjects showed an absence of gingival inflammation and oral hygiene was good among all subjects.

The data collected for DE revealed no tooth had a DE grade 3 on the Eccles and Jenkins erosion scale. However, 27 out of 77 teeth (35%) had some level of DE. Two teeth were grade 2, in which DE involvement of dentin exposure was less than one third of the tooth surface, and 25 teeth or (32.5%) were grade 1, showing only loss of enamel surface structure without dentin exposure. DE was more severe but less frequently seen on maxillary molars, while less severe but more frequently seen on maxillary incisors. Other than the subjects' daily average consumption of 1.7 serving of citrus fruit (two subjects consumed none), no other contributing social or dietary factor was found.

DE is a multifactorial disease. Aside from the primary risk factor of acid reflux, dietary acids may have a negative synergic effect on tooth structure. Evidence of this negative synergy was demonstrated in the youngest subject of this study who showed both a high daily consumption rate of citrus fruit and severe gingival inflammation with associated erosion. The subject was also undergoing GERD treatment for only one year. In contrast, the oldest subject of this study denied citrus fruit consumption, presenting with no inflammation and minimal DE.

The subject was undergoing GERD treatment for the longest period of 25 years among all subjects. Hence, these findings strongly support the idea that early diagnosis and treatment of GERD may limit the negative impact of GERD on DE and GH. Moreover, excessive dietary acids in a GERD patient may increase the likelihood of DE.

We found the average GCF pH at teeth with DE to be nearly neutral at 6.82 ± 0.16 (range of 6.66-7.04). However, unstimulated saliva collected from submandibular ducts was lower in all subjects with a mean pH of 5.09 ± 0.55 (range of 4.560-5.855); whereas normal salivary pH averaged 7.23 and one study reported salivary pH of 6.65 in GERD subjects.⁽²⁶⁾ Saliva functions as an antimicrobial, cleansing agent that also acts to maintain oral pH homeostasis. However, when baseline salivary pH decreases, the protective functions of saliva may be hindered, allowing for an environment that favors DE to persist.

Several limitations of this study should be noted: 1) the most important limitation was the small sample size, 2) our study only evaluated non-restored maxillary teeth, and as a result, DE prevalence could be underreported, 3) DE and gingival health were evaluated with only a limited clinical examination. Comprehensive dental and periodontal examinations would serve to eliminate bias and improve accuracy of all diagnoses, and 5) the addition of a non-GERD control group or an additional examiner would have added more validity to the current study.

CHAPTER V: CONCLUSION

Given the limitations of this study, our military population displayed comparable GH to a non-military population. However, DE prevalence was marginally higher by 6.5%, and salivary pH was lower than previous studies have reported in non-military subjects. Our study is the first to report the pH of GCF in a GERD population and the clinical implications should be explored further. While early diagnosis and treatment for GERD is vital to limit the detrimental effects of acid on oral tissues, patient education in GERD, DE and GH may serve to enhance overall health.

REFERENCES

1. Dent, J., El-Serag, H.B., et al. Epidemiology of gastro-oesophageal reflux disease: a systematic review. *Gut*. 2005; 54: 710-717.
2. El-Serag, H.B., Petersen N.J., et al. Gastroesophageal reflux among different racial groups in the United States. *Gastroenterology*. 2004; 126:1692–1699.
3. El-Serag H.B., Sweet S., et al. Update on the epidemiology of gastro-oesophageal reflux disease: a systematic review. *Gut*. 2014; 63: 871–880.
4. Lazarchik, D.A., Filler, S.J. Effects of gastroesophageal reflux on the oral cavity. *Am J Med*. 1997; 103 (5A); 107S-113S.
5. Touyz, S.W., Liew, V.P., et al. Oral and dental complications in dieting disorders. *Int J of Eating Disorders*. 1993; 14 (3): 341-348.
6. Raibrown, A., et al. Gastroesophageal reflux disease symptom screening in a dental setting. *Journal of Dental Hygiene*. 2017; 91(1): 44-48.
7. Lazarchik, D.A., Filler, S.J. Dental erosion: predominant oral lesion in gastroesophageal reflux disease. 2000; 95(8): S33-S38.
8. Demeester, T.R., Lawrence, F.J., et al. Patterns of gastroesophageal reflux in health and disease. *Ann Surg*. 1976; 184(4): 459-469.
9. Kelleher, M., Bishop, K. Tooth surface loss: an overview. *British Dental Journal*. 1999; 186(2): 61-66.
10. Moazzez, R., Bartlett, D., et al. Dental erosion, gastro-oesophageal reflux disease and saliva: how are they related? *Journal of Dentistry*. 2004; 32: 489-494.
11. Bartlett, D., Evans, D., et al. The relationship between gastro-oesophageal reflux disease and dental erosion. *Journal of Oral Rehabilitation*. 1996; 23: 289-297.

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22. "The changing face of America's veteran population." Pew Research Center. Accessed 03 September 2018.
<http://www.pewresearch.org/fact-tank/2017/11/10/the-changing-face-of-americas-veteran-population/>
23. Deppe, H., Mucke, T., et al. Erosive esophageal reflux vs. non erosive esophageal reflux: oral findings in 71 patients. BMC Oral Health. 2015; 15: 84-91.
24. Eccles, J.D., Jenkins, W.G. Dental erosion and diet. J Dent. 1974; 2(4): 153-9.
25. Loe, H. The gingival index, the plaque index and the retention index system. J Periodontol. 1967; 38(6): S610-6.
26. Sujatha, S., Jalihal, U., et al. Oral pH in gastroesophageal reflux disease. Indian Journal of Gastroenterology. 2016; 35: 186-189.

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