**Paweł Malinowski**
*Fingerprint Examination Department of the Central Forensic Laboratory of the Police*
pawel.malinowski@policja.gov.pl

# Problems encountered in the dactyloscopic investigation of anonymous corpses with fingerprint patterns preserved in silicone molds and the attempt to solve them

## Summary

The article describes experiments conducted using the Automatic Fingerprint Identification System (AFIS), which demonstrated that replacing the standard search type TP/TP (card/card) with the type LT/TP (trace/card) in conducting dactyloscopic investigations with fingerprint patterns preserved in silicone molds leads to optimal results. Moreover, a series of practical tips for investigators are included, covering the AFIS tools that should be used to obtain correct search results in the system and minimize the risk of errors.

**Keywords** dactyloscopic investigation, fingerprint patterns preserved in silicone molds, AFIS, TP/TP (card/card) search type, LT/TP (trace/card) search type

Investigations carried out in the Central Dactyloscopic Registry at the Fingerprint Examination Department of the Central Forensic Laboratory of the Police result in the identification of approximately 230 anonymous corpses annually. The evidence in this type of investigations is usually in the form of ink fingerprints on paper dactyloscopic cards. Sometimes, however, the damaged and often putrefying epidermis of the fingers forces forensic technicians to use another method of preserving fingerprint patterns, e.g., covering the fingers with dactyloscopic powder and transferring fingerprint patterns onto dactyloscopic film, preserving fingerprints in silicone molds or, as a last resort, obtaining permission to cut the fingertips off and then sending them to a forensic laboratory in order to prepare dactyloscopic cards in laboratory conditions.

Due to the fact that dactyloscopic investigations of anonymous corpses with fingerprint patterns preserved in silicone molds are sent to the Central Dactyloscopic Registry (CDR) sporadically, to date they have not attracted the attention of experts in the field of dactyloscopic studies. However, the fact that searching CRD using the card/card (TP/TP) search type in the Automatic Fingerprint Identification System (AFIS) sometimes returns a negative result, even though the corpse's card is registered in the system, resulted in a greater interest in the issue.

Three dactyloscopic investigations with the evidence in the form of fingerprint patterns preserved in silicone molds were analyzed. In two instances, standard TP/TP searches conducted in such cases and an additional LT/TP search at a resolution of 500 dpi gave positive results (HIT). In another case reported by the Municipal Police Department in Tychy, a TP/TP search gave negative results (NO HIT), even though two cards with the fingerprints of the corpse were registered in AFIS. This confirmed earlier problem reports concerning the investigations based on AFIS, therefore the submitted material was analyzed in detail. The letter requesting the dactyloscopic investigation of the corpse of an unidentified man was accompanied by nine pieces of silicone mold and a piece of black dactyloscopic film. In the silicone mold, preserved were the fingerprint patterns of the following fingers of the right hand: thumb (no. 1), index finger (no. 2), middle finger (no. 3), ring finger (no. 4) and littler finger (no. 5), and the following fingers of the left hand: index finger (no. 7), middle finger (no. 8), ring finger (no. 9) and littler finger (no. 10). The fingerprint pattern of the thumb of the left hand (no. 6) was preserved on a film.

In accordance with the *Instructions for dactyloscopic investigation*, a CRD specialist using the submitted material prepared a dactyloscopic card that was subsequently registered in AFIS and compared with

the cards already present in the database. The card/card (TP/TP) search type gave negative results (NO HIT).

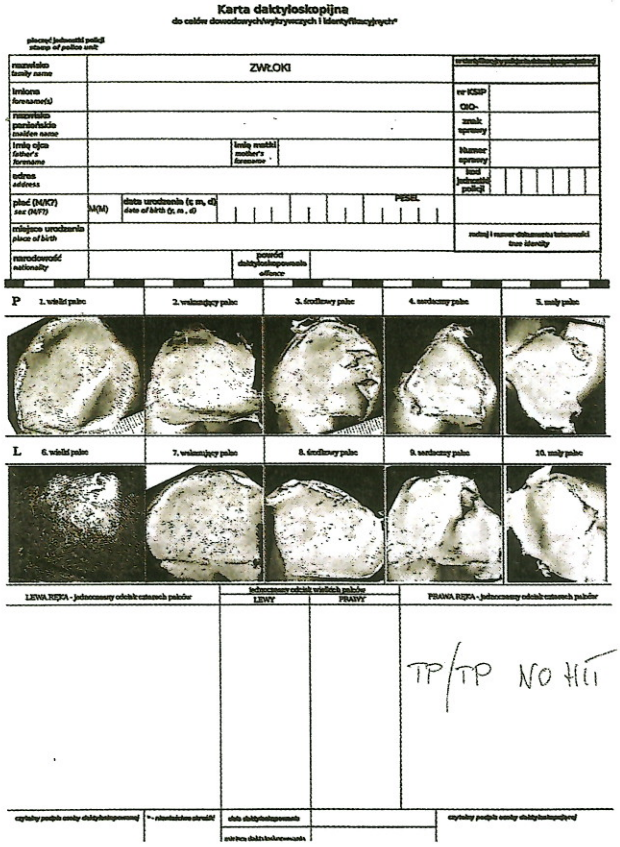


**Fig. 1.** Dactyloscopic card searched in AFIS with the result NO HIT.

It was proposed that the track/card (LT/TP) search type be used instead of the card/card (TP/TP) search type in dactyloscopic investigations with fingerprint patterns preserved in silicone molds. To this end, evaluation of the quality of the fingerprint patterns of all fingers has to be performed and one or two patterns of the best quality have to be chosen.

Since silicone is a plastic material applied on the scanner glass with different force by different operators, variations in the distances between minutiae occur along with shifts in their localization in relation to each other. It was assumed that attempts to compensate the different force applied by each user can be made not only by using the *Minor* algorithm (which is meant to increase the tolerance of the distances between minutiae patterns in the evidence and reference material, taking account that the fingerprints were taken from a teenager, while the crime was committed by an adult) added by the developer of AFIS version 4.0, but also by increasing the resolution. It was decided to search the fingerprint patterns of all fingers at a standard resolution, i.e. 500 dpi, and additionally, at the resolutions: 550 dpi and 600 dpi.

In order to obtain optimal results and create conditions as close as possible to the day-to-day working environment of people using the system, it was assumed that:

- all patterns are coded manually
- registration is performed at a fairly high rate
- the operator registers every fingerprint pattern only once and it is not possible to modify the minutiae pattern after searching
- patterns at the resolutions 500 dpi, 550 dpi and 600 dpi have the same minutiae,

Below are the images of the fingerprint patterns for each finger registered in the system by the operator, including: the number of minutiae, their location, adopted pattern, as well as the location of the central and delta markers.

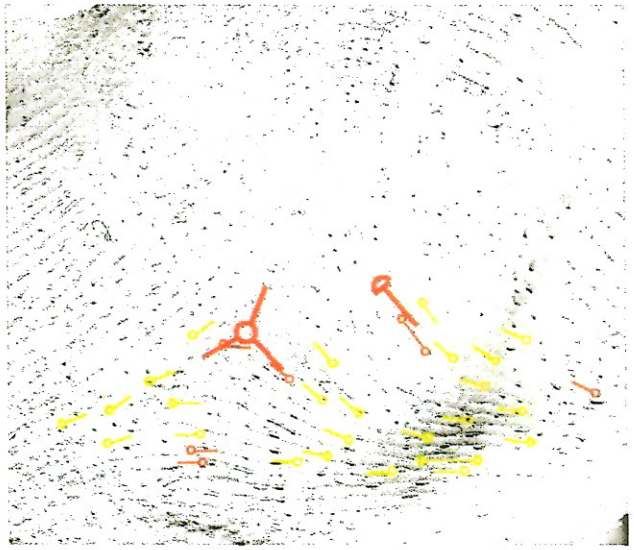

**Fig. 2.** Pattern of the thumb of the right hand, number of minutiae: 21, adopted model: \ .

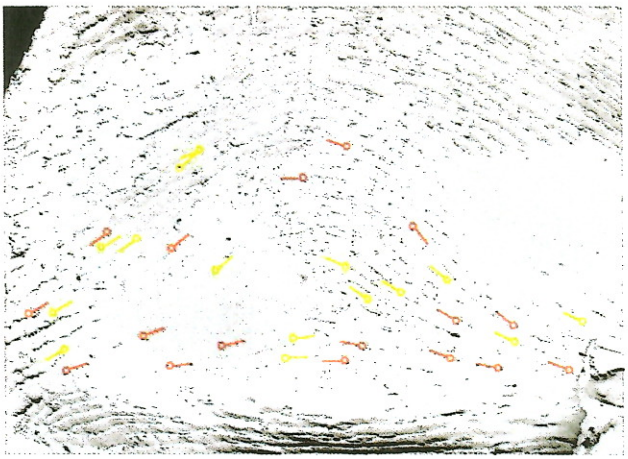

**Fig. 3.** Pattern of the index finger of the right hand, number of minutiae: 32, adopted model: /, A,\ .

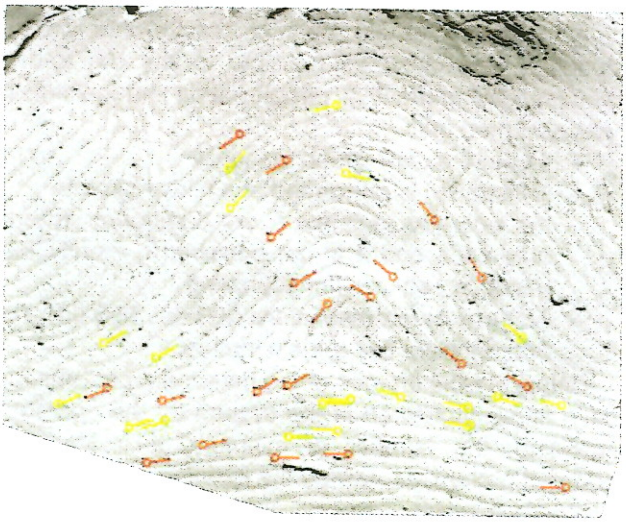

**Fig. 4.** Pattern of the middle finger of the right hand, number of minutiae: 39, adopted model: /,A\.

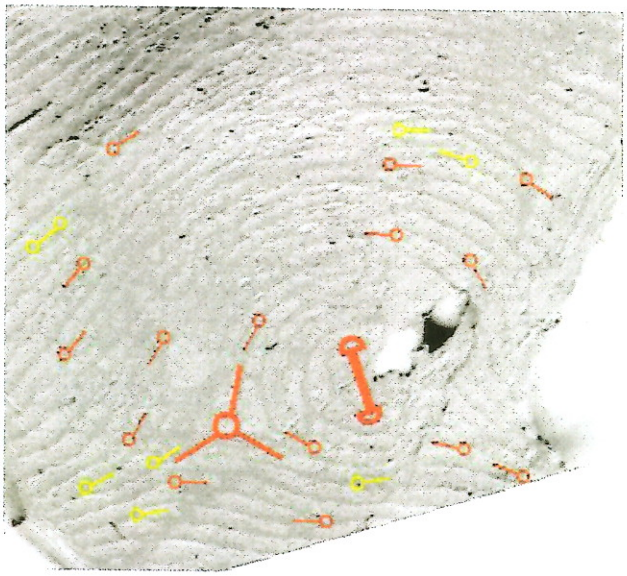

**Fig. 5.** Pattern of the ring finger of the right hand, number of minutiae: 23, adopted model: W.

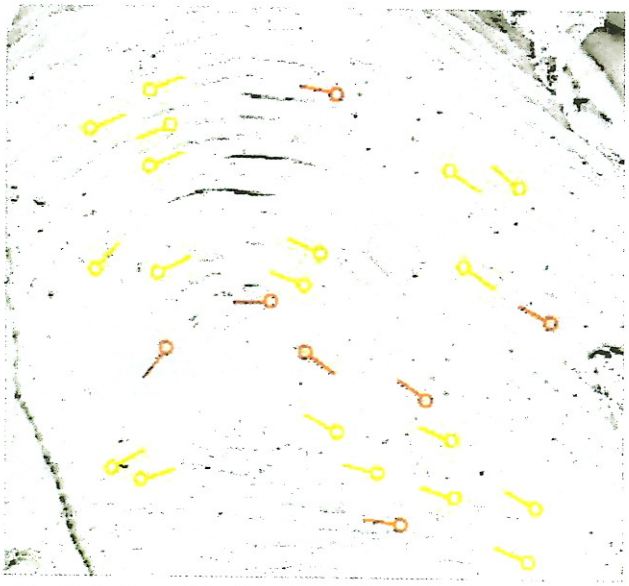

**Fig. 6.** Pattern of the little finger of the right hand, number of minutiae: 26, adopted model: A,\ .

**Fig. 7.** Pattern of the thumb of the left hand, number of minutiae: 37, adopted model: / .

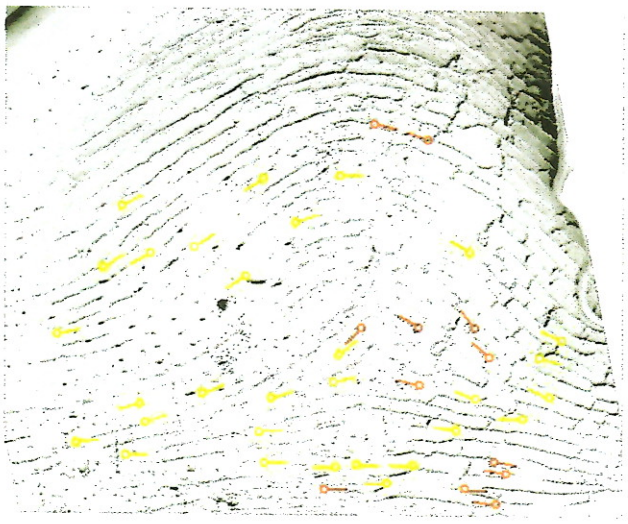

**Fig. 8.** Pattern of the index finger of the left hand, number of minutiae: 42, adopted model: /, A,\ .

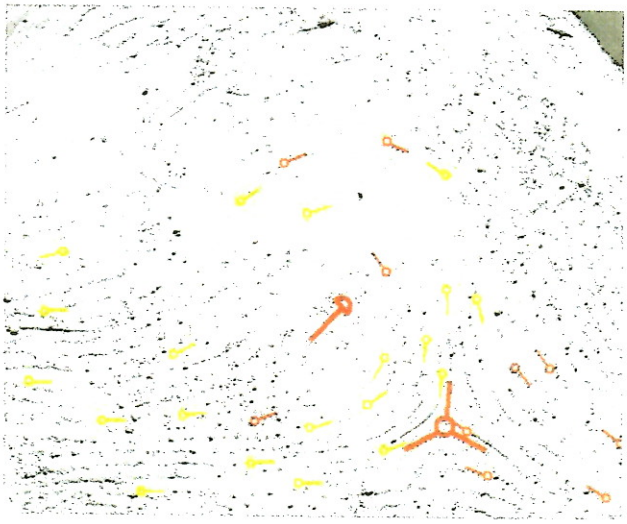

**Fig. 9.** Pattern of the middle finger of the left hand, number of minutiae: 30, adopted model: / .

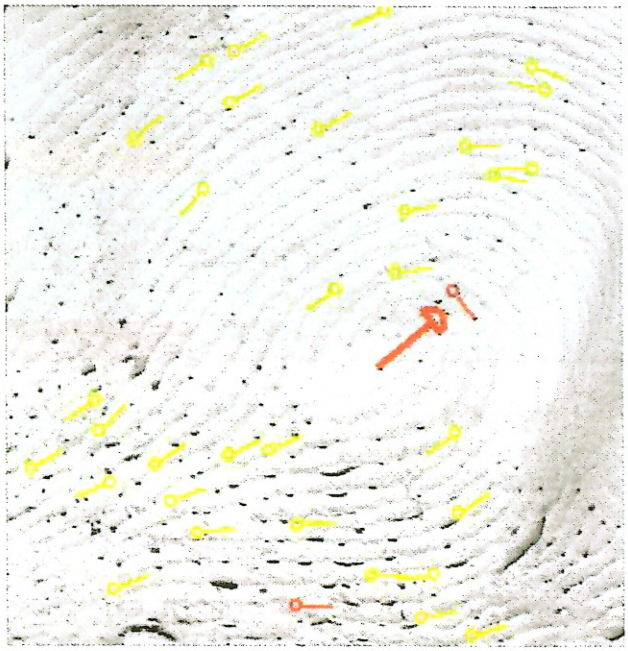

**Fig. 10.** Pattern of the ring finger of the left hand, number of minutiae: 34, adopted model: /.

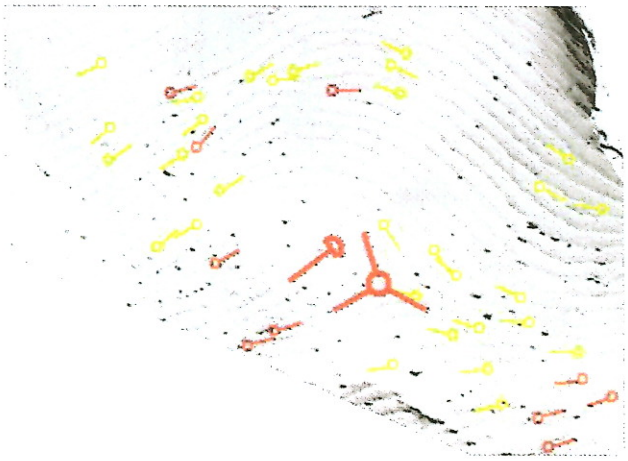

**Fig. 11.** Pattern of the little finger of the left hand, number of minutiae: 41, adopted model: /, A .

Results of the search of fingerprint patterns of each finger in AFIS database are given in Table 1, where:

**1**: Indicates a positive result (HIT) of AFIS search on the list of the first 15 candidates

**0**: Indicates a negative result (NO HIT) of AFIS search on the list of the first 15 candidates

**Table 1** Results of the search of fingerprint patterns of each finger in AFIS database

| Finger number | Method of fingerprint preservation | Scan resolution (DPI) | Standard Search | | Search with the *Minor algorithm* | |
|---|---|---|---|---|---|---|
| | | | card 000477715V | card 000483090W | card 000477715V | card 000483090W |
| 1 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 0 | 0 | 0 | 0 |
| | | 600 | 0 | 1 | 0 | 0 |
| 2 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 0 | 0 |
| 3 | silicone | 500 | 1 | 0 | 1 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 4 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 5 | silicone | 500 | 1 | 1 | 1 | 1 |
| | | 550 | 1 | 1 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 6 | dactyloscopic film black | 500 | 0 | 1 | 1 | 1 |
| | | 550 | 1 | 1 | 1 | 1 |
| | | 600 | 1 | 1 | 1 | 1 |
| 7 | silicone | 500 | 1 | 0 | 1 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 8 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |

| Finger number | Method of fingerprint preservation | Scan resolution (DPI) | Standard Search | | Search with the *Minor algorithm* | |
|---|---|---|---|---|---|---|
| | | | card 000477715V | card 000483090W | card 000477715V | card 000483090W |
| 9 | silicone | 500 | 1 | 0 | 1 | 1 |
| | | 550 | 1 | 1 | 1 | 1 |
| | | 600 | 1 | 1 | 1 | 1 |
| 10 | silicone | 500 | 1 | 0 | 1 | 0 |
| | | 550 | 1 | 1 | 1 | 1 |
| | | 600 | 1 | 1 | 1 | 0 |

By analyzing the results contained in Table 1, it was concluded that:

- at the standard resolution of 500 dpi, the patterns of fingers no. 3, no. 5, no. 7, no. 9, no. 10 yielded correct search results (HIT) against the fingerprints on card 000477715V
- at the resolutions of 550 dpi and 600 dpi, the patterns of fingers no. 2, no. 3, no. 4, no. 5, no. 6, no. 7, no. 8, no. 9, no. 10 yielded correct search results (HIT) against the fingerprints on card 000477715V
- at the resolutions of 500 dpi, 550 dpi and 600 dpi, the pattern of finger no. 1 yielded an incorrect search result (NO HIT) against the fingerprint on card 000477715V
- by using the *Minor* algorithm at the standard resolution of 500 dpi, the pattern of finger no. 6 yielded a correct search result (HIT) against the fingerprint on card 000477715V
- by using the *Minor* algorithm at the resolution of 600 dpi, the pattern of finger no. 2 yielded an incorrect search result (NO HIT) against the fingerprint on card 000477715V
- at the standard resolution of 500 dpi, the patterns of fingers no. 5, no. 6 yielded correct search results (HIT) against the fingerprints on card 000483090W
- at the resolution of 550 dpi, the patterns of fingers no. 5, no. 6, no. 9, no. 10 yielded correct search results (HIT) against the fingerprints on card 000483090W
- at the resolution of 600 dpi, the patterns of fingers no. 1, no. 6, no. 9, no. 10 yielded correct search results (HIT) against the fingerprints on card 000483090W
- at the resolutions of 500 dpi, 550 dpi and 600 dpi, the patterns of fingers no. 2, no. 3, no. 4, no. 7, no. 8 yielded incorrect search results (NO HIT) against the fingerprints on card 000483090W
- by using the *Minor* algorithm at the standard resolution of 500 dpi, the pattern of finger no. 9 yielded a correct search result (HIT) against the fingerprint on card 000483090W,
- by using the *Minor* algorithm at the resolution of 550 dpi, the pattern of finger no. 5 yielded an incorrect search result (NO HIT) against the fingerprint on card 000483090W, similarly to the patterns of fingers no. 1 and no. 10 at the resolution of 600 dpi.

Moreover, detailed analysis of fingerprints on both cards was conducted, leading to the following conclusions:

- the incorrect search result of the pattern of finger no. 1 against card 000477715V (the tested person was 37 years old) was influenced by permanent skin damage of the thumb of the right hand and the incomplete fingerprint pattern of that finger on the card
- the incorrect search results of the patterns of most fingers against card 000483090W (the tested person was 20 years old) was influenced by insufficient rolling of the fingers and blurring of the patterns on the card, causing unreadability of some fingerprints, as well as skin disease.

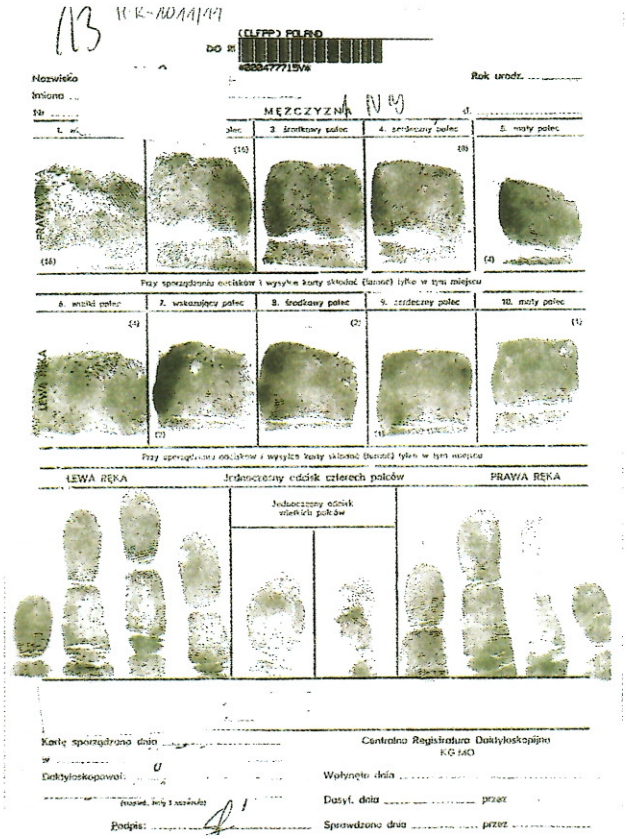


**Fig. 12.** Dactyloscopic card no. 000477715V.

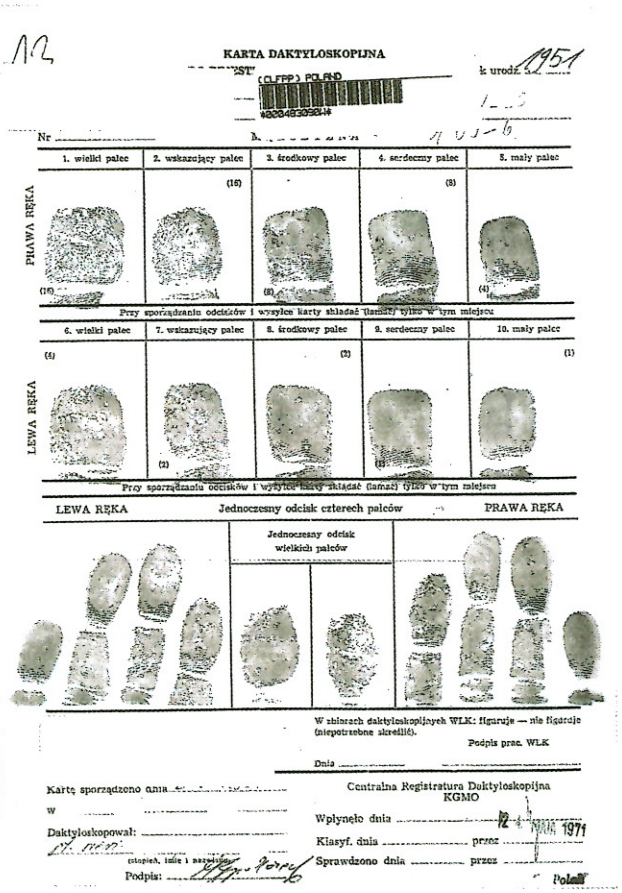


**Fig. 13.** Dactyloscopic card no. 000483090W.

Subsequently, the impact of narrowing the set of the searched fingerprint patterns to a specific finger on the result of AFIS search was investigated. With a correctly prepared dactyloscopic card, we can limit the LT/TP search to one finger, thus reducing the size of the searched collection of patterns by 90%. The obtained results are shown in Table 2.

After the analysis of the results contained in Table 2 and their comparison with the results from Table 1, it was concluded that:

- by limiting the number of samples and using the standard resolution of 500 dpi, the pattern of finger no. 6 yielded a correct search result against the fingerprint on card 000477715V
- by limiting the number of samples and using the *Minor* algorithm at the resolution of 600 dpi, the patterns of finger no. 1 and no. 10 yielded a correct search result against the fingerprints on card 000483090W.

Studies confirmed that AFIS version 4.0 is a system in which the most important factor affecting the search result is the correct identification (determination) of the pattern of minutiae in the evidence fingerprint pattern by the operator. The size of the searched set is of minor importance. Limiting the search to one finger at the standard resolution of 500 dpi resulted in a HIT result for pattern no. 6 against card 000477715V, which improved the search effectiveness by 8% compared to the results obtained with the full set (5 NO

**Table 2**

| Finger number | Method of fingerprint preservation | Scan resolution (DPI) | Standard Search | | Search with the *Minor algorithm* | |
|---|---|---|---|---|---|---|
| | | | card 000477715V | card 000483090W | card 000477715V | card 000483090W |
| 1 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 0 | 0 | 0 | 0 |
| | | 600 | 0 | 1 | 0 | 1 |
| 2 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 0 | 0 |
| 3 | silicone | 500 | 1 | 0 | 1 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 4 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 5 | silicone | 500 | 1 | 1 | 1 | 1 |
| | | 550 | 1 | 1 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 6 | dactyloscopic film black | 500 | 1 | 1 | 1 | 1 |
| | | 550 | 1 | 1 | 1 | 1 |
| | | 600 | 1 | 1 | 1 | 1 |
| 7 | silicone | 500 | 1 | 0 | 1 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |

| Finger number | Method of fingerprint preservation | Scan resolution (DPI) | Standard Search | | Search with the *Minor algorithm* | |
|---|---|---|---|---|---|---|
| | | | card 000477715V | card 000483090W | card 000477715V | card 000483090W |
| 8 | silicone | 500 | 0 | 0 | 0 | 0 |
| | | 550 | 1 | 0 | 1 | 0 |
| | | 600 | 1 | 0 | 1 | 0 |
| 9 | silicone | 500 | 1 | 0 | 1 | 1 |
| | | 550 | 1 | 1 | 1 | 1 |
| | | 600 | 1 | 1 | 1 | 1 |
| 10 | silicone | 500 | 1 | 0 | 1 | 0 |
| | | 550 | 1 | 1 | 1 | 1 |
| | | 600 | 1 | 1 | 1 | 1 |

HITs with card 000477715V and 8 NO HITs with card 000483090W). In this case, increase in resolution had a large impact on improving the search results. The use of 550 dpi resolution resulted in HITs for patterns no 2, no. 4, no. 6 and no. 8 against card 000477715V, and HITs for patterns no. 9 and no. 10 against card 000483090W, which improved the efficiency of search by 46% compared to the results obtained at the standard resolution. The use of the *Minor* algorithm at the standard resolution of 500 dpi had an impact on the correct search results of pattern no. 6 against card 000477715V and pattern no. 9 against card 000483090W, while the use of this function at higher resolutions had no impact or adversely affected the search results. However, important was the condition of the fingerprints from the investigated person and the method of collection of reference material. Too narrow rolling of the fingers, blurred patterns on the card, mechanical damage to the epidermis and skin disease also contributed to incorrect query results.

In light of the above, persons conducting dactyloscopic investigations with fingerprint patterns preserved in silicone molds should:

- use the LT/TP (track/card) search type instead of the TP/TP (card/card) search type
- select two patterns of the best readability for searching
- apply silicone molds with fingerprint patterns directly onto the scanner glass, lightly pressing them with a finger
- use the so-called manual registration, remembering to add markers: center and delta
- limit the searched set to a particular finger by selecting the proper finger in the "Trace" tab (if there are doubts on the correctness of finger labeling by the forensic technician, or labeling is absent, leave all fingers checked)
- search for the pattern at the resolution of 500 dpi, and when NO HIT is obtained, repeat the search at the resolution of 550 dpi
- check the box "Algorithm—Minor" in the „Comparison" tab when searching patterns at the resolution of 500 dpi
- for LT/TP searches, do not select patterns with fingerprint deformities due to mechanical damage to the epidermis or skin disease.

## Sources of figures and tables

Tabs. 1–2: author
Figs. 1–13: author