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# **Palm Prints**

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The friction ridges on the palmar surface of the hands develop in utero during the first and second trimester. Like fingerprints, the ridge flows and patterns that emerge on the palms are the product of the growth stresses and strains on the surface of the skin at the time of friction ridge development. These growth stresses, and the size and shape of any volar pads (VPs) present, influence the resulting patterns displayed on the palms (Wertheim and Maceo).

The friction ridge skin on the palmar surfaces has been studied for more than a century. In the late 1890s through the early 1900s, Inez Whipple researched the ventral surfaces of various species of monkeys' feet, focusing on the apical pads, ridge patterns, deltas, and other 'epidermal markings,' comparing them to human hands and feet. Harris Wilder, in his Palm and Sole Studies, created a system for recording the configurations of various features on the palms and soles into a formula, easily understood and visualized by someone knowing the system. Cummins and Midlo researched pattern frequencies and intensities (number of deltas) in both right and left palms and soles of chimpanzees. Penrose also studied the pattern frequencies of palms and soles, and he and Loesch classified palmar dermatoglyphics, both normal and abnormal. Malhotra et al. researched the methodology for palmar pattern ridge counts, specifically in Indian genetics. Most recently, in 2001, Tietze and Witthuhn published their work on palm patterns, flows, and deltas, including statistical data in left and right palms. Given that the book is written in German, translation and interpretation is limited; however, the charts and graphs and numerous images are most useful.

To further study the distribution of the various patterns on the palms, the authors devised a classification scheme and recorded the various pattern types present in 800 pairs of inked palm prints (left and right). The palm prints were randomly selected from male arrestees in Clark County, Nevada, from the 1990s. The palms were divided into three regions: interdigital, hypothenar, and thenar. Figure 1 illustrates the different regions of the palm.

## **Interdigital Region**

## Deltas

The interdigital region is the most complex area of the palm. In this study, the interdigital region contained anywhere from three to seven deltas. These deltas often existed in various combinations with tented arches, loops, columns, or whorls in the interdigital region. Seven possible delta positions were documented. Four of the delta positions were situated at or near the base of each finger (finger deltas) and were labeled Index (I), Middle (M), Ring (R), and Little (L). The remaining three delta positions occurred between the fingers and were labeled Index/Middle (I/M), Middle/Ring (M/R), and Ring/

Little (R/L). Occasionally, more than one delta was located in a position (e.g., two deltas under the ring finger). Table 1 shows the number of palms with the corresponding number of deltas from the 800 left and right palms. The most common number of interdigital deltas in the left and right hands was four.

The position of each delta and the number of deltas in each position were also recorded. **Table 2** shows the number of palms that contained 0, 1, or 2 deltas in each delta position in the interdigital region. As shown in **Table 2**, the overwhelming majority of palms had a delta associated with each finger.

It was very common for the palms to have only the four finger deltas: 553 of the 586 left palms and 591 of the 605 right palms with four interdigital deltas had only the four finger deltas (I, M, R, and L). Figure 2 is a right palm interdigital region displaying the four finger deltas.

In palms containing only three interdigital deltas, the most common configuration was a delta under the index, middle, and little finger each (the ring finger delta was absent): 31 of 32 left palms and 19 of 19 right palms with three interdigital deltas were missing the ring finger delta. Figure 3 shows the interdigital region below the right ring finger. In this palm, the ring finger delta is absent.

Interdigital regions with four or more deltas often contained at least one pattern area in the interdigital region. The more patterns present in the interdigital region, generally the higher the number of deltas present. Figure 4 is a right palm interdigital region displaying six deltas associated with three interdigital loop patterns. In this study, 13 left palms (1.6%) and 18 right palms (2.2%) presented this configuration of six deltas and three loops.

## **Patterns**

The position and types of patterns in the interdigital region were also documented. These patterns included tented arches, loops, columns, and whorls. Figure 5 illustrates the different patterns. Designation as tented arches, loops, and whorls followed basic fingerprint classification rules. In the interdigital region, however, a tented arch was a ridge flow over an interdigital delta that formed a loop-like pattern (Figure 5(a) and 5(b)). Columns are a series of three or more ending ridges flanked on one or both sides by a delta (Figure 5(d)).

The interdigital region was divided into VP regions II, III, and IV as depicted in Figure 6. The VP II region is between the index and middle fingers. The VP III region is between the middle and ring fingers. The VP IV region is between the ring and little fingers.

The patterns present in each VP position were recorded for the 800 left and right palms. Only 40 of the 800 (5%) left palms and 29 of the 800 (3.6%) right palms displayed no patterns in the interdigital region. Table 3 indicates the number of palms with the various patterns in the VP II position, including the number of palms with tented arches (TA) over the middle finger delta. **Table 4** indicates the number of palms with the various patterns in the VP III position, including the number of palms with tented arches over the ring finger delta. **Table 5** indicates the number of palms with the various patterns in the VP IV position, including the number of palms with tented arches over the little finger delta. In the VP IV position, there could be a single loop or two loops, which is the reason **Table 5** has '1 Loop' and '2 Loops' indicated.

Loops and columns were more prevalent on the right hand (versus the left hand) in the VP II position. This naturally correlates with the higher occurrence of I/M deltas in right palms. The right palms had an equal occurrence of loops in



Figure 1 Three palmar regions: interdigital, hypothenar, and thenar.

Table 1	Number of deltas in the interdigital region ( $n = 800$ for left
and right pa	ms each)

Number of deltas	Left palm	Right palm
3	32 (4.0%)	19 (2.4%)
4	586 (73%)	605 (76%)
5	154 (19%)	137 (17%)
6	28 (3.5%)	37 (4.6%)
7	0	2 (0.25%)

the VP III and IV positions, while left palms had the highest occurrence of loops in the VP IV position. Figure 7 illustrates a rare and complex VP IV position in a left palm. This palm has a column (A) and two loops (B and C) in the VP IV position.

Loops are the most common pattern in the interdigital region of palms. Tables 6 and 7 demonstrate the number of left and right palms containing specific configurations of loops in the various VP positions. For example, there were 111 left palms (14%) with a loop in the VP III position only. There were 13 left palms (1.6%) with a loop in all three VP positions. These tables only refer to loops; other patterns may be present in the VP regions.

## **Hypothenar**

The hypothenar region also contained a variety of patterns. Like fingers, the loops found in the palms flow in a certain direction. For the purposes of this study, the direction the top of the loop was pointing to is indicated (this is reverse from fingerprint classification). For instance, a loop pointing toward the outer edge of the palm is called an 'ulnar loop.' A loop pointing toward the center of the palm is called a 'radial loop,' and a loop pointing toward the base of the palm is called a 'proximal loop.' The ulnar loops are further described by the origin of the ridge flow. If the ridges flow into an ulnar loop pattern from the top of the palm, it is called an 'ulnar loop top.' If the ridges flow into an ulnar loop pattern from the bottom of the palm, it is called an 'ulnar loop - base.' Figure 8 illustrates two right hand hypothenars. One hypothenar has an 'ulnar loop - top' (A) and a radial loop (B). The other hypothenar has an 'ulnar loop - base' (C). The pattern counts for ulnar loops may be artificially low due to the manner in which the palms were recorded. Sometimes ulnar loops are located far out on the edge of the palm and are not displayed during the recording process; for this reason, the data should be viewed with caution.

Figure 9 illustrates the patterns classified as proximal loop, arch, and proximal loop/arch combination. The proximal loop in the proximal loop/arch classification approaches the radial loop classification; however, it is distinguished by the distinct arch pattern.

Figure 10 illustrates the tented arch patterns noted in the hypothenar region. The tented arches can point in the proximal direction (a) or the ulnar direction (b).

Table 2	The number of palms containing 0,	1, or 2 deltas in (	each interdigital delta position	(n = 800  for left and right palms each)
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Delta position	Left palm			Right palm			
	Number of deltas	Number of deltas present			Number of deltas present		
	0 Delta	1 Delta	2 Deltas	0 Delta	1 Delta	2 Deltas	
Index	0	800 (100%)	0	0	800 (100%)	0	
I/M	773 (97%)	27 (3.4%)	0	732 (92%)	68 (8.5%)	0	
Middle	1 (0.12%)	799 (99.9%)	0	0	800 (100%)	0	
M/R	797 (99.6%)	3 (0.38%)	0	782 (98%)	18 (2.2%)	0	
Rina	69 (8.6%)	726 (91%)	5 (0.62%)	39 (4.9%)	755 (94%)	6 (0.75%)	
R/L	696 (87%)	94 (12%)	10 (1.2%)	661 (83%)	132 (16%)	7 (0.88%)	
Little	1 (0.12%)	799 (100%)	0 ` ´	3 (0.38%)	797 (100%)	0`´´	



Figure 2 Right palm interdigital region displaying the index (I), middle (M), ring (R), and little (L) deltas.



**Figure 3** Interdigital region below the right ring finger. The ring finger delta is absent.



Figure 4 Right palm interdigital region with six deltas (I, I/M, M, R, R/L, and L) and three loop patterns (highlighted in blue).

Whorl patterns can also be found in the hypothenar region. Figure 11 illustrates a double-loop whorl (a) and a plain whorl (b) in the hypothenar.

Columns of ridges can also be present in the hypothenar. These columns can manifest vertically near the carpal delta (delta typically found at the base of the palm that separates the hypothenar and thenar regions) or horizontally throughout the hypothenar. Figure 12 illustrates a right palm hypothenar with a vertical column (A) and a right palm hypothenar with a horizontal column (B) and an ulnar loop (C).

There was no pattern present in 547 of the 800 (68%) left palm hypothenars and 514 of the 800 (64%) right palm hypothenars. The most common pattern found in the hypothenar was an ulnar loop – top: 156 (20%) left palms and 146 (18%) right palms. The most common pattern combination in the hypothenar was an ulnar loop – top and a radial loop: 9 (1.1 %) left palms and 11 (1.4%) right palms. Figure 8 (A and B) illustrates this combination.

Table 8 shows the number of palms containing the various hypothenar patterns. Occasionally, two ulnar loops, two radial loops, or two horizontal columns appeared in the hypothenar. A single pattern is designated '(1)' and a double pattern is designated '(2).' One palm could have multiple patterns (e.g., a loop and a horizontal column).

# Thenar

The thenar region displays fewer overall patterns than the other regions of the palm. There is, however, one pattern unique to the thenar – the vestige. A vestige is a ridge flow that runs opposite to the main flow of the ridges. A vestige can be small and independent, or it may be quite large and accompanied by loops, columns, or whorls.

The loops and columns were counted together; hence the combined classification of 'loop/column.' A loop/column above the vestige was termed 'proximal loop/column' because the nose of the loop or ending ridges of the column point toward the base of the palm. Occasionally, both a loop and a column appeared above the vestige. The loop/column below the vestige was termed a 'distal loop/column' because the nose of the loop or the ending ridges of the column generally pointed toward the top of the palm.

Figure 13 illustrates right palm thenars with an independent vestige (a and b), a vestige with a narrow proximal loop/column and narrow distal loop/column (c), and a vestige with a wide proximal loop/column and wide distal loop/column (d).

**Figure 14** illustrates the whorl (a) and double-loop whorl (b) that can be found accompanying vestiges in the thenar



Figure 5 Patterns of the interdigital region. (a and b) Tented arch, (c) loop, (d) column, and (e) whorl.



Figure 6 Volar pad (VP) regions of the right palm interdigital region.

Table 3Number of palms with the designated patterns present in theVP II position (n = 800 left and right palms each)

VP II	Loop	Column	TA middle delta
Left palm	25 (3.1%)	3 (0.38%)	0
Right palm	53 (6.6%)	16 (2.0%)	1 (0.12%)

 Table 4
 Number of palms with the designated patterns present in the

 VP III position (n = 800 left and right palms each)

VP III	Loop	Column	Whorl	TA ring delta
Left palm	185 (23%)	2 (0.25%)	0	192 (24%)
Right palm	373 (47%)	3 (0.38%)	2 (0.25%)	111 (14%)

Table 5Number of palms with the designated patterns present in theVP IV position (n = 800 left and right palms each). The VP IV positionwas the only VP position in this study where two loops occurred in thesame VP position

VP IV	1 Loop	2 Loops	Column	Whorl	TA little delta
Left palm	438 (55%)	31 (3.9%)	58 (7.2%)	4 (0.50%)	1 (0.12%)
Right palm	374 (47%)	9 (1.1%)	36 (4.5%)	2 (0.25%)	0



Figure 7 Left palm VP IV region containing a column (A) and two loops (B and C).

Table 6The number of left palms with different configurations ofloops in the three volar pad positions (n=800)

Left palm					
No. of palms	VP II loop	VP III loop	VP IV loop		
1 (0.12%)	1				
111 (14%)		1			
363 (45%)			1		
13 (1.6%)	1	1	1		
5 (0.62%)	1	1			
56 (7.0%)		1	1		
6 (0.75%)	1		1		
31 (3.9%)			2		
0	1	1	2		
0		1	2		
0	1		2		

Table 7The number of right palms with different configurations ofloops in the three volar pad positions (n = 800)

Right palm					
No. of palms	VP II loop	VP III loop	VP IV loop		
7 (0.88%)	1				
255 (32%)		1			
276 (34%)			1		
18 (2.2%)	1	1	1		
23 (2.9%)	1	1			
75 (9.4%)		1	1		
5 (0.62%)	1		1		
7 (0.88%)			2		
0	1	1	2		
2 (0.25%)		1	2		
0	1		2		

region. The whorl and vestige are also associated with proximal loops/columns above the vestige. Occasionally, a proximal loop/column (c) or a distal loop/column can occur in the thenar independently (no vestige).

Table 9 contains the number of palms displaying a different pattern, and combinations of patterns, found in the thenar region.

Palm prints display four different basic patterns: arches, loops, whorls, and columns. These patterns can occur, independently or in combination, in the interdigital, hypothenar, or thenar regions. The interdigital region displayed the highest frequency of patterns – more than 95% of palms displayed at least one pattern in the interdigital region. Less than 15% of the thenar regions contained a pattern, while approximately 34% of hypothenar regions displayed a pattern.

Latent palm prints are routinely encountered in forensic casework. Through training and experience, analysts develop a sense of the rarity of features, including patterns, in the various regions of the palm. Using data such as these, analysts can better inform their judgments regarding the rarity of these features.



Figure 8 Right palm hypothenars displaying an 'ulnar loop – top' (A), a radial loop (B), and an 'ulnar loop – base' (C).



Figure 9 Right palm hypothenars classified as proximal loop (a), arch (b), and proximal loop/arch (c).



Figure 10 Right palm hypothenars classified as a proximal tented arch (a) and an ulnar tented arch (b).



Figure 11 Left palm hypothenar classified as a double-loop whorl (a) and a right palm hypothenar classified as a plain whorl (b).



Figure 12 Right palm hypothenars displaying a vertical column (A), a horizontal column (B), and an ulnar loop (C).

Table 8Hypothenar patterns ( $n = 800$ for left and right palms each)			Table 8     (Continued)		
Patterns	No. of left palms	No. of right palms	Patterns	No. of left palms	No. of right palms
No pattern Ulnar loop – top (1) Ulnar loop – top (2) Ulnar loop – base (1) Ulnar loop – base (2) Radial loop (1) Radial loop (2) Proximal loop	547 (68%) 156 (20%) 1 (0.12%) 6 (0.75%) 1 (0.12%) 71 (8.9%) 1 (0.12%) 7 (0.88%)	514 (64%) 146 (18%) 0 15 (1.9%) 0 69 (8.6%) 1 (0.12%) 12 (1.5%)	Proximal loop/arch Arch Proximal tented arch Ulnar tented arch Plain whorl Double-loop whorl Horizontal column (1) Horizontal column (2)	1 (0.12%) 2 (0.25%) 1 (0.12%) 0 2 (0.25%) 6 (0.75%) 10 (1.2%) 0	9 (1.1%) 8 (1.0%) 5 (0.62%) 2 (0.25%) 9 (1.1%) 10 (1.2%) 21 (2.6%) 1 (0.12%)
		(Continued)	Vertical column	3 (0.38%)	12 (1.5%)

Table 8 Hypothenar patterns (n = 800 for left and right palms each)



Figure 13 Right palm thenars displaying vestiges.



Figure 14 Left palm thenars displaying vestiges associated with a plain whorl (a) and a double-loop whorl (b). Also shown is an independent proximal loop/column in the thenar (c).

**Table 9** The number of palms containing the various patterns (and combinations of patterns) in the thenar region (n = 800 for left and right palms each)

Pattern	No. of left palms	No. of right palms
No pattern	659 (82%)	745 (93%)
Vestige (in any configuration)	119 (15%)	49 (6.1%)
Vestige only	12 (1.5%)	9 (1.1%)
Vestige, proximal loop/column, and distal loop/column	72 (9%)	27 (3.4%)
Vestige and proximal loop/column only	16 (2.0%)	7 (0.88%)
Vestige and distal loop/column only	10 (1.2%)	2 (0.25%)
Vestige, proximal loop/column, and plain whorl	7 (0.88%)	3 (0.38%)
Vestige, proximal loop/column, and double-loop whorl	2 (0.25%)	1 (0.12%)
Proximal loop/column only (no vestige)	20 (2.5%)	5 (0.62%)
Distal loop/column only (no vestige)	1 (0.12%)	1 (0.12%)

*See also:* **Pattern Evidence:** Bare Footprint Marks; Footwear Marks; The Friction Ridge Skin of the Feet.

# **Further Reading**

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