OSAC 2022-S-0038 Standard for Feature Selection in Friction Ridge Examination

Friction Ridge Subcommittee
Physics/Pattern Scientific Area Committee
Organization of Scientific Area Committees (OSAC) for Forensic Science

OSAC Proposed Standard

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Prepared by
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Organization for Scientific Area Committees (OSAC) for Forensic Science

Version: 2.0
August 2023

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1. Introduction

1.1. This standard has been developed with the objective of improving the quality and consistency of friction ridge examination practices.

1.2. This standard provides a comprehensive list of features and their definitions which may be used during the friction ridge examination process. The features expand on those provided by the Extended Feature Set Detailed Instructions in American National Standard for Information Ssytems; "Data Format for the Interchange of Extended Friction Ridge Features"; ANSI/NIST-ITL 1-2011 (Update:2015), NIST Special Publication 500-290 Edition 3 (2015).

1.3. This standard also includes information about the diagnosticity and factors affecting the appearance of the features. The diagnostic value of each feature is based on the consensus opinion of the OSAC Friction Ridge Subcommittee. Limited scientific literature is referenced, where applicable; however, empirical measures of the rarity of each feature type or combinations of feature types have not been well established within each section of the friction ridge skin or across different populations.

1.4. In addition to the significance of each feature, this standard provides an awareness of the relationship among features that can be used during examination.

1.5. Section 4 specifies the list of features and their definitions. Section 5 provides information about the diagnosticity and factors affecting the appearance of the features. The appendices provide additional information and images depicting the features described in this standard.

1.6. Images depicting friction skin in the figures throughout this standard are reprinted with permission from the *Journal of Forensic Identification*.

1.7. In this standard, the following verbal forms are used: "*shall*" indicates a requirement, "*should*" indicates a recommendation; "*may*" indicates permission; and "*can*" indicates a possibility or capability.

2. Scope

2.1. This standard specifies the features that can be utilized during friction ridge examinations and provides guidance regarding factors affecting the distortion and diagnosticity of those features.

2.2. This standard does not address the examination methodology or documentation.

3. Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1. Attributes: Components of features that can be measured or counted.

3.2. Examination: The act or process of observing, searching, detecting, recording, prioritizing, collecting, analyzing, measuring, comparing, and/or interpreting.

3.3. Examiner (Friction Ridge)/Competent Friction Ridge Examiner: An individual who has successfully completed their FSP's training program and has demonstrated to the FSP that they possess the knowledge, skills and abilities to perform the tasks required of their current position. An individual authorized to conduct friction ridge examinations for the FSP by observing and interpreting data, making decisions, forming conclusions and opinions, issuing reports and/or providing testimony.

3.4. Friction Ridge Features: Structures of the friction ridge skin, as observed in the skin or recorded and observed in an impression. The set of observed data used to compare and interpret similaritities or differences between a questioned impression and the exemplar prints of a donor. Similarities are features that an examiner interprets to be in correspondence between a questioned print and a region within the exemplar prints of a donor. An examiner's interpretation of differences between a question print and exemplar prints of a donor generally leads at attributing the differences to one of two causes: 1) the questioned print and exemplars prints were made by different sources or 2) the questioned print and the exemplars were likely made by the same donor but are displaying variation in appearance due to the limits of persistency of features or distortion factors.

3.5. Pattern force area: A region of friction ridge skin in which minutiae form in a predictable density and orientation due to the influence of nearby ridges [19.1, 19.2, 19.3].

3.6. Rarity (of a feature type): The frequency for which a type of feature is encountered in a group of people (its prevalence), either in isolation or in conjunction with other information about its local context.

3.7. Search Diagnosticity: The usefulness of a feature (or features) to limit the comparisons to specific anatomical regions within the hands or feet, left or right hands or feet, or specific orientations [19.3, 19.4, 19.5].

3.8. Source: an individual from which an item (e.g. crime scene impression) originates.

3.9. Source Diagnosticity: The usefulness of a feature (or features) to include or exclude a potential donor [19.3, 19.4].

4. General Requirements

4.1. Examiners shall use only those features and their associated attributes included on the following list during friction ridge examinations to support suitability determinations and source conclusions. Other aspects of impressions of friction ridge skin may be used to aid in the interpretation of the features and their attributes (e.g., shape and smearing of the impression can indicate the impact of torque during contact, causing differences in the curvature of the ridges).

NOTE: Although the features are defined in relation to the skin, different features can manifest in an impression of the skin in ways that are not easily discernible or distinguishable [19.3].

4.1.1. **Ridges**:

The ridges are the primary feature type in the friction ridge skin. The ridges are the fully formed elevated papillary rows of skin on the volar surfaces of normal human hands and feet. If the friction ridge skin is considered a topographical map, the ridges are typically the feature at the highest elevation and are the main contact regions when the friction ridge skin touches a surface. On the skin, fully formed ridges can be distinguished from incipient ridges by the existence of sweat pores spaced somewhat evenly along the path of the ridge. See Appendix A for examples of ridges and ridge attributes.

4.1.1.1. Attributes:

4.1.1.1.1. Number – count of ridges within a region of skin or within an impression of the skin.

4.1.1.1.2. Ridge Width – distance between the edges of a ridge at a given location on the ridge.

4.1.1.1.3. Furrow Width – distance between the edges of adjacent ridges at a given location on the ridges.

4.1.1.1.4. Length – distance between two locations along the path of a ridge.

4.1.1.1.5. Spacing – distance between the midpoints of two adjacent ridges.

4.1.1.1.6. Direction – angle of the path of a ridge in relation to a fixed point in the skin or impression (e.g., a ridge that is perpendicular to an irregular crease).

4.1.1.1.7. Curvature – change in angles along the path of a ridge for a given segment of the ridge.

4.1.1.1.8. Edge Shape – contour of the edge of a ridge (straight, protrusion, and intrusion).

4.1.1.1.9. Pore Position – location of a pore with respect to the edge of the ridge or another pore.

4.1.1.1.10. Open Field – four or more adjacent and continuous ridges with a visible length of at least 3mm where no minutiae are present within an area of skin.

4.1.2. **Minutiae**:

A minutia defines the end of a ridge and is the primary landmark within the ridged skin used by examiners and biometric systems. A ridge can end in three different manners: 1) no connection to the adjacent ridge above the level of the furrow (i.e., ending ridge), 2) completely connected to the adjacent ridge from the bottom of the furrow to the top of the ridge (i.e., bifurcation) or 3) partially connected to the adjacent ridge (i.e., ambiguous minutiae). The manner in which a ridge ends can change during adolescent growth as the cells of the skin rapidly multiply to keep pace with the growing hand or foot [19.3, 19.6]. Additionally, the connectors between two ridges can change as a result of the aging process [19.3, 19.6]. See Appendix B for examples of minutiae and minutiae attributes.

4.1.2.1. Attributes:

4.1.2.1.1. Number – count of minutiae within a region of skin or within an impression of the skin.

4.1.2.1.2. Density – number of minutiae within a specified surface area (e.g., per mm2).

4.1.2.1.3. Orientation – direction of the path(s) of the ridge(s) emanating from a minutia in relation to a fixed point in the skin or impression.

4.1.2.1.4. Connectedness – extent to which the end point of one ridge segment is joined or linked to a neighboring ridge.

4.1.2.1.5. Compound Minutiae – the combination of multiple minutiae within a close proximity or that manifest as a single structure. Compound minutiae might include the following: short ridge, dot, break, enclosure, overlap, spur, crossbar, bridge, opposing bifurcations, dock, ending ridge plus bifurcation combination, trifurcation/double bifurcation, return, and merge point [19.2, 19.3, 19.7, 19.8, 19.9]. See Table 3 in Appendix B for examples of compound minutiae.

4.1.2.1.6. Pattern Force Minutiae – Minutiae that form in a pattern force area bearing a direction consistent with the majority of minutiae in that area.

4.1.2.1.7. Counter Pattern Force Minutiae – Minutiae that form in a pattern force area bearing a direction not consistent with the majority of minutiae in that area.

4.1.3. **Incipient Ridges**:

Incipient ridges are raised papillary ridges that are typically lower in elevation than the mature ridges (Section 4.4.1). Incipient ridges occupy space in the furrows, between the mature ridges. Unlike the mature ridges, incipient ridges do not have sweat pores. Incipient ridges are typically less than one half the average width of the surrounding mature ridges and often display numerous breaks. The incipient ridges often continue to manifest as people age [19.3, 19.6, 19.10., 19.11]. Incipient ridges can fuse to each other or to the ends of mature ridges and can approach the height and width of the mature ridges [19.3, 19.6]. See Appendix C for examples of incipient ridges and incipient ridge attributes.

4.1.3.1. Attributes:

4.1.3.1.1. Number – count of incipient ridges within a region of skin or within an impression of the skin.

4.1.3.1.2. Density – number of incipient ridges within a specified surface area (e.g., per mm2).

4.1.3.1.3. Width - distance between the edges of an incipient ridge at a given location on the incipient ridge

4.1.3.1.4. Length – distance between two locations along the path of an incipient ridge.

4.1.3.1.5. Direction – angle of the path of an incipient ridge in relation to a fixed point in the skin or impression (e.g., an incipient ridge that is perpendicular to an irregular crease).

4.1.3.1.6. Inter-Incipient Gap – distance between the ends of two incipient ridges (i.e., the separation between incipient ridges within a row of incipient ridges).

4.1.3.1.7. Edge Shapes – contours along the edges of an incipient ridge (straight, protrusion, and intrusion).

4.1.4. **Dissociated Ridges**:

Dissociated ridges are raised portions of the friction ridge skin that are broken into short, wavy or dotlike segments that may be completely disorganized or somewhat follow the ridge flow in a given region of skin [19.12]. Dissociated ridges are typically at the same elevation as any surrounding normal ridges and might or might not contain sweat pores. Dissociated ridges are also known as dysplasia. See Appendix D for examples of dissociated ridges and dissociated ridge attributes.

4.1.4.1. Attributes:

4.1.4.1.1. Number – count of ridge segments within a region of skin or within an impression of the skin.

4.1.4.1.2. Density – number of ridge segments within a specified surface area (e.g., per mm2).

4.1.4.1.3. Ridge Width – distance between the edges of a ridge segment at a given location on the segment.

4.1.4.1.4. Furrow Width – distance between the edges of adjacent ridges at a given location on the ridges.

4.1.4.1.5. Length – distance between two locations along the path of a ridge segment.

4.1.4.1.6. Spacing – distance between the midpoints of two adjacent ridges.

4.1.4.1.7. Direction – angle of the segment of a ridge in relation to a fixed point in the skin or impression (e.g., a segment that is perpendicular to the core of a loop).

4.1.4.1.8. Curvature – change in angles along the path of a ridge segment.

4.1.4.1.9. Edge Shape – contour of the edge of a ridge segment (straight, protrusion, indentation, and discontinuity).

4.1.4.1.10. Pore Position – location of a pore with respect to the edge of the ridge segment or another pore.

4.1.4.1.11. Connectedness – extent to which the end point of one ridge segment is joined or linked to a neighboring ridge.

4.1.5. **Ridge flow**:

Ridge flows are general paths of ridges commonly found in specific regions of the hands and feet that reflect the stresses on the surface of the skin caused by the growth of the hands and feet and the presence of the regular flexion creases at the time the ridges are forming. These ridge flows are not defined "pattern elements," but useful during the examination process because they are predictive for each region of the hand and foot [19.3, 19.4, 19.5]. See Appendix E for examples of ridge flows and ridge flow attributes.

4.1.5.1. Attributes:

4.1.5.1.1. Curvature – change in angles along a series of parallel ridges at a given location along a ridge flow.

4.1.5.1.2. Convergence – loss of ridges along a ridge flow, causing an overall decrease in the width of the ridge flow.

4.1.5.1.3. Divergence – gain of ridges along a ridge flow, causing an overall increase in the width of the ridge flow.

4.1.6. **Pattern Elements – Recurves and Triradii**:

Pattern elements, and the relationships between pattern elements, are most often associated with the development of classification schemes for the digits, palms, and feet. In the examination of partial impressions, the presence of one or more pattern elements can provide anatomical reference points and can be used to reduce the number of potential donors of an impression [19.2, 19.3, 19.4, 19.5, 19.13, 19.14, 19.15].

Pattern elements include triradii (singular "triradius") and recurves. A triradius is a convergence of three ridge fields, which creates three distinct rays from the center of the convergence. A recurve is the portion of a ridge path where the ridge turns with an acute inner angle, reversing the direction of the ridge path and resulting in an approximately 120^{o} - 180^{o} change. When a sequence of ridges makes a turn, the ridge with the acutest angle in the sequence is the recurve. The innermost recurve is often associated with the core in fingerprint pattern classification. [19.36, 19.37]. See Appendix F for examples of pattern elements and attributes as described in this standard.

4.1.6.1. Attributes:

4.1.6.1.1. Number – count of recurves and triradii within a region of the friction ridge skin or in an impression.

4.1.6.1.2. Triradius Angle – angle formed by two rays of a triradius.

4.1.6.1.3. Recurve Ridge Count – number of ridges enclosed by a recurving ridge.

4.1.6.1.4. Pattern Element Relationships – ridge counts, distance, or angles between recurves or triradius centers of two or more pattern elements.

4.1.6.1.5. Recurve Direction – Angle of the bisector of the recurve in relation to a fixed point in the skin or impression.

4.1.7. **Regular Creases**:

The regular creases are those flexion creases which form prior to the friction ridges and prior to flexion of the hand or foot during embryological formation [19.16, 19.17, 19.18]. Regular creases are tightly bound to the underlying palmar aponeurosis and ridges tend not to traverse through these creases. Regular creases are also referred to as primary creases or major creases. The five regular creases of the palm include: wrist crease, thenar crease, distal transverse crease, proximal transverse crease, and palmar digital creases. The only regular creases associated with the sole are the plantar digital flexion creases where the skin of the toe meets the sole.

Thumbs and great toes typically have a distal interphalangeal crease located at the joint between the distal and proximal phalanges (there is typically no medial phalange in the great toe or thumb). The four remaining digits of the hands and feet typically have a distal interphalangeal crease located at the joint of the distal and medial phalanges. The four fingers of the hand typically have a proximal interphalangeal crease located at the joint of the medial and proximal phalanges. In the remaining four toes, it is common for the proximal interphalangeal crease to be poorly formed or missing. See Appendix G for a schematic of the regular creases of the hands and feet and examples of attributes of regular creases.

4.1.7.1. Attributes:

4.1.7.1.1. Number – count of regular creases within a region of skin or within an impression of a skin.

4.1.7.1.2. Configuration – organization of the regular crease as a single structure or a compound structure (e.g., the palmar digital crease of the middle finger is typically a double crease while the palmar digital crease of the index finger is typically a single crease).

4.1.7.1.3. Spacing – distance between the midpoints of two regular creases.

4.1.7.1.4. Position – location of a regular crease within the structure of the hand or foot.

4.1.7.1.5. Width – distance between the edges of a regular crease at a given location on the regular crease.

4.1.7.1.6. Length – distance between two locations along the path of a regular crease.

4.1.7.1.7. Curvature – change in angles along the path of a regular crease for a given segment of the crease.

4.1.7.1.8. Direction – angle of the path of a regular crease in relation to a fixed point in the skin or impression (e.g., a crease that is parallel to the direction of the surrounding ridges).

4.1.7.1.9. Edge shapes – contours of the skin contained within a regular crease.

4.1.7.1.10. Branching – diverging pattern of smaller creases along a regular crease.

4.1.8. **Irregular Creases**:

The irregular creases are those flexion creases which form during or after ridge formation (ridges typically traverse through these creases) [19.16, 19.17, 19.18]. Although not as deep as the regular creases, the irregular creases also have attachments to the underlying structure of the hand or foot. Biologically, irregular creases are distinct from wrinkles; however, in impressions of friction ridge skin, irregular creases and wrinkles both tend to record as a linear void dissecting the ridges. Irregular creases are also referred to as secondary creases or minor creases. The irregular creases show greater variability than the regular creases within the human population. See Appendix H for examples of irregular creases and attributes of irregular creases.

4.1.8.1. Attributes:

4.1.8.1.1. Number – count of irregular creases within a region of skin or within an impression of a skin.

4.1.8.1.2. Density – number of irregular creases within a specified surface area (e.g., per mm2).

4.1.8.1.3. Width – distance between the edges of an irregular crease at a given location on the irregular crease.

4.1.8.1.4. Length – distance between two locations along the path of an irregular crease.

4.1.8.1.5. Curvature – change in angles along the path of an irregular crease for a given segment of the crease.

4.1.8.1.6. Direction – angle of the path of an irregular crease in relation to a fixed point in the skin or impression (e.g., a crease that is parallel to the direction of the surrounding ridges).

4.1.8.1.7. Branching – diverging pattern of smaller creases along an irregular crease.

4.1.8.1.8. Angle of intersection – angle(s) created by the intersection of two or more irregular creases.

4.1.8.1.9. Spacing – distance between the midpoints of two irregular creases.

4.1.9. **Wrinkles**:

Wrinkles are a result of a breakdown in the skin over time. The disorganization of the various fibers and large proteins in the dermis causes the dermis to fold inward, causing a crimp in the epidermis [19.12, 19.19]. Unlike the regular and irregular creases, wrinkles do not have dedicated attachments to the underlying structure of the hand or foot. In impressions of friction ridge skin, wrinkles and irregular creases both tend to record as a linear void dissecting the ridges. See Appendix H for examples of wrinkles and wrinkle attributes.

4.1.9.1. Attributes:

4.1.9.1.1. Number – count of wrinkles within a region of skin or within an impression of a skin.

4.1.9.1.2. Density – number of wrinkles within a specified surface area (e.g., per mm2).

4.1.9.1.3. Width – distance between the edges of a wrinkle at a given location on the wrinkle.

4.1.9.1.4. Length – distance between two locations along the path of a wrinkle.

4.1.9.1.5. Curvature – change in angles along the path of a wrinkle for a given segment of the wrinkle.

4.1.9.1.6. Direction – angle of the path of a wrinkle in relation to a fixed point in the skin or impression (e.g., a wrinkle that is parallel to the direction of the surrounding ridges).

4.1.9.1.7. Branching – diverging pattern of smaller wrinkles along a wrinkle.

4.1.9.1.8. Angles of intersection – angle(s) created by the intersection of two or more wrinkles.

4.1.9.1.9. Spacing – distance between the midpoints of two wrinkles.

4.1.10. **Scars**:

A scar is a disfiguration of the skin as a result of wound healing [19.19, 19.20, 19.21]. The disfiguration can occur in varying degrees dependent on the amount of skin contraction experienced at the site of the injury and medical intervention (e.g., stitches). Some scars are imperceptible, while others are dramatic. Additionally, scars initiated by temperature and chemical burns tend to disfigure the skin differently than cuts or punctures. Simple, linear scars tend to exist at a lower elevation than the tops of the ridges. Complex scars and scars that contain epithelial islands can exist at the same or higher elevation than the normal ridges. See Appendix I for examples of scars and scar attributes.

4.1.10.1. Attributes:

4.1.10.1.1. Number – count of scars within a region of skin or within an impression of a skin.

4.1.10.1.2. Width – distance between the edges of a scar at a given location on the scar.

4.1.10.1.3. Length – distance between two locations along the path of a scar.

4.1.10.1.4. Surface Area – measure of the total area of the surface the scar occupies.

4.1.10.1.5. Curvature – change in angle along the path of a scar for a given segment of a scar.

4.1.10.1.6. Direction – angle of the path of a scar in relation to a fixed point in the skin or impression (e.g., a scar that is perpendicular to the direction of the surrounding ridges).

4.1.10.1.7. Created Minutiae – new minutiae created at the border of a scar due to the misalignment of the original ridges during the healing process.

4.1.10.1.8. Edge Shapes – contours defined by the border of a scar and any epithelial islands created as a result of the injury.

4.1.11. **Unstable features**:

Unstable features are those features temporarily present in the skin as the result of wound healing or disease [19.12, 19.19, 19.22]. Unstable features include, but are not limited to, warts, eczema/psoriasis, actively healing injuries, calluses, and blisters. Depending on the nature of the unstable feature, it may exist lower, equal, or higher elevations than the tops of the main ridges. See Appendix J for examples of more common unstable features found in the friction ridge skin.

4.1.11.1. Attributes:

4.1.11.1.1. Number – count of unstable features within a region in the skin or impression.

4.1.11.1.2. Width – distance between the edges of an unstable feature at a given location on the unstable feature.

4.1.11.1.3. Length – distance between two locations along the path of an unstable feature.

4.1.11.1.4. Surface Area – measure of the total area of the surface the unstable feature occupies.

4.1.11.1.5. Curvature – change in angle along the path of an unstable feature for a given segment of the feature.

4.1.11.1.6. Direction – angle of the path of an unstable feature in relation to a fixed point (e.g., scrape that is parallel to the direction of the surrounding ridges).

4.1.11.1.7. Edge Shapes – contours of an unstable feature.

4.1.12. **Shape of the Impression**:

The shape of an impression is generally dictated by the contact points between a hand or foot and a surface [19.3, 19.4, 19.6]. The shape of an impression is often a combination of outer borders and inner borders. The outer perimeter delineates the maximum surface area of contact between the hand/foot and the surface. Within the outer contact perimeter, inner borders can be created by the topology of the hand/foot (e.g., the mid-palm), the topology of the skin (e.g., regular creases), or movement on the surface (e.g., smears leading to the final stop position of a palm).

The surface area and borders of an impression can help discriminate between potential donor regions of an impressions (e.g., a latent print that only needs to be compared to the interdigital region of the palms), isolate individual latent prints on a lift card or image, or assess the completeness of exemplar prints (e.g., visible non-ridge skin border in an exemplar palm print ensure complete recording of the ridged skin). See Appendix K for examples of shape and shape attributes.

4.1.12.1. Attributes:

4.1.12.1.1. Surface Area – measure of the total area of the surface the impression occupies.

4.1.12.1.2. Outline – the contours along the border of the impression.

4.1.12.1.3. Non-Ridged Skin Border – the junction or transition between the ridged skin and the non-ridged skin.

5. General Recommendations

5.1. The diagnosticity of features should be considered when conducting friction ridge examinations and forming suitability determinations and source conclusions.

5.1.1. Diagnosticity, generally, refers to the usefulness of information to assist in a choice or decision. Diagnosticity of friction ridge features refers to the usefulness of the feature, or attribute of a feature, for establishing search parameters (Search Diagnosticity) or the usefulness of the feature for determining source (Source Diagnosticity).

5.1.2. Features that exhibit low levels of variation in the population can be used for establishing search parameters. Features with generally low variation include the following: shape of the impression, creases, pattern elements, and ridge flows. Conversely, those features that exhibit higher levels of variation in the human population are useful for distinguishing one finger, palm, toe, or foot from another.

5.1.3. Pattern elements, ridge flows, and creases can be useful for excluding a given donor, however these features do not typically provide strong support for same source opinions.

5.1.4. Features that exhibit higher levels of variation in the population can be used to support same source opinions. The most variable features in the population typically include the following: ridges, minutiae, incipient ridges, dissociated ridges, and certain attributes of creases. Acquired features (wrinkles, scars, unstable features) exhibit more complex diagnosticity, depending on the feature.

5.1.5. The overall search diagnosticity and source diagnosticity for a given impression is impacted by the totality of a specific combination of features and available feature attributes. Generally, as the number and diversity of features increase, the search and source diagnosticities also increase. Appendix L contains examples of how combinations of features can be used to determine diagnosticity. Appendix M provides a quick reference table of feature diagnosticity.

5.1.6. The diagnosticity for each of the features include the following:

5.1.6.1. **Ridges**:

5.1.6.1.1. Search Diagnosticity:

5.1.6.1.1.1. The search diagnosticity for the ridges is generally low because all regions of the friction ridge skin are expected to have ridges.

5.1.6.1.2. Source Diagnosticity:

5.1.6.1.2.1. In general, as the surface area of an impression increases (ergo an increase in the number of ridges and the visible lengths of the ridges), the source diagnosticity of the impression also increases [19.3, 19.6, 19.23].

5.1.6.1.2.2. In general, as an open field increases in size (more ridges or longer visible lengths of the ridges), the source diagnosticity of the open field also increases.

5.1.6.2. **Minutiae**:

5.1.6.2.1. Search Diagnosticity:

5.1.6.2.1.1. In regions where growth stresses “force” minutiae to form, there tends to be a high density of minutiae that share direction (the transition zone from the hypothenar into the mid-palm region is one such zone). This concept is called “pattern force”. [19.1, 19.2, 19.3] Pattern force areas can be used to narrow search parameters, which increase search diagnosticity of these minutiae.

5.1.6.2.2. Source Diagnosticity:

5.1.6.2.2.1. Minutiae type(s) and configurations can increase or decrease the source diagnosticity of the cluster of minutiae (e.g., in the distal portion of the fingers, bifurcations tend to

occur less frequently and therefore have higher source diagnosticity compared to ridge endings). [19.2, 19.8, 19.9]

5.1.6.2.2.2. Typically, as the surface area of skin represented in an impression increases, so too does the number of minutiae present within the impression. While the source diagnosticity of a cluster of minutiae typically increases as the number of minutiae increases, the source diagnosticity ranges at a given number of minutiae until a theoretical maximum threshold is achieved (e.g., a rolled fingerprint). Below this theoretical maximum threshold, source diagnosticity for a given cluster depends on anatomical region, the density of the minutiae, the influence of pattern force, the orientation of the minutiae, the distance between the minutiae, and the population of donors under consideration [19.2, 19.24, 19.25, 19.26, 19.27]

5.1.6.3. **Incipient Ridges**:

5.1.6.3.1. Search Diagnosticity:

5.1.6.3.1.1. The search diagnosticity for incipient ridges is generally low because incipient ridges can appear throughout the friction ridge skin and, unlike the ridges and minutiae, are not generally subject to pattern force.

5.1.6.3.2. Source Diagnosticity:

5.1.6.3.2.1. In general, as the number of incipient ridges within an impression increases, the source diagnosticity of the impression also increases.

5.1.6.4. **Dissociated Ridges**:

5.1.6.4.1. Search Diagnosticity:

5.1.6.4.1.1. The search diagnosticity for dissociated ridges is generally low because dissociated ridges can appear anywhere in the friction ridge skin.

5.1.6.4.2. Source Diagnosticity:

5.1.6.4.2.1. In general, as the number of dissociated ridges within an impression increases, the source diagnosticity of the impression also increases.

5.1.6.5. **Ridge flow**:

5.1.6.5.1. Search Diagnosticity:

5.1.6.5.1.1. The search diagnosticity of ridge flows is generally high because the ridge flows follow a predictable distribution in the human population for each region of the friction ridge skin. [19.3, 19.4, 19.5]

5.1.6.5.2. Source Diagnosticity:

5.1.6.5.2.1. Generally, the source diagnosticity of ridge flows is low. Ridge flows tend to show significant left/right symmetry within a person. This symmetry is more pronounced within the corresponding hands of monozygotic twins. [19.3]

5.1.6.6. **Pattern Elements – Recurves and Triradii**:

5.1.6.6.1. Search Diagnosticity:

5.1.6.6.1.1. The search diagnosticity of pattern elements is generally high because patterns follow a predictable distribution within human populations for each region of the friction ridge skin. [19.2, 19.3, 19.5, 19.6, 19.8, 19.13, 19.14, 19.15, 19.35]

5.1.6.6.2. Source Diagnosticity:

5.1.6.6.2.1. The source diagnosticity of pattern elements is generally low. Patterns tend to show significant left/right symmetry within a person. This symmetry is more pronounced within the corresponding hands of monozygotic twins. [19.15, 19.25, 19.26]

5.1.6.6.2.2. The source diagnosticity of a pattern element or group of pattern elements depends on the population under consideration and the region of skin within which it resides. For instance, whorls are less common in the interdigital regions of palms than the interdigital regions of feet based on population frequencies in the United States. [19.13, 19.14]

5.1.6.7. **Regular Creases**:

5.1.6.7.1. Search Diagnosticity:

5.1.6.7.1.1. The search diagnosticity of the regular creases is generally high because the regular creases follow predictable distributions within human populations for each region of the friction ridge skin. [19.28, 19.29]

5.1.6.7.2. Source Diagnosticity:

5.1.6.7.2.1. The source diagnosticity of the number, configuration, and position of the regular creases is generally low. These attributes tend to show significant left/right symmetry within a person. This symmetry is more pronounced within the corresponding hands of monozygotic twins. [19.30, 19.31, 19.32]

5.1.6.7.2.2. The source diagnosticity of the width, length, curvature, and direction of the regular creases is low to moderate. These attributes often show significant left/right symmetry within a person and similarity within the corresponding hands of monozygotic twins. [19.30, 19.31, 19.32]

5.1.6.7.2.3. The source diagnosticity of the edge shapes and branching of a crease is expected to range from moderate to high. These attributes can show significant left/right symmetry within a person and similarity within the corresponding hands of monozygotic twins. [19.30, 19.31, 19.32]

5.1.6.8. **Irregular Creases**:

5.1.6.8.1. Search Diagnosticity:

5.1.6.8.1.1. The search diagnosticity of the number, density, width, length, curvature, and direction of irregular creases depends on the region of skin under consideration. The search diagnosticity of these attributes is higher for thenars of palms, proximal and medial phalanges of the fingers, and the arches of the feet because a high density of creases is expected in these regions. Elsewhere in the friction ridge skin the irregular creases are more variable, and consequently less useful for search diagnosticity. [19.3]

5.1.6.8.2. Source Diagnosticity:

5.1.6.8.2.1. The source diagnosticity of the number, density, width, length, curvature, and direction of irregular creases depends on the region of skin considered. The source diagnosticity is lower for palm thenars, proximal and medial phalanges

of the fingers, and the arches of the feet because a high density of creases is expected in these regions. Elsewhere in the friction ridge skin the irregular creases are more variable, and consequently displaying higher source diagnosticity.

5.1.6.8.2.2. The source diagnosticity of the branching and angles of intersection of irregular creases is expected to range from moderate to high. These attributes can show significant left/right symmetry within a person and similarity within the corresponding hands of monozygotic twins. [19.30, 19.31, 19.32]

5.1.6.9. **Wrinkles**:

5.1.6.9.1. Search Diagnosticity:

5.1.6.9.1.1. The search diagnosticity for wrinkles is generally low because wrinkles can appear anywhere in the friction ridge skin.

5.1.6.9.2. Source Diagnosticity:

5.1.6.9.2.1. In general, as the number of wrinkles within an impression increases, the source diagnosticity of the impression also increases.

5.1.6.10. **Scars**:

5.1.6.10.1. Search Diagnosticity:

5.1.6.10.1.1. The search diagnosticity for scars is generally low because scars can appear anywhere in the friction ridge skin.

5.1.6.10.2. Source Diagnosticity:

5.1.6.10.2.1. In general, as the number or complexity of a scar within an impression increases, the source diagnosticity of the impression also increases.

5.1.6.11. **Unstable features**:

5.1.6.11.1. Search Diagnosticity:

5.1.6.11.1.1. The search diagnosticity for unstable features is generally low because unstable features can appear anywhere in the friction ridge skin.

5.1.6.11.2. Source Diagnosticity:

5.1.6.11.2.1. In general, as the number or complexity of an unstable feature within an impression increases, the source diagnosticity of the impression also increases.

5.1.6.12. **Shape of the Impression**:

5.1.6.12.1. Search Diagnosticity:

5.1.6.12.1.1. The search diagnosticity of size, outline, and non-ridged skin border of an impression is generally high because the size, contours, and skin type transitions of human hands and feet are generally shared in the population. [19.3, 19.6, 19.33, 19.34]

5.1.6.12.2. Source Diagnosticity:

5.1.6.12.2.1. The source diagnosticity of the shape of an impression is low. Hands and feet tend to show significant left/right symmetry within a person and similarity within the corresponding hands of monozygotic twins.

5.2. Factors affecting the appearance of features should be considered when conducting friction ridge examinations and interpreting the features and their attributes.

5.2.1. Variation in the appearance of the features can originate from biological causes or the result of physical contact. Biological factors are those factors affecting the stability of the feature over time in the friction ridge skin (e.g., aging) or the typical development of the feature (e.g., syndactyly). Contact factors are those factors that can affect the appearance of the features when they are recorded in an impression.

5.2.2. The following factors are common causes for features to vary in appearance over time or due to circumstances of touch. These factors are not meant to be exhaustive of all possibilities.

5.2.2.1. Adolescent growth – growth of the hand or foot from the time the ridges form until adult size is attained (typically late teens).

5.2.2.2. Aging – changes in the friction ridge skin that take place because of the natural aging process; typically, these changes begin after the age of forty.

5.2.2.3. Injury – physical damage to the hand, foot, or friction ridge skin that elicits a wound healing response (e.g., cut or burn); certain injuries can result in the formation of a scar.

5.2.2.4. Disease – disorder in the structure or function of the skin that produces specific signs or symptoms and is not related to a physical injury (e.g., wart, psoriasis, or acquired ridge aplasia).

5.2.2.5. Hand flexion – the degrees to which the digits can be flexed at the joints or the rotation of the thumb.

5.2.2.6. Abduction of digits – the degrees to which the digits can be spread apart from one another.

5.2.2.7. Angle of contact – the position of the hand or foot with respect to the surface during contact.

5.2.2.8. Compressive stress – the squeeze of the skin between the bone structure of the hand or foot and a surface (also referred to as "deposition pressure").

5.2.2.9. Shearing stress – tangential force applied to the skin (also referred to as "lateral pressure").

5.2.2.10. Torque – rotational force applied to the skin.

5.2.2.11. Residue factors – any factors related to the residue on the skin that can affect the recording of the skin (e.g., initial composition of the residue, distribution of residue on the skin, or redistribution of residue in an impression due to skin moving on a surface).

5.2.2.12. Surface conditions – any factors related to the surface that affect the recording of the skin (e.g., texture, curvature, pliability, or contaminants).

5.2.2.13. Environmental factors – any factors related to the environment (e.g., temperature, humidity, UV exposure, or time) that affect the appearance of the features after the impression is recorded on a surface.

5.2.2.14. Post-deposition factors – any non-environmental factors that affect an impression (e.g., overlays with other impressions or smearing caused by an object touching an impression).

5.2.2.15. Processing technique – method used to develop the features of a latent impression; each method has a signature appearance that can vary, typically because of residue issues or surface conditions.

5.2.2.16. Recovery method – manner in which an impression is preserved (e.g., lift or photograph) that causes distortion (e.g., crease in tape, lens distortion, poor lighting, poor focus, low resolution).

5.2.2.17. Electronic capture error – inaccurate recording of a feature by an automated device (e.g., livescan stitching error, image acquisition or processing fidelity).

5.2.2.18. Atypical anatomy – any deviation from the typical range of shape, size, or proportions of the human hand or foot or any disruption in the formation of the skin driven by genetic or epigenetic factors (e.g., syndactyly or congenital ridge aplasia). Atypical anatomy does not cause issues related to biological stability or recordability of the features; however, if it is not recognized during analysis, it can cause an examiner to underestimate or overestimate the source diagnosticity or search diagnosticity of a given feature set.

6. Appendix A: Ridges

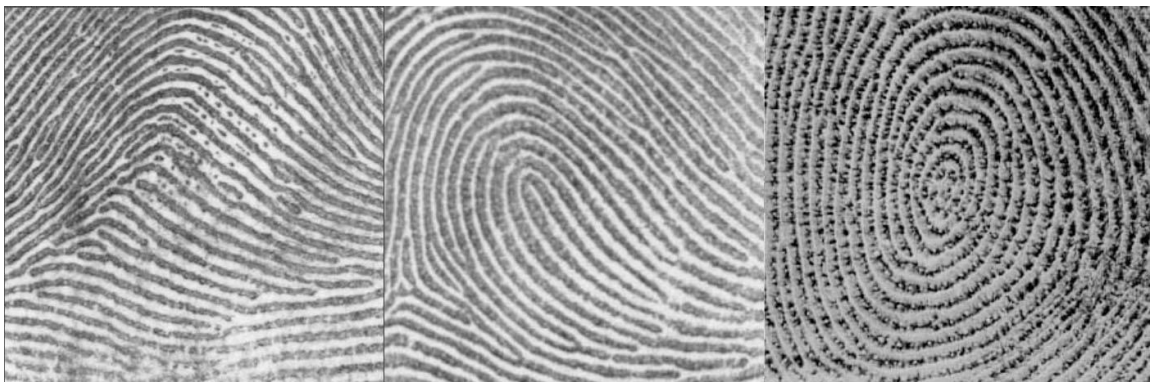


Figure 1 – Examples of ridges in the distal phalanges of the hand.

Ridge Attributes

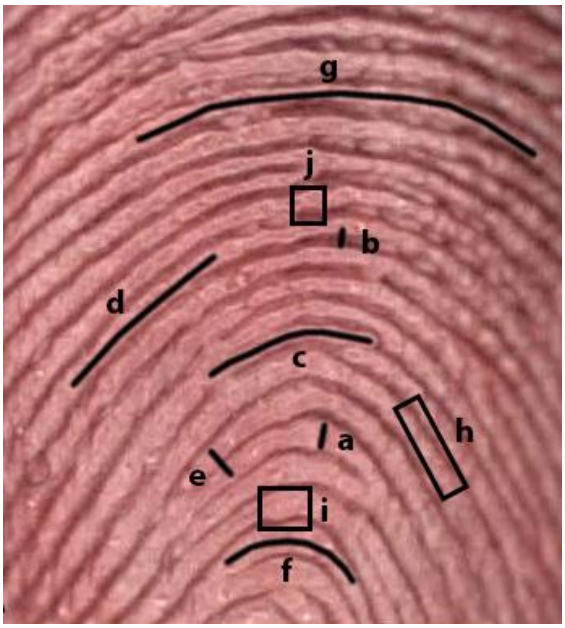
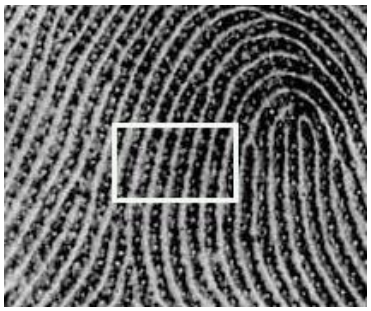
Attribute	Example
Ridge Width (a) Furrow Width (b) Length • Full Length (c) • Partial Length (d) Spacing (e) Curvature (f and g) Edge Shape • Generally Straight (h) • Protrusion (i) • Intrusion (j) Pore Position • Pore to edge of ridge (k) • Pore to Pore (l)	 Figure 2 – Distal phalange photographed touching glass.
Open Field	 Figure 3 –The corresponding open field is noted in the white box.

Table 1 – Examples of attributes of ridges.

7. Appendix B: Minutiae

Minutiae Attributes

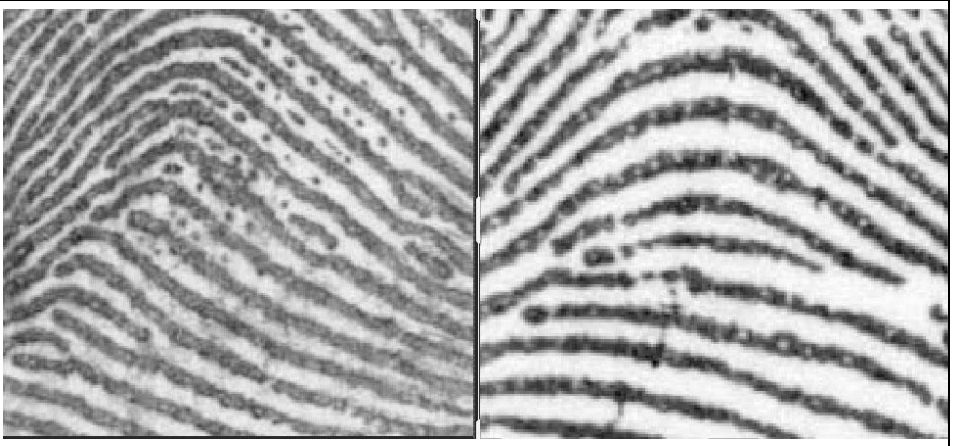
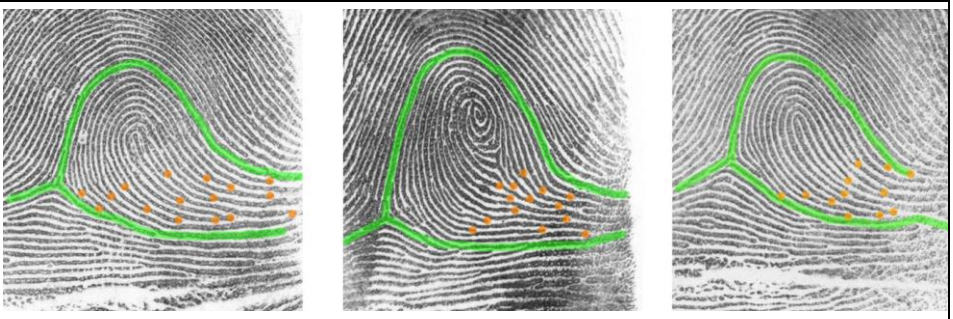
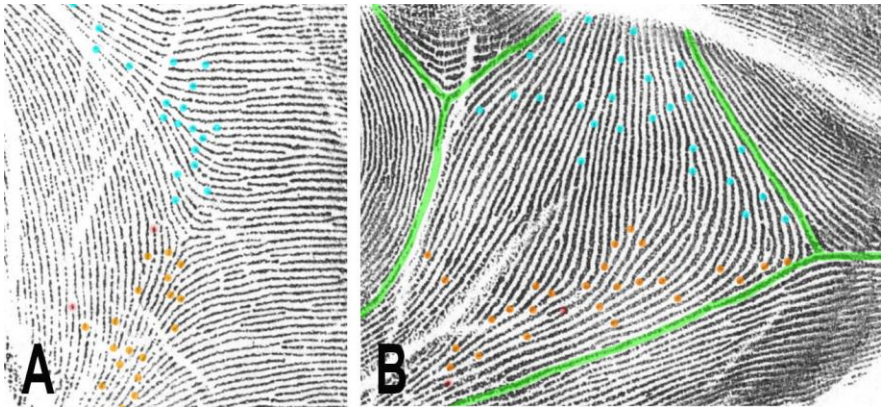
Attribute	Example
Number Density	 Figure 4 –The image on the left has more minutiae and higher minutiae density than the image on the right.
Orientation Pattern Force Minutiae Counter pattern Force Minutiae	 Figure 5 - Pattern force minutiae sharing orientation in the outflow of a right loop on a distal phalange.
	 Figure 6 - Pattern force minutiae (orange and blue) and counter pattern force minutiae (red) in palm impressions.

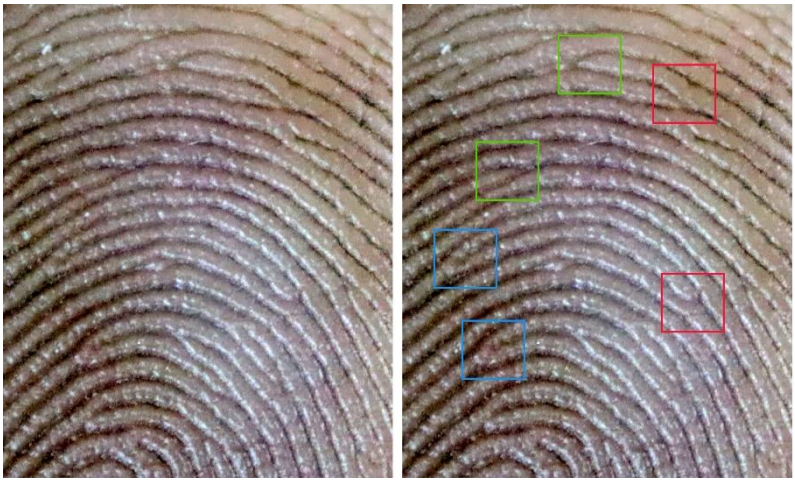
	 Figure 7 - Minutiae (non-pattern force) in a distal phalange of a hand above the core of a left loop.
Connectedness • Ending Ridge • Bifurcation • Ambiguous	 Figure 8 – Ending ridges (green), bifurcations (blue), and ambiguous minutiae (red) in a distal phalange.
Compound Minutiae	See Table 3

Table 2 – Examples of attributes of minutiae.

Compound Minutia Types

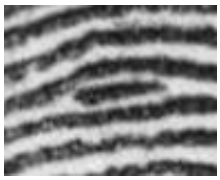
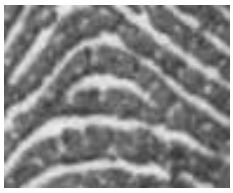
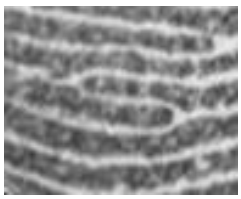
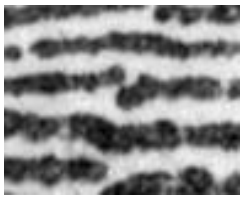
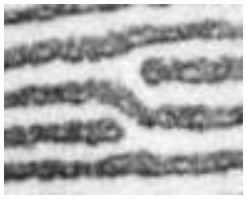
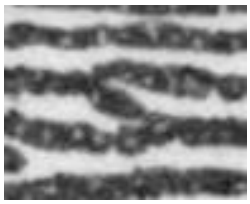
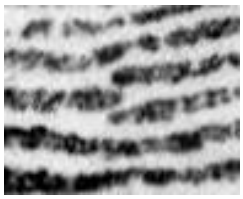
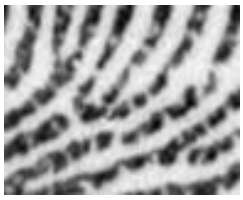
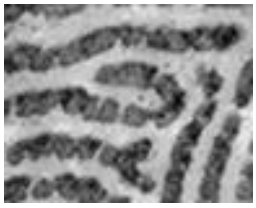
Minutia Type	Definition	Example
Short Ridge	An independent ridge (defined by two ending ridges) with a length that is less than ten times the average width of the ridge.	 Figure 9 – Short ridge
Dot	An independent ridge with a length that is less than two times the average width of the ridge.	 Figure 10 – Dot
Break	A site along the ridge where the course of the ridge is interrupted, like a sink hole in the ridge. This length of the discontinuity is at least the width of the ridge, but no longer than twice the width of the ridge.	 Figure 11 – Break
Enclosure	A minutia defined by the merger of both ends of a short ridge with a neighboring ridge (defined by two bifurcations directed toward each other). The distance between the bifurcations is less than ten times the average width of the ridges.	 Figure 12 – Enclosure
Overlap	Where two ridges meet and overlap. The length of overlap is less than ten times the average width of the ridges.	 Figure 13 – Overlap
Spur	A minutia defined by the merger of one end of a short ridge with a neighboring ridge (defined by one bifurcation and one ending ridge). The distance between the ending ridge and bifurcation is less than ten times the average width of the ridges.	 Figure 14 – Spur
Crossbar	A ridge that alters its course to zig-zag around other minutiae, similar to a train switching tracks. The transfer zone is less than ten times the average width of the ridges.	

		Figure 15 – Crossbar
Bridge	A minutia defined by the merger of a short ridge with two neighboring ridges. The path of the bridge tends not to be parallel to the neighboring ridges and the length of the bridge is no longer than five times the average width of the ridges.	 Figure 16 – Bridge
Opposing Bifurcations	A minutia defined by two bifurcations directed away from each other. The distance between the two bifurcations is less than five times the average width of the ridges.	 Figure 17 – Opposing Bifurcations
Dock	A minutia defined by an overlapping cluster of three ridge endings where the center ridge ending is in the opposite direction of the other two ridge endings and the length of overlap on each side of the center ridge is less than ten times the average width of the ridges.	 Figure 18 – Dock
Ending Ridge + Bifurcation Combination	A minutia defined by the end of a ridge leading to a bifurcation. The distance between the end of the ridge and the bifurcation is less than five times the average width of the ridges.	 Figure 19 – Ending Ridge plus Bifurcation
Trifurcation/Double Bifurcation	A minutia defined by the merger of three ridges into one. This minutia type can appear as a trifurcation when the three ridges emanate from a common vertex or a double bifurcation when one ridge is not centered on a vertex with the other two ridges. The merger of the three ridges is contained within a distance less than three times the average width of the ridges.	 Figure 20 – Trifurcation / Double Bifurcation
Return	The location along an independent ridge where the ridge makes a 180^{o} turn and the return is not part of a recurve associated with a tented arch, loop or whorl pattern.	 Figure 21 – Return

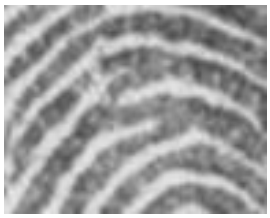
Merge Point	The merger of the legs of two bifurcations into one ridge. The mergers (the points of the "M") are contained within a distance less than five times the average width of the ridges.	 Figure 22 – Merge Point

Table 3 – Examples of compound minutiae.

8. Appendix C: Incipient Ridges

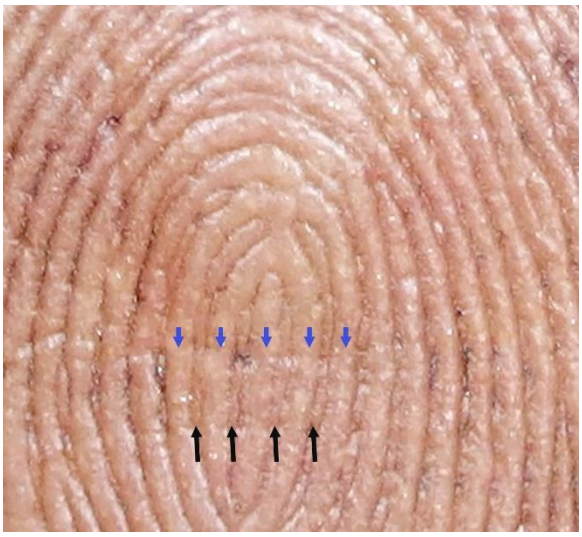


Figure 23 – Mature ridges and incipient ridges (selected incipient ridges are noted with black arrows and mature ridges are noted with blue arrows).

Incipient Ridge Attributes

Attribute	Example
Number Density	 Figure 24 – The distal phalange on the left has fewer incipient ridges and lower incipient ridge density than the distal phalange on the right.

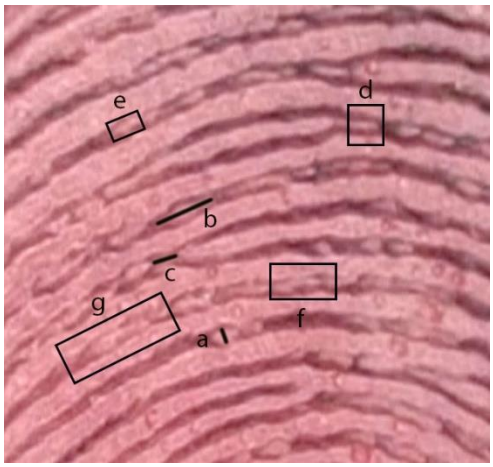
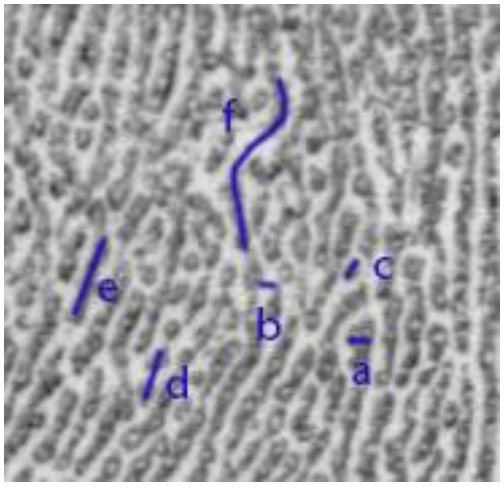
Width (a) Length (b) Inter-Incipient Gap (c) Edge Shapes • Generally Straight (d) • Protrusion (e) • Intrusion (f) Direction (g)	 Figure 25 – Distal phalange photographed touching glass.

Table 4 – Examples of attributes of incipient ridges

9. Appendix D: Dissociated Ridges

Dissociated Ridge Attributes

Attribute	Example
Number Density	 Figure 26 – Impressions displaying dissociated ridges. The impression on the left has fewer dissociated ridges and a lower density of dissociated ridges (within the surface area of the rolled impressions) compared to the impression on the right.
Ridge Width (a) Furrow Width (b) Length (c) Spacing (d) Direction (e) Curvature (f)	 Figure 27 –Impression of a distal phalange displaying dissociated ridges.

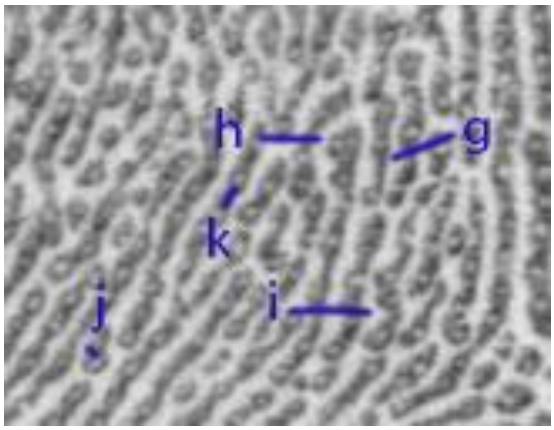
Edge Shape • Generally Straight (g) • Protrusion (h) • Intrusion (i) Pore Position • Pore to edge of ridge (j) • Pore to Pore (k)	 Figure 28 – Impression of a distal phalange displaying dissociated ridges.
Connectedness	See connectedness examples under Minutiae

Table 5 – Examples of attributes of dissociated ridges

10. Appendix E: Ridge Flows

Examples of Ridge Flows

Examples	Examples
 Figure 29 – Tented arch pattern from a distal phalange.	 Figure 30 – Thenar area of the palm.
 Figure 31 – Hypothenar of a right palm.	 Figure 32 – Medial phalange.

Table 6 – Examples of ridge flows.

Ridge Flow Attributes

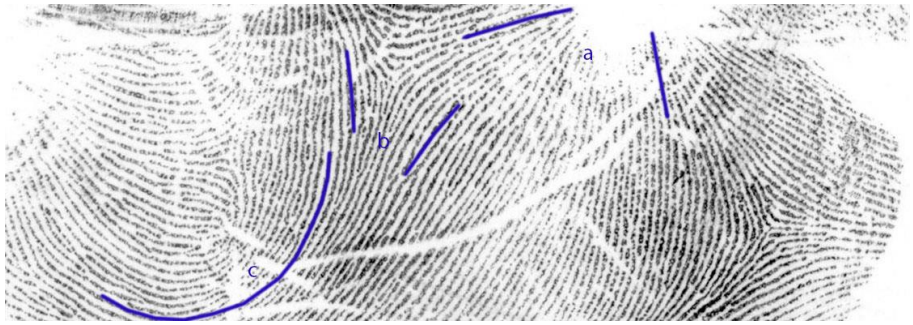
Attribute	Example
Divergence (a) Convergence (b) Curvature (c)	 Figure 33 – Palm interdigital displaying ridge flow attributes.

Table 7 – Examples of attributes of ridge flow.

11. Appendix F: Pattern Elements – Recurves and Triradii

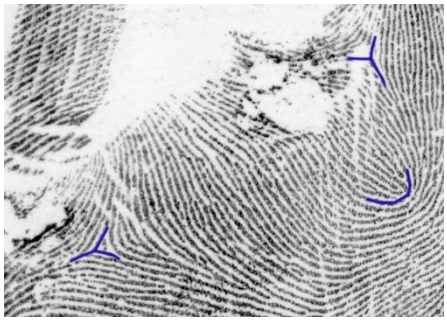
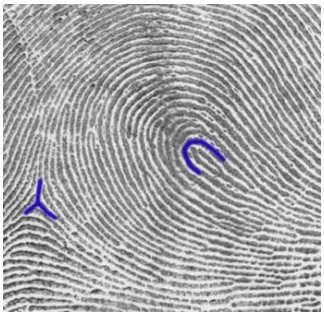
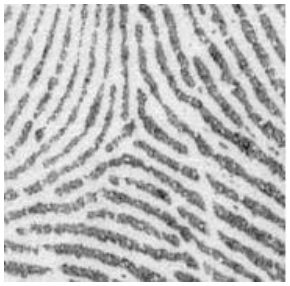
Examples	Examples
 Figure 34 – Palm interdigital with one recurve and two triradii.	 Figure 35 – Distal phalange with one recurve and one triradii.

Table 8 – Examples of recurves and triradii.

Pattern Element Attributes

Attribute	Example
Number	 Figure 36 – Palm displaying two pattern elements (one recurve and one triradius).
Triradius Angle	 Figure 37 – Three angles associated with a triradius.

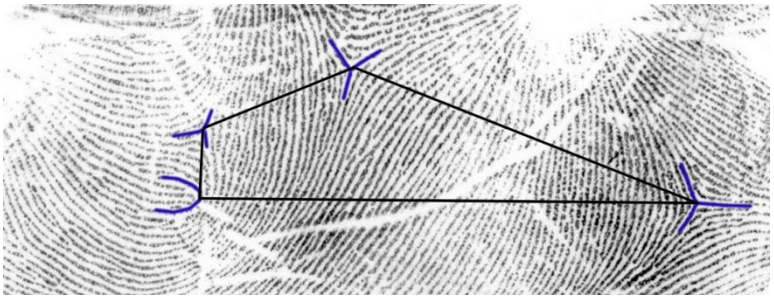
Recurve Ridge Count Recurve Direction	 Figure 38 – Recurves of a double loop whorl in a distal phalange displaying different recurve ridge counts and recurve directions.
Pattern Element Relationships	 Figure 39 – Relationships (black lines) between recurves and triradii in a palm interdigital.

Table 9 – Examples of attributes of pattern elements

12. Appendix G: Regular Creases

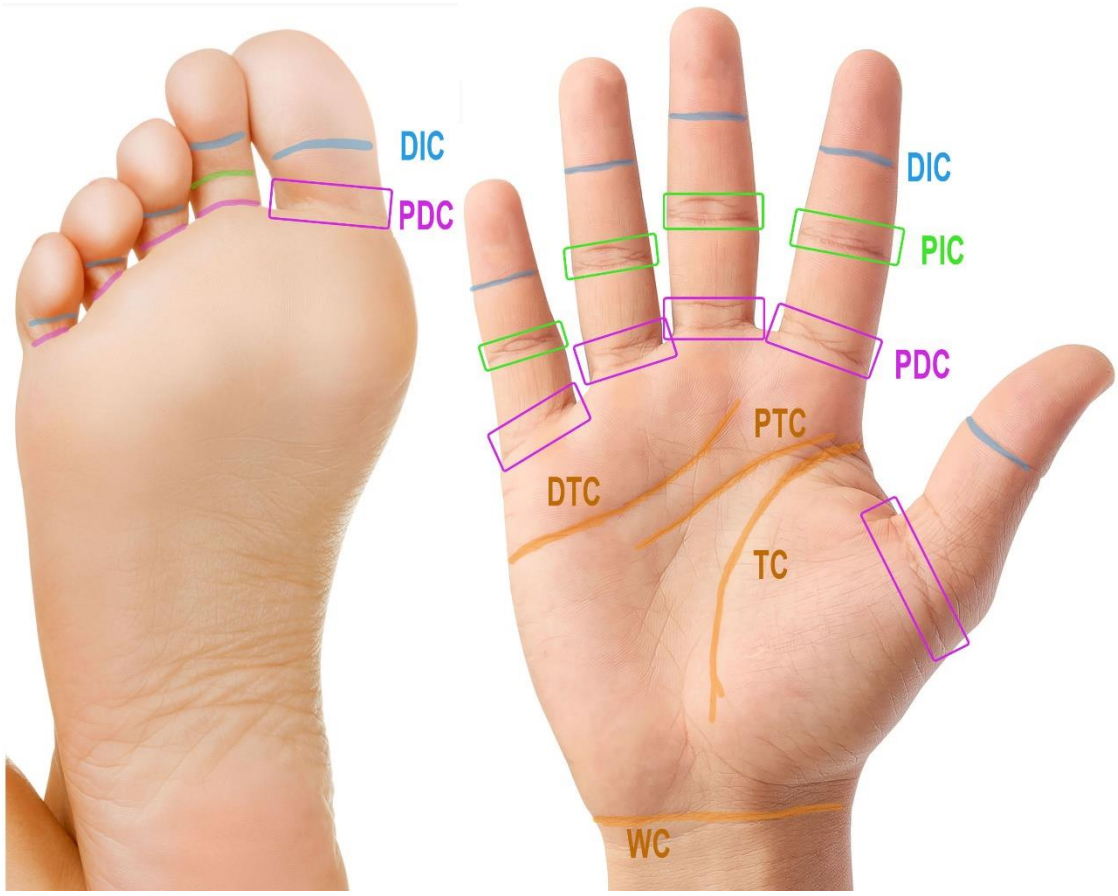


Figure 40 – Regular Creases of the Palm and Foot: DIC – Distal Interphalangeal Crease; PIC – Proximal Interphalangeal Crease; PDC – Palmar Digital Crease/ Plantar Digital Crease; DTC – Distal Transverse Crease; PTC – Proximal Transverse Crease; TC – Thenar Crease; WC – Wrist Crease.

Regular Crease Attributes

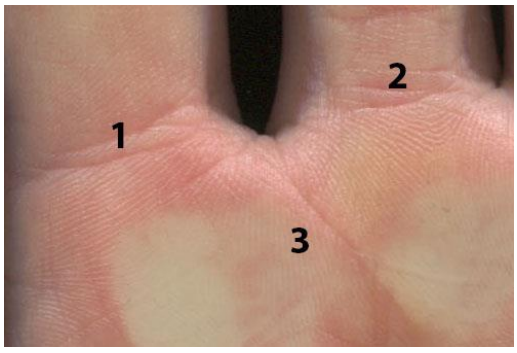
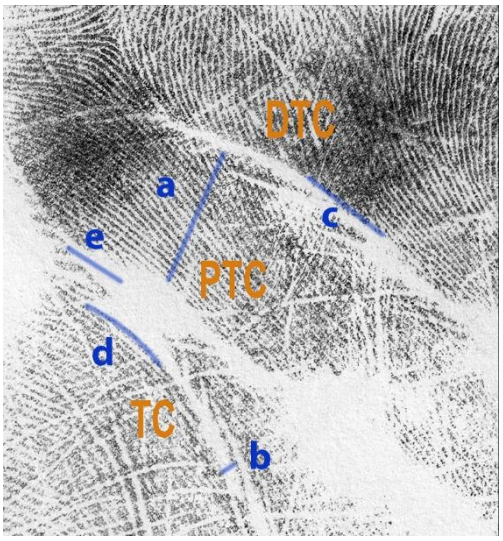
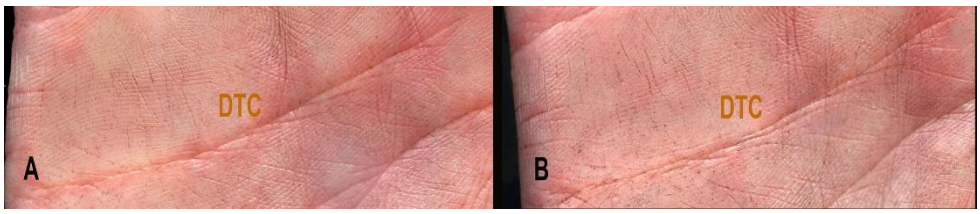
Attribute	Example
Number	

	Figure 41 – Palm with two palmar digital creases and a distal transverse crease.
Configuration	 Figure 42 – Palmar digital crease configured as a single, braided crease and a double crease.
Spacing (a) Width (b) Length • Partial (c) Curvature (d) Direction (e) Position	 Figure 43 – Attributes of regular creases. The positions of the creases in the hand are consistent with the distal transverse crease, proximal transverse crease and the thenar crease.
Edge Shapes	 Figure 44 – Images of palms touching glass. Edge shapes of the distal transverse crease can be observed in the skin from both palms.

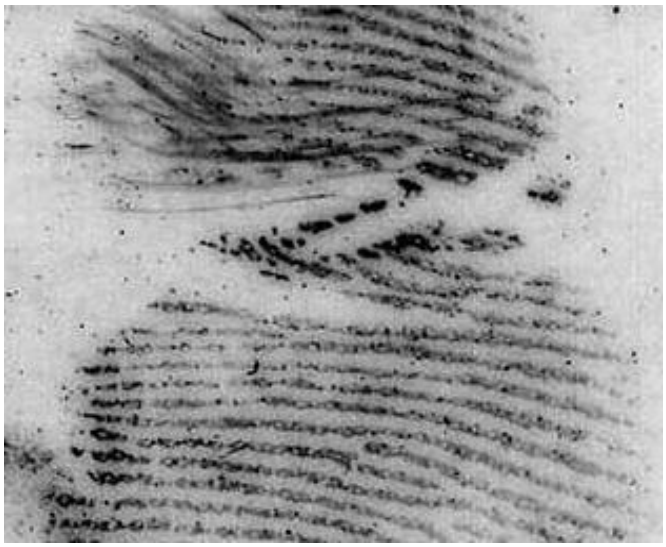
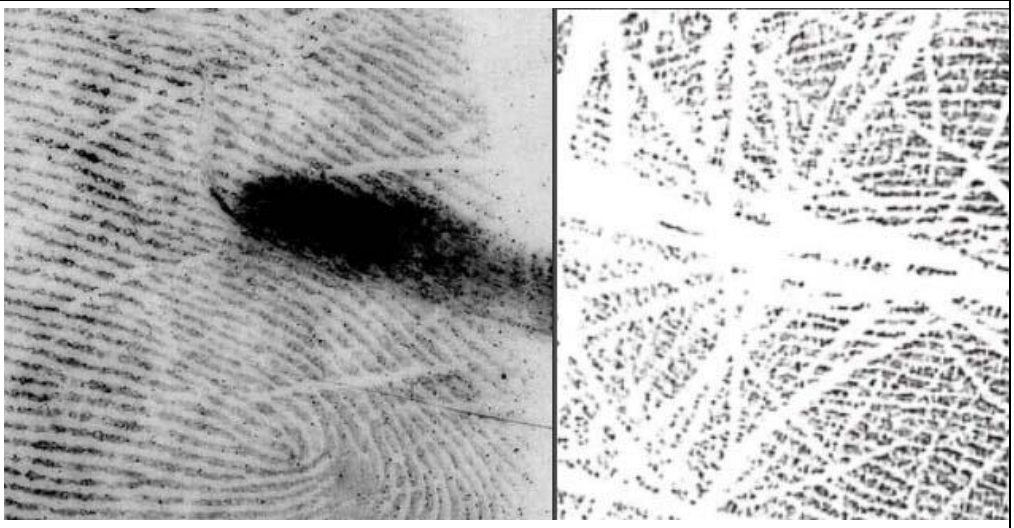
Branching	 Figure 45 – Pattern of branches of the distal transverse crease can be observed in the impression.

Table 10 – Examples of attributes of regular creases

13. Appendix H: Irregular Creases and Wrinkles

Figure 46 – Irregular creases in the medial phalange of a finger (left) and the thenar region of a palm (right).

Irregular Crease and Wrinkle Attributes

Attribute	Example
Number Density	 Figure 47 – A right palm impression on the left has a fewer irregular creases and wrinkles and lower density of irregular creases and wrinkles than the impression on the right.

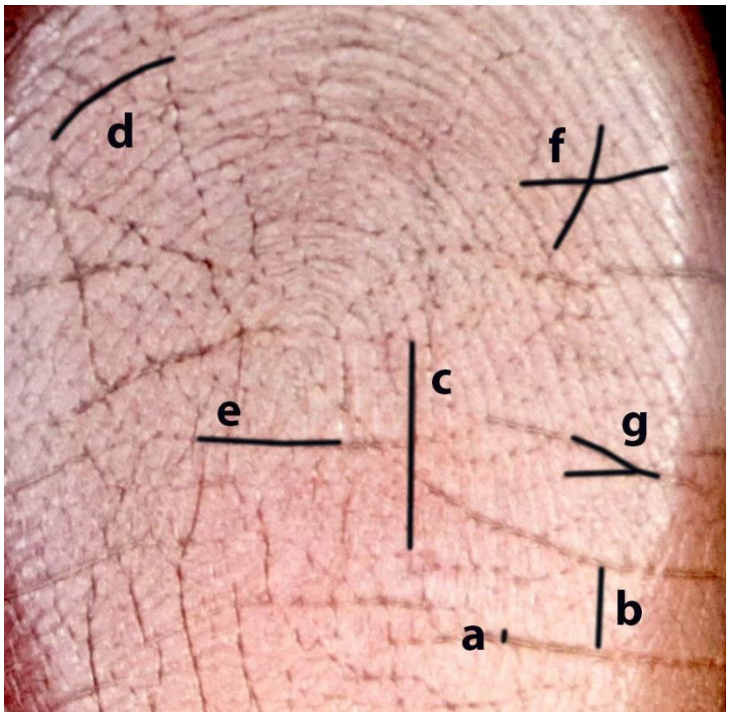
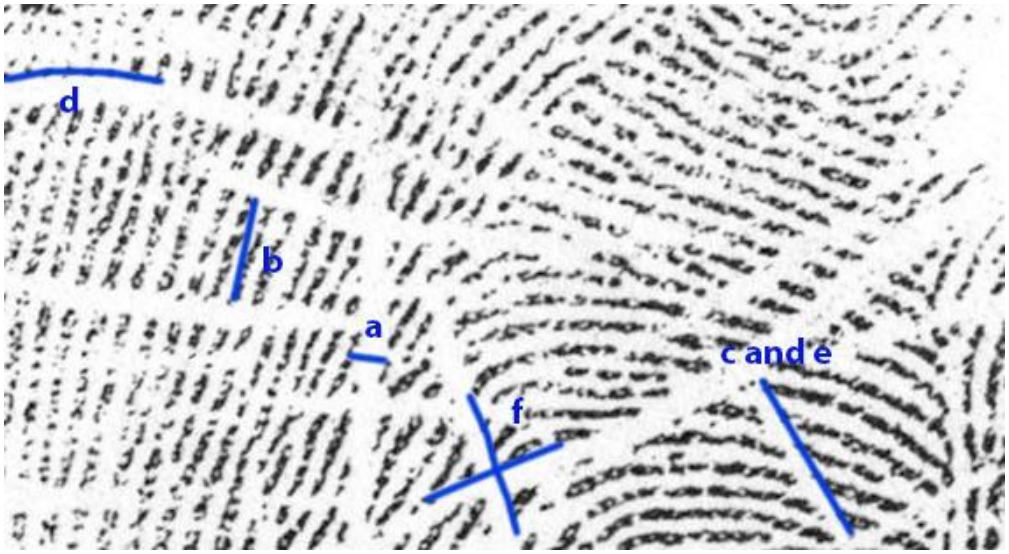
Width (a) Spacing (b) Length (c) Curvature (d) Direction (e) Angle of Intersection (f) Branching (g)	 Figure 48 – Distal phalange with labeled wrinkle attributes.  Figure 49 – Thenar area labeled irregular creases attributes.

Table 11 – Examples of attributes of irregular creases and wrinkles.

14. Appendix I: Scars

Figure 50 – Examples of scars from inked impressions.

Scar Attributes

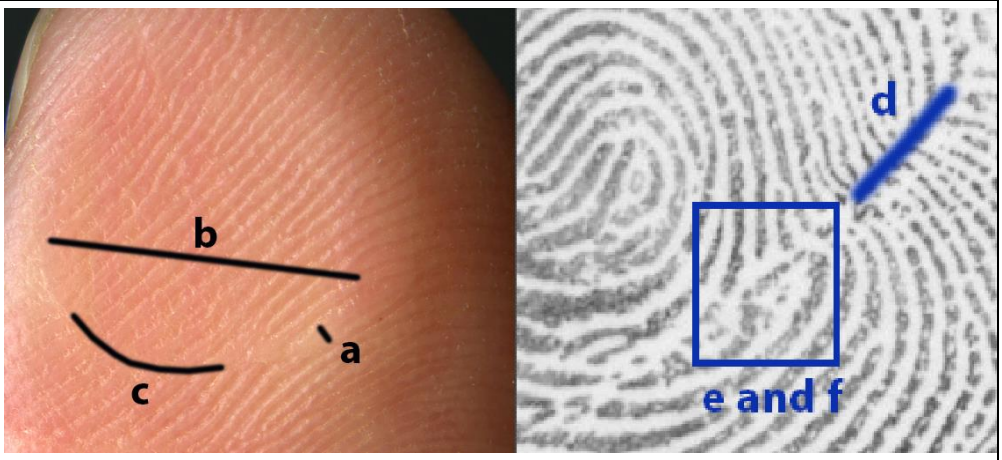
Attribute	Example
Width (a) Length (b) Surface Area Curvature (c) Direction (d) Created Minutiae (e) Edge Shapes (f)	 Figure 51 – Distal phalanges that present scarring.

Table 12 – Examples of attributes of scars.

15. Appendix J: Unstable Features

Figure 52 – Examples of unstable features.

Unstable Feature Attributes

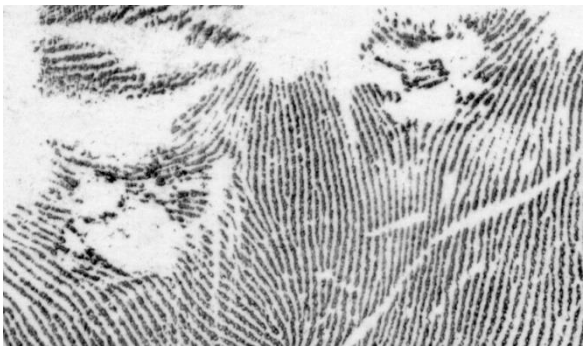
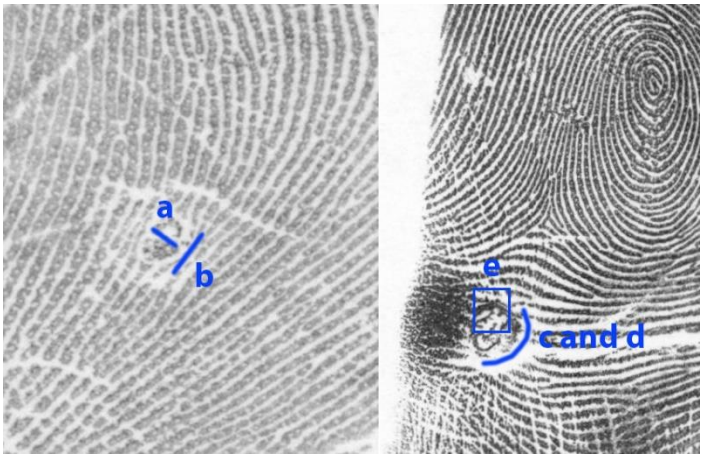
Attribute	Example
Number	 Figure 53 – Palm interdigital with two calluses.
Width (a) Length (b) Surface Area Curvature (c) Direction (d) Edge Shapes (e)	 Figure 54 – Attributes of the unstable feature (warts) are labeled; note the surface area would require a complex calculation.

Table 13 – Examples of attributes of unstable features.

16. Appendix K: Shape of Impression

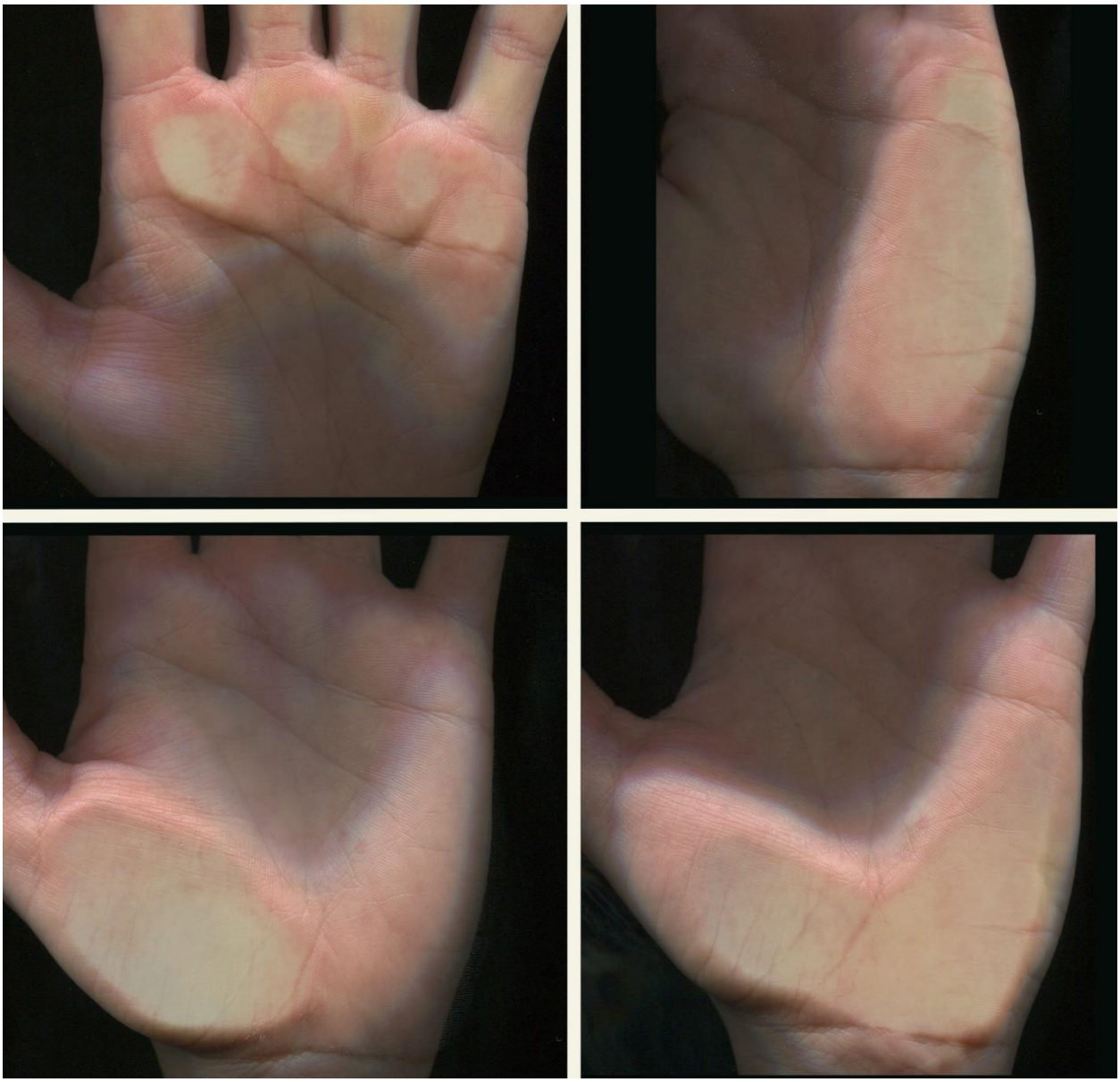


Figure 55 – Different areas of the palm touching glass.

Shape Attributes

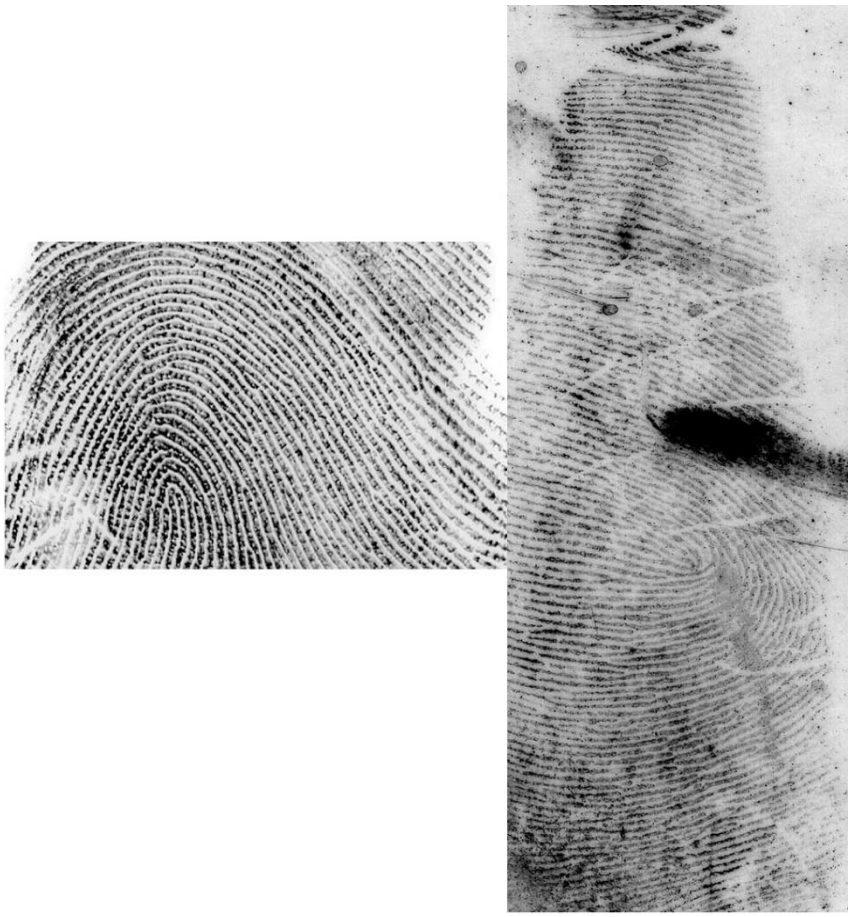
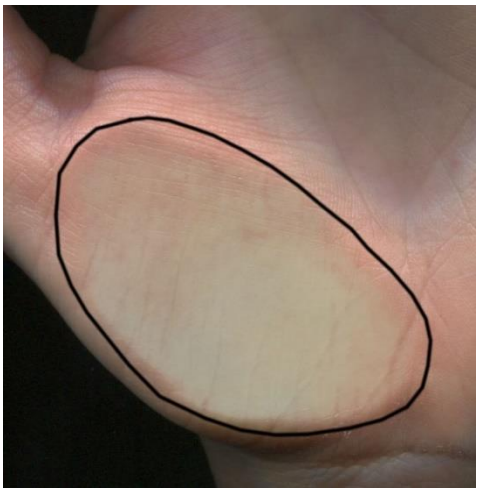
Attribute	Example
Surface Area	 Figure 56 – The surface area of the distal phalange (left) is significantly less than the surface area of a right palm hypothenar (right).
Outline	 Figure 57 – There are natural borders caused by the hand and unnatural borders caused by the cropping of the image. The natural outer borders are traced in black.

Table 14 – Examples of attributes of shape of an impression.

17. Appendix L: Feature Sets and Relationships – Search Diagnosticity and Source Diagnosticity

Image	Discussion
 Figure 58 – Impression from a left palm.	The shape, ridge flow and triradius indicate palm. There is what appears to be a large crease dissecting the ridge flow. This could be the distal transverse crease based on its width and pattern of branching. The triradius angles are most consistent with the triradius under the index finger. Using the triradius as an anchor point, the triradii of all palms must be sufficiently recorded to support an exclusion. If the triradii are poorly recorded or failed to record in the exemplars, the broader ridge flow (to the left of the triradius as positioned) and its proximity to the triradius may provide enough support for exclusion if the exemplars appear to have areas near the triradii adequately recorded. Subsets of the feature set in the impression are adequate to support an identification (i.e., the entire area represented in the impression does not need to be recorded in the exemplar print).
 Figure 59 – Impression of a proximal, medial and partial distal phalange.	Shape, regular creases, irregular creases, ridge flows and pattern elements indicate distal, medial, and proximal phalanges of a finger with orientation shown. All three segments of the finger contain ridge detail; however, the distal phalange area is not adequately present. A standard fingerprint card does not provide fully rolled medial and proximal phalanges. Additional sufficiently recorded lower phalanges of all fingers (thumbs not required as the presence of three segments eliminates the thumbs as donor regions) are required to conduct comparisons. Subsets of the feature set in the impression are adequate to support an identification (i.e., the entire area represented in the impression does not need to be recorded in the exemplar print).

Table 15 – Examples of feature sets and search and source diagnosticity

18. Appendix M: Quick Reference Summary Table

	Attributes	Search Diagnosticity	Source Diagnosticity
Ridges	▪ Number ▪ Ridge Width ▪ Furrow Width ▪ Length ▪ Spacing ▪ Direction ▪ Curvature ▪ Edge Shapes ▪ Pore Position ▪ Open Field	Low	▪ In general: surface area increases, source diagnosticity increases ▪ In general: open field increases in size, source diagnosticity of the open field increases
Minutiae	▪ Number ▪ Density ▪ Orientation ▪ Connectedness ▪ Compound Minutiae ▪ Pattern Force Minutiae ▪ Counter Pattern Force Minutiae	Cluster of minutiae in a pattern force area generally increases search diagnosticity Cluster of minutiae in a non-pattern force area generally decreases search diagnosticity	▪ In general: number increases, source diagnosticity increases ▪ Minutiae in a pattern force area can decrease source diagnosticity ▪ For a given cluster: depends on anatomical region, density of the minutiae, orientation of the minutiae, distance between the minutiae, population of donors under consideration
Incipient Ridges	▪ Number ▪ Density ▪ Width ▪ Length ▪ Direction ▪ Inter-Incipient Gap ▪ Edge Shapes	Low	▪ In general: number increases, source diagnosticity increases
Dissociated Ridges	▪ Number ▪ Density ▪ Ridge Width ▪ Furrow Width	Low	▪ In general: number increases, source diagnosticity increases

	Attributes	Search Diagnosticity	Source Diagnosticity
	▪ Length ▪ Spacing ▪ Direction ▪ Curvature ▪ Edge Shapes ▪ Pore Position ▪ Connectedness		
Ridge Flows	▪ Curvature ▪ Convergence ▪ Divergence	High, elevated in combination with additional features (e.g., shape or regular creases)	▪ Low
Pattern Elements: Recurves and Triradii	▪ Number ▪ Triradius Angle ▪ Recurve Ridge Count ▪ Pattern Element Relationships ▪ Recurve Direction	High	▪ Low ▪ Value depends on the region of skin
Regular Creases	▪ Number ▪ Configuration ▪ Spacing ▪ Position ▪ Width ▪ Length ▪ Curvature ▪ Direction ▪ Edge shapes ▪ Branching	High	▪ Low (number, configuration, position) ▪ Low to moderate (width, length, curvature, direction) ▪ Moderate to high (edge shapes, branching)
Irregular Creases	▪ Number ▪ Density ▪ Width ▪ Length ▪ Curvature ▪ Direction ▪ Branching ▪ Angle of intersection ▪ Spacing	▪ Higher in palm thenars, proximal and medial phalanges of the fingers, arches of the feet ▪ Lower in other regions of skin	▪ Lower in palm thenars, proximal and medial phalanges of the fingers, arches of the feet ▪ Higher in other regions of skin ▪ Branching and angles of intersections moderate to high
Wrinkles	▪ Number	Low	▪ More wrinkles, higher source diagnosticity

	Attributes	Search Diagnosticity	Source Diagnosticity
	▪ Density ▪ Width ▪ Length ▪ Curvature ▪ Direction ▪ Branching ▪ Angles of intersection ▪ Spacing		
Scars	▪ Number ▪ Width ▪ Length ▪ Surface Area ▪ Curvature ▪ Direction ▪ Created Minutiae ▪ Edge shapes	Low	▪ The more complex and frequent, the higher the source diagnosticity
Unstable Features	▪ Number ▪ Width ▪ Length ▪ Surface Area ▪ Curvature ▪ Direction ▪ Edge shapes	Low	▪ The more complex and frequent, the higher the source diagnosticity
Shape of the Impression	▪ Surface area ▪ Outline ▪ Non-Ridged Skin Border	High	Low

Table 16 – Quick Reference Summary Table

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20. Appendix O: Change Log

Version	Date	Change
1.0	09/2023	Original Issue