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ORIGINAL ARTICLE

Assessment of oral health indices and heart rate variability in relation with oral and cardiovascular health.

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ABSTRACT… Objective: To explore the relationship between oral health and cardiovascular health. **Study Design:** Cross Sectional Analytical study. **Setting:** Dental OPD, Baqai Dental College Karachi, Pakistan. **Period:** Jan 2023 – May 2023. **Methods:** The study participants older than 18 years were voluntarily recruited. Heart Rate Variability (HRV) recordings were taken for six minutes by applying HRV sensors either on index finger or ear lobe in relax sitting position according to the choice of study subjects. Dental health of participants DMFT and PDL indices were calculated, and the results were compared with HRV variables. **Results:** There was a significant increase in frequency of decayed, filled and missing teeth in older aged male and female participants. The periodontium of young participants were more healthier. Heartrate variability results show higher sympathetic predominance in participants with increased DMFT and PDL scores. Moreover, stress index and internal coherence levels is low with age in both male and female groups. **Conclusion:** Findings from this study suggest that participants with dental problems (tooth decay and poor oral health) have high sympathetic predominance and low Heart rate variability and poor cardiac health status. This study highly suggest the relation between poor oral health association with mortality of cardiac diseases.

Key words Cardiovascular Health, HRV, Oral Health, Oral Indices.

INTRODUCTION

Oral health is closely related to systemic health. The links between oral diseases and overall health are numerous and intricate.[1] Oral health is influenced by systemic disorders, either directly through pathological pathways or indirectly through disease- or therapy-related behavioral changes.[2] Oral health changes have an impact on overall health. The mortality from cardiovascular illnesses, all-cause mortality, and declines in quality of life are intimately linked to tooth decay and poor periodontal health.[3]

Cardiovascular disease (CVD) is one of the leading causes of chronic disease morbidity and mortality.[4] According to the World Health Organisation, 31% of all deaths globally are due to cardiovascular diseases[5], as heart diseases are exacerbated by a number of risk factors, such as a smoker's cigarette use, obesity, diabetes, hypertension, hyperlipidemia, and poor nutritional intake. Additionally, there is also growing evidence that another potential risk factor for cardiovascular diseases is dental tooth decay and poor oral health.[6]

The two diseases share common risk factors such as smoking, diabetes, and advanced age.[7] The issue has potential impact because both the conditions have a high incidence, while cardiovascular disease is the leading cause of death worldwide, oral health disease is one of the most common diseases and is closely linked to daily activities.[8] The control of the cardiovascular system is accomplished in part by the autonomic nervous system (ANS), which is composed by the sympathetic and parasympathetic pathways that command the cardiovascular system by releasing neurotransmitters that increase or decrease heart rate (HR), respectively.

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The periodic oscillations in HR and RR intervals of consecutive heart beats, modulated by the activity of ANS on the heart is known as heart rate variability.[9]

The study of HRV has helped to detect and characterize some situations in which diseases affect the autonomic control.[10] A high HRV is a sign of good adaptation, featuring a healthy individual, with efficient autonomic mechanisms, whereas low variability is often an indicator of abnormal and insufficient adaptation of the ANS, implying the presence of physiological malfunction in the individual.[11] And the study of HRV allowed, in a non-invasive, safe and reproducible way to assess the neural control of the heart.[12] The relationship of oral health with relation to the physical health of an individual can play a role in promoting overall better cardiovascular health. Therefore, this study was conducted to identify the relationship between oral and cardiovascular health.

METHODS

This cross-sectional study was conducted in the dental section of tertiary care hospital during Jan 2023 – May 2023. Ethical approval was taken from the university with approval no. BMU-EC/06-2022. Sample size of 323 subjects (using Open EPI software version 2.01) using the findings of Suresh et al.[13] This study included individuals with multiple occupations, age more than 18 years, and who signed a consent form. The study excluded individuals who were unwilling to participate. All the study participants were explained about the study one day prior to their report in their study room, and those who gave their consent were requested to report next day at 10:00 am in the morning. The subjects were kept in a quiet calm and temperature regulated room and were given 30 minutes to relax. After this HRV recordings were taken for six minutes by applying HRV sensors either on index finger or ear lobe in relax sitting position according to the choice of study subjects. HRV use baevsky stress index to evaluate stress levels. Subsequently, HRV data was analyzed using emWave pro plus software which is an advanced tool for analyzing and preparing the data from HRV. Furthermore, Kubios method analysis software of HRV was also used for HRV data analysis, which is a cutting-edge and simple to use freeware for coronary HRV analysis. It comprises an improvised QRS detection algorithm and tools for noise correction, trend removal and analysis sample selection.

After HRV analysis to assess the dental health of participants DMFT index is calculated by counting the number of decayed, missing, and filled teeth in a person's mouth. DMFT index is just one of many tools used in dentistry to assess oral health. After that the Periodontal Ligament (PDL) Index is used to assess the health of the periodontal ligament of participants through dental mirror, periodontal probe and cotton rolls or gauze.

Statistical analysis was performed using SPSS version 23. The frequency and percentages were reported for categorical variables such as gender and occupation.

RESULTS

The overall assessment of sample using DMFT showed that the tooth decay was higher in older age group male participants (95.8%). The younger group male participants have less tooth decay (79.1%) among all other groups with highest healthy periodontium. In female groups, the younger age group have much healthy periodontium (95.7%) as compared to older age participants. In middle aged female have highest tooth decay as compared to older age participants with lowest tooth decay among all groups. Periodontium of older age female participants is less healthy (60%) as young aged group (95.7%). The male had more decayed, missing and filled teeth as compared to the female subjects. Furthermore, as the age was increasing, the frequency of decayed, missing and filled teeth were also increased. (Table-I)

There was increased frequency of decayed teeth in male subjects with sympathetic predominance (82.6-100%). However, in female subjects, all the age groups had increased frequency of decayed teeth with sympathetic predominance (74.4-100%). In the male subjects, except of age group 42-53 years (31.2%), all the other

age groups had increased frequency of missing teeth with sympathetic predominance. However, in female subjects, the younger age group i.e. 18-29 years, had decrease frequency of missing teeth. Regarding the filled teeth, it was found that female subjects with sympathetic predominance had increased frequency of filled teeth (71.4%). However, in males, there were increase frequency of filled teeth and sympathetic dominance in older aged male participants (64.7%).

The DMFT scoring was also stratified according to the coherence and stress index. The subjects who had low coherence had increased frequency of decayed, missing and filled teeth as compared to the ones with good, very good and excellent coherence. Furthermore, stress index showed that subjects who had moderate or severe stress index, showed increased frequency of DMFT as compared to subjects with lower stress index. (Table-II) Healthy PDL status in participants with sympathetic predominance shows in older male as compared to young group. Male participants having healthy PDL have more parasympathetic dominance as compared to female groups. Coherence and stress index level is low with age in both groups. (Table-III)

DISCUSSION

Oral health is important for maintaining general health and is associated with cardiovascular disease which is a major cause of their morbidity and mortality, in spite of significant improvements in disease prevention, detection and treatment over recent decades. The two most common diseases affecting oral health are dental caries and periodontitis.[14] Dental caries is the localised destruction of susceptible dental hard tissues by acidic by-products from bacterial fermentation of dietary carbohydrates. Periodontitis is a chronic inflammatory disease caused by bacterial infection of the supporting tissues around the teeth.[15]

Gender	Age group	DMFT	Percentages	Periodontal Status	Percentages
Male N = 161	18-29 years N = 67	Decayed	79.1	Healthy	97.0
		Missing	20.9	Gingivitis	3.0
		Filled	35.8	Periodontitis	0
	30-41 years N = 43	Decayed	90.7	Healthy	88.4
		Missing	23.3	Gingivitis	11.6
		Filled	44.2	Periodontitis	0
	42-53 years N = 27	Decayed	88.9	Healthy	77.8
		Missing	37	Gingivitis	18.5
		Filled	51.9	Periodontitis	3.7
	54-65 years N = 24	Decayed	95.8	Healthy	79.2
		Missing	62.5	Gingivitis	20.8
		Filled	58.3	Periodontitis	0
Female N = 162	18-29 years N = 70	Decayed	68.6	Healthy	95.7
		Missing	20.0	Gingivitis	4.3
		Filled	35.7	Periodontitis	0
	30-41 years N = 58	Decayed	93.1	Healthy	89.7
		Missing	41.4	Gingivitis	10.3
		Filled	56.9	Periodontitis	0
	42-53 years N = 24	Decayed	75	Healthy	75.0
		Missing	33.3	Gingivitis	20.8
		Filled	54.2	Periodontitis	4.2
	54-65 years N = 10	Decayed	60	Healthy	60
		Missing	70	Gingivitis	20
		Filled	60	Periodontitis	20

Table-I. Status of DMFT and periodontal status of subjects stratified according to age and gender.

DMFT: Decayed, Missing, Filled teeth.

Gender	Age group	DMFT %	ANS dominance		Coherence				Stress index		
			Parasympathetic	Sympathetic	Low	Good	Very good	Excellent	Low	Moderate	Higher
Male N = 161	18-29 years N = 67	Decayed	77.3	82.6	83	64.7	100	100	76.1	88.9	83.3
		Missing	20.5	21.7	24.8	5.9	100	100	21.7	22.2	16.7
		Filled	43.2	21.7	36.2	35.3	100	100	43.5	11.1	25
	30-41 years N = 43	Decayed	94.7	87.5	93.3	84.6	-	-	95.2	85.7	86.7
		Missing	21.1	25	23.3	23.1	-	-	23.8	14.3	26.7
		Filled	36.8	50	40	53.8	-	-	47.6	28.6	46.7
	42-53 years N = 27	Decayed	81.8	93.7	91.7	50	-	100	81.8	90	100
		Missing	45.5	31.2	37.5	50	-	100	36.4	30	50
		Filled	54.5	50	54.2	0	-	100	54.5	50	50
	54-65 years N = 24	Decayed	85.7	100	100	80	-	-	88.9	100	100
		Missing	57.1	64.7	63.2	60	-	-	44.4	50	81.8
		Filled	42.9	64.7	68.4	20	-	-	44.4	25	81.8
Female N = 162	18-29 years N = 70	Decayed	61.3	74.4	68.6	70.6	50	-	63.9	73.3	73.7
		Missing	22.6	17.9	19.6	17.6	50	-	25	20	10.5
		Filled	35.5	35.9	33.3	41.2	50	-	38.9	40	26.3
	30-41 years N = 58	Decayed	91.7	94.1	94.6	94.7	50	-	92.9	92.3	94.1
		Missing	54.2	32.4	29.7	68.4	0	-	46.4	53.8	23.5
		Filled	54.2	58.8	54.1	68.4	0	-	57.1	69.2	47.1
	42-53 years N = 24	Decayed	100	100	100	100	-	-	100	100	100
		Missing	30	35.7	38.1	0	-	-	30	66.7	27.3
		Filled	30	71.4	57.1	33.3	-	-	30	100	63.6
	54-65 years N = 10	Decayed	100	100	100	100	-	-	100	100	100
		Missing	50	75	75	50	-	-	33.3	100	75
		Filled	50	62.5	62.5	50	-	-	33.3	100	50

Table-II. Percentages of decayed, missing and filled teeth stratified according to age, gender and HRV results.

Gender	Age Group	PDL Status %	ANS Dominance		Coherence				Stress Index		
			Parasympathetic	Sympathetic	Basic	Good	Very Good	Excellent	Low	Moderate	Higher
Male N = 161	18-29 years N = 67	Healthy	97.7	95.7	95.7	100	100	100	97.8	88.9	100
		Gingivitis	2.3	4.3	4.3	-	-	-	2.2	11.1	0
		Periodontitis	0	0	0	-	-	-	0	0	0
	30-41 years N = 43	Healthy	89.5	87.5	86.7	92.3	-	-	95.2	71.4	86.7
		Gingivitis	10.5	12.5	13.3	7.7	-	-	4.8	28.6	13.3
		Periodontitis	0	0	0	0	-	-	0	0	0
	42-53 years N = 27	Healthy	72.7	81.3	79.2	100	-	0	81.8	80	66.7
		Gingivitis	18.2	18.8	16.7	-	-	100	18.2	10	33.3
		Periodontitis	9.1	0	4.2	-	-	0	0	10	0
	54-65 years N = 24	Healthy	85.7	76.5	73.7	100	-	-	77.8	100	72.7
		Gingivitis	14.3	23.5	26.3	0	-	-	22.2	0	27.3
		Periodontitis	0	0	0	0	-	-	0	0	0
Female N = 162	18-29 years N = 70	Healthy	100	92.3	94.1	100	100	-	100	86.7	94.7
		Gingivitis	-	7.7	5.9	-	-	-	0	13.3	5.3
		Periodontitis	-	0	0	-	-	-	0	0	0
	30-41 years N = 58	Healthy	83.3	94.1	94.6	78.9	100	-	85.7	92.3	94.1
		Gingivitis	16.7	5.9	5.4	21.1	-	-	14.3	7.7	5.9
		Periodontitis	0	0	0	0	-	-	0	0	0
	42-53 years N = 24	Healthy	80	71.4	71.4	100	-	-	80	66.7	72.7
		Gingivitis	10	28.6	23.8	0	-	-	10	33.3	27.3
		Periodontitis	10	0	4.8	0	-	-	10	0	0
	54-65 years N = 10	Healthy	50	62.5	62.5	50	-	-	66.7	66.7	50
		Gingivitis	50	25.0	25	0	-	-	33.3	33.3	25
		Periodontitis	0	12.5	12.5	50	-	-	0	0	25

Table-III. Periodontal status of subjects stratified according to age and gender and HRV results.

Our study results shows that the older aged male participants have poor dental health as young participants. FDI research shows nearly all adults have tooth decay, and severe periodontal disease occurs in 15 to 20% of middle-aged adults.[16] While in our results middle aged female participants have high decayed teeth as other groups. Increasing occurrences of untreated caries have been attributed to population growth and longevity and a significant decrease in tooth loss.[17] In a study by Iran J Public Health, oral health status of the adult population was alarming and undesirable and had the highest level of dental decay in young population with association with the DMFT index.[18] Meanwhile our study results shows that as the age increase there is a significant increase in DMFT score and periodontal health.

Ther is a bi-directional relationship exists between oral and cardiovascular health. Many systemic diseases (e.g., immune deficiency disorders) may appear first in the mouth.[19] In HRV we compared autonomic nervous system (sympathetic/parasympathetic), coherence and stress index with gender and age groups, DMFT & PDL index of participants. The systematic review by Dai et al. (2015) highlights that hypertensive or stroke patients have poorer oral health-related quality of life and oral function.[20] A systematic review by Dai et al. found that patients with stroke have significantly higher caries prevalence (DMFT) scores than healthy controls and there are evidence that dental caries and disease associated with infections from dental caries or periodontal tissues are associated with incidence of cardiovascular disease.[21]

Our study results shows that with increase age there is increase in tooth decay and poor periodontal health with sympathetic predominance. Humphrey et al. (2008) pooled estimates, demonstrating that individuals with 0–10 teeth had a relative risk of coronary heart disease and coronary death compared to patients with 25–32 teeth.[22] In male participants of our study the increased frequency of missing teeth with sympathetic predominance was noticed. Two systematic reviews[23,24], suggest that tooth loss is associated with an increased risk of cardiovascular disease, in particular the risk of coronary heart disease and stroke. Also a systematic review with meta-analyses have demonstrated patients with poor oral health have an increased risk of developing coronary heart disease.[25]

Furthermore, our study participants with poor oral health have low coherence and moderate to high stress levels as compared to participants with good oral health. The HRV scores results shows participants with high sympathetic drive have poor oral health with relation to high sympathetic dominance. That shows there is high quality evidence to support an association between cardiovascular disease and oral health. Kelly et al. (2013) had highlighted some significant structural and methodological variability among the published systematic reviews and meta-analyses regarding the connection between oral and cardiovascular health.[26]

Moreover, it is the first study where oral and cardiac parameters are measured using HRV device. Our study shows firm association between oral and cardiovascular health and proves that HRV is a valuable tool for investigating the association between oral and cardiovascular health.

CONCLUSION

Dental tooth decay and poor periodontal health has a strong link with cardiovascular health. Through this study we can find signs of poor cardiovascular health through oral cavity by using HRV device which is a safe, non invasive and easy tool to assess the neural control of heart and can help in early diagnosis of heart diseases through oral cavity.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Syeda Gulrukh Shah:** Data collection, material and methods, abstract writing,
2	**Asif Ahmed:** Review, Proof reading
3	**Aqeel Ahmed:** Statistical analysis, results compilation