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Original Article

Dentistry Section

Correlation of Dermatoglyphics and Hormonal Fingerprints with Dental Caries among 3-6-year-old Children: A Cross-sectional Study

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ABSTRACT

Introduction: Dermatoglyphics, which develops concurrently with tooth enamel during embryogenesis, has been explored as a genetic marker. The second-to-fourth digit ratio (2D:4D), or hormonal fingerprints, is another potential biological marker for predicting dental caries. Early detection of children at high risk for caries may enable timely preventive interventions, and reducing progression of caries and improve long-term oral health outcomes.

Aim: To evaluate the correlation between dermatoglyphics and hormonal fingerprints as predictors of dental caries among three to six-year-old children.

Materials and Methods: This cross-sectional study was conducted among school-going children aged 3-6 years enrolled in government, private schools and anganwadi centres in Bhimavaram, Andhra Pradesh, India from October 2024 to December 2024. including 98 healthy children aged 3-6 years with parental consent. Participants were divided equally into two groups- caries-active (def ≥1) (group I) and caries-free (def=0) (group II) per World Health Organisation (WHO) oral health assessment criteria. Fingerprints of all 10 digits were recorded using the Cummins and Midlo ink method, then examined under 2× magnification and classified as arch, loop, or whorl. The 2D:4D ratio of the right hand was measured with a digital Vernier caliper and categorised as high (≥1) or low (<1). Statistical analysis performed using Chi-square and Independent t-tests for group comparisons, Pearson's correlation for associations, and regression analysis for predictive value, with statistical significance was set at as p-value <0.05.

Results: Fingerprint patterns were significantly associated with dental caries, with loops as the predominant dermatoglyphic pattern among caries-active children, followed by whorls (p-value <0.05). Hormonal fingerprints were not significantly associated with caries activity (p-value >0.05) but correlated positively with loop patterns in the right hand and both hands combined (p-value <0.05). Regression analysis showed no significant predictive association between either markers and caries (p-value >0.05).

Conclusion: The higher prevalence of loops in caries-active children suggests dermatoglyphics as a predictor for assessing dental caries risk. However, the cross-sectional single-centre design limits causal inference and generalisability.

Keywords: Biological markers, Finger phalanges, Preschool children

INTRODUCTION

Dental caries is a multifactorial disease influenced by genetic and environmental factors [1]. While diet, oral hygiene, and bacterial activity contribute significantly, genetic predisposition also affects susceptibility. Dermatoglyphics, the study of dermal ridge patterns formed during the same embryonic period as tooth enamel, offers potential as a non invasive indicator of caries risk. Another possible biomarker is the second-to-fourth digit ratio (2D:4D), or hormonal fingerprint. The novelty of the study lies in simultaneously evaluating dermatoglyphics and hormonal fingerprints as predictors of dental caries in preschool children, aiming to establish simple, early screening tools to guide timely preventive measures.

The term "dermatoglyphics" was introduced by Cummins and Midlo in 1926 and is derived from the Greek words "Derma" (skin) and "Glyphic" (carvings) [2]. Nehemiah Grew is recognised as the first person in the Western world to systematically study and document dermatoglyphics, providing detailed observations and descriptions of fingerprint pattern [3].

Epidermal ridges on digits, palms, toes, and soles develop between the 3rd and 19th weeks of gestation, influenced by neurovascular bundles located between the epidermis and dermis. Interestingly, both dermatoglyphic ridge patterns and dental enamel originate from the ectoderm and develop simultaneously during the 6th-7th week of gestation. Therefore, dermatoglyphics can provide insights into dental tissue, whether normal or abnormal. Genetic factors linked to caries susceptibility, including abnormalities in tooth structures such as enamel composition, tooth eruption, and development, may be reflected in dermatoglyphic patterns like whorls and loops [4-7].

Dermatoglyphics is considered as significant marker for identifying genetic disorders such as Down syndrome [8], Alzheimer's disease [9], Multiple sclerosis [10]. It serves as a sensitive marker for detecting intrauterine dental anomalies such as cleft lip and palate [11], Periodontal disease [12], Bruxisim [13], Malocclusion [14] and Oral submucous fibrosis [15].

In addition to dermatoglyphics, hormonal fingerprints, specifically the 2D:4D ratio, have also been explored as potential biomarkers for caries risk. The 2D:4D ratio represents the length ratio of the second digit (index finger) to the fourth digit (ring finger) and is considered a marker of prenatal androgen exposure. This ratio is determined by the 14th week of gestation and remains stable throughout life. A lower 2D:4D ratio (indicating higher prenatal androgen exposure) has been linked to various conditions, including metabolic syndrome, chronic heart disease, malocclusion, and dental caries. Studies suggest that individuals with lower 2D:4D ratios tend to have a higher risk of dental caries, possibly due to factors such as reduced salivary flow, a preference for sweet foods, and enamel variations [16-18].

Despite growing interest, limited research has examined the relationship between dermatoglyphics, the 2D:4D ratio, and dental caries, particularly in children. This study was planned with an objective to evaluate the potential association between dermatoglyphic patterns and hormonal fingerprints with dental caries, exploring their role as non invasive diagnostic markers for early prediction. The null hypothesis of the study is that there is no correlation between dermatoglyphics and hormonal fingerprints among three to six-year-old children with dental caries while alternate hypothesis is there is correlation between dermatoglyphics and hormonal fingerprints.

MATERIALS AND METHODS

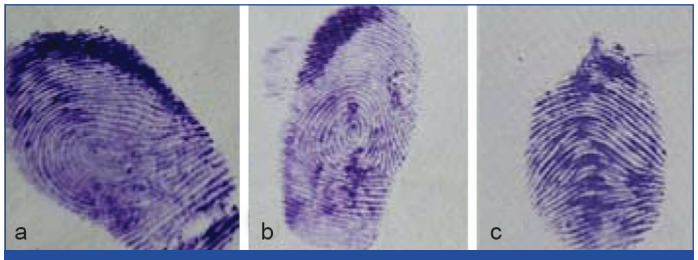
This cross-sectional study was conducted among school-going children aged 3-6 years enrolled in government, private schools and anganwadi centres in Bhimavaram, Andhra Pradesh, India from October 2024 to December 2024. The study protocol was explained to school authorities, and written informed consent was obtained from both school authorities and parents prior to data collection. Ethical clearance was obtained from the Institutional Ethics Committee (IECVDC/24/PG01/PPD/IVV/102).

Inclusion and Exclusion criteria: Healthy children of age 3-6 years with informed consent from parents were included, while those with special health care needs, skin diseases were excluded from the study

Sample size calculation: Using G power version 3.1.9.4 With an effect size of 0.51, the sample size was calculated using the formula for comparing proportions at a 95% confidence level and 80% power. Based on previous study by Uma E et al., the minimum sample size required was 94, which was rounded to 98., 49 in each group based on the def score [19].

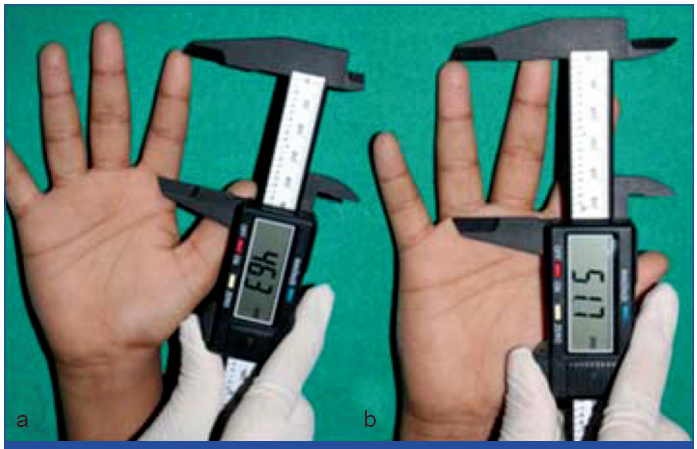
Study Procedure

The dental caries experience was recorded using visible light, mouth mirror, and community periodontal index probe. Children with def score ≥ 1 were included in caries active group (group I) and those with def score '0' were included in caries free group (group II) based on the WHO Oral Health Assessment Criteria [20]. The fingerprints of children were collected by the stamp pad method (Cummins and Midlo's ink method) [21]. The subject's hands were cleaned with soap and water and then scrubbed thoroughly with an antiseptic solution and then allowed to dry. The right hand thumb was pressed onto the stamp pad firmly for the ink to spread evenly, and then the subject was asked to press his/her fingerprint on to the white paper. This was repeated two to three times until the second or third impression was found to be satisfactory and readable. The same procedure was repeated for the left hand. Finger prints were dried. The obtained dermatoglyphic patterns for finger tips were analysed with the help of a hand magnifying glass 2x. The fingertip pattern configurations were classified into three broad groups as loop, whorl and arch patterns [Table/Fig-1] [22]. Arch is the simplest ridge pattern, which is formed by a series of one or more parallel ridges crossing the finger from side to side without recurving. In loop pattern, a series of ridges enter the pattern area on one-side of the digit, recurve abruptly, and leave the pattern area on the same side. Loops may vary considerably in shape and size. Whorl has concentric arrangement of ridges and could be spiral, symmetrical, double looped, central-pocketed, or accidental depending upon the internal structure of the whorl pattern.



[Table/Fig-1]: Image of a-Loop, b-Whorl, c-Arch.

Hormonal fingerprints were obtained by measuring the length ratio of index (2D) to ring finger (4D) with the help of digital Vernier calliper from the ventral surface of the right hand from the middle of the basal crease to the tip of the digit. In case there were multiple creases at the bottom of the digit, dimensions were taken from the maximum proximal of these creases with the help of digital Vernier caliper. The digit ratio is obtained by dividing 2D:4D values. The children were categorised as those with low 2D:4D ratio (ratio <1) and high 2D:4D ratio (ratio ≥1) based on the calculations of 2D:4D [Table/Fig-2] [23].



[Table/Fig-2]: Image of a-measuring the length of Index finger, b-Ring finger using Vernier calliper.

STATISTICAL ANALYSIS

The data were entered into Microsoft Excel XP software program. Statistical analysis was done by Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM SPSS ver 26.0, Chicago, IL, USA). Independent t-test was used to find the mean difference between caries activity and dermatoglyphic fingerprint patterns. To find out the association between the hormonal fingerprints and dental caries Chi-square test was used. Pearson's correlation analysis was done to identify correlated factor, considering hormonal fingerprints and dermatoglyphic patterns as the independent variables and dental caries as a dependent variable. Linear regression was done to identify the dermatoglyphic pattern and Hormonal fingerprints that could predict dental caries. A p-value ≤0.05 was considered statistically significant.

RESULTS

A total of 98 children were included, comprising 49 in the caries-free group and 49 in the caries-active group [Table/Fig-3]. The age distribution ranged from 3 to 6 years, with the largest proportion (44.9%) being six-year-old and the children included were of 44 males (44.9%) and 54 females (55.1%) denoting an unequal distribution of age and gender groups.

Variables	Category	n (%)
Age	3 years	17 (17.3)
	4 years	22 (22.4)
	5 years	15 (15.3)
	6 years	44 (44.9)
Gender	Male	44 (44.9)
	Female	54 (55.1)

[Table/Fig-3]: Age and gender distribution of study participants N=98.

The distribution of fingerprint patterns among caries free and caries active children suggesting a potential association between fingerprint patterns and dental caries [Table/Fig-4]. The mean and

Fingerprint patterns	Hand	Group	Mean±SD	t-value	p-value
Loops	Right hand	Group I	2.93±1.39	2.54	0.013*
		Group II	2.24±1.39		
	Left hand	Group I	2.93±1.42	2.04	0.044*
		Group II	2.36±1.34		
	Total	Group I	5.79±2.21	2.90	0.005*
		Group II	4.57±2.00		
Whorls	Right hand	Group I	1.30±1.22	-1.69	0.094
		Group II	1.75±1.39		
	Left hand	Group I	1.04±1.09	-1.24	0.214
		Group II	1.32±1.16		
	Total	Group I	2.32±1.90	-1.96	0.053*
		Group II	3.10±2.01		
Arches	Right hand	Group I	0.63±1.25	-0.86	0.391
		Group II	0.83±1.08		
	Left hand	Group I	0.87±1.23	-1.09	0.276
		Group II	1.16±1.34		
	Total	Group I	1.20±1.81	-1.89	0.060
		Group II	1.95±2.10		

[Table/Fig-4]: Distribution of fingerprint patterns among caries-active (Group I) and caries-free (Group II).
Independent t-test; p<0.05 considered statistically significant. SD: Standard deviation; Group I- Caries active; Group II- Caries free

SD show the average no of loops, whorls and arches for the right hand, left hand, and both hands combined. These were compared between caries-active (Group I) and caries-free (Group II) children using an independent t-test. The predominance of loop patterns among caries-active children suggesting a possible association with genetic predisposition influencing enamel susceptibility. Caries active children had a higher prevalence of loops, with significant differences observed in both hands together and individually (p-value<0.05). In contrast, whorls are more common in caries-free children, with significant differences observed together (p-value<0.05) but not significant in the individual hands (p-value=0.053). Arches show no significant variation between caries active and caries free individuals (p-value=0.060).

No statistically significant association (p-value=0.341) between hormonal fingerprint ratio and caries activity was observed in the study population [Table/Fig-5].

Groups (n=49)	Hormonal fingerprint ratio		Chi-square value	p-value
	Low (<1)	High (≥1)		
Group I	30	19	0.377	0.341
Group II	27	22		

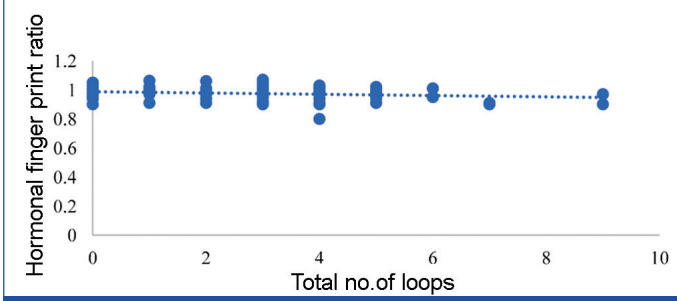
[Table/Fig-5]: Association between hormonal fingerprint ratio (2D:4D) and dental caries status.
Chi-square test; p<0.05 considered statistically significant. Group I- caries active; Group II- caries free

The Pearson's correlation analysis between the hormonal fingerprint ratio and fingerprint patterns among the study participants (n=98) is presented in [Table/Fig-6]. A significant positive correlation was found between the hormonal fingerprint ratio and the number of loops on the right hand (r=0.297, p-value <0.01) as well as the total loops in both hands combined (r=0.228, p-value <0.05). These relationships are illustrated in the scatter plots [Table/Fig-6a], the positive correlation between hormonal fingerprint ratio and total loops on both hands combined (r=0.228, p-value <0.05) This relationship suggests that an increased hormonal fingerprint ratio is moderately associated with a higher overall number of loop patterns.

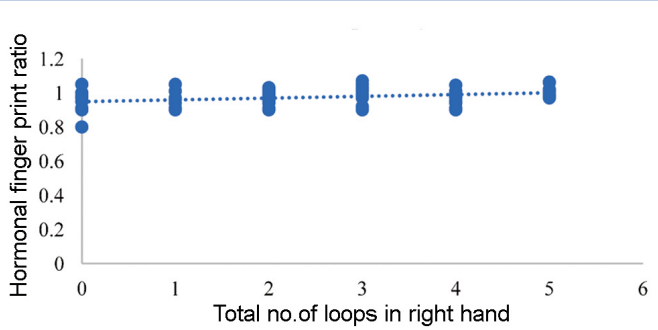
Illustrating the positive correlation between hormonal fingerprint ratio and right-hand loops (r=0.297, p-value=0.003) [Table/Fig-6b]. The upward trend of data points indicates that children with higher hormonal fingerprint ratios tend to have more loop patterns on the right hand.

	Fingerprint pattern	r-value	p-value
Hormonal fingerprint	Right hand loops	0.297	0.003**
	Left hand loops	0.106	0.299
	Total loops(R+L)	0.228	0.024*
Hormonal fingerprint	Right hand whorls	-0.192	0.058
	Left hand whorls	-0.065	0.523
	Total whorls (R+L)	-0.178	0.079
Hormonal fingerprint	Right hand arches	-0.066	0.518
	Left hand arches	0.017	0.866
	Total arches (R+L)	-0.020	0.843

[Table/Fig-6]: Correlation between hormonal fingerprints and dermatoglyphics pattern.
Pearson's Correlation Test, p<0.05 considered statistically significant, R+L=right and left hands combined



[Table/Fig-6a]: Correlation of hormonal finger print ratio to total no. of loops in both the hands.



[Table/Fig-6b]: Correlation of hormonal finger print ratio to total no of loops in right hand.

Multiple linear regression analysis assessed the predictive value of hormonal fingerprint ratio and fingerprint patterns (total loops, whorls, and arches) on dental caries [Table/Fig-7]. None of the predictors showed statistically significant associations (p-value >0.05), indicating that neither hormonal fingerprint ratio nor dermatoglyphic patterns are strong predictors of dental caries in the study population.

Dependent variable	Predictors	Unstandardised coefficients		Standardised coefficients	T-value	p-value
		B	Std. error	Beta		
Dental caries	(Constant)	2.217	1.027		2.158	0.033
	Hormonal fingerprints	-1.545	1.028	-0.150	-1.503	0.136
	Total loops (R+L)	0.015	0.039	0.067	0.399	0.691
	Total whorls (R+L)	-0.069	0.039	-0.275	-1.780	0.078
	Total arches (R+L)	-0.064	0.040	-0.252	-1.604	0.112

[Table/Fig-7]: Multiple linear regression analysis of hormonal fingerprint ratio and fingerprint patterns with dental caries as the dependent variable.
Multiple linear regression. B = Unstandardised coefficient; Std. Error = Standard error of B; Beta = Standardised coefficient; p<0.05 considered statistically significant; R+L = right and left hands combined

DISCUSSION

Dermatoglyphic patterns have been explored as potential markers for assessing genetic predisposition to dental caries in children. As fingerprints are unique, permanent, and genetically determined, they provide a quick, cost-effective, and non invasive diagnostic tool [24-26]. The present study examined the relationship between dermatoglyphic patterns, hormonal fingerprints (2D:4D ratio), and dental caries prevalence among children aged 3-6 years.

Several studies have reported a strong correlation between loops and caries activity, with loops being the most prevalent pattern in caries-active children [27-30], present study findings align with this trend, with loops dominating in the caries-active group, followed by whorls. Singh E et al., in Lucknow, reported whorls on the right-hand index finger to be associated with a lower risk of caries [31], and others have noted a higher prevalence of whorls in special children with caries, possibly due to the shared ectodermal origin of finger buds and the primary palate [32].

Similarly, some studies have linked whorls, rather than loops, to higher caries risk. In Lucknow [33] and Chennai [6], whorls were associated with higher dmft scores, while loops were protective. Similar associations have been noted in Belgaum [25], Bhopal [34], Patna, and Vadodara [35,36].

The present study found a higher prevalence of loop patterns in caries-active children, suggesting a genetic link between dermatoglyphics and dental caries, as both develop from the ectoderm during the same prenatal period. However, regression analysis showed that fingerprint patterns alone are not strong predictors of dental caries, as environmental and behavioural factors like diet, oral hygiene, and socioeconomic status play a greater role. Regional differences in genetic make-up, prenatal conditions, and lifestyle further influence fingerprint patterns, emphasising the need for region-specific research to establish its clinical relevance of dermatoglyphics as a screening tool rather than a predictor.

Hormonal fingerprints show sexual dimorphism due to Homeobox genes HoxA and HoxD, which regulate gonad and digit development. The 2D:4D ratio, fixed from the second trimester onward, reflects prenatal androgen sensitivity. Lower ratios indicate higher exposure to testosterone and oestrogens, influencing craniofacial development and caries susceptibility.

Studies suggest a strong correlation between a low 2D:4D ratio and increased risk of dental caries [23], along with associations to malocclusion, reduced salivary flow, sweet food preference, and greater caries susceptibility [17,18,37-39]. This link may be due to prenatal hormonal influences, as elevated testosterone exposure associated with lower 2D:4D ratios can impact enamel development, craniofacial morphology, immune response, and saliva's protective role, while also encouraging higher sugar intake [18]. Research by Verma P et al., and Lakshmi CR et al., supports using the 2D:4D ratio as a simple, non invasive tool to identify high-risk individuals, though larger, more diverse studies are needed to confirm its diagnostic value [17,18].

However, the present study contrasts with these findings, as no significant association was found between the 2D:4D ratio and caries activity. While previous research suggests that hormonal influences may contribute to caries susceptibility, the present study did not establish a conclusive link between hormonal fingerprints and dental caries prevalence.

Based on the results of the present study, the null hypothesis was partially accepted, as no significant association was observed for the 2D:4D ratio; however, loop patterns demonstrated statistically significant differences between groups ($p<0.05$). No significant association was found between the 2D:4D ratio and dental caries, and although loops were more common in caries-active children and whorls in caries-free children, multiple regression analysis confirmed that neither dermatoglyphic patterns nor the 2D:4D ratio are reliable predictors of caries in this population.

Limitation(s)

The present study had certain limitations including a small, geographically restricted sample and unequal gender distribution, potentially affecting dermatoglyphic pattern and 2D:4D ratio findings. Caries assessment by a single examiner without inter-rater reliability data, and the absence of full blinding between dermatoglyphic classification and caries evaluation, may have bias. Larger, more diverse samples with examiner calibration, inter-rater reliability checks, and blinded methodologies are recommended to improve result reliability.

CONCLUSION(S)

The loop patterns were the most prevalent dermatoglyphic feature among caries-active children, suggesting a higher risk of dental caries in individuals with loops. Dermatoglyphics has the potential to serve as a non invasive, inexpensive, and effective early screening tool for predicting dental caries, particularly in developing countries like India, where early detection and prevention are crucial. However, it was observed that neither dermatoglyphics nor hormonal fingerprints (2D:4D ratio) reliably predicted dental caries in the study population. Further research with larger, more diverse sample sizes is essential to establish a definitive link and assess the clinical utility of these methods in dental health assessment and caries prevention strategies. Region-specific studies are necessary to validate the clinical relevance of dermatoglyphics and 2D:4D ratios, to account for genetic, environmental, and socioeconomic variations in predicting dental caries risk.

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