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Forensic Dermatoglyphics: A Cross-Sectional Study on Fingerprint Patterns in Relation to Sex and ABO Blood Groups

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Abstract

The term *dermatoglyphics* is derived from the Greek words *derma* (skin) and *glyphics* (carving), and was coined by Harold Cummins in 1926 to describe the scientific study of epidermal ridge patterns on the fingers, palms, toes, and soles [1,2]. Dermatoglyphics focuses primarily on fingerprint patterns, which are formed during early fetal development and remain unchanged throughout life [3].

The differentiation of epidermal ridges occurs between the third and fourth months of intrauterine life, resulting in permanent and unique fingerprint patterns [4]. These friction ridges are located on the distal phalanges, with raised portions termed papillary ridges and depressions between them known as furrows. Fingerprint patterns are broadly classified into three major types: loops, whorls, and arches, with further sub-classification based on ridge configuration and complexity [5].

Fingerprint patterns are genetically determined, remain constant throughout an individual's lifetime, and regenerate even after superficial injuries. Because of their permanence and individuality, fingerprints constitute one of the most reliable methods of personal identification in forensic science [6]. The scientific use of fingerprints for identification, known as dactyloscopy, has been further strengthened by modern Automated Fingerprint Identification Systems (AFIS) in forensic investigations and digital identity verification [6].

Dermatoglyphics also has significant applications in the study of congenital anomalies and genetic disorders such as Down syndrome, Turner syndrome, and Klinefelter syndrome, where aberrant ridge patterns are frequently observed [3]. The ABO blood group system, discovered by Karl Landsteiner in 1901, remains a cornerstone of transfusion medicine and biological identification; it classifies individuals according to specific antigens on red blood cells, while the Rhesus system further classifies blood by the presence or absence of the D antigen [7].

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Introduction

The term *dermatoglyphics* is derived from the Greek words *derma* (skin) and *glyphics* (carving), and was coined by Harold Cummins in 1926 to describe the scientific study of epidermal ridge patterns on the fingers, palms, toes, and soles [1,2]. Dermatoglyphics focuses primarily on fingerprint patterns, which are formed during early fetal development and remain unchanged throughout life [3].

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Sex determination constitutes one of the fundamental components of biological profiling in forensic investigations, alongside age and stature estimation [8]. Identifying associations between dermatoglyphic patterns, sex, and blood groups may therefore contribute to narrowing down the identity of unknown individuals in medico-legal cases. Earlier studies have explored such associations, including Bloterogel and Bloterogel's report on relationships between physical characteristics and blood groups [9], and Mandrah and Kanwal's investigation of fingerprint variations in relation to thumb whorl patterns [10]. However, population-specific findings remain variable, underscoring the need for region-specific research.

The present study was therefore undertaken to analyse fingerprint pattern distribution in relation to sex and ABO blood groups among adults at Chettinad Hospital and Research Institute, Kelambakkam, and to evaluate its potential application in forensic identification.

Materials And Methods

Study Design And Participants

A cross-sectional study was conducted among 300 healthy individuals aged 18–40 years, comprising students, teaching staff, and non-teaching staff members at Chettinad Hospital and Research Institute, Kelambakkam. The study was carried out after obtaining approval from the Institutional Human Ethics Committee (Proposal ID: IHECII/0880/25). All participants provided written informed consent prior to enrolment. Data collection was performed over a period of three months from July 2025 to September 2025.

Inclusion And Exclusion Criteria

Participants were included if they were aged between 18 and 40 years, possessed documented ABO and Rh blood group records, and provided written informed consent. Participants were excluded if they had damage to the finger pulp due to injury, trauma, or application of mehndi; hand deformities, known congenital anomalies, or genetic syndromes affecting fingerprint clarity; or dermatological conditions that could alter epidermal ridge patterns.

Fingerprint Collection Procedure

Prior to fingerprint recording, participants were instructed to wash their hands thoroughly with soap and water to remove oil, dirt, and sweat. Residual moisture was eliminated using spirit, and hands were allowed to air-dry completely. Fingerprints were obtained using a CAMLIN ink pad (157 × 96 mm). Each finger was uniformly inked in a proximal-distal direction and impressions were recorded on plain white A3-sized paper placed on a firm, flat surface. The fingerprint recording sheet contained ten designated blocks corresponding to the fingers of both hands.

Participants were asked to stand comfortably at a forearm's distance from the recording surface. Each finger was placed at a right angle to the paper, pressed gently, and rolled uniformly in a radioulnar direction to ensure complete ridge pattern transfer. Collected fingerprints were examined using a magnifying lens;

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selected prints were additionally scanned and digitally enlarged for detailed analysis.

Classification Of Fingerprint Patterns

Fingerprint patterns were classified according to Henry's classification system [6] into: ulnar loops, radial loops, plain whorls, double loop whorls, superficial arches, tented (deep) arches, and composite patterns. For each participant, ABO blood group and Rh status were recorded alongside the fingerprint patterns. Collected data were tabulated and subjected to statistical analysis using the chi-square test. A p-value of < 0.05 was considered statistically significant.

Results

A total of 300 participants were enrolled, yielding 3,000 individual fingerprint impressions for analysis. Tables 1–4 summarise the key findings across blood group distribution, sex-wise pattern distribution, overall pattern frequencies, and finger-wise pattern distribution.

Distribution Of ABO Blood Groups

Blood group B was the most prevalent in the study population (n = 112), followed closely by blood group O (n = 109), blood group A (n = 64), and blood group AB (n = 15), as detailed in Table 1. This distribution is consistent with earlier studies reporting a predominance of blood group B in comparable South Indian populations [12–15].

Table 1 : Distribution of ABO blood groups among study participants (n = 300)

Blood Group	Number of Participants
A	64
B	112
O	109
AB	15

Overall Distribution of Fingerprint Patterns

Analysis of 3,000 fingerprints demonstrated that the ulnar loop was the most common fingerprint pattern (n = 1636; 54.53%), followed by plain whorls (n = 887; 29.57%), superficial arches (n = 254; 8.47%), tented arches (n = 105; 3.50%), radial loops (n = 50; 1.67%), double loop whorls (n = 45; 1.50%), and composite patterns (n = 23; 0.77%), as shown in Table 3. The predominance of ulnar loops is consistent with earlier dermatoglyphic studies across different population groups [15–17].

Table 3 : Overall distribution of fingerprint patterns (n = 3,000 fingerprints)

Pattern	Count	Percentage (%)
Ulnar Loop	1636	54.53
Radial Loop	50	1.67
Plain Whorl	887	29.57
Double Loop Whorl	45	1.50
Superficial Arch	254	8.47

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Tented Arch	105	3.50
Composite	23	0.77

Notable sex-based differences were observed in fingerprint pattern distribution, as shown in Table 2. Ulnar loops were more frequently identified in females (61%) compared to males (48%), whereas plain whorls were more prevalent in males (39%) than females (21%). Arch patterns showed slightly higher prevalence in females (superficial arch 10.25% vs 7%; tented arch 5% vs 2%), while composite patterns showed minimal sex-based variation (0.83% vs 0.73%). These sex-based differences were statistically significant ($p < 0.05$), consistent with earlier dermatoglyphic studies reporting sex-specific pattern tendencies [15–17].

Table 2 : Sex-wise distribution of fingerprint patterns

Pattern	Female (%)	Male (%)	Total Count
Ulnar Loop	61.0	48.0	1636
Radial Loop	1.5	2.0	50
Plain Whorl	21.0	39.0	887
Double Loop Whorl	0.6	2.36	45
Superficial Arch	10.25	7.0	254
Tented Arch	5.0	2.0	105
Composite	0.83	0.73	23

Finger-wise Distribution of Fingerprint Patterns

Finger-specific analysis revealed that ulnar loops were predominantly present in the thumbs, index fingers, and little fingers of both hands, whereas whorl patterns were more commonly observed in the middle and ring fingers, as summarised in Table 4. Radial loops were most frequently identified in index fingers. This consistent bilateral distribution suggests that finger-wise dermatoglyphic variation may have potential value in forensic comparative fingerprint analysis.

Table 4 : Finger-wise distribution of the most common fingerprint pattern

Finger	Most Common Pattern
Right Thumb	Ulnar Loop
Right Index	Ulnar Loop
Right Middle	Whorl
Right Ring	Whorl
Right Little	Ulnar Loop

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Left Thumb	Ulnar Loop
Left Index	Ulnar Loop
Left Middle	Whorl
Left Ring	Whorl
Left Little	Ulnar Loop

Distribution of Fingerprint Patterns Across ABO and Rh Blood Groups

Ulnar loops were the most frequent pattern across all ABO blood groups, with particularly high prevalence among AB-positive individuals (88%). Plain whorls showed relatively higher distribution among A-positive and O-negative individuals. Statistical analysis revealed a significant association between ABO blood groups and fingerprint patterns ($p < 0.05$), while no statistically significant association was observed with the Rh factor ($p > 0.05$). Similar findings have been reported in earlier studies examining dermatoglyphics in relation to blood groups [11,12,16].

Discussion

Fingerprints are among the most reliable biological markers in forensic identification due to their permanence, individuality, and resistance to environmental alteration. They also adhere to Locard's principle of exchange, whereby secretions from friction ridges may be transferred to surfaces and later recovered during crime scene investigation [11]. Accordingly, studying associations between fingerprint patterns, sex, and blood groups may enhance biological profiling capacity when complete identification is not immediately achievable.

Distribution of ABO and Rh Blood Groups

In the present study, blood group B was the most prevalent, followed by O, A, and AB (Table 1). This distribution is comparable with earlier studies that reported a predominance of blood group B in similar South Indian population cohorts [12–15]. Regarding the Rh factor, the majority of participants were Rh positive, consistent with previously reported population distributions [11,16,17].

Overall Distribution of Fingerprint Patterns

Analysis of 3,000 fingerprints confirmed that the ulnar loop was the most common fingerprint pattern, followed by plain whorls (Table 3). Other patterns, including arches, double loop whorls, radial loops, and composites, were comparatively less frequent. The predominance of ulnar loops is consistent with earlier dermatoglyphic research across diverse populations [15–17], supporting the established concept that loop patterns are the most common dermatoglyphic configuration in the human species.

Sex-wise Distribution of Fingerprint Patterns

The present study demonstrated statistically significant sex-based differences in fingerprint pattern distribution (Table 2). Ulnar loops were more frequently observed in females, whereas plain whorls were more common in males. Arch patterns showed slightly higher prevalence in females, while composite patterns showed minimal variation between sexes. Similar observations have been reported in prior dermatoglyphic studies, suggesting that fingerprint pattern distribution may contribute to probabilistic sex determination in forensic investigations when combined with other biological parameters [15–17].

Finger-wise Distribution of Fingerprint Patterns

Finger-specific analysis revealed that ulnar loops predominated in the thumbs, index fingers, and little fingers, whereas whorls were more common in the middle and ring fingers of both hands (Table 4). Radial loops were most frequently observed in index fingers. This consistent bilateral pattern suggests that finger-wise dermatoglyphic variation has meaningful potential in forensic identification and comparative fingerprint analysis.

Distribution of Fingerprint Patterns Across ABO Blood Groups

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In the present study, ulnar loops were the most frequent pattern across all ABO groups, with particularly high prevalence in AB-positive individuals. Plain whorls showed relatively higher distribution among A-positive and O-negative individuals. Statistical analysis demonstrated a significant association between ABO blood groups and fingerprint patterns ($p < 0.05$), while no significant association was observed with Rh factor ($p > 0.05$). These observations are consistent with earlier studies examining dermatoglyphics in relation to blood groups [11,12,16]. Although dermatoglyphics alone cannot determine blood group, its association with genetically determined biological traits may support a supplementary role in forensic identification.

Forensic Implications

The findings of this study reinforce the importance of dermatoglyphics as a non-invasive and cost-effective tool in forensic science. When combined with biological parameters such as sex and blood group, fingerprint pattern analysis may assist in narrowing down identity in medico-legal investigations, mass disaster victim identification, and unidentified body cases. However, dermatoglyphic patterns should be interpreted as supportive evidence rather than definitive proof of identity or biological traits.

Conclusion

Ulnar loops were the most dominant fingerprint pattern across sexes, individual fingers, and all ABO blood groups in this study population. Statistically significant associations were observed between fingerprint patterns and both sex and ABO blood group, while the Rh factor did not yield a significant association. These findings underscore the potential of dermatoglyphics as a non-invasive, reliable, and cost-effective tool for forensic identification and biological profiling, offering valuable insights for medico-legal investigations. This study presents an extensive classification of fingerprint patterns and their distribution with respect to each blood group subtype, representing a contribution to the region-specific dermatoglyphic literature. Further research incorporating genetic analysis is warranted to advance the application of dermatoglyphics in forensic medicine and allied fields.

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