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ORIGINAL ARTICLE

Dermatoglyphic Assessment in Subjects with Different Dental Arch Forms: An Appraisal

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Abstract Successful rehabilitation of edentulous individuals involves selection and arrangement of artificial teeth in accordance with the patient's original arch form. Various criteria exist for harmonious tooth arrangement but none is accepted universally. Finger and palm prints are unique to an individual and once formed in the sixth week of intra-uterine life, remain constant thereafter. Since dental arches are also formed during the same prenatal period, it is believed that the similar genetic factors may be involved in formation of dental arches and dermal patterns. This study was conducted to identify the association if any between type of dental arch forms and type of dermatoglyphic patterns. If specific dermal characteristics exist in individuals with specific dental arch forms, dermatoglyphic assessment of long standing edentulous subjects may help identify the patients preexisting dental arch form and thus aid in proper tooth arrangement. Ninety dentulous subjects were categorized into three groups on the basis of dental arch form (square, tapering or ovoid) and their finger and palm prints were recorded. The type of fingertip patterns, distribution of palmar patterns, Total Finger Ridge Count and angle atd were assessed. Subjects with square arches demonstrated a significantly high frequency of loops and a large atd angle with palmar patterns being most frequent in I_3 region. Subjects with tapering arches showed a high frequency of whorls, a small atd angle and greatest distribution of palmar patterns in I_4 region. In ovoid arched subjects, loops were the most common and palmar patterns were mostly observed in I_4. Since distinctive dermal patterns were observed in subjects with different dental arch forms, it is believed that dermatoglyphics may be used as a reliable tool for identifying original arch form in edentulous patients.

Keywords Dental arch form · Dermatoglyphics · Fingertip patterns · TFRC

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Introduction

Finger and palm prints have, over a century, been used as reliable means of personal identification. Cummins [1] coined the term dermatoglyphics *(Derm = skin; Glyphe = carving),* which refers to the study of configurations formed by dermal ridges on palms, soles and digits. The ridge patterns first appear as bulges at about sixth week of intrauterine life and once established, do not change during the rest of prenatal and post-natal life. These dermatoglyphic patterns are strongly influenced by heredity and have been used by geneticists as helpful tools in identifying specific syndromes of genetic origin such as Down's syndrome [2], Klinefelter's syndrome [3] and Trisomy-18 [4].

Since the development of the human dentition, alveolus and palate is also known to occur during the first few months of intrauterine life, it is believed that similar hereditary and environmental factors may govern the establishment of dermal patterns as well as dental tissues. Studies have been performed to determine the association

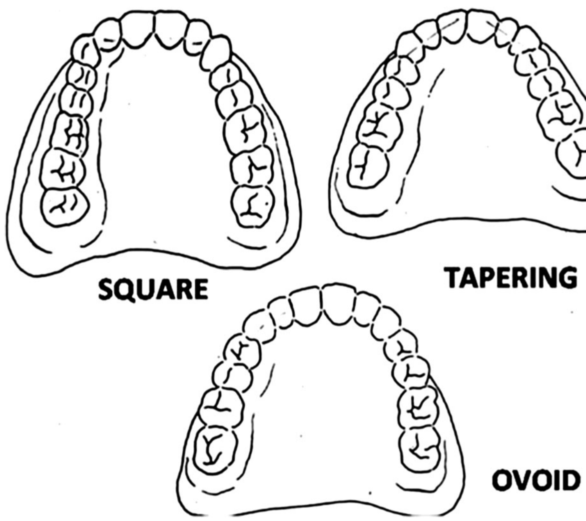

Fig. 1 The three types of natural dental arch forms

between dermatoglyphics and malocclusion [5], craniofacial skeletal pattern [6] and cleft lip and palate [7].

It is speculated that individuals with distinctive dental arch forms may also possess peculiar dermatoglyphic patterns. This study was undertaken to evaluate the dermatoglyphic characteristics in dentate individuals with square, tapering and ovoid dental arch forms. If any association can be determined between dental arch form and dermal patterns, it would indicate that specific dermatoglyphic patterns do exist in subjects with specific dental arch forms. This information may be utilized through dermatoglyphic assessment in edentulous patients to identify the kind of dental arch form they once possessed and the artificial denture teeth can be selected and arranged accordingly [8, 9].

Materials and Method

This descriptive, cross-sectional observational study was conducted in the Department of Prosthodontics, King George's University of Dental Sciences, Lucknow, India. Ethical clearance was obtained from an institutionally constituted ethical committee of King George's University of Dental Sciences and a written informed consent was obtained from each subject prior to the study. Study models of the maxillary dentitions of dentate undergraduate dental students in the age range of 18–30 years were prepared. The subjects were selected on a general basis and those with any missing permanent teeth (apart from 3rd molars), history of previous orthodontic treatment and any large coronal restoration were excluded from the study group.

On the basis of the maxillary dental arch form [10, 11] (Fig. 1), a convenience sample of 90 subjects was

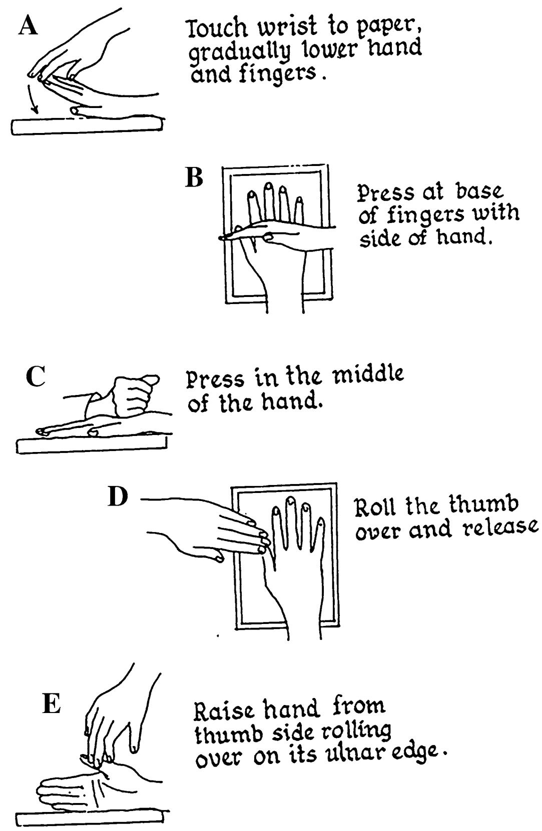

Fig. 2 Method of recording finger and palm prints

categorized into three groups of 30 each with an equal number of males and females. Group I comprised of subjects with a square maxillary arch form, Group II of those having a tapering arch form and Group III comprised of subjects with an ovoid arch form. Subjects with arch forms showing mixed features were not included in the study.

Palm and finger prints of both the right and left hands were recorded for each subject. Rolled impressions of each finger were also obtained using the ink-printing method described by Cummins and Midlo [12] (Figs. 2, 3).

Assessment of Finger Tip Patterns

The finger prints so obtained were assessed and the number of triradii, i.e. the point where three dermal ridges meet, was discerned. On the basis of the number of triradii present, three types of finger tip patterns, namely arches, whorls and loops were identified (Fig. 4).

a) *Arches*: Simple patterns lacking any triradius or any abrupt ridge curvatures were identified as arches.
b) *Loops*: Configurations demonstrating a single triradius, with the ridges being abruptly received at one extremity and continuing in the opposite direction in the manner of an open field were identified as loops.

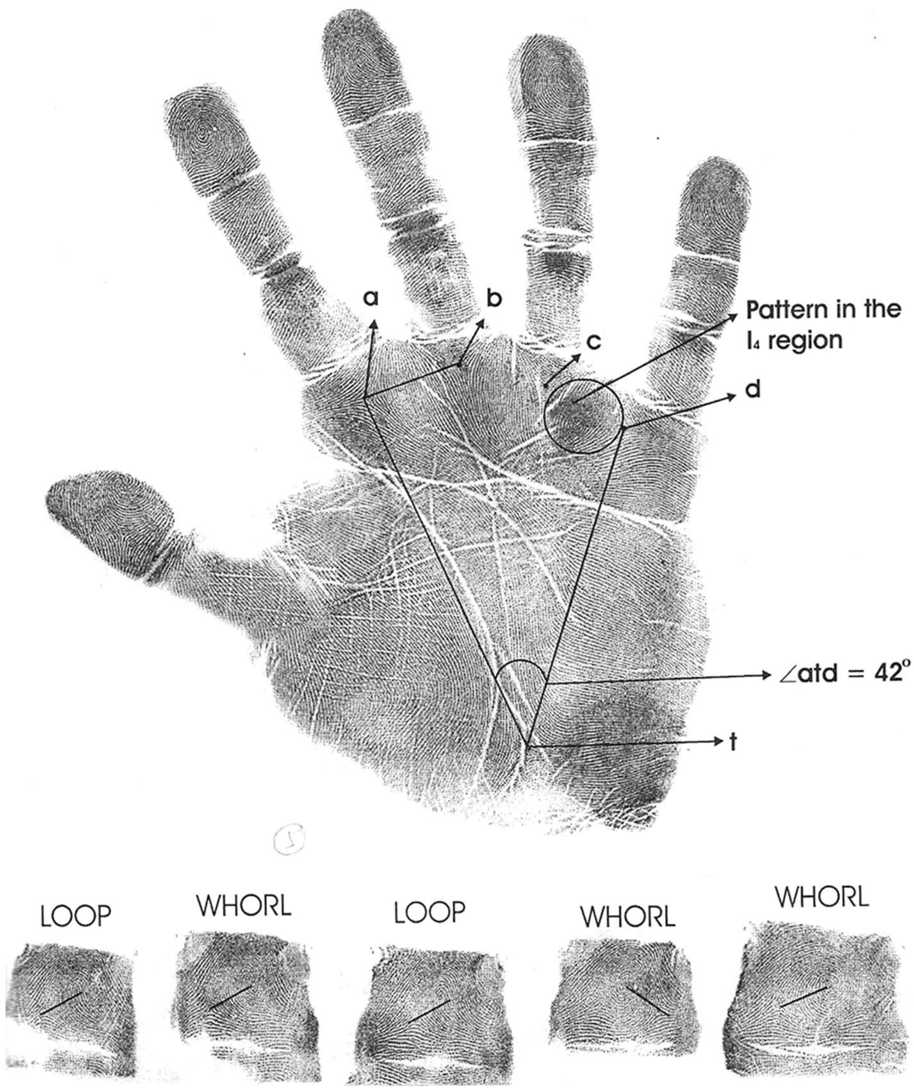

Fig. 3 Palm and finger print of a subject showing the various dermatoglyphic features

c) *Whorls*: The most complex patterns with two triradii were identified as whorls.

The number of ridges in each fingertip was also counted in accordance with the method described by Bonnevie [13]. A straight line was drawn from the triradius to the center of the pattern and the number of ridges contacting this straight line was counted (Fig. 4). The ridge count on each of the 10 fingers was summed up and the Total Finger Ridge Count (TFRC) was determined.

Assessment of Palmar Patterns

The palm has been divided into six configurational zones by Wilder [14] namely the Hypothenar, Thenar and four Interdigital zones, I_1, I_2, I_3, I_4 from the radial to ulnar side (Fig. 5), with I_1 conventionally considered with the thenar area. The palm prints of each subject were evaluated to determine the presence or absence of patterns in these configurational zones.

Angle atd was evaluated as a quantitative parameter. The axial triradius (t) which is situated near the base of fourth metacarpal bone was identified on the palm prints as were the four digital triradii (designated as a, b, c, d from the radial to ulnar side). Lines were drawn to the axial triradius (t) from the triradius at the base of the index finger (a) and from the triradius at the little finger (d) and the angle so formed (angle atd) was measured (Fig. 3). In cases where more than one triradius was present, the most distal one was used for analysis.

The data so obtained was subjected to suitable statistical analyses and tests of significance such as the Chi square test and *t* test were used for the intergroup comparison of parameters wherever necessary.

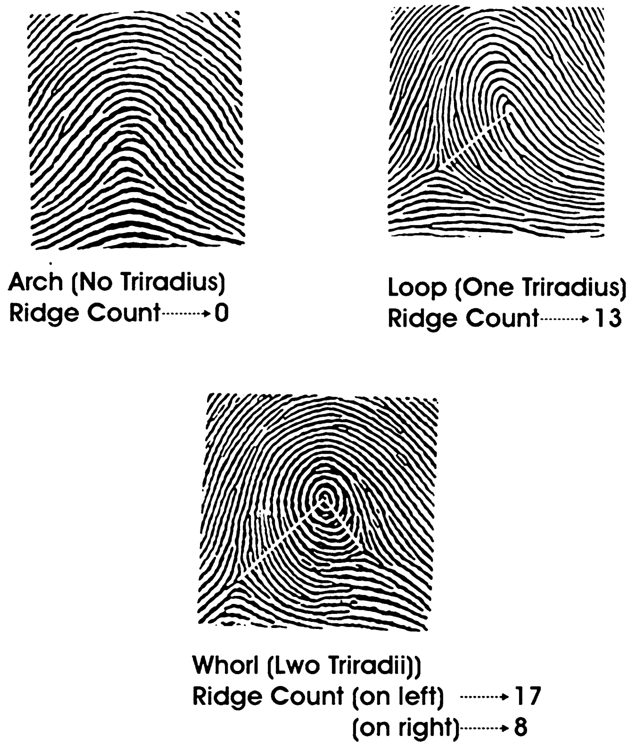

Fig. 4 The three basic types of finger tip patterns and method of ridge counting

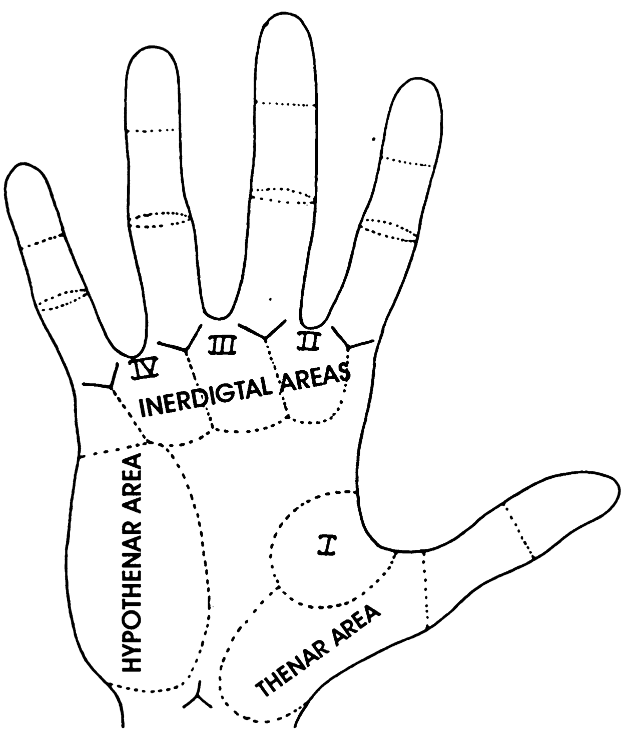

Fig. 5 The six chief dermatoglyphic areas of the palm

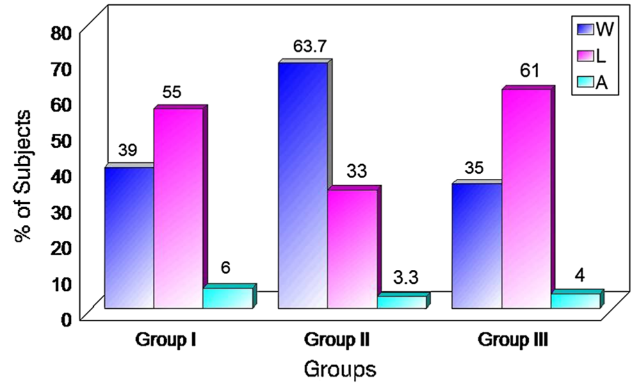

Fig. 6 Percentage distribution of finger-tip patterns in the three arch groups

Table 1 Comparison of finger tip patterns in the three arch groups

Comparison	χ^2	*P*
Group I (Square arch)		
Whorls vs Loops	16.05	<0.001
Whorls vs Arches	97.50	<0.001
Loops vs Arches	176.37	<0.001
Group II (Tapering arch)		
Whorls vs Loops	74.92	<0.001
Whorls vs Arches	283.04	<0.001
Loops vs Arches	71.34	<0.001
Group III (Ovoid arch)		
Whorls vs Loops	41.68	<0.001
Whorls vs Arches	90.45	<0.001
Loops vs Arches	222.15	<0.001

Results

Types of Finger Tip Patterns

Loops were the most frequently occurring finger tip patterns among all subjects followed by whorls and arches. In the square arch form group (Group I), loops were present in 55 % of subjects, whorls in 39 % and arches in 6 % of the subjects. In Group II (tapering arch form), 64 % of the subjects demonstrated whorls and 33 % had loops while the remainder presented with arches. Group III (ovoid arch form) subjects presented with predominance of loops (61 %) followed by whorls (35 %) and arches (4 %) (Fig. 6). Statistical analysis using the Chi-square test revealed that in Group I and Group III, the frequency of occurrence of loops was significantly higher than whorls or arches. In Group II, the frequency of occurrence of whorls was significantly higher than loops or arches (Table 1).

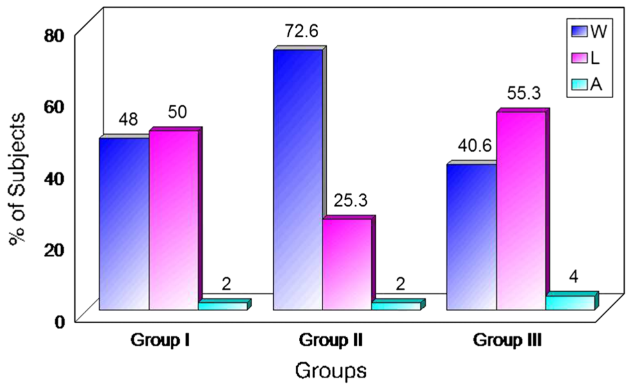

Fig. 7 Percentage distribution of finger tip patterns in males in the three arch groups

Table 2 Intergroup comparison of finger tip patterns among male and female subjects

Finger tip pattern	Males		Females	
	χ^2	*P*	χ^2	*P*
Group I vs Group II				
Whorls	31.83	<0.001	21.65	<0.001
Loops	13.13	<0.001	12.82	<0.001
Arches	0	NS	9.51	<0.01
Group I vs Group III				
Whorls	1.63	NS	0.04	0.70
Loops	3.00	0.081	0.71	0.40
Arches	1.03	0.31	3.03	0.064
Group II vs Group III				
Whorls	46.72	<0.001	25.15	<0.001
Loops	28.05	<0.001	19.34	<0.001
Arches	1.03	0.31	2.05	0.15

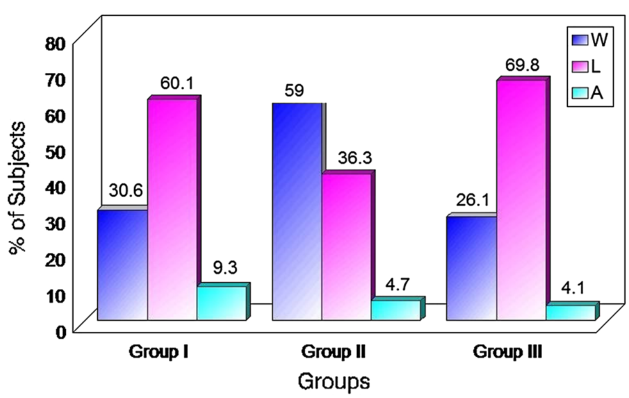

Fig. 8 Percentage distribution of finger tip patterns in females in the three arch groups

Inter group comparison of patterns in male subjects (Fig. 7; Table 2) revealed that the frequency of occurrence of whorls was significantly higher in Group II (tapering arch) than in other groups, while loops were significantly more frequent in Group I or Group III as compared to Group II. The difference in occurrence of arches was not statistically significant. Comparison of finger tip patterns in females in the three groups (Fig. 8; Table 2) revealed findings similar to those of the male subjects apart from the fact that arches were significantly more frequent in Group I than in Group II.

Table 3 Comparison of distribution of palmar patterns in the three arch groups

Palmar areas	χ^2	*P*
Group I		
Hypothenar vs Thenar	27.74	<0.001
Hypothenar vs I_2	36.58	<0.001
Hypothenar vs I_3	9.19	<0.01
Hypothenar vs I_4	3.43	0.06
Thenar vs I_2	1.88	0.1
Thenar vs I_3	60.48	<0.001
Thenar vs I_4	13.23	<0.001
I_2 vs I_3	82.90	<0.001
I_2 vs I_4	14.25	<0.001
I_3 vs I_4	22.75	<0.001
Group II		
Hypothenar vs Thenar	8.29	<0.01
Hypothenar vs I_2	15.85	<0.001
Hypothenar vs I_3	18.54	<0.001
Hypothenar vs I_4	30.35	<0.001
Thenar vs I_2	3.08	0.08
Thenar vs I_3	43.76	<0.001
Thenar vs I_4	58.88	<0.001
I_2 vs I_3	54.15	<0.001
I_2 vs I_4	69.67	<0.001
I_3 vs I_4	1.71	0.19
Group III		
Hypothenar vs Thenar	5.43	<0.05
Hypothenar vs I_2	10.91	<0.001
Hypothenar vs I_3	5.26	<0.05
Hypothenar vs I_4	15.00	<0.001
Thenar vs I_2	2.03	0.15
Thenar vs I_3	19.42	<0.001
Thenar vs I_4	33.41	<0.001
I_2 vs I_3	25.45	<0.001
I_2 vs I_4	40.08	<0.001
I_3 vs I_4	2.76	0.10

A comparison of pattern distribution between male and female subjects of the entire sample revealed that whorls were significantly more frequent in males than in females in each of the three groups. Loops were more frequently observed in females than in males, but the difference was significant only in Group II. Arches were also more common in females than males in each of the three groups, the difference being significant in Group I.

Total Finger Ridge Count

TFRC was found to be higher in males as compared to females in each of the three groups. There was however not much inter- group variation in TFRC.

Distribution of Palmar Patterns

Evaluation of palmar patterns (Table 3) revealed that in individuals with square arch form, incidence of patterns was significantly higher in the I_3 region than in any other area followed by the hypothenar and I_4 regions. Thenar/I_1 and I_2 demonstrated significantly lower pattern occurrence.

In Group II & Group III, the greatest incidence of patterns was in the I_4 region followed by I_3, but the difference was not statistically significant. A significantly lower incidence of patterns was seen in the Hypothenar, Thenar/I_1 and I_2 zones.

The difference in palmar pattern distribution among male and female subjects was however not statistically significant.

Angle atd

Inter group comparison using the Student's *t* test revealed that the value of angle atd was significantly higher in Group I than in Group II or III (Fig. 9; Table 4).

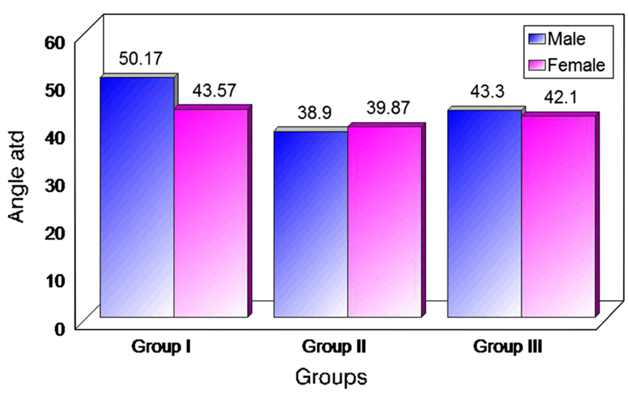

Fig. 9 Mean angle atd of both hands in males and females of the three arch groups

Table 4 Intergroup comparison of angle atd values

	T	*P*
Group I vs Group II	7.79	<0.001
Group I vs Group III	3.50	<0.01
Group II vs Group III	8.07	<0.01

Test for significance of difference in male and female subjects revealed that the difference was statistically significant only in Group I.

Discussion

One of the most significant steps in the successful rehabilitation of an edentulous patient is the appropriate selection and arrangement of artificial teeth. Over the past several decades, various methods have been proposed for determining the ideal form and position of teeth but these remain to be topics of controversy.

A number of guides that have been used for selecting the form of artificial teeth include pre-extraction records such as the patients' old photographs, old study casts, previous dentures and the form of the face, shape of edentulous maxillary arch, patient's preference, gender, and age [8, 15].

Tooth selection has been traditionally based on the "Law of Harmony" [16, 17], which states that the basic tooth form of square, ovoid or tapering generally corresponds to the outline of the patient's face. It is believed that the most ideal position of artificial teeth is the one in which they were placed by nature [18, 19]. The form of the patient's maxillary dental arch is often used as a guide for artificial tooth selection and arrangement. However in long standing edentulous cases with severely resorbed ridges, an assessment of the pre-existing arch form becomes quite difficult.

In the present study, dentulous subjects with different maxillary dental arch forms were selected and their dermatoglyphic patterns were assessed to determine the association, if any, between these two attributes. Any significant association if found would indicate that subjects with particular dental arch forms possess specific dermatoglyphic attributes. Such information may be reciprocally utilized in edentulous patients to identify the kind of dental arch form they once possessed.

Dermatoglyphic carvings, like the human dentition, are known to be strongly influenced by heredity [20]. Variations in these patterns may be seen in different ethnic groups, in the two genders and even within the same family [21].

The palm and finger prints were recorded in subjects with square, tapering and ovoid dental arch forms using the ink and roller method described by Cummins and Midlo [12]. This method is economical, simple to perform and allows permanent records of finger and palm prints to be obtained with clarity and finer details.

Analysis of finger prints so obtained revealed that among all subjects, loops were the most frequently occurring finger tip patterns followed by whorls and arches.

This finding is in accordance with those of Morgan [22] who reported a similar frequency of pattern occurrence in his study on Bengalis. Comparable results have also been reported by Bhasin [23] in his extensive study on the dermatoglyphics of Indian population. This finding further corroborates the fact that dermatoglyphic findings in normal individuals of same ethnic background are relatively similar.

In the present study, subjects with tapering arch form were found to have a significantly higher incidence of whorls as compared to loops or arches. In subjects with square and ovoid arch forms, the frequency of occurrence of loops was significantly higher than whorls or arches. Arches on the whole, were the least frequently appearing fingertip patterns in the study. When present, they were however, more common in square arch form than in the other two groups. Distinctive finger tip patterns were thus observed in subjects with different dental arch forms.

The results of this study demonstrate a definite sexual dimorphism in the occurrence of finger tip patterns with whorls being frequent in males, and loops and arches in females. Similar results have also been reported by Holt [24] in her study on British population and by Reddy [25] in Indians.

The TFRC, which was studied as a quantitative trait, was not found to differ significantly in the three dental arch groups. Intra group comparison, however, revealed that TFRC was significantly higher in males than in females in each of the three groups. This finding is also in accordance with those of Reddy [25], Kumar et al. [21] and Holt [24]. Penrose [26] believes that X chromosome tends to reduce the number of ridges, thus causing a lesser TFRC in females. In males, the presence of an X-chromosome is believed to diminish the total number or ridges in a pattern nearly three times as much as does the presence of Y-chromosome.

Evaluation of palmar patterns revealed that in individuals with square arch form, the greatest frequency of occurrence of patterns was in the I_3 region. On the other hand, in subjects with tapering and ovoid arches, the greatest incidence of patterns was in the I_4 region, with no patterns in I_2. Studies in Indian population, including those by Kumar and Kumar [21] and by Bhasin [23] have reported palmar patterns to be most frequent in the I_4 and I_3 regions along with a rapidly decreasing frequency from hypothenar to thenar/I_1 and the I_2 region. Saha [27] on the other hand, has reported a high frequency of patterns in the I_2 region in children with chromosomal abnormalities. The contrasting results of this study further confirm the fact that the dermatoglyphic findings in normal healthy individuals differ from those in individuals with genetic defects. The distribution of palmar patterns as seen in the present study indicates that individuals with tapering and ovoid arch forms more or less follow the same trend as seen in the general population, while those with square arches differ, though not very significantly.

Angle atd has been evaluated as a quantitative parameter in a number of dermatoglyphic studies. Kumar and Kumar [21] reported the normal value of this angle to be 44.5°. In the present study, subjects with an ovoid arch form were found to have an angle atd value in close approximation to this norm. Another significant finding was that square arched subjects, particularly males, had a characteristically high angle atd value, while those with tapering arches had relatively small values for the angle.

Subjects with different maxillary dental arch forms thus demonstrated characteristic dermatoglyphic patterns. This knowledge may be used in edentulous patients, especially in those with severely resorbed ridges to help identify the original dental arch form the patient once possessed and thus aid in favorable tooth selection and arrangement. Though a number of conclusive findings were observed, this is, by no means, the end to the establishment of dermal and dental arch relationships. This study is only a preliminary observational study in which individuals from just one particular geographic area and similar ethnicity have been examined. The results obtained can be further corroborated through more conclusive studies on individuals of varying ethnic and geographical backgrounds. Similar results in studies on a larger, more stratified sample may further establish the role of dermatoglyphics as an important guide to artificial tooth selection and placement.

Conclusions

In subjects with square arch form, the most common finger tip patterns were loops, palmar patterns were most frequent in I_3 region and the value of angle atd was larger than that in other subjects. Individuals with tapering arch form had whorls as the most common finger tip patterns with palmar patterns being most frequent in I_4 region. No patterns were seen in I_2 and the value of angle atd was least in these subjects. In subjects with ovoid arch form, the most common finger tip patterns were loops and the greatest frequency of palmar patterns was in I_4 region, with no patterns in I_2.

Individuals with distinctive dental arch forms were thus found to possess peculiar dermatoglyphic characteristics. The type of dermatoglyphic pattern an individual possesses may thus indicate the shape of the patient's dental arch form. This information is especially beneficial in long standing edentulous cases when selecting artificial teeth and arranging them in the most harmonious positions. The results of the study suggest that dermatoglyphic assessment can thus be used as a reliable adjunct to various other pre extraction records in edentulous patients with severely resorbed ridges. Specific dermal patterns relating to an individual's identity may also help instill new interest in the field of forensic odontology.

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