Original Article

Comparative analysis of cheiloscopy, pulpal tissue and fingerprint for gender identification

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Abstract

Background: The most important step in identifying an unknown person is determining one's gender and as a dentist, the oral tissues are potential sources of information in this aspect. A study was carried out to assess and evaluate the accuracy of cheiloscopy, pulp tissue, and fingerprints in determining gender.

Material and Methods: A study comprising of 160 individuals (80 males and 80 females) was conducted. After obtaining informed written consent and recording their bio-data; lip prints, and fingerprints were recorded. The patients' extracted tooth was collected, their pulp extirpated, for assessment of the Barr body.

Results: We found that every lip pattern was unique and hence can be used to identify an unknown individual. The occurrence of the Barr body was determined, and all female samples were found to be positive for the existence of the Barr body. In fingerprint patterns, a significant difference was noted between both sexes with ulnar loops and whorl patterns only. A highly significant difference was observed in the fingerprint ridge density between genders.

Conclusions: We conclude that the Barr body in pulpal tissue can be considered as the best possible technique for gender determination within the dental tissues. Lip prints did not show any differences in genders and had no role to play in gender determination. Fingerprint ridge density can also be used to determine gender.

Keywords: Barr body, cheiloscopy, fingerprint, gender identification, pulp tissue, sexual dimorphism

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INTRODUCTION

One of the most fascinating challenges in the world of forensic pathology is identifying a person.[1] It also plays a difficult duty in any criminal investigation. Identification has been justified for a variety of reasons, including legal and humanitarian concerns. In many cases, identifying a person is difficult since the remains have been damaged or burned beyond recognition.

Anthropometry, dactyloscopy, DNA finger type, height measurement, post-mortem reporting, and blood group

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differentiation are examples of traditional means of identifying a person. In many cases, these strategies are effective. These strategies, however, cannot always be employed, and a few lesser-known procedures can be used instead.[2,3]

The ability to recognise a person using dental tissues has been crucial in both natural and man-made disasters since the jaws and teeth can resist severe temperatures and give vital evidence.[4] The most crucial stage in identifying an unknown individual is detecting gender, and as a dentist, oral tissues can provide gender information, thus research was conducted to see how reliable cheiloscopy, pulp tissue, and dactyloscopy are in diagnosing gender. The goal of the study was to evaluate and compare the efficacy of various gender-determination procedures, including cheiloscopy, pulp tissue, and fingerprinting.

MATERIAL AND METHODS

Source of data and sample size

The research lasted eighteen months and included 160 patients between the ages of 18 and 45 who were referred to the Department of Oral Medicine and Radiology. The study was conducted with ethical approval from the institutional review board. The study included an equal number of men and women (80 each). People who were recommended to have teeth extracted met the inclusion criteria of having caries-free, periodontally compromised teeth or teeth that needed to be removed for orthodontic therapy. The patients were given a thorough explanation of the study's goals and were asked to sign a permission form to participate.

Methods

On the proforma, a total of 160 lip prints were captured and examined for lip groove patterns. Both the right and left thumb fingerprints were taken. The removed teeth were collected, their pulp extirpated and submitted to the Department of Oral and Maxillofacial Pathology for further study of the Barr body to determine the gender.

Cheiloscopy for gender determination

After wiping the lips clean with a compress, a dark-coloured lip paint was placed uniformly over the vermilion zone of the top and below lips to create the lip prints. To distribute the lipstick, the patient was forced to touch both lips together. The glue part of a strip of transparent adhesive tape was put to the lips to create a lip print. This tape was removed after around 2 min and then attached on white paper. These lip prints served as a permanent record that was then examined under a magnifying lens for the existence of lines and furrows, as well as their length, number, branching, and combinations.

Each print was topographically separated into six parts for analysis: lower right; lower centre; lower left; upper right; upper centre; upper left. According to Sivapathasundharam B. *et al*., 2001,[5] the middle part of the lower lip was selected as the most representative location for the analysis. The patterns were classified using Suzuki K and Tsuchihashi's (1971)[6] categorization. [Figure 1] The most prevalent line pattern was thought to be the lip pattern. When two patterns were visible, the lip print was deemed indeterminate.

Using Pulp Tissue for gender determination

For orthodontic reasons, a healthy tooth was removed and placed in a 5% formalin solution for 7 days. The pulp was extirpated with K-files (Mani®, India) through an access cavity formed on the occlusal surface of the teeth. For another 7 days, the pulpal tissues were kept in a 5% formalin solution. The tissues were treated, and 5-µm thick histological slices were cut at various levels, with five sections chosen at random and stained with haematoxylin and eosin stain. Using a compound microscope (Olympus® CX 21i) at 100× magnification, they were methodically examined for Barr bodies [Figure 2].

Figure 1: Lip print patterns. Type I: Complete vertical; Type I`: Incomplete vertical; Type II: Branched; Type III: Intersecting; Type IV: Reticular; Type V: Undetermined

Fingerprint analysis for gender determination

The participants were instructed to wash their hands and eliminate any oil or dirt from their hands. On white paper, the impressions of the left and right thumbs were taken. The subjects were instructed to smear their fingertip with an ink pad and transfer their prints on a specially prepared worksheet with consistent pressure. By keeping the fingers from slipping, the smudged print was eliminated. Internal Loops, External Loops, Whorls, and Arches were identified using a magnifying lens and categorised using Vucetich's system[7] based on the appearance of ridgelines. This constituted the qualitative assessment of the fingerprints.

The fingerprint ridge count density was used to build up the quantitative fingerprint pattern analysis. The analysis was carried out according to Acree M.[8]'s instructions.

The top radial side of the central core area of the fingerprints was chosen for analysis because it shows a comparable ridge flow in all fingerprint pattern types. On a translucent sheet, a 5 × 5 mm square was cut out and put on the fingerprint sample at the desired location. The epidermal ridges were counted from one corner of the square to the slantwise opposite corner. With the dots removed, the forks were approximated as two ridges bypassing the handle and the lake as two ridges. Counting the number of ridges in a 25 mm^2 area yielded the density value. Individuals with a mean ridge density of fewer than 12 ridges/25 mm^2 were more likely to be male. Females were more likely to have a ridge count of 13 ridges/25 mm^2 than males.

The data was analysed and statistically interpreted. A master chart was created utilising a Microsoft Excel® 2019 sheet that included numerical values for all of the study's parameters. For additional statistical analysis, the SPSS VERSION 22.0® application was employed. To analyse gender differences in lip pattern and fingerprint pattern, a "χ-test" was utilised for proportions. The sex differences in fingerprint ridge density and pulpal tissue were assessed using an independent *t*-test. A *P*-value of less than 0.05 was considered statistically significant.

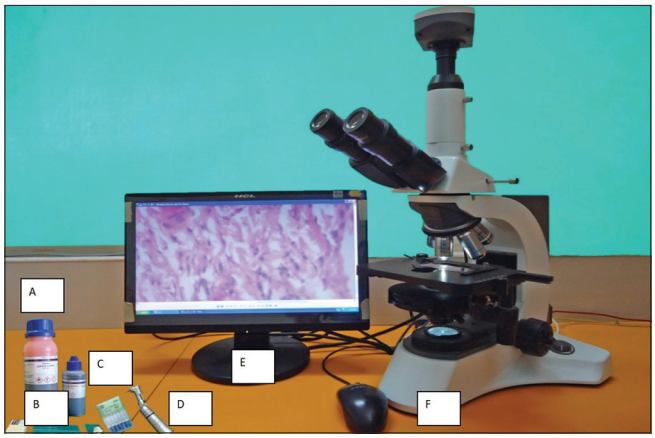

Figure 2: Materials used in Barr body estimation in pulpal tissue. A: Haematoxylin and Eosin Stain; B: Glass Slides and Coverslips; C: K-Files; D: Micromotor handpiece; E: Image analyzer; F: Trinocular microscope

RESULTS

The current study was conducted in an attempt to ascertain the reliability of gender determination from various field techniques such as cheiloscopy, pulp tissue, and fingerprint. We were able to re-establish the idea that lip prints are one-of-a-kind since no two lip prints were the same. The intersecting pattern (Type III) was discovered to be the most prevalent among both males and females, with 45% and 32.5%, respectively. Vertical grooves (Type I and Type I') were the least frequent pattern in men, although they were not detected in our research sample (0%), whereas the indeterminate pattern (Type V) was the least common in females (2.5%).

In this study, we discovered that Type III 45% (36), was the most common pattern in males. Type IV– 35% (28), Type II – 12.5% (10), Type V – 7.5% (6), Type I and I` – 0 constituted other cases, while in females, we found Type III – 32.5% (26), Type I – 22.5% (18), Type II – 20% (9), Type I` – 12.5% (10), Type IV– 10% (8) and Type V – 2.5% (2) in descending order. [Table 1] A statistically significant difference was perceived between genders in Type I, I` and IV lip print patterns. Overall, ten per cent of lip prints studied from both males and females were repeated as they were of poor quality.

The presence of the Barr body per 50 cells was counted under oil immersion. [Figure 3]. In males, 30% of individuals didn't have any Barr body, while 37.5% had 1 cell with Barr body and 32.5% of males had a maximum of two Barr body-positive cells. The positive cell for the Barr body ranged from 0–2 cells per 50 cells in males. All male samples had ≤4% of Barr-body-positive cells. All tested samples from females were positive for the presence of the Barr body. In females, the Barr body-positive cells ranged from 18 to 29 and the average number of cells with Barr body

Table 1: *Z*-test for proportion to assess sex differences in lip pattern

Lip Pattern	Male	Female	*Z* cal	*P*	NS/S
I	0	18	3.184	0.001	S
I`	0	10	2.309	0.021	S
II	10	16	0.909	0.363	NS
III	36	26	1.147	0.250	NS
IV	28	8	2.677	0.007	S
V	6	2	1.026	0.303	NS

was 22.23 per 50 cells. All women showed ≥36% positive cells for the Barr body. A highly significant difference between genders was noted [Table 2].

Fingerprint patterns were studied and classified as whorls, ulnar loops, radial loops, and arches. [Figure 4] In males, the whorl pattern (53.75%) was the most common pattern noted, ulnar loops were noted in 33.75% of males, and arches were noted in 12.5% of males. Radial loops were not recorded in any male individual. In females, the ulnar loop (56.25%) was most commonly observed. 36.25% of females had a whorl pattern, whereas 5% of females had an arch pattern and only 2.5% of females had radial loop patterns. A statistically significant difference was noted between both sexes when ulnar loops and whorl patterns were compared [Table 3].

The fingerprint ridge densities were also analysed to study the ridge densities towards recording the differences between genders. A high statistically significant variation was observed in the fingerprint ridge density between genders. The fingerprint densities ranged from 10 to 15 ridges/25 mm^2 among males and 10 to 17 ridges/25 mm^2 among females. The males had average ridge densities of 11.98 ± 1.22 ridges/25 mm^2, whereas females had higher ridge densities and the average densities were 13.65 ± 1.55 ridges/25 mm^2 [Table 4].

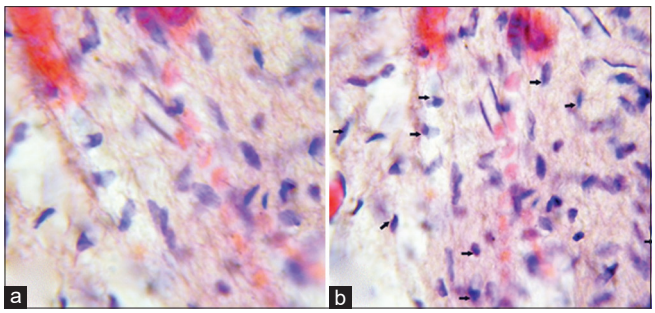

Figure 3: Photomicrograph of a dental pulp histological section stained with haematoxylin and eosin. (Original magnification X100). (a) Male – Fibroblast negative for Barr body observation; (b) Female – Fibroblasts positive for Barr body observation

DISCUSSION

In identifying an individual using forensic sciences, the oral cavity permits countless possibilities. Using dental tissue is one of the most prevalent ways to identify a person.[3,9] Criminal cases encompass identifying both victims and suspects. A comparative analysis is usually required in the majority of the investigations, where latent or chance impressions situated on smooth surfaces have come across.[9] These latent imprints can come from a variety of places, with oral and perioral soft tissue prints being one of them. Lips and the hard palate, in particular, are known to contain features that might contribute to an individual's characteristics.[3] Determining gender is considered one of the initial and principal steps in forensics.[10]

Table 2: Independent *t*-test for No. of Barr body in pulp to assess sex differences

Male			Female			*t*-test	*P*	NS/S
No.	Mean	S.D	No.	Mean	S.D			
80	1.03	0.80	80	22.23	2.82	45.684	0.000	HS

Table 3: *Z*-test for proportion to assess gender differences in fingerprint pattern

Fingerprint Pattern	Male		Female		*Z* cal	*P*	Ns/S
	No.	%	No.	%			
A	10	12.5	4	5	1.679	0.093	NS
E	0	0	2	2.5	1.423	0.156	NS
I	27	33.75	45	56.25	2.860	0.004	S
V	43	53.75	29	36.25	2.225	0.026	S

Table 4: Independent *t*-test for Fingerprint Ridge Density to assess gender differences

Fingerprint ridge Density	Male			Female			*t*-test	*P*	NS/S
	No.	Mean	S.D	No.	Mean	S.D			
Left	80	12.15	1.35	80	14.00	1.78	5.231	0.000	HS
Right	80	11.80	1.22	80	13.30	1.62	4.672	0.000	HS
Average	80	11.98	1.22	80	13.65	1.55	5.365	0.000	HS

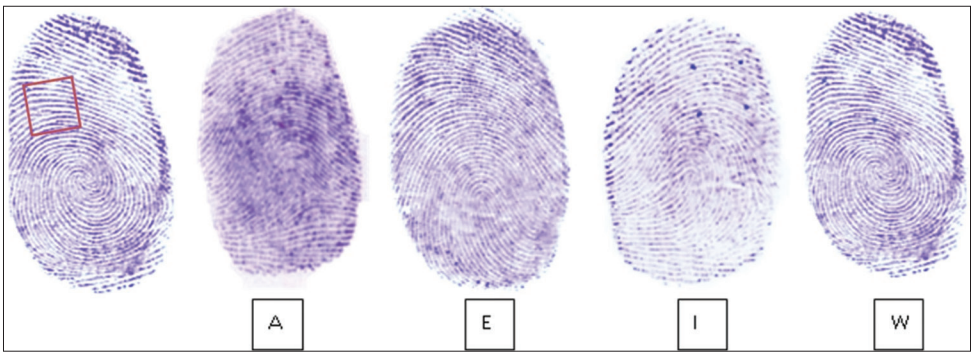

Figure 4: Technique used to count fingerprint ridge density. All ridges within the depicted 5 mm × 5 mm square were counted. Types of the fingerprint pattern. A: Arch; E: External loop; I: Internal loop; V: Whorl

Lines and clefts in the lip's transition zone between the outer skin and the labial mucosa are known as lip patterns. The raised reddish portions indicated by these clefts appear as dark areas in lip prints, while the wrinkles on the vermilion zone of the lips appear as white areas, comparable to the ridges and furrows of the skin ridge.[11] Cheiloscopy is the scientific study of these lip marks. Except for monozygotic twins, cheiloscopy is important since lip prints are unique to each individual. Lip patterns, like fingerprints, are unchangeable and permanent. Lip prints may be seen in foetuses as early as six weeks into their pregnancy, and these groove patterns seldom alter.[3,11]

The present study comprised 160 participants (80 males and 80 females) who visited the outpatient department. Lip prints were obtained on cellophane tape by placing them over the upper and lower lips and applying light pressure, then transferring the tape to a white paper. The Suzuki and Tsuchihashi classifications were used to analyse the lip grooves.[6] According to another research, the study region for categorization was the centre section of the lip (about 10 mm wide).[5] They claim that this zone can be seen in almost any trace and that defining the pattern is based on the highest number of lines in this zone. In the present study, we found that two lip patterns never matched with one another, thus creating the lip prints' uniqueness, for forensic identification. Tsuchihashi *et al*.,[12] proclaimed that two lip patterns were never the same, not even in uniovular twins.

A specific lip print pattern tendency was frequent in any gender, according to Vahanwala S *et al*. (2005).[13] However, we discovered that Type III (intersecting pattern) was the most prevalent in both men and women. The current findings are consistent with those of prior investigations.[5] The findings of this study contrast with those of Vahanwala[13] who discovered that females had Type II and men have Type III and Thermadam TP *et al*.,[14] who found Type I and I' common in males and Type IV and V common in females. These differences may be due to racial variations in the study population.

We commonly see situations when a single tooth is the only tissue left at the crime scene after a murder or an attack. A tooth or set of teeth might be crucial in determining an individual's identity. Determining sex from tooth pulp tissue after death is imaginable since the teeth are a firm part of the skeleton and the pulp is well-protected. Barr bodies develop when the second X chromosome is inactivated in a female cell. Lyonization is the term for this inactivating process. The sex of any individual may be easily determined by identifying Barr body-positive cells.[15,16] Barr chromatin and techniques for determining sex have been described in a variety of tissues[17,18] as well as dental pulp.[18]

In the present study, a total of 160 teeth were collected as per the criteria and examined the freshly extracted pulp after 7 days of formalin fixation. The Barr body in females was in the range of 18-29 with a mean of 22.23, when compared to males (1.03) it is highly significant. Studies have indicated that the Barr bodies were observed in 25-30% of cellular nuclei in women with normal karyotype.[10,19]

Our study displayed pseudo-Barr bodies in males in the range of 0-2 with a mean of 1.03 for the samples tested and this is in agreement with Das N *et al*.,[20] who found Barr bodies to be 2.12 ± 1.41% and a maximum of six Barr bodies were seen in any male, and with Duffy *et al*.,[19] who found a count of Barr bodies in males 0%-6%. However, in preparations of male patients, Suazo GI *et al*.,[10] detected no Barr body-positive cells. Barr bodies are more common than seen in our study. During histological preparations, the chromatin adheres to the nuclear membrane, and they are hidden behind or in front of the nucleus leading to their obscurity.[19] In a recent study, Baby TK *et al*.,[21] demonstrated Barr bodies in AF Schiff stain better compared to PAP stain.

A recent study by Bhardwaj N *et al*.,[22] stated that Barr bodies were better analysed and appreciated in histopathological sections than in cytopathological technique.

In our studies, we have recorded both fingerprint patterns and fingerprint ridge densities. We found that the whorl pattern and ulnar loop pattern was the commonest pattern detected in males and females respectively. In the total population combined ulnar loop and whorl patterns were seen in equal proportions followed by arches. The radial loop pattern was only detected in two females, making it the least common pattern in the whole group. Our findings are comparable to those of Gangadhar MR and Reddy RK,[23] who discovered that loop patterns were present in 57.11% of both males and females, followed by 27.89% of whorls and 15.00% of arches patterns. In their research of indigenous black Zimbabweans, Igbigbi PS and Msamati BC[24] saw the same pattern.

Nagasupriya A *et al*., 2011[25] recorded a significant correlation between lip and finger patterns for identifying gender. They concluded that males had a branched type of lip pattern accompanying finger pattern of an arch, loop, and whorl; while females significantly had vertical lip pattern along with arch-type finger pattern and reticular lip pattern linked with whorl-type fingerprints. A recent study by

Shivakumar HG *et al*.,[26] in 2021 studied the correlation between the lip prints and fingerprints in obese and normal people. They found no differences in lip prints of obese and non-obese individuals.

In the present study, the finger ridge densities were also analysed to study the differences between genders. The total ridge count displayed noteworthy sexual dimorphism. The males had average ridge densities of 11.98 ± 1.22 ridges/25 mm^2, whereas females had higher ridge densities and the average densities were 13.65 ± 1.55 ridges/25 mm^2.

Our results are as per studies conducted by Acree MA,[8] who exhibited that females have more ridge density than males. Gungadin (2007)[27] has also stated that a male likely had ridge count ≤13 ridges/25 mm^2 while a female had ridge count ≥14 ridges/25 mm^2. Few studies[28-31] have found females to have significantly briefer finger breadth, lesser square area, increased ridge count and ridge density when compared with males.

CONCLUSION

Lip prints did not demonstrate sexual dimorphism in this investigation, since all lip print forms were detected in both men and females. In both boys and females, the intersecting pattern (Type III) was the commonest lip print pattern in this study sample. In Type I, I', and IV lip patterns, statistically significant differences were found across genders. The mean percentages of Barr body-positive cells in females were found to be higher than in males proving the fact that the determining gender was possible using the human tooth pulp. We also ascertain the fact that for accurate diagnosis the Barr body positive in female samples must be more than 4%. A highly significant difference between genders can be noted in our study.

Fingerprints are inimitable and each person can be identified positively. There was no sexual dimorphism in the fingerprint pattern. In both males and females in the research group, the whorl pattern and the ulnar loop were the commonest patterns. Males had lower average ridge densities in their fingerprints, but females had greater ridge densities, which may be used to determine gender. The difference in fingerprint ridge density across genders was found to be quite significant.

Cheiloscopy can be used to identify a person with a high degree of confidence. Although there have been several scientific studies on lip prints, pulpal tissue, and fingerprints, this study was conducted to compare and link all of these factors.

When dental tissues are taken into account, it may be stated that the Barr body in pulpal tissue is the best conceivable approach for gender determination. Lip prints revealed no gender differences. The density of fingerprint ridges can also be used to determine gender. To validate our findings, future studies with more complete and deep research can be conducted with a bigger study sample size.

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Conflicts of interest

There are no conflicts of interest.

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