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Association of Dermatoglyphic Patterns with DMFT Score, Salivary pH and Plaque Index Score: An In-Vivo Study

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Abstract

Background: Dental caries, although of infectious origin along with its multiple predisposing factors, may have a genetic predisposition. This study was executed to evaluate the association of dermatoglyphics as a genetic predictor of the susceptibility of participants to acquire dental caries considering environmental factors such as salivary pH, Decayed, Missing and Filled Permanent (DMFT) Score and Plaque Index Score. **Methods:** 531 student volunteers of a dental college were included in the study. Thumbprint patterns of the thumbs of their respective dominant hands were analyzed. DMFT Index, Plaque Index Score and Salivary pH for each subject was recorded. Statistical analysis was executed using nonparametric chi-square tests, correlation coefficients and measures of central tendencies. **Results:** The predominant thumbprint pattern seen was loop type followed by whorl and arch type with 52%, 31% and 17% of occurrence and a salivary pH of 7, 5 and 6 respectively. The Chi-Square tests concluded that whorl type of thumbprints show association with increased DMFT score. Mean and median plaque index score was considerably higher in the individuals with a whorl type of thumbprint. **Conclusion:** There was distinct association between pattern of thumbprints and prevalence of dental caries. Whorl type thumbprint could prove itself as a genetic predictor towards increased caries incidence.

Keywords: Decayed, Missing and Filled Permanent (DMFT) Score, Dental Caries, Dermatoglyphics, Plaque Index Score, Salivary pH, Thumbprint Pattern

Introduction

In 1926, dermatoglyphics was coined by Cummins and Midlo[1] which is a branch of genetics that involves the skin ridge system. The skin ridge system exclusively describes the intricate details of the skin surface[2]. The study of dermatoglyphics has been a forte of fortune tellers and a definitive tool for identification by forensic experts for

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several decades[1]. With due credit to scientific research and development, it is established that fingerprints in modern era have embarked on serving as a mode to resolve a wider horizon of biomedical problems. Besides predicting one's lifespan, it might just be a tool in foreseeing the number of visits to a dentist.

Fingerprints remain to be one of the most crucial forms of data as from our first to last breath, as they remain unchanged. The miniscule details of these skin ridges are perpetual. "There are notably variable characters that are not replicated in other people even in monozygotic twins or even in the same person, from location to location. Even after death, decomposition of the skin is last to occur in the area of the dermatoglyphic configurations"[2].

The correlation of dermatoglyphic patterns to dental caries is rationalized due to the parallels of environmental and genetic factors between teeth and skin during their development[3]. The skin ridge system and teeth develop from the same embryonic layer known as the ectoderm during embryogenesis usually around the sixth week[3]. Hence, we can infer that "genetic information contained in the genome is dissipated during this period, and any disturbance affecting tooth development and structure will be concurrently reflected through change in dermatoglyphic patterns"[3].

This cross-sectional study was executed to interpret the association of thumbprints pattern types and dental caries along with its associated environmental factors to enable early detection of susceptibility of an individual to dental caries. This was established by studying its genetic basis by effectively utilizing non-invasive, economical, and effective tools that help early prediction of dental caries, thereby restricting the disease from progressing to an advanced stage and preventing further tooth exfoliation. The null hypothesis proposed was that there would be no association between dermatoglyphics and the prevalence of dental caries and that no correlation would be found amongst the many predisposing factors that influence dental caries.

Materials and Methods

Study Design and Source of Data

A cross-sectional study was undertaken comprising of 531 dental students. Stratified random sampling technique was used to select samples for the study. A total of 441 dental undergraduate students and 90 dental postgraduate students were assessed to attain a total sample size of 531.

Informed Consent and Ethical Clearance

Before proceeding with the examination, all participants were requested to read through a written informed consent and duly sign it. Institutional Ethical Committee of ITS Dental College, Research Centre and Hospital, Greater Noida reviewed the study and provided the necessary approval.

Infection Control

All examiners made use of appropriate personal protective equipment like disposable mouth masks and gloves during examination. Autoclaved instruments like Mouth Mirror, No. 23 Shepherd Hook Explorer and Sterile Cotton were employed for dental examination.

Method of Collection of Data

During the study, the method of collecting data was standardized to minimize the error in statistical analysis.

Method of Recording of Thumbprints

Thumbprint pattern of the thumb of their dominant hand i.e. hand used over the other to perform fine and gross motor tasks was recorded for assessment. The most common method used to record dermatoglyphic prints is the 'Ink Method', first described by Cummins and Midlo (1943)[4]. Hands of the study subjects were cleaned using antiseptic solution and allowed to dry. The thumb was rolled on the ink pad and the side of the finger bulb was placed upon an A4 size white sheet of paper and rolled to the other side until it faced the opposite direction. The ink was removed by applying coconut oil.

Recording of Salivary pH

Unstimulated saliva was collected in a sterile container 2 hours after food intake to record the salivary pH. Subjects were requested to spit into a medicine cup; one end of the litmus paper was placed in the cup to draw the saliva onto the paper which was laid on a paper towel for 30 seconds. The colour reading was matched against the indicator chart in the pH test packaging.

Recording of Decayed, Missing and Filled Permanent *(DMFT) Index Score*

"The DMFT Index described by Henry T. Klein, Carrole E. Palmer and Knutson J.W[5] is based on the fact that the dental hard tissues are not self-healing and establishes that caries leave a scar of some sort". The DMFT Index is therefore an irreversible index, measuring the lifetime caries experience. For each subject, the DMFT index was calculated according to the number of decayed (D), missing (M), filled (F) permanent teeth (Figure 1). The DMFT Score was hence interpreted as total of each component, i.e. D, M, & F separately, then, total D+M+F = DMFT Score.

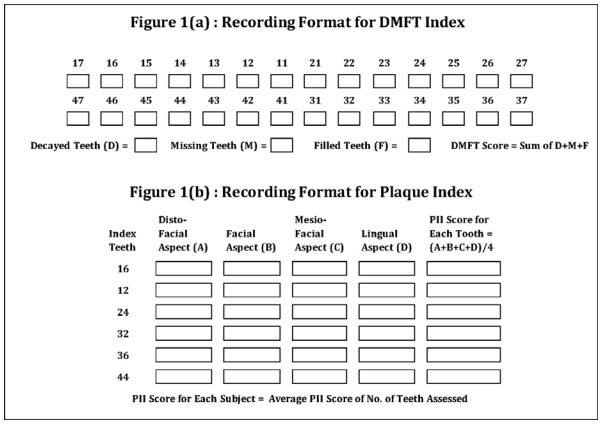

Figure 1. Chart used for recording DMFT Index and plaque index scores.

Recording of Plaque Index Score

The plaque index described by Silness and Loe[5] has demonstrated good validity and reliability. A single examiner was trained to assess each subject to reduce the subjectivity in estimating plaque. The gingival aspects of disto-facial, facial, mesio-facial and lingual surfaces of 6 index teeth i.e. 16, 12, 24, 32, 36 and 44 were assessed (Figure 1). The tooth was air dried and a visual examination was done. The cervical third was surveyed with the help of an explorer. When none, mild, moderate or severe accumulation of plaque deposits were seen by the naked eye, a score of 0, 1, 2, and 3 was assigned respectively. Score for a tooth was calculated as scores of

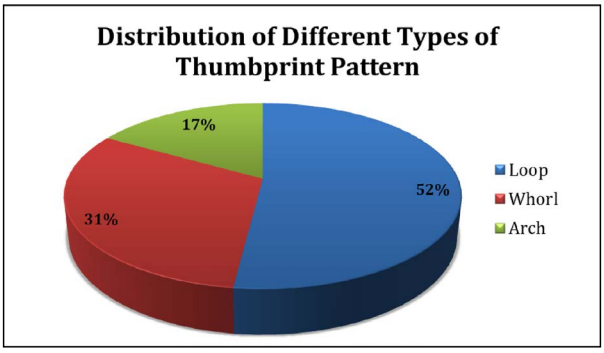

Figure 2. Representation of pattern of distribution of different types of thumbprint patterns in our study population.

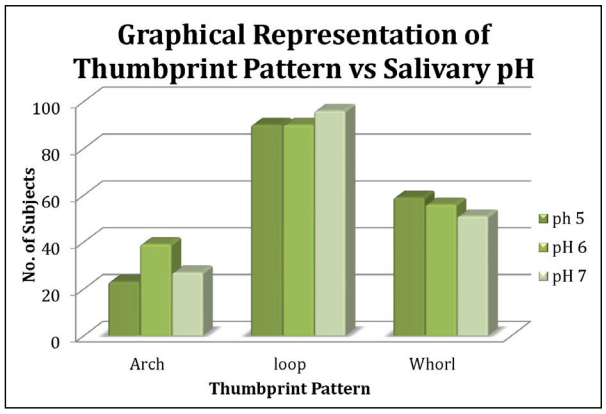

Figure 3. Representation of thumbprint patterns in comparison to salivary pH recorded in our study population.

Table 1. Comparative statistics of the predisposing factors for various thumbprint patterns

Thumbprint Pattern Types	Sum of Thumbprint Pattern Types (n=531 subjects)	Salivary pH of Subjects			Mean of DMFT Score	Median of DMFT Score	Mean of Plaque Index Score	Median of Plaque Index Score
		pH 5	pH 6	pH 7				
Whorl	166	23	39	27	2.33	2.00	0.61	0.56
Arch	89	90	90	96	2.29	2.00	0.65	0.58
Loop	276	59	56	51	2.98	3.00	0.74	0.63

Table 2. Statistical analysis of dermatoglyphics based on DMFT score

Table 2(a) : Categorical overview of the DMFT score recorded for the various types of thumbprint patterns. The total number of subjects with DMFT Score <4 and >4 were noted for the application of Chi-Square Test.

Thumbprint Pattern Types	DMFT Score of Subjects											
	0	1	2	3	4	Subjects with DMFT Score < 4	5	6	7	10	11	Subjects with DMFT Score > 4
Arch	33	27	32	28	24	144	6	11	4	1	0	22
Loop	6	10	19	17	15	67	11	4	5	1	1	22
Whorl	48	63	54	49	24	238	10	11	12	1	4	38

Table 2(b) : Chi-Square Test I, II, III

I	DMFT Score < 4	DMFT Score > 4
Whorl Pattern	67	22
Loop Pattern	238	38
Chi Square Value	5.875	
p-Value	0.015	

II	DMFT Score < 4	DMFT Score > 4
Loop Pattern	238	38
Arch Pattern	144	22
Chi Square Value	0.023	
p-Value	0.878	

III	DMFT Score < 4	DMFT Score > 4
Arch Pattern	144	22
Whorl Pattern	67	22
Chi Square Value	5.334	
p-Value	0.02	

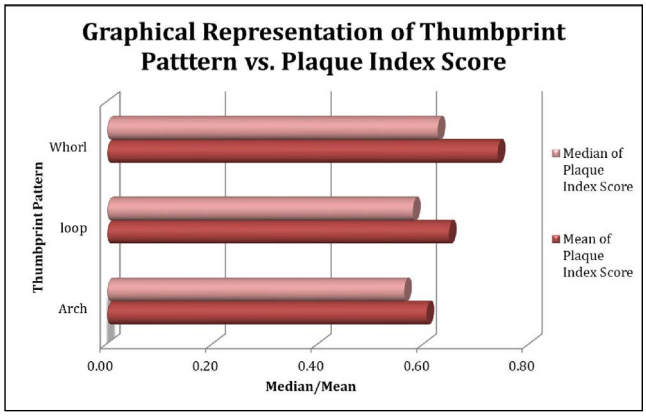

Figure 4. Representation of thumbprint patterns in comparison to the mean and median of Plaque Index Score recorded in our study population.

the 4 areas divided by 4. Score for a subject was calculated as total score divided by number of teeth examined.

Evaluation of Fingerprints

Dermatoglyphic patterns were analyzed using a 10x magnifying lens and categorized according to three basic patterns of dermatoglyphics which comprise of whorl type, loop type and arch type patterns. Subtypes of these patterns were recorded as their respective parent pattern. Microsoft excel was used to compile the cumulative data and statistical analysis was performed using R (R × 64 3.2.4 Revised) programming on R Studio Version 1.1.463 – © 2009-2018 R Studio, Inc. Statistical analysis which included nonparametric chi-square tests, correlation coefficients and measures of central tendencies were performed to interpret the results.

Results

Distribution of Thumbprint Patterns in Study Population

The distribution of our study sample comprising of 531 subjects, based on their thumbprint patterns was compiled (Table 1).

It was found that a predominant sample size had a loop type of thumbprint with relatively smaller sample sizes of whorl and arch type of thumbprints respectively (Figure 2).

Association between Thumbprint Patternsand Salivary pH Score

From the gathered data, salivary pH was evaluated individually for every subject (Figure 3). The data was

classified in two ways, by thumbprint category and salivary pH (Table 1).

The loop type of thumbprints showed a tendency of higher pH value i.e. pH 7 whereas the pH value for whorl type of thumbprints had a lower modal pH value i.e. pH 5.

Association between Thumbprint Patterns and DMFT Score

In order to describe an association between thumbprint patterns and DMFT Score, Chi-Square Tests I, II, and III were performed. Sample proportions that were considered for all the varying thumbprints were total number of subjects having a DMFT Score below 4 and total number of subjects having a DMFT Score above 4 (Table 2).

The relationship between loop and whorl type, arch and whorl type of thumbprints, with the DMFT Score was statistically significant. Whereas, it was statistically insignificant between the loop type thumbprint, arch type of thumbprint and DMFT Score.

Association between Thumbprint Patterns and Plaque Index Score

Plaque Index Scores had a range of different readings from 0 to 3 (Table 1). Hence, the best way to analytically evaluate the impact of Plaque Index on the various types of thumbprints was to study the measures of central tendencies i.e. mean and median of the Plaque Index scores amongst the different categories (Figure 4).

Amongst 531 subjects, it was found that the mean and median plaque index score was significant higher in the individuals with a whorl type of thumbprint.

Discussion

Dental caries is most commonly observed amongst the modern population with complex, chronic and multi-factorial facets. Although it is known to be associated with multiple environmental factors it always requires a susceptible host. The factors involved with the host include the status of the dentition, saliva and immune response which are influenced by genetics. Also, caries appears to have shown polarization i.e., it is seen affecting a specific group of people and thus, heredity has been linked with its incidence in scientific literature for many years now[6].

Dental caries is controlled primarily by genetic and environmental factors. Vieira[7] assessed the specific loci of genes which predispose to low or high evidence of dental caries. Through their study, it was established that "several genes likely influence individual susceptibility to caries and consist of three main groups: genes involved in enamel development, saliva formation and composition, and immune response. Dental caries is an outcome of the interaction of host factors, microbial infection, and substrate that enhance progression of cariogenic microbiota. There are underlying genetic mechanisms modulating each of these factors, such as saliva factors, which influence bacterial adhesion or acidic buffer capacity"[7].

Kaczmarek *et al.*[8] has laid emphasis on dietary habits and enzymatic activity during developmental stages and physiologic functioning of the organism. Several inherited determinants were concluded, the most recognizable being "structural and surface characteristics of dental hard tissue, tooth morphology, time of eruption, alignment of teeth, salivary flow rate and its immunological response to microorganisms. Inherited thresholds for taste and smell also play a significant role, which affect taste preferences and thus dietary habits and activity of specific enzymes participating in regulation processes during various stages of development"[8].

Dermatoglyphics is the term specified to the scientific study of finger prints[9]. A dermatoglyphic fingerprint develops in the embryonic phase, and is a distinctive characteristic in primates[10,11]. The fingerprint patterns have been classified by a number of researchers, but the most commonly used classification was given by Sir Edward Richard Henry in 1900[12]. The three basic fingerprint patterns are "loop", "whorl" and "arch", which constitute 60–65%, 30–35% and 5% of all fingerprints, respectively[11,13]. In wider perspective, it has been concluded that genetic factors greatly contribute to the dermatoglyphic pattern of a human fingerprint[14].

Numerous studies pertaining to dermatoglyphic patterns and genetic disorders/diseases have been studied by scientists where heredity has a predominant role in its etiology. Studies have proved that dermatoglyphics facilitate diagnosis of intrauterine anomalies and identification of various diseases like breast carcinoma[15], type I diabetes mellitus[15], congenital heart disease[2], leukemia[2], celiac disease[2], schizophrenia[2], and many other medical conditions. This relation between different dermatoglyphic patterns and various diseases is evidence that "morphogenesis of epidermal ridges and organogenesis occurs at same period during

embryogenesis and programmed by genetic expressions which are interlinked"[16].

"In 1973, Fuller suggested that many genes which are involved in the development of finger and palm dermatoglyphic development may also predispose in propagation of several forms of malignancy[17]. Borgaonkar *et al.*[18] mentioned that chromosomal imbalance of any magnitude has an effect on the dermatoglyphic pattern, which they established in specifically Down syndrome. Ridges-of-the End syndrome in two families and the Nelson Syndrome, both of which are dermatoglyphic syndromes, perhaps inherited as autosomal dominant traits have been described by David"[19].

A total of 531 subjects were selected on the basis of stratified random sampling technique. According to standardizations that were established prior to the examination, thumbprints, DMFT Score, Salivary pH and Plaque Index Score were recorded individually. After garnering the data, statistical analysis which included nonparametric chi-square tests, correlation coefficients and measures of central tendencies were performed along with R (R × 64 3.2.4 Revised) programming on R Studio Version 1.1.463 – © 2009-2018 R Studio, Inc. On dermatoglyphic analysis, our study reflected recurrence of loop type pattern the most which is in consonance with most of the research conducted in various population-based studies on dermatoglyphics[14]. The loop type thumbprint was followed by whorl and arch type thumbprints.

The dermatoglyphics of each volunteer were followed by assessment of their DMFT index, salivary pH values and plaque index scores. Upon calculating the correlation coefficients, salivary pH values and plaque index scores when compared with the total DMFT score (≥4 and ≤4), a statistically significant correlation could be ascertained between low salivary pH and total DMFT score ≥4 ($p<0.05$) and also between higher plaque index score and total DMFT score ≥4($p<0.05$). This reinforces the fact that reduction in the salivary pH values and increasing plaque index scores are the predisposing factors associated with dental caries.

The null hypothesis was that there was no association between dermatoglyphics and the prevalence of dental caries and that no correlation would be found amongst the many predisposing factors that influence dental caries. In view of the cascade of Chi-Square tests performed to know the association of dermatoglyphics on the DMFT index, the whorl type of thumbprints appeared to have some influence on DMFT Score. Hence, the results are indicative of the statistical significance of our inference.

To support the finding, the whorl thumbprint type presented a higher mean and median DMFT score as compared to loop and arch thumbprint types. Though the median shows (Table 1) that the DMFT score of the whorl type thumbprint is a 150% of that of arch and loop, but based on the mean we can safely say that the DMFT score of patients with whorl type thumbprint is at least 130% of the average DMFT of patients having arch and loop type thumbprints.

"When the salivary pH or the pH of plaque falls below a 'critical value' of about 5.5, the saliva or plaque becomes unsaturated with respect to tooth minerals[20]. Thus, acidic conditions facilitate in bringing phosphate and hydroxyl ions below saturation levels, permitting the solid hydroxyl apatite crystals of the tooth mineral to dissolve[20]. However, when the pH is above this value, the saliva and plaque are supersaturated with respect to tooth minerals"[20]. According to Table 2 and Figure 2, from the Salivary pH data gathered we could ascertain that the modal appearance of the lowest salivary pH i.e. pH 5 in whorl type thumbprint pattern. Further, the mean DMFT score for whorl type of thumbprint was statistically indicated to be higher.

"Dental plaque is also implicated in dental caries, which is associated with shifts in the microbial balance of the bio-film resulting in increased proportions of acid producing and acid tolerating bacteria, especially but not exclusively streptococcus mutans and lactobacilli[21]. The regular intake of fermentable dietary sugars, or impaired saliva flow produces persistent conditions of low pH within the bio-film, which selects for these cariogenic bacteria"[21]. From the data garnered from the 531 subjects, we found that the mean and median plaque index score was significantly higher in the individuals with a whorl type of thumbprint.

Gupta *et al.* (2012)[20] conducted a similar study where in 1250 children participated and their age varied from five to twelve years and concluded that there was 83% correlation between dental caries susceptibility of an individual and increase in the incidence of whorl pattern. On the basis of study, it was established that "digital dermatoglyphics may have a crucial role in distinguishing people either with or at increased risk of dental caries so that either risk reduction measures or prevention therapy can be implemented".

According to Yamunadevi *et al.*[3] the occurrence of whorl with double loop and whorl within a loop should be suspected for more genetic susceptibility toward development of dental caries. Specifically, caries-free individuals showed increased incidence of ulnar loop, whereas subjects with high caries score had a higher percentage of whorl patterns[3]. Veeresh *et al.*[16] in accordance to our study also reported "salivary pH was lower in high caries individuals and loop patterns were observed in caries free persons, whereas whorl patterns were common in individuals with high DMFT score".

Our findings also corroborate with the results of the study presented by Singh *et al.*[22] where a study consisting of as many as 512 preschool children in the age bracket of two to six years of age showed increased incidence of whorl type patterns in the children reflecting a higher DMFT score. Although the results of Akyuz *et al.*[23] are contrary to outcomes of our study, which established that loop type patterns were most often associated with individuals having a higher DMFT score, these results could be contributed by the subjective differences in assessing the thumbprint pattern types or due to the difference in age at which the subjects were examined. The study population in our study had a varying age group from 17-27 years. This allows the carious lesions to be more established over a period of time, which in a younger age group may not be clinically assessable.

In conclusion, the dermatoglyphic patterns have been used as an oral health marker according to Madan *et al.*[24] which can determine the genetic predisposition to dental caries.

Under the limitations of this study, the null hypothesis was rejected and following conclusions were drawn:

1. There was distinct association between thumbprint patterns and prevalence of dental caries with a definitive correlation amongst the predisposing factors influencing it.
2. The whorl type thumbprint was associated with an increased caries incidence.

Dermatoglyphic patterns being a viable tool for screening can be employed to effectively evaluate the genetic basis of dental caries. However, the scope for research and development in the study of dermatoglyphics remains abundant.

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