Research Article
Detection of Dental Caries’ and Dermatoglyphics’ Association with Relative Enamel Thickness Using CBCT Images in Saudi Subpopulation: A Novel Approach

A. A. Dawasaz,1 Ibrahim Alshahrani,2 Syed M. Yassin,2 Sadatullah Syed,1 Mohammad Shahul Hameed,1 Fawaz Baig,3 Rafi Ahmad Togoo,2 and Luqman Master1

1Department of Diagnostic Sciences and Oral Biology, College of Dentistry, King Khalid University, Abha, Saudi Arabia
2Department of Pediatric Dentistry and Orthodontic Sciences, College of Dentistry, King Khalid University, Abha, Saudi Arabia
3Department of Oral and Maxillofacial Surgery, College of Dentistry, King Khalid University, Abha, Saudi Arabia

Correspondence should be addressed to A. A. Dawasaz; adwasaz@kku.edu.sa

Received 26 January 2021; Revised 13 April 2021; Accepted 5 July 2021; Published 26 July 2021

Academic Editor: Li Wu Zheng

Copyright © 2021 A. A. Dawasaz et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background. Dental caries is the localized destruction of dental hard tissues (enamel and dentine). Decayed, Missing, and Filled Teeth (DMFT) index is the most commonly used dental caries index. Thickness of the outermost part of the tooth called the enamel is determined by the rate of deposition of enamel proteins. Relative enamel thickness (RET) gives a measure of enamel thickness with respect to dentine. Dental caries is influenced by a genetically determined factor called dermatoglyphics (DG). As the genes responsible for RET and DG lie on the same chromosome and develop during the same time of intrauterine life, it is biologically plausible to correlate RET and DG. Aims. This study consists of two primary aims: (1) to assess RET using cone beam computed tomography images and correlate it with caries and (2) to correlate RET with DG. Materials and Methods. 148 dental subjects were assessed for DMFT caries score and were categorized as Group 1 with DMFT = 0 and Group 2 with DMFT ≥ 1. Following this, their DG pattern was recorded digitally. The CBCT images of these subjects were assessed for RET, and the data were analyzed statistically. Results. Mean RET in our sample population is 18.45 (SD 3.79) while mean DMFT is 5.34 (SD 5.13). Mean RET in Group 1 subjects was 19.82 (SD 4.05) while that in the Group 2 was 17.68 (SD 3.43). RET and DMFT showed a statistically significant negative correlation (p = 0.007). The “Single Loop” DG characteristic showed a statistically significant difference between males and females (p = 0.031). The “Simple Arch” type of DG was positively correlated with RET. Conclusion. This is the first in vivo study to assess RET using CBCT images and correlate with DMFT and DG. RET is inversely related to DMFT while directly proportional to the “Simple arch” DG pattern. Males and females differed in their “Single Loop” DG characteristic.

1. Introduction

Dental caries is a universal noncommunicable disease that costs the global economy billions of dollars annually. The most common health condition seen globally remains to be untreated dental caries of the permanent dentition (34%) [1]. Although the prevalence of dental caries has declined over the past years in developed countries, the World Health Organization (WHO) goal to achieve a Decayed, Missing, and Filled Teeth (DMFT) score less than 3 for a 12-year-old child is still a distant dream for a significant proportion of the global population [2]. In 2015, the highest untreated dental caries prevalence in permanent dentition was seen in the younger age group of 15–19 years [1]. In Saudi Arabia, the prevalence of dental caries in permanent dentition in 2010 was 59-80% [3]. It is known that many causative factors have already been extensively investigated and documented in the literature. However, many other factors for
Study subjects ($n = 148$)

Dental caries (DMFT)
Group 1 (DMPT = 0) Group 2 (DMPT $\geq 1$)

Step 1: Dental caries (DMFT)
Group 1 (DMPT = 0) Group 2 (DMPT $\geq 1$)

Step 2: Assessment of Dermatoglyphic (DG) pattern (loops, arches and whorls) using digital fingerprint reader

Step 4: Correlation of RET with dental caries

Step 5: Correlation of RET with DG

Calculating relative enamel thickness (RET) of study subject using CBCT images of mandibular first permanent model

Figure 1: Study protocol.

Loops
Arches
Whorls

- Single loop
- Double loop
- Simple arch
- Tented arch
- Symmetrical
- Spiral

Figure 2: Dermatoglyphic characteristics.

Figure 3: Relative enamel thickness (RET) measurement on CBCT image. $c =$ area of enamel cap in mm$^2$; $e =$ length of DEJ in mm; $b =$ area of dentin under DEJ in mm$^2$. 
the development and progression of dental caries remain unknown. Caries usually begins from the tooth's outermost layer called dental enamel, composed of densely packed hydroxyapatite crystals [4]. The effect of the thickness of dental enamel in caries progression has never been explored. Relative enamel thickness (RET) has been previously studied for various reasons, including orthodontic treatment needs like proximal stripping, investigating relationships between different animal species, and analyzing dentition adaptation to specific diets. It has also been successfully applied in evolutionary studies to deduce taxonomic identity, phylogenetic relationships, and dietary and behavioral adaptations of different species [5]. In humans, racial and gender differences have also been reported in previous literature [6, 7]. Mandibular first permanent molars (MFPMs) were used in this study to assess RET. These teeth are necessary to maintain dental arches' integrity, and their overall health is influenced by their early eruption in the oral cavity and large bulky crowns with deep pits and fissures on their occlusal surfaces [8]. Technological advancements in dentistry have reached a new milestone after the introduction of cone beam computed tomography (CBCT). Its versatility has created new avenues for research. Our study has utilized CBCT imaging to assess RET of MFPM accurately.

The most commonly used dental caries index is the DMFT index. It helps evaluate both present (decayed teeth) and past (missing and filled teeth) caries experiences in the entire permanent dentition. It is pertinent to note that DMFT of MFPM can provide updated information on a full dentition's health status [9]. Hence, authors have utilized a novel method for assessing the RET data of the mandibular first permanent molar to correlate DMFT information of the whole dentition. Population mean DMFT scores have been well documented. In Abha, Saudi Arabia, 6- to 13-year-old children demonstrated an 85.4% prevalence of dental caries, whereas the mean DMFT was 0.8 [10]. The national average data (2010) showed mean DMFT scores ranging from 1.53 to 2.93 in children 12–13 years old and from 2.24 to 4.08 in children 15–18 years old [11].

Another critical factor that has recently gained much interest in caries research is "Dermatoglyphics" (DG). Ridges seen on the palm and sole skin are used for person identification due to their unique characteristics in every individual. The term "Dermatoglyphics" was coined by Cummins and Midlo [12] as a study of intricate dermal ridge configurations on the skin covering the palmar and plantar surfaces of the hands and feet [13, 14]. In previous literature, it is also reported that genetic markers for both DG and tooth structures are present on the same chromosome 4, which may explain the significant association of DG with dental caries [15].

Table 1: Descriptive statistics of study subjects (n = 148).

| RET   | DMFT | S loop | D loop | T arch | S arch | Symm | Spiral |
|-------|------|--------|--------|--------|--------|------|--------|
| Mean  | 18.44| 5.34   | 0.93   | 0.68   | 2.78   | 2.47 | 1.08   | 2.07   |
| SEM   | 0.31 | 0.42   | 0.09   | 0.06   | 0.17   | 0.15 | 0.08   | 0.14   |
| SD    | 3.79 | 5.13   | 1.17   | 0.79   | 2.11   | 1.92 | 1.07   | 1.77   |
| Skewness | 0.35 | 0.41   | 1.58   | 0.81   | 0.75   | 0.81 | 1.05   | 1.21   |
| Minimum | 10.52| 0      | 0      | 0      | 0      | 0   | 0      | 0      |
| Maximum | 32.80| 17     | 6      | 3      | 9      | 8   | 5      | 9      |

SEM: standard error mean; SD: standard deviation.

Table 2: Association of RET and gender with DMFT.

| Group 1 (DMFT = 0) | Group 2 (DMFT ≥ 1) |
|-------------------|--------------------|
| RET               | Spearman's rho coefficient = −0.223 |
| n                 | 53                 |
| Mean              | 19.82              |
| SD                | 4.05               |
| Male              | 25                 |
| Mean              | 8.11               |
| SD                | 4.11               |
| Female            | 28                 |
| Mean              | 8.48               |
| SD                | 3.98               |

Table 3: Descriptive statistics of RET and DMFT in males and females p ≥ 0.05.

| Gender | n  | Mean  | SD  | SEM  |
|--------|----|-------|-----|------|
| RET    |    |       |     |      |
| Male   | 68 | 18.43 | 3.80 | 0.46 |
| Female | 80 | 18.45 | 3.81 | 0.42 |
| DMFT   |    |       |     |      |
| Male   | 68 | 5.13  | 5.11 | 0.62 |
| Female | 80 | 5.51  | 5.17 | 0.58 |

SD: standard deviation; SEM: standard error mean.
The research protocol used in this study

2.2. Data Collection.

clinically sound MFPMs. Patients with a history of systemic

were included in the study. All study subjects had fully erupted
dental CBCT scans done no more than six months prior were

nationals aged twelve to eighteen years who had previous

sampling was used to select study subjects. Healthy Saudi

board, College of Dentistry, King Khalid University

ber 2020. The study was approved by the institutional review

clinics, College of Dentistry, from February 2017 till Novem-

Following DMFT scoring, these patients’ dermatoglyphic

(DG) patterns were recorded for all ten digits of the hands

using a digital fingerprint reader (Dactyscan® 84C, Fulcrum

Biometrics, India). The sample population’s DG patterns

were categorized into three classes, namely: loops, arches,

and whorls, with their subtypes as described by AlShahrani

et al. [15]. Loops were subclassified as a single loop (S loop)
or a double loop (D loop), arches were categorized as a simple

arch (S arch) or a tented arch (T arch), while whorls were
either symmetrical or spiral as shown in Figure 2.

Lastly, dental CBCT (Kavo 3D Pro, USA) images of the

study subjects were retrieved from the hospital records for

assessing the RET of MFPMs. Each image was acquired using

the following parameters: 89 kVp, 9.0 mA, and 16 sec expo-

sure. The 2D images of either mandibular right or left MFPM

were selected, showing the maximum mesiodistal width. All

images were digitally adjusted using the command “High

Boost” to get finer details of the enamel, dentin, and pulp

space. The area of the enamel cap (c) and dentine (b) area

under dentin-enamel junction (DEJ) (in mm²) and the length

of DEJ (e) in mm were measured as shown in Figure 3. Rela-
tive enamel thickness was calculated using the formula:

\[
RET = \left(\frac{c-e}{\sqrt{b}} \times 100\right)
\]

[23].

The collected data were statistically analyzed using SPSS®
(version 21.0/PC; Chicago, IL, USA). Spearman’s rho corre-
lation test was conducted to assess RET correlation with car-
dies status and DG. Linear regression analysis was used to
evaluate the effect of RET on DG and dental caries. Gender
differences in DG characteristics were assessed using the
Mann–Whitney U test, whereas the independent samples t-
test was used for association between RET and DMFT.
Interobserver agreement using kappa statistic was 0.81 for
RET and 0.85 for DMFT, thereby indicating congruence
between the two observers.

This human observational study manuscript has con-
formed to STROBE guidelines used for cross-sectional study
design.

3. Results

RET and DMFT data in our sample population showed nor-
mal distribution, while DG data were not distributed nor-
mally. There were 53 subjects in Group 1, while there were
95 subjects in Group 2. There were 68 and 80 male and
female subjects, respectively. Descriptive statistics (Table 1)
revealed mean that RET in our sample population was
18.45 (SD 3.796) while the mean DMFT was 5.34 (SD
5.134). The maximum number of DG characteristics
revealed mean that RET in our sample population was
18.45 (SD 3.796) while the mean DMFT was 5.34 (SD
5.134). The maximum number of DG characteristics
observed was T arch, while D loop was at a minimum.
Table 2 shows that the mean RET in Group 1 subjects was
0.71 ± 0.03, while the mean RET in Group 2 subjects was
0.71 ± 0.03, indicating a statistically significant difference
between the two groups (p-value < 0.05).

Table 5: Linear regression analysis of RET with DMFT score and S arch DG characteristic.

| RET | Spearman’s rho | Correlation coefficient | Sig. (2-tailed) |
|-----|----------------|------------------------|---------------|
| DMFT | -0.087 | -0.037 | 0.294 | 0.654 |
| S arch | 0.991 | 0.002 | 0.405 | 0.578 |
| Symm | 0.069 | 0.046 |
| Spiral | 0.294 | 0.654 |
| T arch | 0.031 | 0.382 | 0.210 | 0.282 | 0.494 | 0.545 |

| Gender | Mann–Whitney’s U | Z value | Sig. (2-tailed) |
|--------|------------------|---------|---------------|
| Male | -2.156 | -0.874 | -1.253 | -1.077 | -0.684 | -0.605 |
| Female | 0.031 | 0.382 | 0.210 | 0.282 | 0.494 | 0.545 |

Many studies have either assessed RET in animals or in
humans using intraoral radiographs [16–19]. The association
between DG and dental caries has also been well established
[13, 14, 20, 21]. However, this is the first study aimed at assess-
ing RET in vivo using CBCT and testing the association
between RET and caries and RET as DG in a Saudi
subpopulation.

2. Materials and Methods

2.1. Study Design and Subject. The present cross-sectional
study was conducted in King Khalid University’s dental
clinics, College of Dentistry, from February 2017 till Novem-
ber 2020. The study was approved by the institutional review
board, College of Dentistry, King Khalid University
(SRC/REG/2017-2018/98). Nonprobability convenience
sampling was used to select study subjects. Healthy Saudi
nationals aged twelve to eighteen years who had previous
dental CBCT scans done no more than six months prior were
included in the study. All study subjects had fully erupted
clinically sound MFPMs. Patients with a history of systemic
illness and developmental and congenital anomalies were
excluded.

2.2. Data Collection. The research protocol used in this study
is shown in Figure 1.

After informed consent from parents/guardians, dental
examination was performed in pediatric dental clinics by
two calibrated dentists using a mouth mirror and explorer
No. 17. According to the World Health Organization
(WHO) guidelines [22], the DMFT score of each subject
was noted. These were then categorized as Group 1 with
DMFT = 0 and Group 2 with DMFT ≥ 1.

Table 4: Association of RET and gender with DG characteristics in study subjects (n = 148).

| RET | S loop | D loop | T arch | S arch | Symm | Spiral |
|-----|--------|--------|--------|--------|-------|--------|
| RET | Spearman’s rho | Correlation coefficient | Sig. (2-tailed) |
| DMFT | -0.087 | -0.037 | 0.294 | 0.654 |
| S arch | 0.991 | 0.002 | 0.405 | 0.578 |
| Symm | 0.069 | 0.046 |
| Spiral | 0.294 | 0.654 |
| T arch | 0.031 | 0.382 | 0.210 | 0.282 | 0.494 | 0.545 |
19.82 (SD 4.05), while that in the Group 2 was 17.68 (SD 3.43). RET and DMFT showed a statistically significant negative correlation ($p = 0.007$). It is observed that gender differences in RET are not significant in our sample population. Mean DMFT in Group 2 males and females is shown in Table 2 ($p \geq 0.05$), while mean RET and DMFT in males and females are shown in Table 3. RET demonstrated a strongly positive correlation with the S arch characteristic ($p = 0.002$), while the S loop DG characteristic showed a statistically significant difference between males and females ($p = 0.031$) (Table 4).

Table 5 shows that linear regression analysis used to assess RET’s influence on caries development was significant, and the adjusted $R^2$ value was 0.061. The relationship of RET and DMFT is inversely proportional as shown in a scatter plot diagram (Figure 4(a)).

The effect of S arch on RET was significant, having an adjusted $R^2$ value of 0.034. The direct proportional relationship of RET with S arch is shown in Figure 4(b). It is also worthy to note that as RET increased, caries status decreased by 35%, while the number of S arch characteristics increased by 10.1%.

4. Discussion

In the present study, we chose MFP to assess RET, the reason being that MFPs are considered crucial teeth in the oral cavity for maintaining the integrity of dental arches. More importantly, they have a high caries prevalence due to various factors like its anatomic morphology that accumulates many acid-producing S. mutans bacteria, and its early eruption during childhood [8]. Hence, they need special attention during dental examination and careful preventive strategies, including fissure sealant, topical fluoride application, and meticulous home care.

It is also interesting to consider the biologic plausibility that the thickness of the enamel layer is influential to dental caries’ progression. It is proven that the rate and duration of enamel secretion and the number of active enamel-producing cells influence an individual’s enamel thickness [24]. It is also affected by the enamelin (ENAM) gene on chromosome 4 reference sequence NM_031889 (UCSC Genome Browser March 2006 Assembly) [25]. It is conducive to enamel crystal formation and facilitates elongation perpendicular to the outer surface of the tooth [26, 27]. Gender differences in RET in our study population were insignificant ($p \geq 0.05$), indicating similar enamel secretion rates in both males and females. This finding is in contrast with other studies that point to gender differences in enamel thickness [18].

4.1. RET and Caries Association. DMFT gives a general picture of patients’ caries experience. The mean DMFT of our study population was above the national average [11]. Awareness regarding proper oral hygiene and caries preventive strategies are therefore needed for the general public. It was also seen in the results of this study that DMFT was strongly correlated with RET ($p = 0.003$). It can therefore be inferred that the thicker the enamel the better is the protection for the tooth against caries. However, since it is a multifactorial disease, other factors may also play a significant role in developing caries. It is also worth noting that the statistically significant relationship between RET and DMFT is negative. Therefore, it can be inferred that they are inversely proportional to each other.

Possible confounders for our study could be regressive changes of dental enamel, viz., attrition, erosion, and abrasion. Additionally, post eruptive enamel maturation does not alter the dimensional measurements in children [28]. Hence, considering the age of the sample subjects, this effect could be negligible. Furthermore, studies have reported that fluoride uptake can maintain the morphological and chemical integrity of the enamel. However, it was not effective in maintaining the mechanical properties of the enamel [29].

4.2. RET and DG Association. It is known that both the epithelium of finger buds and enamel are ectodermal in origin.
and develop at the same time of intrauterine life, which forms a basis for considering the DG pattern as a genetic marker [30–32] for enamel thickness. DG characteristics are genetically influenced by the SMARCAD 1 gene located on chromosome 4, long arm at position 22.3 [33]. Due to the close relationship of both genes that code for RET and DG, it can be concluded that some characteristics of DG and RET will have a significant relationship. Thus, DG may be an important influencing factor for RET.

In both males and females, it has been observed that the most common characteristic was T arch and the least common was D loop. A Mann–Whitney U test showed significant gender difference in the single loop characteristic only ($p = 0.031$). This is in accordance with other studies that reported a similar finding [21]. It has also been observed from Table 4 that the S arch DG characteristic has a high positive correlation with RET. Thus, it can be inferred that the number of S arch characteristics correlated well with the RET of MFPM. However, since the adjusted $R$ square value was low, the influence of S arch DG characteristic amongst all other factors in determining the thickness of enamel is minimal.

5. Conclusion

A humble novel attempt has been made to study RET’s relationship with dental caries and dermatoglyphics. It is important to note that RET was inversely proportional to the caries experience of an individual. Additionally, RET was directly proportional to the number of S arch type DG patterns. Lastly, the gender of an individual also has an influence on the S loop DG characteristic.

6. Further Studies

The authors will be studying machine learning’s efficacy in the automated analysis of radiographic images to assess RET. It is also further proposed to carry out multicenter, multiethnic, and cohort animal studies to confirm the genetic influence on the cause-and-effect relationship of RET, DG, and DMFT.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Acknowledgments

This work was supported by the Deanship of Scientific Research, King Khalid University, Saudi Arabia (Grant no. G.R.P.-367-39).

References

[1] N. J. Kassebaum, A. G. C. Smith, E. Bernabé et al., “Global, regional, and national prevalence, incidence, and disability-adjusted life years for oral conditions for 195 countries, 1990-2015: a systematic analysis for the global burden of diseases, injuries, and risk factors,” Journal of Dental Research, vol. 96, no. 4, pp. 380–387, 2017.

[2] P. E. Petersen, D. Bourgeois, H. Ogawa, S. Estupinan-Day, and C. Ndiaye, “The global burden of oral diseases and risks to oral health,” Bulletin of the World Health Organization, vol. 83, no. 9, pp. 661–669, 2005.

[3] M. A. Peres, L. M. D. Macpherson, R. J. Weyant et al., “Oral diseases: a global public health challenge,” Lancet, vol. 394, pp. 10194, pp. 249–260, 2019.

[4] A. M. Kelly, A. Kallistova, E. C. Küchler et al., “Measuring the microscopic structures of human dental enamel can predict caries experience,” Journal of Personalized Medicine, vol. 10, no. 1, p. 5, 2020.

[5] L. Martín-Francés, M. Martinón-Torres, M. Martínez de Pinillos et al., “Tooth crown tissue proportions and enamel thickness in Early Pleistocene Homo antecessor molars (Atapuerca, Spain),” PLoS One, vol. 13, no. 10, article e0203334, 2018.

[6] L. J. Ghose and V. S. Baghdadty, “Analysis of the Iraqi dentition: mesiodistal crown diameters of permanent teeth,” Journal of Dental Research, vol. 58, no. 3, pp. 1047–1054, 1979.

[7] S. E. Bishara, J. R. Jakobsen, E. M. Abdallah, and A. Fernandez García, “Comparisons of mesiodistal and buccolingual crown dimensions of the permanent teeth in three populations from Egypt, Mexico, and the United States,” American Journal of Orthodontics and Dentofacial Orthopedics, vol. 96, no. 5, pp. 416–422, 1989.

[8] H. A. Hashim and S. Al-Ghamdi, “Tooth width and arch dimensions in normal and malocclusion Samples: An Odontometric Study,” The Journal of Contemporary Dental Practice, vol. 6, no. 2, pp. 36–51, 2005.

[9] A. P. Pontigo-Loyola, M. . L. Márquez-Corona, M. Minaya-Sánchez et al., “Correlation between the caries status of the first permanent molars and the overall DMFT Index,” Medicine, vol. 99, no. 5, article e19061, 2020.

[10] M. A. Abolfotouh, K. H. Hassan, M. S. Khattab, R. M. Youssef, A. Sadek, and M. El-Sebaie, “Dental caries: experience in relation to wasting and stunted growth among schoolboys in Abha, Saudi Arabia,” Annals of Saudi Medicine, vol. 20, no. 5–6, pp. 360–363, 2000.

[11] D. E. Al Agili, “A systematic review of population-based dental caries studies among children in Saudi Arabia,” The Saudi Dental Journal, vol. 25, no. 1, pp. 3–11, 2013.

[12] H. Cummins and C. Midlo, Finger prints, palms and soles: an introduction to dermatoglyphics, vol. 319, Dover Publications, New York, 1961.

[13] T. Veeresh, A. Mujahid, P. Deepu, and R. Sivaprakash, “Correlation between dermatoglyphics, dental caries and salivary pH: an invivo study,” Ethiopian Journal of Health Sciences, vol. 29, no. 1, pp. 929–934, 2019.

[14] S. Konde, N. S. Raj, N. C. Kumar, P. Peethamber, and C. Anitha, “Dermatoglyphics: a genetic marker of early childhood caries,” Journal of Indian Society of Pedodontics and Preventive Dentistry, vol. 32, no. 3, p. 220, 2014.

[15] I. AlShahrani, A. A. Dawasaz, S. Syed, M. Ibrahim, and R. A. Togoo, “Three-dimensional palatal anatomic characteristics’
correlation with dermatoglyphic heterogeneity in angle malocclusions,” *The Angle Orthodontist*, vol. 89, no. 4, pp. 643–650, 2019.

[16] L. Buti, A. Le Cabec, D. Panetta et al., "3D enamel thickness in Neandertal and modern human permanent canines,” *Journal of Human Evolution*, vol. 113, pp. 162–172, 2017.

[17] T. M. Smith, A. J. Olejniczak, D. J. Reid, R. J. Ferrell, and J. J. Hublin, "Modern human molar enamel thickness and enamel-dentine junction shape,” *Archives of Oral Biology*, vol. 51, no. 11, pp. 974–995, 2006.

[18] S. A. Fernandes, F. Vellini-Ferreira, H. Scavone-Junior, and R. I. Ferreira, "Crown dimensions and proximal enamel thickness of mandibular second bicuspids,” *Brazilian Oral Research*, vol. 25, no. 4, pp. 324–330, 2011.

[19] A. J. Olejniczak, P. Taftoreau, R. N. M. Feeney, and L. B. Martin, "Three-dimensional primate molar enamel thickness,” *Journal of Human Evolution*, vol. 54, no. 2, pp. 187–195, 2008.

[20] M. Agarwal, A. Alex, and S. Konde, "Relationship between dermatoglyphics, cheiloscopy, rugoscopy, and dental caries: a cross-sectional study in Bengaluru, Karnataka,” *Contemporary Clinical Dentistry*, vol. 9, no. 4, pp. 577–581, 2018.

[21] R. Somani and A. Sharma, "Dermatoglyphic interpretation of dental caries and its correlation to salivary bacteria interactions: An in vivostudy,” *Journal of Indian Society of Pedodontology and Preventive Dentistry*, vol. 27, no. 1, p. 17, 2009.

[22] W.H. Organization, *Oral Health Surveys; Basic Methods*, World Health Organization, 1977.

[23] L. Martin, "Significance of enamel thickness in hominoid evolution,” *Nature*, vol. 314, no. 6008, pp. 260–263, 1985.

[24] F. E. Grine and L. B. Martin, "Enamel thickness and development in *Australopithecus* and *Paranthropus*," in *Evolutionary History of the "Robust" Australopithecines*, Aldine de Gruyter, New York, 1988.

[25] J. L. Kelley and W. J. Swanson, "Dietary change and adaptive evolution of enamelin in humans and among primates,” *Genetics*, vol. 178, no. 3, pp. 1595–1603, 2008.

[26] A. Nanci, *Ten Cate’s Oral Histology-e-Book: Development, Structure, and Function*, Elsevier Health Sciences, 2017.

[27] D. M. Daubert, J. L. Kelley, Y. G. Udod et al., "Human enamel thickness and ENAM polymorphism,” *International Journal of Oral Science*, vol. 8, no. 2, pp. 93–97, 2016.

[28] R. J. M. Lynch, "The primary and mixed dentition, post-eruptive enamel maturation and dental caries: a review,” *International Dental Journal*, vol. 63, pp. 3–13, 2013.

[29] C. Robinson, S. Connell, J. Kirkham, S. J. Brookes, R. C. Shore, and A. M. Smith, "The effect of fluoride on the developing tooth,” *Cartes Research*, vol. 38, no. 3, pp. 268–276, 2004.

[30] L. Mathew, A. M. Hegde, and K. Rai, "Dermatoglyphic peculiarities in children with oral clefts,” *Journal of the Indian Society of Pedodontics and Preventive Dentistry*, vol. 23, no. 4, pp. 179–182, 2005.

[31] J. Pons, "Genetics of the a-b ridge count on the human palm,” *Annals of Human Genetics*, vol. 27, no. 3, pp. 273–277, 1964.

[32] S. B. Holt, "The hypothenar radial arch, a genetically determined epidermal ridge configuration,” *American Journal of Physical Anthropology*, vol. 42, no. 2, pp. 211–214, 1975.

[33] C. N. Adra, J. L. Donato, R. Badovinac et al., "SMARCAD1, a novel human helicase family-defining member associated with genetic instability: cloning, expression, and mapping to 4q22-q23, a band rich in breakpoints and deletion mutants involved in several human diseases,” *Genomics*, vol. 69, no. 2, pp. 162–173, 2000.