

Polygenic Traits & Dermatoglyphics

Dermatoglyphics refers to the **ridge patterns** found on fingers, palms, and soles, which form during fetal development and remain unchanged throughout life. These are **highly heritable, polygenic**, and often used in **population studies, forensic science, and medical genetics**.

a. Finger-Ball Pattern Types

Fingerprints are formed by ridges on the skin of the fingers and palms. These ridges make distinct patterns on the tips of our fingers, which are called **finger-ball patterns**. These patterns are fully developed before birth (by the 4th fetal month) and remain unchanged throughout life. They are genetically controlled, but can also be influenced by environmental factors in the womb.

There are **three main types** of fingerprint patterns:

1. Loops

Loops are the most common type of fingerprint pattern. In this type, the ridges **enter from one side of the finger, curve around, and exit on the same side**.

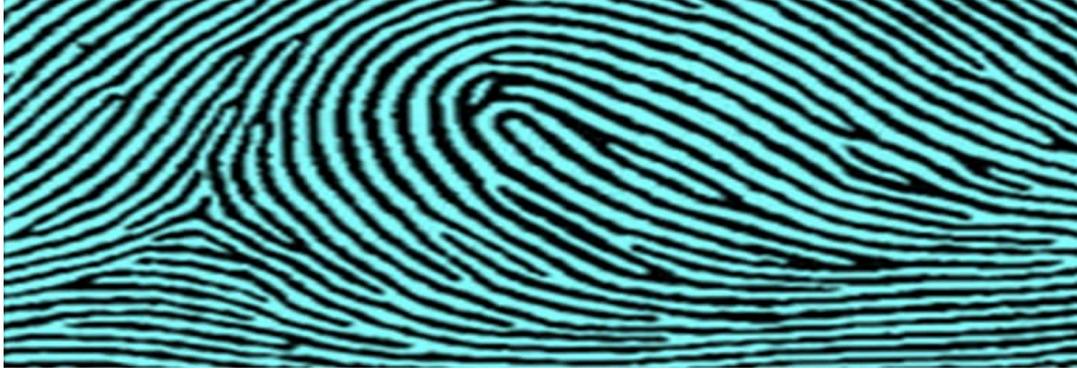
There are two types of loops:

- **Ulnar Loops:** Open towards the **little finger (ulna side)**. These are more



common in most populations.

- **Radial Loops:** Open towards the **thumb (radius side)**. These are less common.



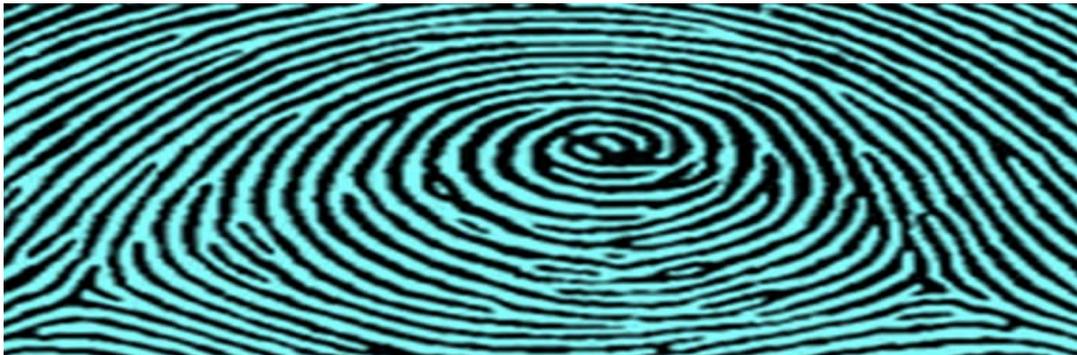
Example: In Indian populations, ulnar loops are very frequent, while radial loops are relatively rare. Among Europeans, radial loops are slightly more frequent than in Asians.

2. Whorls

Whorls are more complex than loops. In whorl patterns, the ridges form **concentric circles, spirals, or other rounded patterns**, usually with **two or more triradii** (triangular points where ridges meet).

Types of whorls include:

- **Plain Whorl**



- **Central Pocket Loop**



- **Double Loop Whorl**



- **Accidental Whorl**



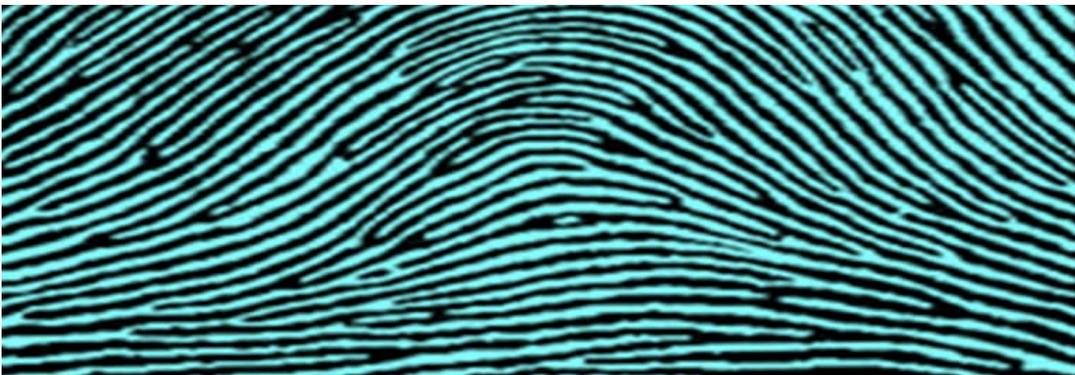
Example: Whorls are more common in some East Asian populations, like the Chinese and Koreans, compared to African populations, where loops dominate.

3. Arches

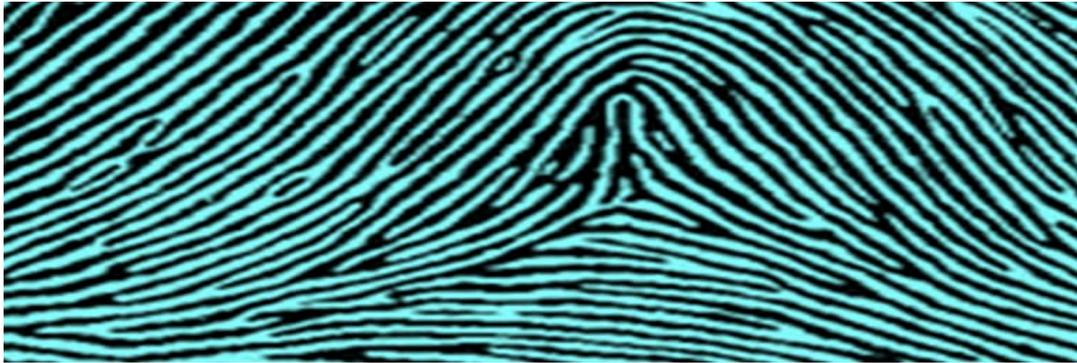
Arches are the **simplest and least common** fingerprint pattern. The ridges **enter from one side of the finger and exit on the other side**, rising in the middle like a wave or hill. Arches usually **lack triradii** or have only one.

There are two types:

- **Plain Arch**



- **Tented Arch** (which has a sharper rise in the middle)



Example: Arches are most common in Australian Aboriginal populations and lowest among Japanese and Korean groups.

b. Dankmeijer's Index

Dankmeijer's Index is a simple mathematical formula used in **dermatoglyphics** (the study of fingerprint patterns) to compare how frequently **arches** occur in relation to **whorls** in a population.

$$\text{Dankmeijer's Index} = \left(\frac{\text{Number of Arches} \times 100}{\text{Number of Whorls}} \right)$$

Interpretation:

- **Low Dankmeijer's Index:** Means arches are rare compared to whorls (common in East Asian and European populations).
- **High Dankmeijer's Index:** Means arches are relatively more frequent (seen in some African and Australian Aboriginal groups).

Example:

Let's say in a tribal population study:

- Arches = 30
- Whorls = 150

$$\text{Dankmeijer's Index} = \left(\frac{30 \times 100}{150} \right) = 20$$

This index value of **20** suggests a **moderate presence of arches** in the population.

Example: Indian tribal populations tend to have **higher Dankmeijer's Index values** than urban Indian populations, reflecting different ancestry or mating patterns.

c. Furuhata's Index

Furuhata's Index is another dermatoglyphic measure used to compare the **relative frequency of whorls to loops** in a population. While Dankmeijer's Index focuses on arches and whorls, Furuhata's Index compares whorls with loops.

Formula:

$$\text{Furuhata's Index} = \left(\frac{\text{Number of Whorls} \times 100}{\text{Number of Loops}} \right)$$

Interpretation:

- **Higher Furuhata's Index:** Indicates more whorls relative to loops (e.g., often found in Mongoloid populations).
- **Lower Furuhata's Index:** Indicates more loops than whorls (common in Caucasoid and some African populations).

Example:

In a study of a local community:

- Whorls = 120
- Loops = 200

$$\text{Furuhata's Index} = \left(\frac{120 \times 100}{200} \right) = 60$$

This **index of 60** shows that loops are more common than whorls in this group.

Example: Japanese and Chinese populations often have **higher Furuhata's Index** (more whorls), while many Indian populations show **lower values**, indicating more loops.

d. Pattern Intensity Index (PII)

Pattern Intensity Index is a quantitative measure that reflects how complex the fingerprint patterns are in a population. It focuses on the **number and type of pattern triradii** (triangular regions at the base of fingerprint patterns).

Key Idea:

Each fingerprint pattern has a **certain number of triradii**:

- **Loops** usually have **1 triradius**
- **Whorls** usually have **2 triradii**
- **Arches** have **0 triradii**

The **Pattern Intensity Index** is calculated by counting the total number of triradii across all 10 fingers of an individual, and then dividing by the number of fingers studied (usually 10).

Formula:

$$PII = \frac{\text{Total number of triradii on all fingers}}{10}$$

Interpretation:

- **Higher PII** = More complex patterns (more whorls and double loops)
- **Lower PII** = Simpler patterns (more arches and single loops).

Example:

If an individual has:

- 6 loops (1 triradius each) = 6 triradii
 - 3 whorls (2 triradii each) = 6 triradii
 - 1 arch (0 triradius) = 0 triradii
- Total triradii = 12**

$$\text{PII} = \frac{12}{10} = 1.2$$

This **PII of 1.2** suggests a moderate pattern complexity in this person.

Example: Some African populations have lower PII values due to a higher frequency of loops, while Central Asian groups may show higher PII values due to more whorls.

e. Total Finger Ridge Count (TFRC)

Total Finger Ridge Count (TFRC) is a commonly used dermatoglyphic measure that represents the total number of **ridge lines** between the **triradius** and the **core** of the fingerprint pattern on each finger.

This count gives a quantitative value to the fingerprint pattern and is widely used in population studies, genetics, and anthropology.

How is TFRC Calculated?

1. Each fingerprint pattern (except arches) has a **triradius** and a **core**.
2. The number of ridges **between the core and the triradius** is counted for each finger.
3. TFRC is the **sum of these ridge counts across all 10 fingers**.

Important Rules:

- **Arches** have **no triradius**, so their ridge count is considered **0**.
- For **whorls** (which have 2 triradii), only the **higher ridge count** from one triradius is taken.
- Loops have one triradius, so the ridge count is directly measured from it.

Formula:

$$\text{TFRC} = \sum (\text{ridge count on each finger})$$

Example:

If an individual has the following ridge counts:

- Right hand: 13, 15, 17, 0 (arch), 18

- Left hand: 12, 14, 0 (arch), 16, 19
Then,

$$\text{TFRC} = 13 + 15 + 17 + 0 + 18 + 12 + 14 + 0 + 16 + 19 = 124$$

So, the **TFRC = 124**

Interpretation:

- TFRC gives an idea of **genetic variability** within and between populations.
- It is often **normally distributed** (bell-shaped curve) in large populations.
- Used in **genetic counseling**, twin studies, and **studies of congenital disorders**

f. Absolute Finger Ridge Count (AFRC)

Absolute Finger Ridge Count (AFRC) is another important dermatoglyphic measure that gives a **more comprehensive count** of the ridge patterns in fingerprints, especially in the case of **whorls**, which have **two triradii**.

Unlike **TFRC**, which takes only the **larger ridge count** in a whorl, **AFRC includes both ridge counts** from each triradius. This makes AFRC a **more detailed and inclusive** measure.

How is AFRC Calculated?

1. For **loops**, which have one triradius:
 - Ridge count is measured from the **triradius to the core**, same as in TFRC.
2. For **arches**, which have no triradius:
 - Ridge count = **0**
3. For **whorls**, which have **two triradii**:
 - Ridge count is measured **from both triradii to the core**
 - **Both counts are added**, unlike TFRC, where only the higher value is taken.

Formula:

$$\text{AFRC} = \sum (\text{ridge count from each triradius on all 10 fingers})$$

Example:

Let's say a person has these fingerprint types:

- Finger 1: Loop → 14
- Finger 2: Whorl → 13 (left triradius) + 11 (right triradius)
- Finger 3: Arch → 0
- Finger 4: Whorl → 12 + 14
- Finger 5: Loop → 10
- Similar values on the left hand...

If we calculate both triradius counts for all whorls and add ridge counts of loops and zeros for arches, we get something like:

$$\text{AFRC} = 14 + (13 + 11) + 0 + (12 + 14) + 10 + [\text{Left hand counts}] = \dots$$

The **AFRC value** will be **higher than the TFRC**, as it includes **both ridge counts** for each whorl.

Key Differences from TFRC:

Feature	TFRC	AFRC
Whorl ridge count	Only one (larger one)	Both triradii included
Level of detail	Moderate	More detailed & accurate
Use in twin studies	Common	More reliable for comparisons

g. Palmar Formula and Mainline Index

The **palmar formula** and **mainline index** are dermatoglyphic tools used to analyze **ridge flow patterns on the palm**, especially the **main lines** that radiate from the **digital triradii** under the fingers.

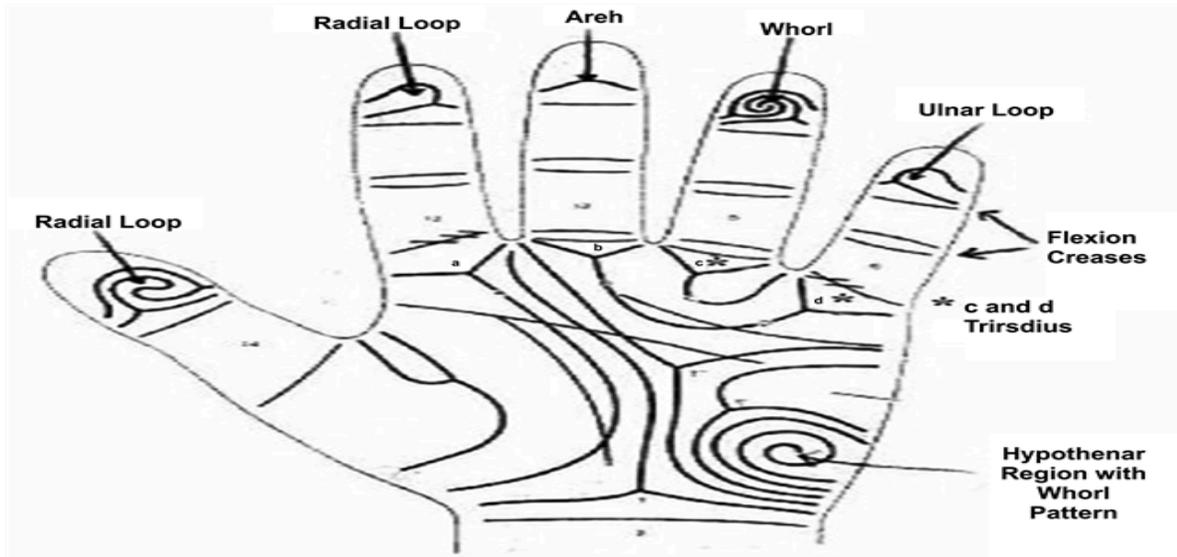
These patterns are more complex than fingerprints and provide insights into **population differences, genetic inheritance**, and even **developmental anomalies**.

1. Palmar Formula

What is it?

The palmar formula is a **notation system** used to describe the direction of the four main lines—**A, B, C, and D**—that originate from the four digital triradii located under fingers II to V.

Each of these lines flows toward a specific area or triradius on the palm and is denoted by a **code** based on where it ends.



Example Format:

$$\text{Palmar Formula} = AxByCzDw$$

Where:

- A, B, C, D = main lines from triradii under fingers
- x, y, z, w = direction codes (e.g., 1, 2, 3... depending on end location)

Interpretation Example:

- A1 B2 C3 D4 could mean:
 - Line A ends near triradius 1
 - Line B ends near triradius 2
 - And so on...

This formula helps in **comparing palmar pattern trends** across individuals and populations.

2. Mainline Index

What is it?

The **Mainline Index** is a **numerical value** calculated based on how far the main lines (A, B, C, D) travel across the palm. It's a way of **quantifying the length and orientation** of these lines.

Each direction or end point is given a **numerical score**, and the **average** of these values is the **Mainline Index**.

Formula:

$$\text{Mainline Index} = \frac{\text{Sum of Directional Scores of A, B, C, D}}{4}$$

Purpose:

- A **low mainline index** means the lines terminate **closer to their origin** (i.e., a more vertical or inward direction).
- A **high mainline index** means the lines run **further across the palm**, often more horizontal or outward.

Example in Population Study:

- A study comparing Indian tribal and non-tribal groups might find:
 - Tribal group has palmar formula A1 B1 C2 D2 and index of 2.0
 - Non-tribal group has A2 B3 C4 D5 and index of 3.5This reflects **different genetic drift** and **population histories**.

h. Transversality

Transversality refers to how the skin ridge lines (the fine, raised lines on the palm) are arranged and how they move across the palm—especially in the **horizontal direction**. It focuses on the overall direction the ridges take and whether they cross an imaginary vertical line running down the center of the palm from the middle finger to the wrist.

Key Concept

1. Direction of Ridge Flow

- Ridges on the palm do not run randomly; they follow general directions.
- These can be:
 - **Longitudinal ridges:** running from top to bottom (along the length of the palm).
 - **Transverse ridges:** running from side to side (across the width of the palm).
- **Transversality** describes how much the ridges run *horizontally* rather than vertically.

2. Crossing the Midline

- Imagine a straight vertical line drawn from the base of the middle finger down to the wrist.

- In some people, ridge lines cross this line frequently, creating a *high level of transversality*.
- In others, ridge lines may stay mostly on their side of the palm, leading to *low transversality*.

3. Measuring Transversality

- **Qualitative Method:** Visual observation—ridges are categorized as having low, moderate, or high transversality.
- **Quantitative Method:** Researchers draw angles between the ridge lines and the central axis of the palm to assign numerical values.
 - A **greater angle** suggests more horizontal ridge flow.
 - A **smaller angle** means more vertical or longitudinal ridges.

Illustrative Example

Let's consider two tribal communities studied in dermatoglyphic research:

- **Community X:** Most individuals have ridge lines that run vertically or slightly slanted. Very few lines cross the center of the palm.
 - **Interpretation:** *Low transversality*.
- **Community Y:** Many individuals show horizontal ridge lines that cross over from one side of the palm to the other.
 - **Interpretation:** *High transversality*.

These differences may be due to population history, such as genetic isolation or unique evolutionary changes in ridge formation.

i. ATD Angle and Flexion Creases

ATD Angle

The **ATD angle** is a specific measurement made on the palm. It helps researchers and medical experts study the pattern of **ridge meeting points**, which are called **triradii**.

What Are Triradii?

Triradii are points where three sets of ridges meet and diverge at different angles. On the palm, three main triradii are important:

- **'a' triradius:** Located near the base of the **index finger**.
- **'d' triradius:** Found near the base of the **little finger**.
- **'t' triradius:** Found towards the bottom of the palm, closer to the **wrist**, often slightly to the inner side. This is called the **axial triradius**.

How to Measure the ATD Angle

1. Draw a straight line from 'a' to 't'.
2. Draw another line from 'd' to 't'.
3. The angle formed at 't' (where the two lines meet) is called the **ATD angle**.

Understanding the Angle

- In most people, the ATD angle falls between **40° and 45°**.
- If the 't' triradius is placed **lower** (closer to the wrist), the angle becomes **larger**.
- If the 't' triradius is placed **higher**, the angle becomes **smaller**.

Population Example

In a dermatoglyphic study:

- **Group A:** Most individuals had an ATD angle around 42°, suggesting average placement of triradii.
- **Group B:** Most had angles above 60°, indicating a lower placement of the 't' triradius. This feature was consistent across many individuals in the group.

Flexion Creases of the Palm

Flexion creases are the visible lines on the palm that develop when the hand bends during fetal life. They are different from the fine **ridge lines** that make up fingerprints and dermatoglyphs, but they can also reveal information about development.

Main Types of Flexion Creases

1. **Distal Transverse Crease**
 - Also called the **upper main crease**.
 - It lies just below the fingers and runs across the upper palm.
2. **Proximal Transverse Crease**
 - Found below the distal crease.
 - Often curves across the palm near its middle section.
3. **Thenar Crease**
 - Curves around the base of the thumb in a semicircular shape.
 - Helps in thumb movement.

Variations and Terms

Simian Crease

- A **single horizontal line** across the palm, created when the **distal and proximal transverse creases merge into one**.

- This crease has been observed in:
 - Some individuals with **Down syndrome**
 - **Fetal alcohol syndrome**
 - **Other congenital or developmental disorders**
- It may also occur in some healthy individuals as a normal variation.

Sydney Crease

- An **unusually long proximal transverse crease** that stretches across the palm more than normal.
- It has been observed in people with certain developmental conditions.

Example from Research

In a population study of children:

- A subset of children showed the **simian crease** on both palms.
- Some of them were later diagnosed with chromosomal anomalies.
- Another subset had the **Sydney crease**, which helped in identifying developmental delays early.

PYQ Insights

- *"Which of the following is not a basic fingerprint pattern?"*
(Options: Loop, Arch, Spiral, Whorl)
- *"Dankmeijer's Index is calculated using the ratio of:"*
(Options: Arches to Whorls, Loops to Arches, Whorls to Loops, Arches to Loops)
- *"Furuhata's Index is expressed as:"*
(Options: Whorls × 100 / Loops, Arches × 100 / Whorls, etc.)
- *"The ATD angle is used to study:"*
(Options: Palmar dermatoglyphics, Body mass index, Skull shape, Blood groups)
- *"Which index indicates the total number of ridges on all 10 fingers?"*
(Options: TFRC, AFRC, Pattern Intensity Index, Mainline Index)
- *"Palmar formula is associated with:"*
(Options: Mainline terminations, Ridge count, Flexion creases, Thumb patterns)