Research Paper

Forensic Examination of Fingerprint Patterns among Different Generations in South Indian Families

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Abstract

Fingerprint patterns are unique and reliable for identification. This research paper focuses on a comparative analysis to determine the inheritance of fingerprint patterns within Indian families. The sample collection process for this comparative analysis involved working with 10 families. The study aims to gain insights into the hereditary aspects of fingerprint characteristics among the Indian population. The research methodology involves the collection of fingerprints and the analysis of patterns using microscopes, magnifying lenses, and software. The results reveal both class and individual characteristics within fingerprints, contributing to our understanding of dermatoglyphics. The average class characteristics percentage totals around 71.5%, with an average individual characteristic percentage of approximately 13.6%. The research has implications for forensic investigations, genetics, and personal identification systems. Further studies with larger sample sizes and genetic analysis integration are recommended for future research.

Keywords: Fingerprint Patterns, Inheritance, Comparative Analysis, Indian Families, Dermatoglyphics.

Introduction

Fingerprint patterns have long been recognized as a unique and reliable form of biometric identification [1]. The study of fingerprints is known as dermatoglyphics[2]. Dermatoglyphics (ancient Greek derma: skin, glyphic: craving) the scientific study of prints of skin viz., [3] They are the perfect instrument for identifying an individual because they are created during early development and remain constant throughout life. Fingerprint analysis has been extensively studied and utilized in forensic science, criminal investigations, and personal identification. [4] There are various methods employed in the examination of fingerprints to extract relevant information for identification purposes. These methods include Visual Examination, Latent Fingerprint Development,[5] Fingerprint Imaging, and Automated Fingerprint Identification Systems (AFIS). [6] The most common fingerprint patterns in the Indian population are loop (65%), whorl (30%), and arch (5%). It is possible for family members to have similar fingerprints. This is due to our genetic codes.

There is an inheritable quality to fingerprint [7]. Pattern types are often genetically inherited, but the individual details that make a fingerprint unique are not. However, there has been limited research on the comparative analysis of fingerprint patterns in

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different generations of Indian families. Integrating genetic analysis techniques would provide a deeper understanding of genetic information [8]. Comparative analysis of fingerprint patterns in different generations of Indian families can provide valuable information about the inheritance patterns of fingerprint traits. It can help in understanding whether certain fingerprint patterns are more prevalent within families and whether they are pass on from one generation to the next. [9] The manuscript shed light on the heritability of fingerprint patterns in the Indian population and contribute to our understanding of the genetic basis of these traits. The study of fingerprint patterns in different generations of Indian families holds several potential benefits and applications. By understanding the familial patterns of fingerprints, accuracy of fingerprint-matching algorithms can be improved and the security of various systems that rely on fingerprint recognition, such as law enforcement databases, access control systems, biometric passports, criminal investigations, missing person cases, and disaster victim identification efforts can be enhanced. Examining fingerprint patterns within different generations of Indian families can provide valuable insights into the hereditary aspects of dermatoglyphics and their potential utility in various domains. The primary objective of this research is to conduct a comparative analysis of fingerprint patterns within different generations of Indian families, aim to:

- To Examine the similarities and differences in fingerprint class and individual characteristics across generations.
- To assess the hereditary aspects of dermatoglyphics within Indian families.
- To investigate the potential applications of family-based dermatoglyphics studies in forensic investigations and biometric authentication.

Materials and Methodology

Sample Collection & Preparation

1. For hygiene and accuracy, hands were sanitized prior to fingerprint collection. Fingerprint samples were systematically collected using a black stamp pad and placed on dedicated fingerprint cards, ensuring precise and accurate prints.
2. The sample collection for the comparative analysis involved obtaining fingerprints using fingerprint cards. The sample collection process for this comparative analysis involved Working with 10 families, each comprising a father, mother, and child. Fingerprint cards are standardized forms that include all the necessary details of an individual, along with their fingerprint data.
3. For the collection of fingerprints, a stamp pad with black ink was used. Specifically, the stamp pad used was the Writeaway Artline Stamp Pad, which is a small-sized pad measuring 101x61 mm. It is known for its 25% more ink/pad area and impressions, durable plastic case, and the ability to produce bright, smudge-free, and long-lasting clear impressions. It is designed to prevent ink transfer on the backside of the paper, ensuring the quality of the fingerprint impressions.
4. Explicit consent was obtained from everyone before their fingerprints were collected.

Informed Consent

Explicit consent was obtained from all participating families before collecting their fingerprints. Participants were informed about the purpose of the study, the methods involved, and the potential implications of the research. This ethical practice ensured that the families involved were willing contributors to the study, aligning with established research ethics guidelines.

Instrumentation Used

1. Compound Microscope [Sipcon, WF 15X].
2. Magnifying Lens [Gyanduly 5X, LxWxH22.3x10.9cm].
3. Adobe Photoshop Express[Version: 10.6.56].

Table 1: Shows abbreviation and meaning of fingerprints and its parameters

S.NO	ABBREVIATION	MEANING	ABBREVIATION	MEANING
1.	RT	Right thumb	UL	Ulnar loop
2.	RI	Right index	RL	Radial loop
3.	RM	Right middle	PW	Plain whorl
4.	RR	Right ring	TWL	Twinned double loop
5.	RL	Right little	CPL	Central pocket loop
6.	LT	Left thumb	DL	Double loop
7.	LI	Left index	TL	Twinned loop
8.	LM	Left middle	PA	Plain arch
9.	LR	Left ring	TA	Tented arch
10.	LL	Left little	AP	Accidental pattern

Results

The outcomes, after analyzing 10 families, were computed and are presented in below tables numbered 2, 3, 4, 5, 6, and 7.

Table 2: Shows the Fingerprints of the Mother, Father and Child of a Family

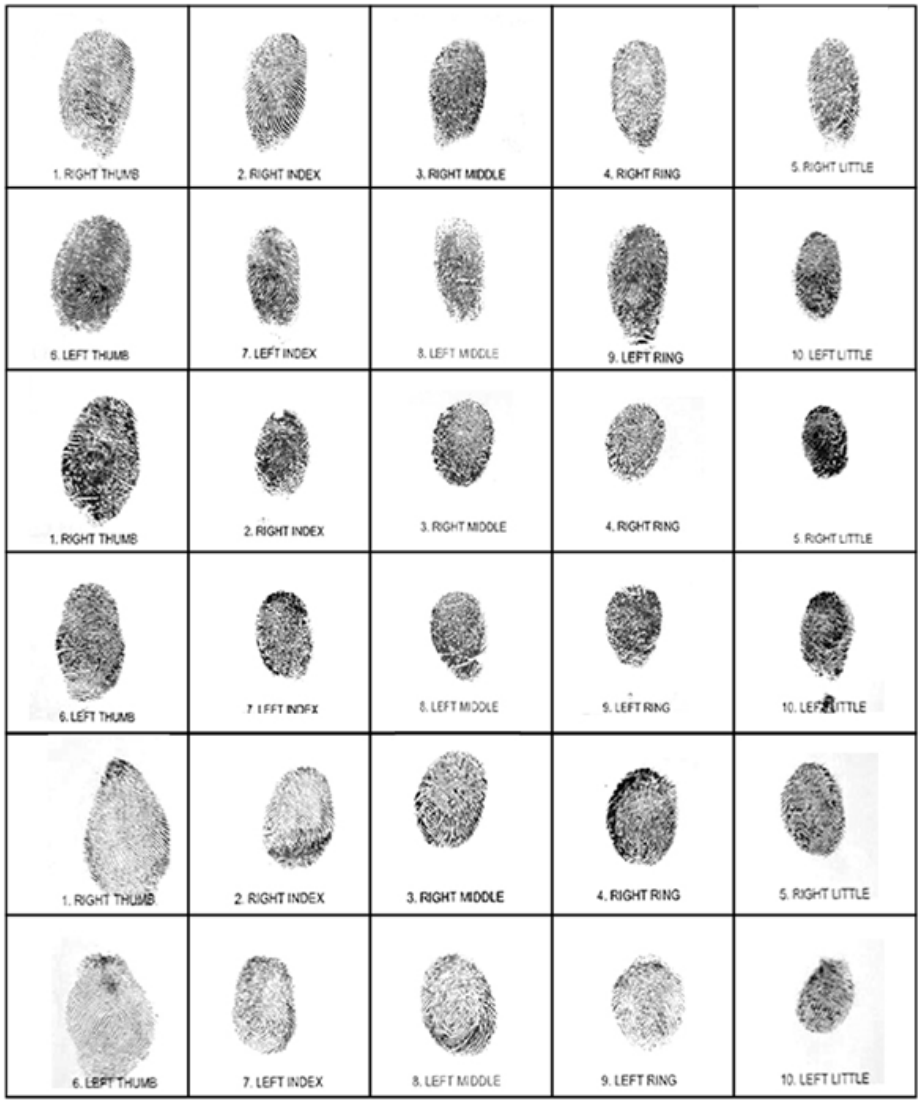

Table 3: Shows class characteristics of fingerprints (1-10 families)

S.NO	FAMILY	MEMBERS	PARAMETERS									
			RT	RI	RM	RR	RL	LT	LI	LM	LR	LL
1	FAMILY 1	F	UL	UL	UL	UL	UL	RL	RL	RL	RL	RL
		M	PW	RL	UL	UL	UL	DL	UL	RL	RL	RL
		C	UL	RL	UL	UL	UL	RL	RL	RL	RL	PA
2	FAMILY 2	F	PW	PW	PW	PW	PW	RL	RL	PW	RL	RL
		M	PW	UL	PW	PW	PW	PW	PW	PW	PW	PW
		C	PW	PW	UL	PW	PW	PW	PW	PW	PW	PW
3	FAMILY 3	F	UL	PA	TA	UL	UL	RL	PA	RL	RL	RL
		M	UL	UL	UL	UL	UL	RL	RL	RL	RL	RL
		C	TDL	RL	UL	UL	UL	RL	RL	RL	RL	RL
4	FAMILY 4	F	PW	PA	UL	UL	PW	TDL	PA	PW	PW	PW
		M	UL	UL	UL	UL	PW	RL	RL	RL	PW	PW
		C	PW	PA	RL	UL	UL	PW	PA	PA	RL	RL
5	FAMILY 5	F	PW	UL	UL	PW	RL	RL	RL	RL	RL	RL
		M	RL	RL	UL	PW	PW	PW	PW	PW	PW	PW
		C	PW	PW	PW	PW	PW	RL	RL	RL	RL	RL
6	FAMILY 6	F	TDL	UL	UL	UL	UL	CPL	RL	RL	RL	RL
		M	UL	PW	UL	UL	UL	RL	PW	RL	PW	RL
		C	UL	PW	PW	PW	UL	RL	PW	PW	PW	RL
7	FAMILY 7	F	UL	PW	PW	PW	UL	PW	PW	PA	RL	RL
		M	PW	PW	PW	PW	PW	PW	PW	PW	PW	RL
		C	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW
8	FAMILY 8	F	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW
		M	PW	PW	PW	PW	PW	PW	PW	PW	PW	PW
		C	PW	PW	PW	PW	PW	PW	PW	PW	PW	RL
9	FAMILY 9	F	UL	PW	PW	PW	UL	RL	PW	PW	PW	RL
		M	DL	UL	UL	UL	UL	RL	RL	RL	RL	RL
		C	PW	PW	PW	UL	UL	RL	RL	RL	RL	RL
10	FAMILY 10	F	PW	UL	UL	PW	UL	DL	PW	RL	PW	RL
		M	PW	UL	UL	RL	UL	DL	TA	RL	RL	RL
		C	PW	PW	PW	UL	UL	PW	RL	RL	RL	TL

Table 4: Shows individual characteristics of fingerprints (1-5 families)

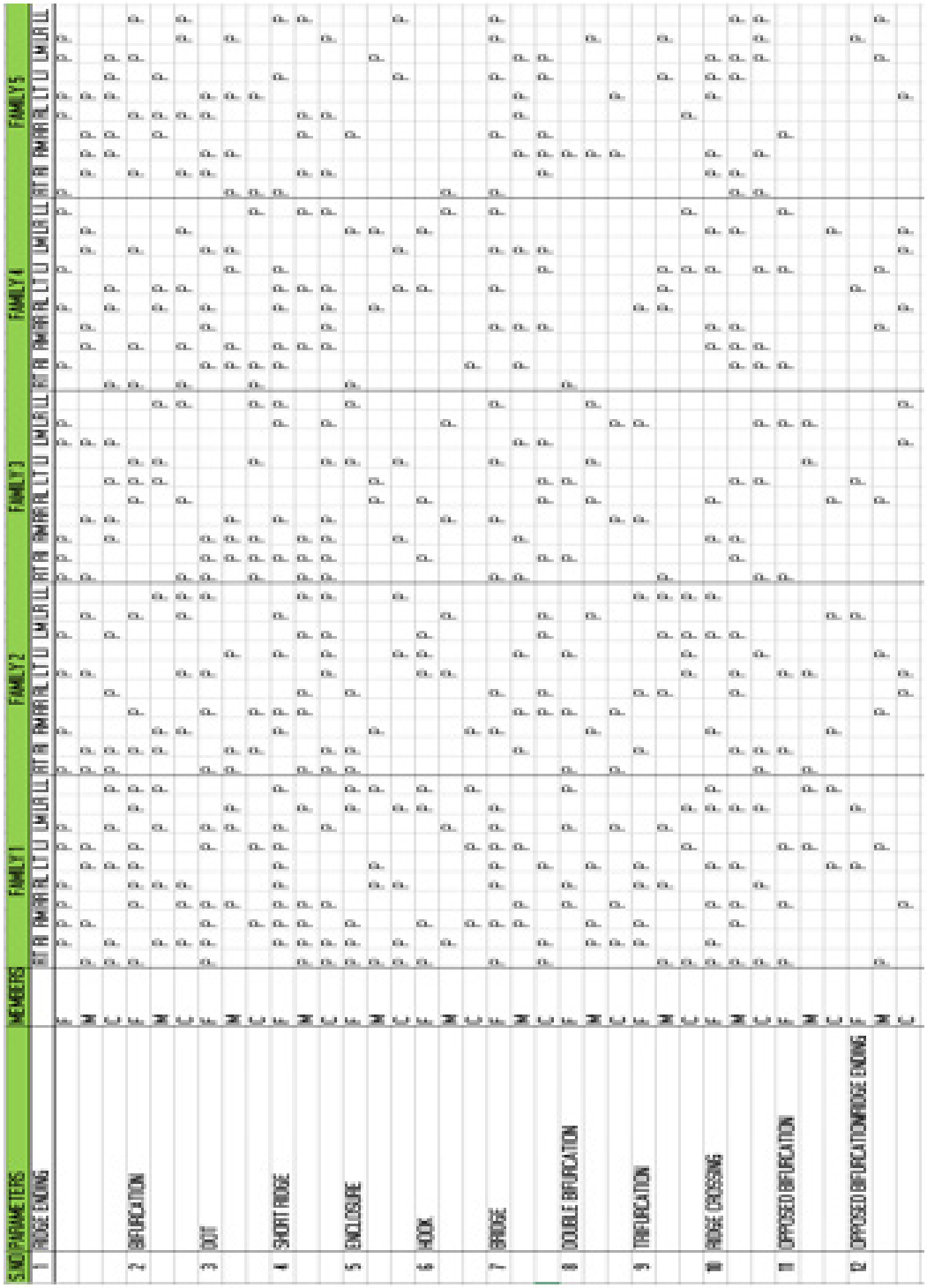

Table 5: Shows individual characteristics of fingerprints (6-10 families)

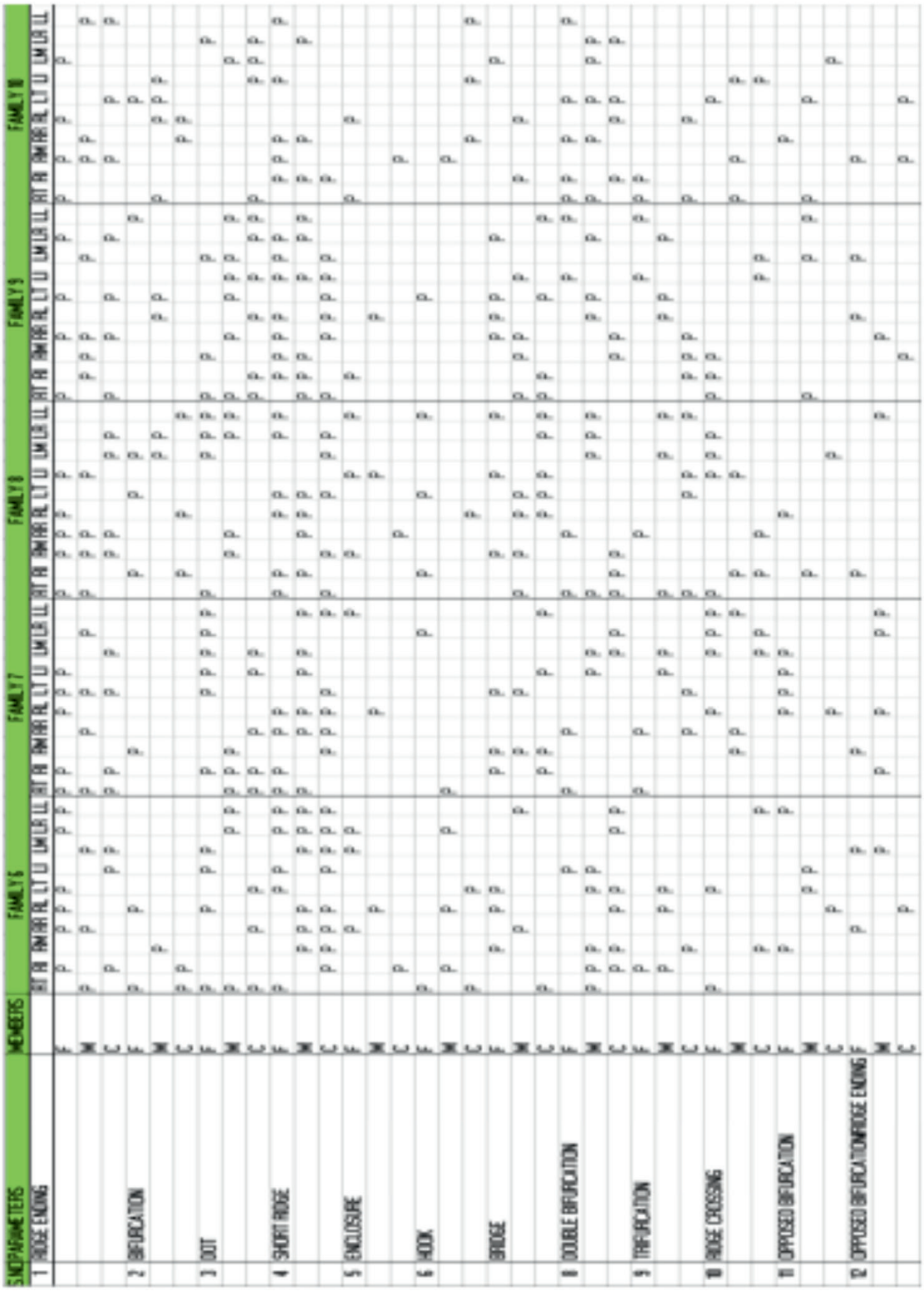

Table 6: Depicting Class Characteristics in Fingerprints of 10 South Indian Families

FAMILY	RIDGE DETAILS
1	RM (UL), RR (UL), RL (UL), LM (RL), and LR (RL) are similar
2	RT (PW), RR (PW), RL (PW), and LM (PW) are similar
3	RR (UL), RL (UL), LT (RL), LM (RL), LR (RL), and LL (RL) are similar
4	RR (UL) are similar
5	RR (PW) are similar
6	RL (UL) and LL (RL) are similar
7	RI (PW), RM (PW), LT (PW), and LI (PW) are similar
8	Only LL is dissimilar, other all fingers are like PW pattern
9	RL (UL), LT (RL), and LL (RL) are similar
10	RT (PW), RL (UL), and LM (RL) are similar

Table 7: Shows Individual Characteristics in Fingerprints of 10 South Indian Families

FAMILY	RIDGE DETAILS
1	In RT (Enclosure, ridge crossing), RI (Short ridge), RM (Bridge), RR (Short Ridge), RL (Bifurcation), and LR (Ridge crossing) is shows similarities with M1, M2, and M3
2	In RT (Ridge ending), RI (Bifurcation), RM (Ridge crossing), and LL (Trifurcation) is shows similarities with M1, M2, and M3
3	In RI (Dot, short ridge), RM (Dot) and LM (Ridge ending) show similarities with M1, M2, and M3
4	In RI (Dot), RM (Short ridge), RR (Bridge), LT (Short ridge), and LM (Bridge) Show similarities with M1, M2, and M3
5	In RM (Double bifurcation), RL (Bifurcation) and LT (Ridge ending, dot) Shows similarities with M1, M2 and M3
6	LR (Short ridge) and LL (Short ridge) show similarities with M1, M2, and M3
7	In RT (Ridge ending), RI (Dot), RR (Short ridge), RL (Short ridge) and LT (Ridge ending) Shows similarities with M1, M2, and M3
8	In RM (Ridge ending), RR (Ridge ending), and LT (Short ridge) Show similarities with M1, M2, and M3
9	RT (Dot) and LI (Short ridge) Show similarities with M1, M2, and M3
10	RI (Short ridge) and RR (Ridge ending) Show similarities with M1, M2, and M3

Discussion

The study reveals that in Family 1, ridge details such as RT (Enclosure, ridge crossing), RI (Short ridge), RM (Bridge), RR (Short Ridge), RL (Bifurcation), and LR (Ridge crossing) exhibit similarities with M1, M2, and M3. These parallels suggest a potential genetic connection between Family 1 members. In Family 2, the analysis uncovers correlations between certain ridge patterns Specifically, RT (Ridge ending), RI (Bifurcation), RM (Ridge crossing), and LL (Trifurcation) showcase resemblances with these established patterns, indicating a possible genetic influence on these ridge characteristics. In Family 3, distinct ridge features such as RI (Dot, short ridge), RM (Dot), and LM (Ridge ending) exhibit similarities with M1, M2, and M3. This observation suggests a potential hereditary basis for these specific ridge details among family members. For Family 4, the analysis highlights parallels between their ridge patterns (RI Dot, RM Short ridge, RR Bridge, LT Short ridge, LM Bridge). This similarity indicates a possible genetic influence on the formation of these specific ridge characteristics. Similarly, Family 5 showcases alignments between specific ridge characteristics (RM Double bifurcation, RL Bifurcation, LT Ridge ending, dot). This suggests shared genetic factors contributing to these ridge features. In Family 6, the ridge features LR (Short ridge) and LL (Short ridge) are show some similarities. This points towards a potential genetic basis for these specific ridge patterns within the family. Within Family 7, certain ridge characteristics like RT (Ridge ending), RI (Dot), RR (Short ridge), RL (Short ridge), and LT (Ridge ending) are show similarities. This indicates a possible genetic correlation between family members. The analysis of Family 8 ridge characteristics, including RM (Ridge

ending), RR (Ridge ending), and LT (Short ridge), highlights similarities with the M1, M2, and M3. In Family 9, the ridge details RT (Dot) and LI (Short ridge) exhibit similarities with the M1, M2, and M3. Finally, Family 10 demonstrates parallels between patterns such as RI (Short ridge) and RR (Ridge ending) are show similarities. This all suggesting a genetic basis for these specific ridge characteristics. This study contributes to our understanding of the complex relationship between genetics and fingerprint patterns, with potential implications in forensic and genetic research fields.

The distribution of class and individual characteristics percentages among the examined families' fingerprints provides valuable insights. When aggregating the percentages across all families, the average class characteristics percentage totals around 71.5%, with an average individual characteristic percentage of approximately 13.6%. This collective data offers a comprehensive view of the prevalence of these characteristics across all examined families' fingerprints. The formula used for calculation is Percentage = (Number of specific characteristics / Total characteristics) * 100. This formula allowed us to quantify the prevalence of both class (Arch, Loop, Whorl) and individual (Ridge Ending, Bifurcation, etc.) characteristics across the family fingerprints.

This research paper distinguishes itself from others, such as "A Study by Iju Shrestha et al. (2019)," [10] "Chinmayi Y et al.'s Findings (2020)," [11] in several significant ways. First, This comprehensive approach considers various fingerprint traits and employs advanced tools, including compound microscopes, magnifying lenses, and specialized software, to ensure precision. Unique to this study is the distinction between class and individual characteristics within families, a differentiation with practical implications in forensic investigations and identification systems. Furthermore, the paper provides quantified similarity percentages for both class and individual characteristics, aiding in interpretation. Looking ahead, there is a proposal for future research that integrates genetic analysis techniques and expands the sample size, with collaboration from experts in genetics and biostatistics to enrich insights into the genetic basis of fingerprint patterns within Indian families.

Conclusion

The paper examines the comparative analysis of fingerprint patterns in different generations of Indian families and has revealed both class characteristics and individual characteristics among the 10 families. The class characteristics identified similarities in specific fingerprint patterns across different family members within the same family. Individual characteristics were observed within each family, indicating unique fingerprint patterns that differentiate individuals even within the same family. These individual characteristics varied across different fingers. The average class characteristics percentage totals around 71.5%, with an average individual characteristic percentage of approximately 13.6%. While the current study included a diverse set of Indian families, future research should aim to increase the sample size. A larger sample size would provide more robust evidence regarding the inheritance patterns of dermatoglyphics within the Indian population.

Ethical Clearance: No Ethical clearance Required

Conflict of Interest: None to declare

Source of Funding: None to declare

Data Retention: We took several measures to ensure the confidentiality and ethical handling of the collected data. All fingerprint samples and associated data were securely stored in locked filing cabinets in a restricted-access area within our research facility. Access to this data was limited to authorized personnel directly involved in the study. Additionally, we removed personal details from confidential materials such as fingerprints and other identifiers during the analysis process to protect the privacy of the participants. Once the analysis was completed and the study findings were documented, all physical and digital copies of the collected data were securely disposed of in accordance with data protection regulations.

Ethical Clearance: While our manuscript did not mention ethical clearance directly, we want to clarify that we obtained consent from all participating families before collecting their fingerprints. Participants were fully informed about the purpose of the study, the methods involved, and the potential implications of

the research. This ethical practice ensured that the families involved were willing contributors to the study and aligned with established research ethics guidelines.

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