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## Comparative Study on Frequency of Various Papillary Pattern Types in Estonian Men and Women

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### Abstract

The authors of the article conducted a comparative study to determine the incidence frequency of various papillary patterns in men and women. In the framework of this study, the authors collected and performed analysis on data published in the subject literature. Comparative analysis was performed to check for potential similarities and differences in papillary patterns, types, and groups in men and women, using data on the patterns in both hands. This article presents the results of the study.

*Keywords:* arch ridge pattern, comparative analysis, left hand, loop ridge pattern, men, right hand, whorl ridge pattern, women.

### Introduction

Forensic literature defines shapes formed by papillary ridges and allows to identify various papillary ridge patterns. The papillary ridges are classified by type as arch, loop and whorl ridge patterns.

These types of papillary ridges are further classified into individual forms and groups. Based on the construction of papillary ridges, it is also possible to classify papillary patterns. Papillary patterns are classified as simple, complex, false, rare, and aberrant ridges according to their structure (Ogle, Plotkin, 2017).

In forensics, a system of general and special features is applied in identification and analysis of fingerprint ridges. Structure-wise, the simplest ridge pattern is the arch, which occurs in about 5 % of human fingerprints. Loop ridge patterns form about 65 % and whorl ridge patterns about 30 % of total ridge patterns found on human fingers (Lindmäe, 1976).

This knowledge prompted the authors of this article to conduct a study to determine the presence of common features and different classifications in male and female fingertips. The study included fifty-seven men and thirty-one women, and the gender of five individuals remained unknown. Since fingerprints of unidentified persons were nevertheless suitable for analysis, dactyloscopic maps of ninety-three persons were examined in the first part of the study. The second and third parts of the study analysed dactyloscopic cards of fifty-seven men and thirty-one women; the fingerprints were made on formal cards, using black ink. The study focused on the following:

- 1) determination of distribution of papillary patterns on the fingers and comparing it with the results published in the literature;
- 2) identification of possible differences and similarities in papillary ridge patterns on the fingertips of women and men;
- 3) results of comparison of papillary ridge patterns on the fingers of the right and left hand in both women and men;
- 4) determination of distribution of papillary ridge patterns on the left hand fingers in both women and men.

In the framework of this study, no attention was paid to specific characteristics that distinguish papillary ridges; instead, the authors sought to check connections between types and groups of papillary ridges.

In order to determine the suitability of a fingerprint for identification, a qualitative and quantitative assessment of identification features and their set should be provided (Averjanova, Statkus, 2011). It should be borne in mind that structural details of papillary ridges, as well as their general properties, are not uniform.

The authors of this article also focused on treatment of common issues of statistical dactyloscopy by various authors, such as A. J. Paliashvili (Krilov, 1961), I. I. Prorokov (Prorokov, 1980), V. A. Andrianova (Edzubov, 1999), V. E. Kornouhov (Kornouhov, 1982), J. W. Osterburg and R. H. Ward (Osterburg, Ward, 2010), H. M. Daluz (Daluz, 2014), J. A. Eterno and C. Roberson (Eterno, Roberson, 2015), I. V. Kantor (Kantor, 2003), Melcon S. Lapina (Lapina, 1996), M. Reinhardt (Reinhardt, 2016), N. P. Mailis (Mailis, 2008) and U.S. Department of Justice (U.S. Department of Justice, 2014).

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The study by A. J. Paliashvili dates back to the 1960s. He discussed the materials of the study in his presentation at a conference on forensic issues held in Leningrad on 28 June–2 July, 1960. A similar study was carried out by I. I. Prorokov in the 1980s. Comparison of the general characteristics of the papillary ridge patterns presented by the authors of this article in 2021 and those presented in earlier decades shows the importance of statistical dactyloscopy in the field of expertise, its constancy and, looking ahead, the evolution towards digitisation. In the current article, the authors do not delve into specific traits discussed by A. J. Paliashvili within the framework of his study, and focus on general traits instead.

The authors of this article used the first section of the table provided in the practical material *Dactyloscopy and Dactyloscopic Expertise* (Anishchenko, 2013) which covered the groups and types of papillary ridge patterns. The authors of the article divided the table into three types according to types of papillary ridges and analysed the data presented there comparing it with the data collected by them.

## Course of the Research

Determination of distribution of the pattern of papillary ridges on the fingers and comparing it with the results published in the literature

As noted in the introduction, the incidence of whorl ridge pattern according to the literature is about 30%. Of the ninety-three people in the study (out of 930 fingerprints taken), whorl ridges were recorded on 276 fingers.

*Table 1.* Whorl Ridge Pattern Frequency

Feature		Occurrence frequency of feature, %		
		A. J. Paliashvili, 50 people (500 prints)	I. I. Prorokov, 1000 people (10 000 prints)	A. Lall, 93 people (930 prints)
Whorl ridge patterns of nail phalanges of fingers		25.60	30.00	29.67
1	Plain-circle	—	93.60	61.21/6.15
2	Oval	9.00	16.50	21.01
3	Spiral	16.60	71.00	19.20
4	Loop-spiral	—	—	14.85
5	Complex-loops-spirals	—	3.80	15.94
6	Loops-bifurcated loop-coils	—	2.60	13.04
7	Loops-one-way ending loop-coils	—	—	2.17
8	Loop-snail	—	—	0.36
9	Curved loop	—	8.50	—
10	False-incomplete	—	4.00	6.52
11, 12	Rare whorl patterns	—	—	0.72

If we look at the table where the appearance of whorl ridge pattern was studied in groups of fifty, 1000 and ninety-three people, it can be concluded that what was reported in the literature also corresponds to what has been found in practice. Although the incidence of whorl ridge pattern is less than 30% (25.6%) for the 500 fingerprints left by fifty people, it can be claimed that in 1000 people and 10,000 prints and ninety-three people and 930 prints the incidence is 30%.

In the explanation in Table 1, the simple ridge pattern includes a circle, an oval, a spiral and also a loop spiral. The A. J. Paliashvili study does not specify how many participants had simple ridge patterns in the form of a circle.

The I. I. Prorokov (Prorokov, 1980) study does not provide the percentage of simple circle-type ridge patterns; however, proportionally speaking, it is 6.1% of all simple ridge patterns. In his study, 93.6% of the studied patterns consisted of simple ridge patterns, i.e. circle, oval, spiral and loop-spiral ridge patterns. Of the fingerprints of ninety-three people studied by the authors of the article, 61.21% had simple ridge patterns and 6.15% of these were circular in shape. Thus, in the case of both 10,000 prints and ninety-three prints, the percentage of circular ridges was 6.1–6.15%, i.e. the same. The most common simple pattern in the current study of 930 fingerprints was the oval pattern, which constituted for 21.01% of all patterns. In the Prorokov study, the corresponding number was 16.5% and for A. J. Paliashvili it was 9%. Spiral pattern frequency in the I. I. Prorokov study was 7.1%, in the A. J. Paliashvili study 16.6% and in the current study 19.2%. Loop-spiral type whorl ridge pattern was only recorded in the current study (14.85%) and other studies do not appear to have measured its frequency.

The complex ridge block provided in the table is divided as follows: loop-spirals, bifurcated loop-coil, one-way ending loop coil, snail-loop and curved loop.

A. J. Paliashvili's study does not address these ridge pattern types. It records loop-spirals as 3.8% of the total, whereas the authors of the article found the corresponding pattern frequency to be 15.95%. According to the A. J. Paliashvili study, the frequency of bifurcated loop-coil is 2.6% and in the current study, the corresponding frequency was 13.04%. The frequency of the one-way ending loop-coil and the snail-loop ridge pattern was not recorded in the A. J. Paliashvili study. According to the authors of this article, the frequency of these patterns is correspondingly 2.17% and 0.36%. A. J. Paliashvili records the frequency of snail-loop ridge in total of 8.5% fingerprints. The authors of this article did not record snail-loop ridge type in the participants of this study.

False-Incomplete whorl ridge patterns and rare whorl ridge patterns were not covered in the A. J. Paliashvili study. In the studies conducted by I. I. Prorokov and the authors of the article, false or incomplete whorl ridge patterns occurred in 4% and 6.25% of the fingerprints, respectively. Rare whorl ridge patterns occurred in 0.72% of the study participants.

The incidence of the arch ridge pattern is considered to be 5%. Based on Table 2, it can be noted that the results of 7.4% per 50 people studied by A. J. Paliashvili and 7% per 1000 people studied by I. I. Prorokov show the incidence of the arch ridge pattern, which corresponds closely to the data presented in the literature.

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Table 2. Arch Ridge Pattern Frequency

Feature	Frequency of the feature, %		
	A. J. Paliashvili, 50 people (500 prints)	I. I. Prorokov, 1000 people (10 000 prints)	A. Lall, 93 people (930 prints)
Arch ridge patterns of nail phalanges of fingers	7.40	7.00	13.01
1 Plain-plain arch pattern	5.40	—	22.31
2 Complex-tented arch pattern	2.00	—	8.26
3 Arch pattern with undefined core structure	—	—	5.78
4, 5 False-false loop arch patterns	—	—	56.19
6, 7 False-false whorl arch patterns	—	—	7.43
8 Rare patterns – rare pattern related to arch pattern	—	—	—
9 Abnormal – abnormal pattern	—	—	—

The current study concluded that 13.01 % of ninety-three participants had arch ridge patterns on their fingertips; this is almost two times more than the 5 % suggested in the literature. However, it should also be noted that the data provided by I. I. Prorokov is limited to general arch ridge pattern percentage.

Similarly to how the whorl ridge pattern is classified according to the structure of papillary patterns, the arch ridge pattern is also divided into several groups: simple or regular; complex, which includes ridge pattern with an undefined centre; false arch patterns, which include false loop arch pattern and false whorl arch pattern. The grouping also includes rare arch patterns and anomalous ridges. Since the present study did not include any participants with the following two groups and A. J. Paliashvili and I. I. Prorokov did not record such groups, these lines were removed from the table.

The simple or regular arch ridge pattern occurred in 5.4 % out of fifty people and 22.31 % out of ninety-three people. Complex or pyramid/tented patterns occurred in 2 % of fifty people and in 22.31 % of ninety-three people.

The ninety-three-person study carried out by the authors of this article demonstrated that the incidence of the ridge pattern with an undefined core was 5.78 %; false arch ridge pattern, which also includes false loop arch ridge pattern, occurred in 56.19 % of the cases and false whorl arch pattern in 7.43 % of the cases.

A. J. Paliashvili and I. I. Prorokov's studies did not record ridge patterns with an undefined core, which includes false loop arch pattern and false whorl arch pattern.

According to the literature, the loop ridge pattern occurs in 65 % of all prints. In Table 3, the papillary patterns are classified according to their structure as a simple loop, a curved loop, a half loop, and a closed loop. The complex pattern group includes parallel and reverse loops.

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*Table 3. Loop Ridge Pattern Frequency*

Feature	Occurrence frequency of feature, %		
	A. J. Paliashvili, 50 people (500 prints)	I. I. Prorokov, 1000 people (10 000 prints)	A. Lall, 93 people (930 prints)
Loop ridge patterns of nail phalanges of fingers	67.00	63.00	57.31
1 Simple – simple / plain loop	—	95.00	83.86
2 Curved loop	—	Units	1.13
3 Half loop	—	2.00–2.50	4.13
4 Closed loop	4.00	—	4.13
5 Complex – parallel loops	—	—	—
6 Complex – reverse loops	0.20	—	—
7, 8 False – false whorl loop patterns	—	—	6.75
9 Rare pattern – rare patterns related to loop patterns	—	—	—

The false pattern group consists of false whorl loop ridge patterns, and the rare pattern group includes ridges that are rarely found and which belong under the loop ridge type.

Studying the data presented in Table 3, it can be stated that 67% prints out of 500 and 63% out of 10,000 had loop ridge patterns, which quite closely follows the data provided in the literature. The study of 930 prints shows a small difference, since only 57.31% of participants had loop ridge patterns. Compared to the literature, the difference is 7.7%.

A. J. Paliashvili has not recorded any information on the simple or the regular loop ridge pattern. In the I. I. Prorokov study the incidence of the simple pattern is 95% per 10,000 prints and in the study conducted by the authors of this article it is 83.86% per ninety-three people. A. J. Paliashvili's study does not include any data on the curved and half loop ridge pattern. Since the proportion of the curved ridge pattern in the studied prints was quite low, I. I. Prorokov has listed only a few values in his table, and the authors of this article found the corresponding incidence to be 1.13% of the data collected. In the study of 10,000 prints, I. I. Prorokov found that the half loop occurred in 2.0–2.5% of the cases, whereas the authors of this article found the corresponding value to be 4.13%.

I. I. Prorokov has not provided any data on the closed ridge pattern, while the records of A. J. Paliashvili, for 500 prints and the authors of the article for 930 prints show 4% and 4.13%, respectively. As for the parallel loops, which belong in the complex ridge pattern group, none of the people in the study appeared to have any. As for the reverse loops which belong to the same group, A. J. Paliashvili noted that these occurred in 0.2% in their recorded cases. I. I. Prorokov and the authors of this article did not identify reverse loop ridges in any of the collected fingerprints. False whorl loop ridge pattern of

the false group was recorded in 6.75 % cases in total of 930 prints. In the data collected by A. J. Paliashvili and I. I. Prorokov, false whorl loop ridge pattern does not occur. In this study, no rare loop ridge patterns were found.

### **Identification of potential similarities and differences in papillary ridge patterns in the fingerprints of men and women**

The study included ninety-three people, fifty-seven men and thirty-one women, and five participants could not be identified, thus the gender-based papillary pattern comparison was carried out on eighty-eight people. The fingertips were analysed using the same ridge classification system as in previous tables.

Out of 310 fingerprints belonging to women, the arch ridge pattern was found in fifty fingerprints, i.e. 16.12 %. The loop ridge pattern was found on 166 fingers, which is 53.54 %, the whorl ridge pattern in ninety-four fingers, or 30.32 % of fingerprints studied.

Examination of 570 male fingerprints showed that sixty-three fingers, or 11.05 %, have an arch ridge pattern. The loop ridge pattern occurred on 330 fingers, which is 57.89 % of the studied prints. The whorl ridge pattern was observed in 177 fingers or 31.05 % of male fingerprints.

**Whorl Ridge Pattern.** Of the fifty arch ridge patterns identified in women, fifteen had simple or regular ridge patterns. A complex-tented pattern was detected in six prints, four prints had an unidentified core, the false-false loop arch ridge was on twenty two prints and a false-false whorl ridge pattern on three prints.

Of the sixty-three arch ridge patterns that appeared on male fingerprints, twelve were simple or regular ridge patterns. The complex or pyramid/tented pattern was discovered in four prints, undefined centre in three prints, false-false loop in thirty-eight prints, and false-false whorl in twenty-six fingerprints. Rare arch ridge patterns and anomalous ridges were not observed in either hands.

**Loop Ridge Pattern.** The loop ridge pattern was found in the fingerprints of 166 women. Of these, 137 prints had simple or regular ridge patterns. Simple ridges had curved loops in two, half loop in four, and closed loop in ten fingerprints. False-false whorl loop ridges were found in thirteen fingerprints.

330 male fingers had the loop ridge pattern. Of these, 277 fingerprints had simple or regular ridge patterns. Simple ridges with curved loops were found in three, half loop in eighteen, and closed loop in eleven fingerprints. False-false whorl loop ridge pattern was found on twenty-one fingers. Neither complex ridges – parallel and reverse loop ridges nor rare loop ridges were detected in any of the collected loop ridges.

**Whorl Ridge Pattern.** In the study, a whorl ridge pattern was found in ninety-four female fingerprints. Of these, a simple or circular pattern was found in five, oval in thirty,

spiral in seventeen, loop-spiral in eight fingerprints. Complex loop-spirals were found in fourteen, bifurcated loop-coil in eleven, loop-coils with endings in the same direction in three, and false-incomplete whorl ridge pattern in six fingerprints.

177 male fingerprints had a whorl ridge pattern. Of these, simple ridge was found on twelve, oval on twenty-eight, spiral on thirty-six and loop spiral on thirty-three fingers. Complex loop-spirals were found in thirty, bifurcated loop-coil in twenty two, loop-coil with endings in the same direction in three and snail-loop coil in one fingerprint. False-incomplete whorl ridge pattern was found in ten and rare whorl ridge in two cases. No complex curved loop was found in any cases containing the whorl ridge pattern.

### **Results of comparison of papillary ridge patterns on the right and left hands of men and women**

**Arch Ridge Pattern.** Women who participated in the study had an arch ridge pattern on the right hand in twenty and on the left hand in thirty cases. Percentually, this means 12.90% for the right and 19.35% for the left hand, 32.25% in total. The following analysis covers arch ridge patterns that were found in the course of the study.

Female thumbs had two ridge patterns of which false loop arch pattern was on five fingers and false whorl arch pattern on one finger. On index fingers, a simple ridge pattern was found in six cases, pyramid/tented ridge pattern in three, ridge pattern with an undefined core in one case, false loop arch was found on seven fingers and false whorl arch ridge pattern on one finger. On middle fingers, a simple ridge pattern was found in six cases, pyramid/tented ridge pattern and a ridge pattern with an undefined core in two cases, and false loop arch pattern was found in three cases. Ring fingers had a simple, pyramid/tented, undefined core and false whorl arch pattern in one case. False loop arch ridge pattern was found on four fingers. On little fingers, there were no instances of pyramid/tented, undefined core and false whorl arch ridge detected. Rare arch ridge patterns and anomalous ridges were not detected on any of the collected fingerprints.

Of male study participants, twenty-six had arch ridge patterns on the right hand and thirty-seven on the left hand, i.e. 9.12% for the right and 12.98% for the left hand; 22.10% in total.

Following analysis covers arch ridge patterns found in fingerprints of male participants.

Male thumbs had two ridge patterns, of which false-false loop arch ridge pattern occurred in two cases and the ridge pattern with an undefined core in one case.

On index fingers, simple ridge pattern was found in eight cases, pyramid/tented ridge pattern in three, ridge pattern with an undefined core in one case, false-false loop arch was found on four fingers and false-false whorl arch ridge pattern on one finger. On middle fingers, a simple ridge pattern was found in two cases, pyramid/tented ridge pattern and ridge pattern with an undefined core in one case and false-false loop arch

pattern was found in three, and false-false whorl ridge pattern in two cases. Ring fingers, however, had a simple ridge pattern in one case, false loop arch in five and false whorl ridge pattern in two cases. On little fingers, a simple ridge pattern was found in one case, false loop arch in nine and false false whorl ridge pattern in one case.

Similarly to women, rare arch ridge patterns and anomalous ridges were not detected on any of the fingerprints collected from men.

**Loop Ridge Pattern.** Female fingerprints were found to have a loop pattern on the right hand in sixty-five cases and on the left hand in eighty-six cases, which means that the figure is 51.61 % for the right hand and 55.48 % for the left hand, for a total of 107.09 % of both hands. This indicates that the loops are far more common than the arches.

Female thumbs had a simple ridge pattern in twenty-seven cases and false whorl loop pattern in two cases. Index fingers had a simple ridge pattern in twenty-two cases, making this the most common pattern, whereas curved and false whorl loop pattern occurred twice in both cases, half and closed loop pattern in one case. Middle fingers had a simple ridge pattern in thirty-one cases, closed loop ridge was found in one and false whorl loop ridge patterns in three instances. Ring fingers had simple ridges in fourteen instances, half loop pattern in one, closed loop pattern in seven and false whorl loop pattern in four instances. Little fingers had most commonly the simple loop pattern (forty-three instances), whereas half loop ridge was found in two, closed loop in one and false whorl loop ridge in two instances. Neither complex ridges with parallel and reverse loops nor rare loops were detected in loop pattern analysis.

In men, the loop pattern was found on the right hand in 157 cases and on the left hand in 173 cases, making the value 55.08 % for the right and 60.70 % for the left hand, with 115.78 % in total. This indicates that the loop pattern is also several times more common for men than the arch pattern.

Male thumbs were found to have the simple ridge-regular loop fifty-nine times, curved loop in two, and half loop in one case. Index fingers had regular loop ridge forty-four times, curved loop one time, half loop five times, and closed loop four times. Middle fingers had the regular loop sixty-four times, half loop two times, and false-false whorl loop pattern four times. Ring fingers had a regular loop forty times, half loop five times, and closed loop five times. Little fingers had a regular loop seventy times, half loop five times, closed loop two times, and false-false whorl loop pattern four times. Neither complex ridges with parallel and reverse loops nor rare loop ridges were detected on either hands.

**Whorl Ridge Pattern.** Women were found to have the whorl ridge pattern on the right hand in fifty-five instances and on the left hand in thirty-nine instances, meaning that the frequency value for the right hand is 35.48 %, for the left hand 25.16 % and in total – 60.64 %. It may be claimed that the whorl ridge pattern is more common than the arch pattern, but also twice as uncommon as the loop pattern.

Female thumbs most frequently had the simple type of the whorl ridge pattern; the circle pattern was found in one case, oval ridge in four cases, spiral ridge and loop spiral

in two cases, complex spiral loop in nine cases, bifurcated loop coil in nine cases, one-way ending loop-coil in one case, and false incomplete whorl ridge pattern in one case. No snail loop, curved loop or rare loop patterns were found on any of the thumb prints.

On index fingers, a simple pattern, i.e. circle, was found in two instances, oval in five instances, spiral in six instances, complex loop spiral in two instances, and bifurcated loop-coil and one-way ending loop-coil were each found in one instance. No loop-spiral, snail-loop, curved loop ridge patterns, false-incomplete whorl ridge and rare whorl ridge were found on index fingers. In middle fingers, oval ridge was found five times, spiral once, complex loop-spirals twice, bifurcated loop-coils twice, one-way ending loop-coils once and a false incomplete whorl ridge pattern was found three times. However, middle fingers did not have any instances of simple circular, oval, loop-spiral, snail-spiral, curved loop and rare whorl ridge patterns. Nevertheless, ring fingers were found to have a simple circular pattern in two cases, oval in fourteen cases, spiral in six cases, loop-spiral in four cases, and false incomplete whorl pattern in two cases. The little finger had oval, spiral and loop spiral ridges in two cases and complex spiral loop in one case. No circular simple ridge, one-way ending loop-coil, snail-loop, curved loop, false incomplete whorl ridge and rare whorl ridges were found on little fingers.

Men had the whorl ridge pattern on the right hand in 102 and on the left hand in seventy-five instances, making it 35.78 % for the right hand and 26.31 % for the left hand, and 62.09 % in total. It can be stated that the whorl ridge pattern is more common than the arch pattern, yet nearly twice as rare as the loop pattern.

Male thumbs had the simple circular ridge in three cases, oval in two cases, spiral in six cases, and loop-spiral in seven cases. Complex ridge loop spirals were found in thirteen cases, bifurcated loop-coil in fifteen cases, one-way ending loop-coils in one case, and false incomplete whorl ridge pattern in two cases. On index fingers, a simple circular ridge was found in three cases, oval in seven cases, spiral in four cases, and loop-spiral in eight cases. Complex loop-spirals were found in six cases, one-way ending loop-coils in one case, snail loop in one case, and false incomplete whorl ridge pattern in one case. Middle fingers were found to have the simple circular ridge in three cases, oval in two cases, spiral in seven cases, and loop-spiral in six cases. Complex ridge loop spirals were found in five cases, bifurcated loop-coils in two cases, false incomplete whorl ridge in one case, and rare whorl ridge patterns in two cases. Ring fingers were found to have the simple circular ridge in three cases, oval in fifteen cases, spiral in thirteen cases, and loop-spiral in nine cases. Complex loop spirals and false incomplete whorl ridge patterns were found in one case. Little fingers had the simple circular ridge in one case, oval in two cases, spiral in six cases, and loop spiral in three cases. Complex loop spirals were found in one case, bifurcated loop coil in two cases, one-way ending loop-coil in one case, and false incomplete whorl ridge pattern in five cases.

Complex ridge – snail loop and curved loop ridge were not found in any left hand prints taken from the male participants. No curved loop ridges were found on the right hand prints.

## **Determination of distribution of papillary ridge patterns in male and female right and male and female left hand**

The ten-finger dactyloscopic record system has been designed to identify individuals by using all of their ten fingers. In order to keep the dactyloscopic record and systematisation of ten fingers according to set principles and to simplify the work, the dactyloscopic cards have been numbered in a way that allows to record the fingers of the right (1–5) and left (6–10) in set order. The fingers are numbered in the table in accordance with this system.

Of the total of 880 prints (eighty-eight men and women), the arched ridge pattern was found on the right hand in forty-six cases and on the left hand in sixty-seven cases, making 5.23% for the right hand, 7.61% for the left hand and 12.84% in total for both hands.

As for the frequency of the arch ridge pattern on the right hand for men and women and the left hand of men and women, it must be noted that false-false looped arch ridges have been detected as the most common. This pattern type occurs on all fingers of both hands. Although the frequency varies, depending on the finger, it is most common on index fingers, middle fingers and little fingers. Simple or regular and complex – pyramid/tented arch ridge was missing on both left and right thumbs for both men and women. Simple – regular arch ridge was found on all other fingers to a lesser degree. The patterns with an undefined core and false whorl ridge pattern were also found to a lesser degree.

Since no rare arched ridge patterns were found on any of the participants, this line was not represented in Table 4 (line 9).

According to Table 5, the loop pattern was found in 237 right hand prints and 259 left hand prints of eighty-eight male and female participants (880 prints in total), which means that the incidence frequency of the loop pattern for the right hand is 26.93% and for the left hand 29.43%, which in turn yields a total of 56.36% for both hands. The right hand most commonly had the simple loop pattern, as also evident from the Table. Thumbs, index and middle fingers had a similar loop pattern distribution frequency, ranging from two to six. On the ring and little fingers, the distribution frequency was greater, ranging from thirteen to fourteen. Simple ridge-curved loop was found on two fingers – twice on the thumb and the index finger of the left hand and once on the index finger of the right hand. The curved loop was not detected on the middle, ring and little fingers of either hands. No simple ridge – half loop and closed loop was found on the middle finger of the left hand. On other right and left hand fingers, the above listed types were detected to a lesser degree.

Since none of the participants had any instances of complex, and rare loop ridge patterns, these lines were not represented in Table 5 (lines 5, 6 and 9).

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*Table 4. Arched Ridge Pattern Divided Men / Women Right Hand and Men / Women Left Hand*

Ridge name / pattern Data of 88 male and female study participants	Right and left hands									
	Thumb		Index finger		Middle finger		Ring finger		Little finger	
Arch loop R-46 L-67	1	6	2	7	3	8	4	9	5	10
1 Simple – regular	—	—	5	9	2	6	1	1	1	2
2 Complex – pyramid / tented	—	—	2	4	1	2	—	1	—	—
3 Undefined core	1	—	—	2	1	2	—	1	—	—
4,5 False-false looped arch ridge	2	5	8	8	6	10	3	5	8	5
6,7 False-false whorl ridge pattern	—	1	—	2	1	1	3	—	1	—

*Table 5. Looped Ridge Pattern Divided Men / Women Right Hand and Men / Women Left Hand*

Ridge name / pattern Data of 88 male and female study participants	Right and left hands									
	Thumb		Index finger		Middle finger		Ring finger		Little finger	
Loop pattern R-237 L-259	1	6	2	7	3	8	4	9	5	10
1 Simple – simple / regular loop	40	46	34	32	50	45	20	34	50	63
2 Curved loop	—	2	1	2	—	—	—	—	—	—
3 Half loop	—	1	4	2	2	—	1	5	3	4
4 Closed loop	—	—	2	3	1	—	9	3	3	—
7,8 False-false whorl loop pattern	—	2	3	1	4	3	7	8	3	3

Data of Table 6 indicate that the whorl pattern was found in 157 right hand prints and 114 left hand prints of eighty-eight male and female participants (880 prints in total), which means that the frequency of the whorl ridge pattern for the right hand is 17.84% and for the left hand 12.95%, which in turn yields a total of 30.79% for both hands.

It is interesting to note that nearly all whorl ridge pattern types have been represented on both hands of both genders. Most commonly indicated patterns are simple ridges – oval which occurs twenty-two times and spiral which occurs eleven times on the ring finger of the right hand. Complex type – loop-coil with a one-way ending was recorded eleven times on thumbs. The least common complex ridge was snail-loop, which was recorded once on the index finger of the right hand. Rare whorl ridge was found on the middle fingers of both hands, once per hand. Simple ridges – circle, oval, spiral, loop-spiral were found on all fingers. Complex ridges – loop-spirals were most commonly found on thumbs and index fingers (10/12 and 5/7); on other fingers the frequency was lower.

Since none of the participants had any instances of complex curved ridge patterns, this line was not represented in Table 6 (line 9).

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*Table 6. Whorl Ridge Pattern Divided Men / Women Right Hand and Men / Women Left Hand*

Ridge name / pattern Data of 88 male and female study participants	Right and left hands									
	Thumb		Index finger		Middle finger		Ring finger		Little finger	
Whorl ridge pattern R-157 L-114	1	6	2	7	3	8	4	9	5	10
1 Simple – circle	3	1	4	1	3	—	3	1	1	—
2 Oval	4	2	7	5	4	3	22	7	3	1
3 Spiral	6	2	4	6	7	1	11	8	4	4
4 Loop-spiral	7	2	5	3	2	6	6	7	3	2
5 Complex-loops-spirals	10	12	5	7	2	5	1		1	1
6 Bifurcated loop-coils	11	11	—	1	1	3	—	3	2	1
7 One-way ending loop-coils	2	—	1	1	—	1	—	—	—	—
8 Snail-loop	—	—	1	—	—	—	—	—	—	—
10 False – incomplete whorl ridge pattern	3	—	1	—	2	2	1	2	5	—
11 Rare whorl ridge patterns	—	—	—	—	1	1	—	—	—	—

## Conclusions

The authors studied the distribution of papillary ridge patterns on fingertips of the participants and compared the results with the results published in the literature.

It was found that the results published in the literature, which reflect the incidence frequency of the whorl ridge pattern on fingertips of fifty, 1000 and ninety-three people, coincide with the results of the present study. Although in the study with fifty people and 500 fingerprints the incidence frequency of the whorl ridge pattern is below 30% (25.6%), by looking at 1000 people and 10,000 prints and ninety-three people and 930 prints, it can be maintained that it constitutes for 30% of found patterns. It is therefore possible to claim that the results obtained by the authors of this article and the results published in the literature are quite similar.

In case of the arch pattern, there was a notable difference between the data collected by the authors of this article and that provided in the literature; the difference is approximately 6%.

In the case of loop patterns, the number of ridge patterns listed by A. J. Paliashvili is lower than the values found in the studies of I. I. Prorokov and A. Lall. It is nevertheless possible to say that in general the values are not significantly different.

Since the studies of A. J. Paliashvili and I. I. Prorokov did not divide the participants by gender, the further study was carried out by the authors of this article on the basis of data collected by A. Lall. The authors sought an answer to possible differences and coincidences in papillary patterns on fingerprints of men and women.

Arch ridge pattern was found in fifty fingerprints taken from 310 women who participated in the study, constituting 16.12% of the total. The same ridge pattern was found

in sixty-three fingerprints taken from 570 male participants, which in turn constitutes for 11.05% of the total. Loop ridge pattern was found in the 166 fingerprints taken from women, constituting 53.54% of the total. The same ridge pattern was found in 330 fingerprints taken from men, which in turn constitutes for 57.89% of the total. Whorl ridge pattern was found in ninety-four fingerprints taken from women, constituting 30.32% of the total. The same ridge pattern was found in 177 fingerprints taken from men, which in turn constitutes for 31.05% of the total. Thus, it can be claimed that the percentages for all three ridge pattern types are very close for both genders, despite the fact that thirty-one women and fifty-seven men participated in the study.

By comparing papillary ridge patterns on the right and left hands of both men and women, it was noted that both genders have a lower incidence of arched ridge patterns on both hands. For women, arch ridge pattern occurred on the right in 12.90% of the cases and on the left hand in 19.35% of the cases, which adds up to 32.25% for both hands. For men, these values were 9.12% for the right and 12.98% for the left hand; 22.10% in total. A commonality for the left hand in men and the right hand in women was that the rare arch ridge and anomalous ridges were not found. On the right hands of women, no ridges with an undefined core were found, whereas such a ridge was found on the right hands of men in two instances.

For women, loop ridge pattern occurred on the right in 51.61% of the cases and on the left hand in 55.48% of the cases, which adds up to 107.09% for both hands. For men these values were 55.08% for the right and 60.70% for the left hand; 115.78% in total. The loop ridge pattern occurrence is several times more frequent in both male and female fingerprints than the arch ridge pattern. It was also noted that neither complex loops with parallel and reverse loops nor rare loop ridge were found on any of the hands of both male and female study participants.

For whorl ridge pattern, it must be noted that it was found on the right hand in 35.48% and on the left hand in 25.16% for female participants, yielding a total of 60.64%. For men whorl ridge pattern was found on the right hand in 35.78% and on the left in 26.31% of the cases, making a total of 62.09%.

It can be stated that the whorl ridge pattern prevails the arch pattern; however, it also occurs nearly two times less frequently than the loop pattern. It is also interesting to note that for the whorl ridge pattern, a simple circular ridge was not found on index, middle, ring and little fingers of the left hand. The women also had the simple circular ridge only on two of the left hand fingers – index and ring finger to be precise.

Interestingly, both women and men had the same percentage of whorl ridge pattern on both hands. Thus, for the whorl ridge pattern the results in both groups in the study were similar despite the fact that fewer women than men (thirty-one women and fifty-seven men) participated in the study.

To determine the distribution of papillary ridge patterns on fingerprints of the right hand of men and women and the left hand of men and women, papillary ridge patterns of eighty-eight male and female study participants (880 prints in total) were

examined by the authors. In the course of the process, arches were found in forty-six cases in the right hand prints of the subjects and in sixty-seven cases in the left hand prints, therefore, the frequency is 5.23 % for the right hand and 7.61 % for the left hand, which totals to 12.84 % of incidence frequency for the arch pattern in both hands of men and women.

The study participants had a loop ridge on the right hand in 26.93 % of the cases and on the left in 29.43 % of the cases, which in total constitutes 56.36 % of the loop ridge pattern on both right and left hands of men and women.

The percentage for the whorl ridge patterns for the right hand was 17.84 % and for the left hand 12.95 %, which constitutes 30.79 % in total for whorl ridge patterns for both men and women. It is interesting to note that practically all whorl ridge types were represented on the right and left hands of men and women. The complex pattern – curved loop was not found in the fingerprints provided by the study participants.

As a result of the survey and analysis, the authors dare to state that regardless of the number and gender of the survey participants and the decade, the distribution of gutter types is very close to the figures reported in the literature. It has therefore been confirmed that there are fewer arches than other types of ridges, that loop ridges are the most common ridges followed by the whorl ridge pattern. A similar percentage distribution of patterns was observed in the right and left hands of men and women in this study, as well as in the cross-comparison of papillary ridge patterns, based on fingerprints of men and women.

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## Bibliography

1. Anishchenko, I. A. (2013). *Daktiloskopija i daktiloskopicheskaya ekspertiza* (Eng. *Dactyloscopy and dactyloscopic examination*). 2-e izdanie. Moskva: Yurlitinform.
2. Averjanova, T. V., Statkus, V. F. (2011). *Prakticeskoje rukovodstvo po proizvodstvu sudjebnih ekspertiz dlja ekspertov i specialistov* (Eng. *A Practical Guide to Production of Forensic Examinations for Experts and Professionals*). Moskva: Jurait.
3. Daluz, H. M. (2014). *Fundamentals of Fingerprint Analysis*. Volume 2. CRC Press.
4. Edzubov, L. G. (1999). *Statisticeskaja daktiloskopija: metodiceskoe posobije* (Eng. *Statistical dactyloscopy: methodological tests*). Moskva: JL
5. Eterno, J. A., Roberson C. (2015). *Detective's Handbook*. Apple Academic Press Inc.
6. Kantor, I. V. (2003). *Kriminalisticeskoje isledovanije sledov koznovo pokrova: ucebno – metodiceskoje posobije* (Eng. *Forensic examination of traces of the cover: a teaching aid*). Volgograd: VA MVD Rossii.
7. Kornouhov, V. E. (1982). *Kompleksnoje sudjebno-ekspertnoje issledovanije svojstv celoveka* (Eng. *Comprehensive forensic examination of human properties*). Krasnojarsk.

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8. Krilov, L. F. (1961). *Sledi na mestje prestuplenija* (Eng. *Tracking crime instantaneously*). Izdatelstvo Leningradskovo Universiteta.
9. Lapina, M. S. (1996). *Fingerprint Identification*. Manila.
10. Lindmäe, H. (1976). *Kriminalistika tehnika* (Eng. *Forensic technology*). Tallin: Eesti raamat.
11. Mailis, N. P. (2008). *Daktiloskopija: ucebniik* (Eng. *Dactyloscopy: course book*). Moskva: Izdatelstvo Sit-M.
12. Ogle, R., Plotkin, S. (2017). *Crime Scene Investigation and Reconstruction*. 4<sup>th</sup> ed. Pearson.
13. Osterburg, J. W., Ward, R. H. (2010). *Criminal Investigation*. 6<sup>th</sup> ed. Anderson.
14. Prorokov, I. I. (1980). *Kriminalisticeskaja ekspertiza sledov* (Eng. *Forensic examination of traces*). Volgograd VSS MVD SSSR.
15. Reinhardt, M. (2016). *Guide To Fingerprint Identification and Classification*. Online Business Education.
16. U. S. Department of Justice. (2014). *The Fingerprint Sourcebook*. CreateSpace Independent Publishing Platform.