IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 3, March 2022

DOI: 10.17148/IARJSET.2022.9338

RECENT TECHNIQUES FOR TOOLMARK EXAMINATION: A REVIEW

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Abstract: Toolmark examination plays a very important role in identification of weapon used during scene of crime. Further toolmark provide a link between suspect and incidence of crime in many cases like burglary, robbery, theft, murder, suicide, assault and forged cases. Documentation of toolmarks done in following steps like photography, collection, packaging, transportation, analysis of toolmark and result report presentation in court. In this paper, reviewing the recent techniques developed for toolmark examination and also mention the technique used nowadays. Firstly, Photography of toolmark was done using digital camera. Collection of toolmark mainly depend on the surface which bear toolmark mainly paper bag used for small toolmark or cartoon box for large object, if object no taken to lab then casting is done by Microsil silicone casting. Automated system provide 3D data for toolmark and toolmark comparison and analysis done through integrated system automatically. Stereomicroscope help to differentiate between types of saw. MANTIS (Manipulative Toolmark Inspection Suite software) help to differentiate between different types of tool. It is a portable 3-D optical profilometer manufactured by Alicona, GmbH. Integrated system GE/2 is uses a kinematic model which describes the process of the groove generation. Tool Mark Imaging System Database (TRAX) device is designed for collection, restoration and comparing of tool images and their textual descriptors' width, kind of tool mark. Statistical analysis SVMs help to determine between types of tool. Micro-CT Scanning used mainly for saw mark analysis, statistical analysis used to differentiate between different tools, toolmark width can determine by tool blade width, and different toolmarks formed under different methodological conditions like tissue presence and flesh. In this review paper, we also provide a comparison table of toolmark between different tool help to differentiate between a class and individual characteristic.

Keywords: Toolmarks , Microsil silicone casting , Stereomicroscope ,Statistical Analysis

INTRODUCTION:

Toolmark is an impression which is formed by the different tool on any surface with sufficient force. Marks are left, permanently on the receptive surface (01). It may be present in the form of irregularities, indentation or imprint. AFTE defines tool mark as "If any object or instrument reaches the surface with enough force to allow its signature design to be indented, this form of marking is referred to as a tool mark." Mark can be produced by low to strong force depending on surface.

Example: - In the case of burglary, a burglar chooses a wooden door or windows to entrance into a home, and building. In attempt of opening the door and window number of tools are used which produce marks on the surface of door and window. It acts as strong evidence for solving the crime scene. If the tool is linked with, or close to, a suspect, it helps for the identification between the accused person and the incidence of the crime.

TYPES OF TOOLMARK: -

- **Compression marks:** The imprint which is formed on the softer material due to the pressure applied on it by tool (01). It produces negative representation of the surface of the tool which caused by pressure, blow or gouge of the tool on the surface of a wood, metal or other surface. Tool mainly used are pipe wrenches, hammer, bolt cutter, pry bar, chisel and die stamp to produce it e.g. –bolt cutter leaves compressed mark as the squeeze the material.
- **Striated toolmark:** The imprint which are produced when tool applied opposite to the surface of object with sufficient pressure (01). It also known as friction, abrasion and scratch mark. It produces parallel striation move across

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the surface. Mainly produce by flat tools like screwdriver, plier, drill bit, and pry bar. E.g. -Bull cutter marks on rods or wires, screwdriver scratch marks and knife or axe cut marks

- **Multi stroke mark:** the imprint which is formed due to the repetitive use of particular tool at a same time. Mainly knife and saw are used to produce it. E.g. - Saw moving back and forth create multi stroke.
- **Crush or cut marks:** the imprint which is formed by the tool when it applied force on both side of object for cutting and crushing purpose mainly. E.g. - Bolt cutters, pliers, and wire cutter used to cut wire or any other material.

PRINCIPLE OF COMPARISION: -

Principle of Comparison – **"ONLY LIKE CAN BE COMPARE WITH LIKE".** It reinforces the need for samples and specimens to be included for comparison with the objects in question.
LIMITATION: examine the manufacturing patterns associated with the "control" object (01).

CHARACTERISTICS OF TOOLMARKS: -

- **Class characteristic:** It help to mainly classify the type of tool with general shape and dimensions, help to exclude the evidence.
- **Individual characteristic:** There are number of individual characteristics which help to include or exclude the evidence. Mainly indentations, ridges, unique/irregularities on surface, striations, oxidize or rust making**,** tools with serial numbers and microscopic imperfection on edge of tool surface. It is caused due to continue use, manufacturing process (stamping, hammering, milling and grinding), abuse and rust.

TOOL MARK ANALYSIS ON BONE:

- The bones are examined to identify any remnants of tool marks is called kerf mark. It helps to identify the traumatic injury analyzing the tool marks left on bone plays an important role in understanding the shape, angle, and characteristics of a weapon used in a dismemberment. Sharp force trauma can involve a variety of weapons and tools. KCW (KNIFE CUT WOUND) in bone is indicated when a sharp-edged tool superficially incises bone. A non-stabbing KCW often follows the contour of a bone. A stab KCW may puncture, nick, or gouge a bone. To allow forensic anthropologists to macroscopically and microscopically recognize their relation to the context in which the individual was killed or their remains were disposed off. Eg. - Saw trauma, axe trauma, and knife trauma. (6)
- **Knife tool marks-** Retained on hard tissues can be used to outline the shape and angle of a knife. A chopping stage with a gravity accelerator and a fixed bone platform was designed to reconstruct the chopping action. Digital microscope was also used to measure the knife angle (θ) and retained V-shape tool mark angle (ψ). (11)
- **Saw mark -** Research is focused on collecting data on variation found in microscopic features of cut bone. Data are then applied to saw blade and tooth characteristics of size, set, shape, and power. Information is used to indicate saw class, subclass, or type. (12)
- **Hesitation mark-** It originally used for suicidal knife cut marks to skin. It forms with inexperience and reluctance to continue the cutting action may have been related to pain. Attached to any shallow cut marks associated with soft tissue.

METHODOLOGY: -

There are number of methods to examine the toolmark for solving the crime scene.

1. **Photography: -** Firstly, we need to take the pictures of overall view of entire scene with the object having toolmark. Next, close-up photos take with placing ruler beside toolmark and producing detail picture. It helps to documents tool and tool mark evidence. It helps to determine the direction of tool use and whether or not the tool is physically capable of making the mark (14).
2. **Collection, packaging and transportation of toolmark: -** The photos should be submitted, with the evidence, for examination. Toolmarks should be completely documented prior to removal or casting. Firstly, trace evidence like painted surface is collected and packaged. Next whenever is possible whole toolmark submit to lab, instead just remove area contain mark. Never used evidence tape over toolmark surface. Removal and marking of evidence are done.
3. **Casting:** There are number of casting materials: - negative molding, Microsil Silicone Casting low-melting metal alloys (e.g., wood metal) and silicone rubber (14). The silicone rubber casting material is supplied as a partly polymerized base with which a catalyst must be mixed in order to allow polymerization. (01)

Procedure of casting toolmark:

- Prepare the casting material as per manufacturer's specifications.

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- Cascade the casting material over the toolmark to be casted.
- Allow the cast the appropriate amount of time to cure.
- Gently lift the cast off the toolmark.
- Consideration must be given to placing identifying marks as well as orientation marks on the back of the cast. (01, 14)

4. Automated system: An automated tool mark identification system uses an acquisition method. Processing of 3D data from tool marks left by tools on the sample surface. A signature generation module for the generation of tool mark signatures from the data collected. An analysis unit for the comparison of pairs of tool mark signatures in order to obtain a numerical similarity value representing their identical characteristics. The process is carried out with the aid of an integrated computer (01).

5. Stereomicroscope: Information is used to indicate saw class, subclass, or type like hand saw/electrical saw, crosscut and universal saw/rip saw, size of the teeth ("teeth per inch" TPI), and set type to determine it (12). Observed- the minimum width of the kerf, the profile of the lesions (concave or convex), and the shape of the edges (narrow-wide pattern, necking in the middle, or straight pattern) (13).

6. MANTIS: Manipulative Toolmark Inspection Suite software developed at AL/ISU. System based on a portable 3-D optical profilometer manufactured by Alicona, GmbH (02). System consists of an optical profilometer and a laptop computer which is small, portable, lightweight (80 lbs), and can be packed into a hardshell traveling case. It used C++, for coding purpose, open GL and GPU (Graphical processing unit) it helps to understand visualize geometric data on screen by the virtual mark of tool produce at particular angle and resolution (02). Procedure consists of three steps, Data Cleaning, Masking, and Data Analysis. Objective: 1) Provide the clean raw data files by using the Alicona hardware 2) Compare the data files from the cleaned tool marked surfaces as comparison microscope 3) Obtain objective statistical evaluation of comparisons made between those data files and 4) Explain factors which help to classify types of tool marks were made, e.g., angle of the tool (02).

7. Integrated system GE/2: It consisting of the Image Acquisition Station and a computer to perform the processing of the data. Automate the comparison of striation marks are based on extracting intensity profiles along lines perpendicular to the direction of the groove's strategy (03). It is model-based as it uses a kinematic model which describes the process of the groove generation, circumferential surface, and straight grooves- eg. Pristine bullet. Plane surface, curved grooves- screwdriver mark. Curved surface, curved grooves- eg. Deformed bullet (03).

8. Databases of tool marks: Tool Mark Imaging System Database (TRAX): - The Netherlands in collaboration with the Dutch Police developed a database for tool marks (04). System is developed for image acquisition, entering textual descriptors, image retrieval, and image comparison (04). It stores images of tool marks and their textual descriptors. The device is designed for collection, restoration and comparing of tool images and their textual descriptors' width, kind of tool mark, etc. EG. Bolt cutters, wire cutters or crowbars have been used to break a door in many cases of burglary.

9. Statistical analysis of impression evidence: - Every measurement of a feature is a random variable. Petraco showed that a combination of principal component analysis (PCA), canonical variate analysis (CVA) and support vector machines (SVM) help to understand only completed striated toolmark Collection of various features into a list constitutes the feature vector, x for that pattern. The feature vector may consist of anywhere from 1 component (one-dimension or 1D-univariate feature) to n-components (n-dimensional or n D-multivariate features). Extracted the feature vectors can be subjected to a myriad of statistical pattern recognition methodologies depending on their dimensionality. Univariate techniques are usually based around a 1D feature statistic which is a measure of similarity between two patterns (so called "score based" techniques). An example for comparing striated tool marks. Multivariate techniques used to perform a comparison of tool marks and footwear evidence. Support vector machine (SVM) discrimination algorithm combined with PCA. SVMs help to determine between types of tool.

10. Micro-CT Scanning: It uses an X-rays to see inside an object layer by layer. It used to visualise and measure toolmarks left on bones by a tool. Objective: (i) Mainly for saw mark analysis, (ii) statistics used to differentiate between different tools, (iii) Toolmark width can determine by tool blade width, and (iv).Different toolmarks formed under different methodological conditions like tissue presence and flesh (5). Cut mark angle captured by micro-CT imaging used to determine knife tool. Statistics used cut marks to determine knife type, serrated or plain, can be expected from cut mark width and wall angle. To analyse the morphology of knife lesions on fleshed bones in detail by the three imaging techniques (μCT, macro photography and SEM) all based on the measured distances between the walls of the kerf marks.(7) Stab marks left by serrated blades and non-serrated blades. Low power and scanning electron microscopy were used to record distinctive 'T'-shaped stab marks from non-serrated blades and 'Y'-shaped stab marks from serrated blades. Histological examination of bone and soft tissue around a penetrating injury. Scanning electron microscope-Energy-dispersive X-ray spectrometry (SEM/EDS) used to identify exogenous particles from marks. Determine the type and timing of injuries by help of it. Constructed pivoting arm device was used to inflict wounds with controlled forces and direction. A larger knife and a greater force caused longer and wider bone wounds. Comparisons of different knives

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at the two impact produced different results in the bone wounds. Serrated-edge and non-serrated knives can be distinguished from the appearance of the wound.

Observation table: Different types of tool with their toolmark impression.

Fig. 01 Different tool with their toolmark

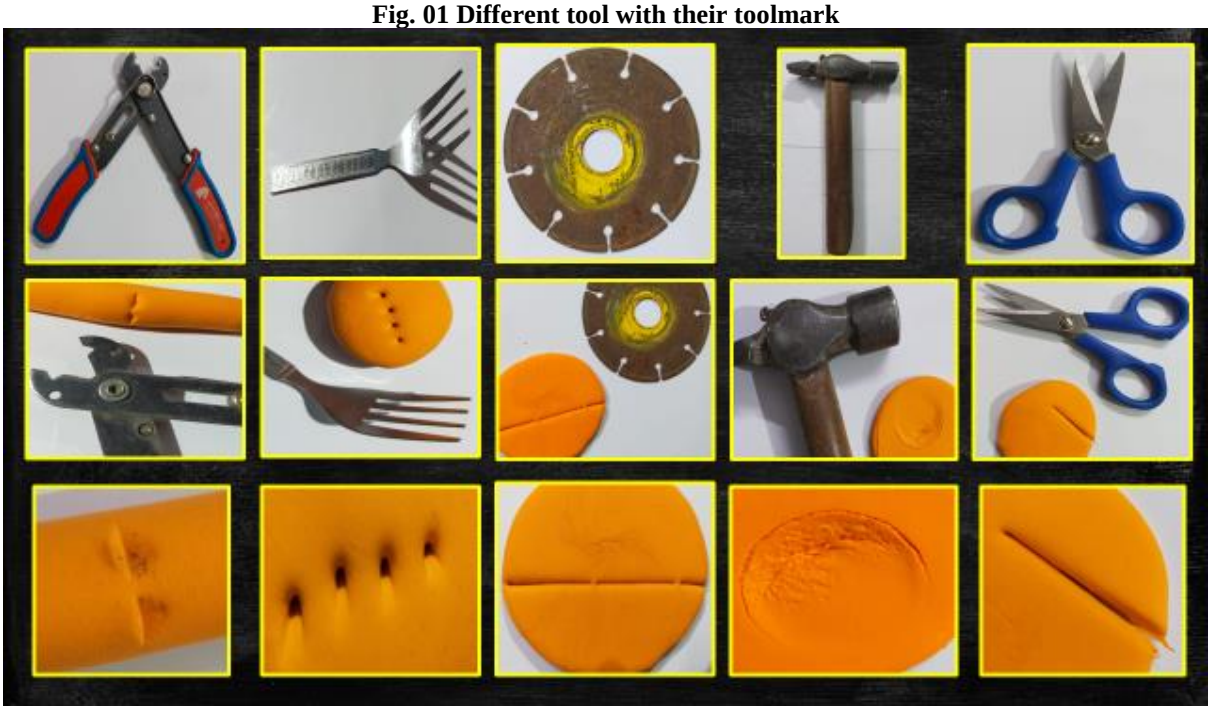

Fig. 02- Different tool with their toolmark

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Fig. 03 Different tool with their tool mark

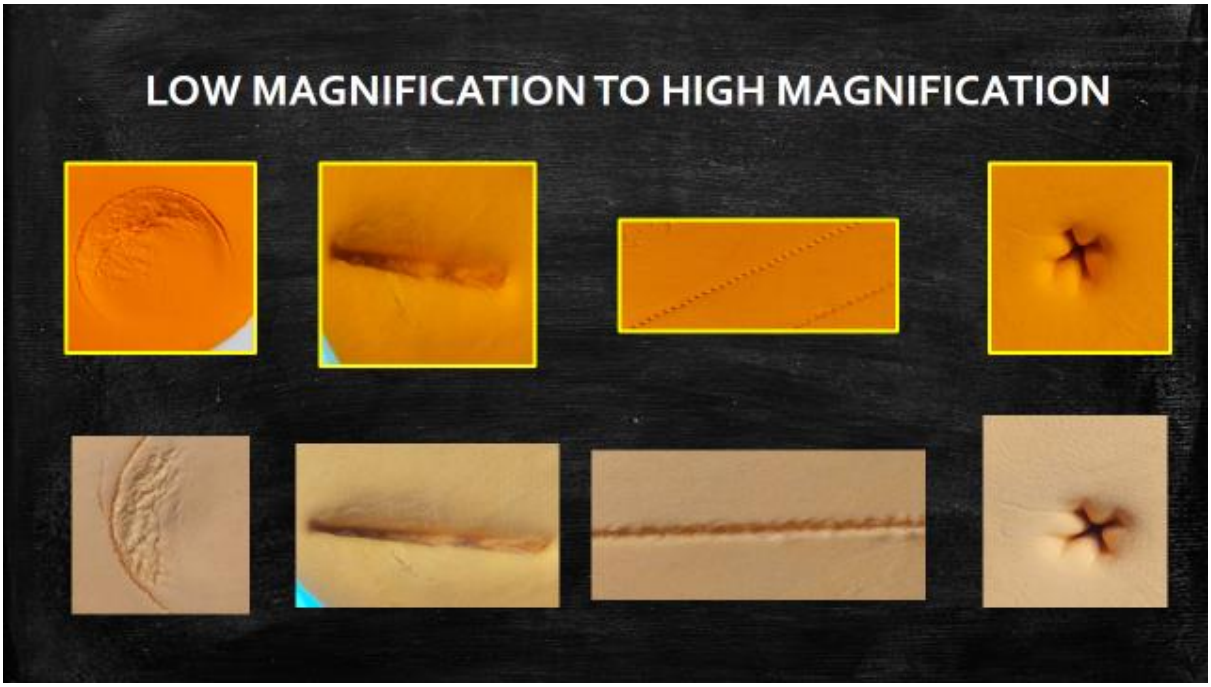

Fig. 04- Magnification of toolmark from low to high magnification

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Fig. 5: Differentiation between low to high impact on same surface

PREPARATION OF TEST AND QUESTIONED SAMPLE OF TOOLMARK:

Test toolmark impressions: - An investigator produces negative test tool marks using the suspect tool and compare microscopic surface characteristics between known test tool marks and evidence tool marks. It are created on sheets of soft metal or metal alloy, bars or tubes such as lead, wood alloy and, more recently, lead tape.

Questioned tool mark impression: - Questioned tool marks were present on soft surfaces such as wood, plastic, painted surface**.** Test tool marks can be made directly on soft lead sheet or pieces of lead sheeting wrapped around pipe, modeling wax sheets of varying hardness, pieces of modeling waxes produced in the shape of cylinders or blocks, on modeling clays of varying hardness, and on pieces of textiles, and leather. In cases involving wire cutters, cable cutters and similar tools, the test tool marks can be made directly on strands of thin gauge wire or cable made from copper or aluminum. Unique identifier, test mark number, tool used, date and initials of the individual preparing the test tool marks.

TOOL MARK IMPRESSION COMPARISON: Prepare a test and questioned tool mark and compare between the stereomicroscope and a comparison microscope. Compare and record the class and individual characteristics on the questioned tool mark to the known test tool mark. Determine and record if the known tool can be included or excluded as a source of the questioned tool mark(s). Close and seal case.

RESULT:

Firstly, determine the Class and individual characteristic. Determine the number and characteristics of the impression present on the questioned tool. Class characteristics can be easily determined with the help of given comparison table of different tool with their marks shown in fig. 01, 02, and 03. Individual characteristic also identifies by microscopic examination at high magnification as shown in above fig. 05. Also determine the different impact on particular surface as shown in fig. 04.

- Exclusion- When no one class characteristics are match between test and questioned sample toolmarks.
- Inclusion- When class characteristic is match but not much sufficient individual characteristics are present, then both test and question sample take in consideration.
- Conclusion- When class characteristic and individual characteristics both are sufficiently available, then both test and question sample are same.

CONCLUSION:

In the forensic science, toolmarks play very important role in solving the cases mainly related to burglary, robbery, theft, assault, suicide and homicide cases. Recent advancement done in toolmark MANTIS- is a portable automated system

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used for comparison purpose, micro-CT used to determine histological examination of bone and soft tissue, to analyse the morphology of knife lesions on fleshed bones in detail and to differentiation between different types of tools. SEM/EDS used to identify exogenous particles from marks. TRAX used mainly for comparison purpose nowadays. Recent application, toolmark examination in case of dismemberment of bone by different tool like saw, knife and any other sharp object. Even chopping bone can easily determine by which tool they can chop. In this review paper, a toolmark comparison table for determining class and individual characteristic are given.

REFERENCES:

1. Sachil kumar, Geetika Saxena and Archana Gautam "Forensic analysis and interpretation of tool mark" June 18th 2021. https://www.intechopen.com/chapters/77222
2. L.S. Chumbley, S. Zhang, M. Morris Development of a Mobile, Automated Tool Mark Characterization/ComparisonSystem,February2017https://www.ojp.gov/pdffiles1/nij/grants/250569.pdf
3. M. Heizmann and F. Puente León "Automated analysis and comparison of striated toolmarks" https://ies.anthropomatik.kit.edu/ies/download/publ/publ_2001_hzm_sptm2001.pdf
4. Geradts Z; Keijzer J; Keereweer I; "A New Approach to Automatic Comparison of Striation Marks, Journal of Forensic Sciences, 1994, 39(4), pp. 974-980.
5. Norman DG, Baier W, Watson DG, Burnett B, Painter M, Williams MA. Micro-CT for saw mark analysis on human bone. Forensic Sci Int. 2018 Dec; 293:91-100. Doi: 10.1016/j.forsciint.2018.10.027. Epub 2018 Nov 3. PMID: 30415097.
6. Norman DG, Watson DG, Burnett B, Fenne PM, Williams MA. The cutting edge - Micro-CT for quantitative toolmark analysis of sharp force trauma to bone. Forensic Sci Int. 2018 Feb; 283:156-172. Doi: 10.1016/j.forsciint.2017.12.039. Epub 2017 Dec 30. PMID: 29304390.
7. Komo L, Grassberger M. Experimental sharp force injuries to ribs: Multimodal morphological and geometric morphometric analyses using micro-CT, macro photography and SEM. Forensic Sci Int. 2018 Jul; 288:189-200. Doi: 10.1016/j.forsciint.2018.04.048. Epub 2018 May 1. PMID: 29758447.
8. Thompson TJ, Inglis J. Differentiation of serrated and non-serrated blades from stab marks in bone. Int J Legal Med. 2009 Mar; 123(2):129-35. Doi: 10.1007/s00414-008-0275-x. Epub 2008 Jul 30. PMID: 18665384.
9. Delabarde T, Cannet C, Raul JS, Géraut A, Taccoen M, Ludes B. Bone and soft tissue histology: a new approach to determine characteristics of offending instrument in sharp force injuries. Int J Legal Med. 2017 Sep; 131(5):1313-1323. Doi: 10.1007/s00414-017-1613-7. Epub 2017 May 30. PMID: 28560543.
10. Humphrey C, Kumaratilake J, Henneberg M. Characteristics of Bone Injuries Resulting from Knife Wounds Incised with Different Forces. J Forensic Sci. 2017 Nov; 62(6):1445-1451. Doi: 10.1111/1556-4029.13467. Epub 2017 Feb 23. PMID: 28230905.
11. Shaw KP, Chung JH, Chung FC, Tseng BY, Pan CH, Yang KT, Yang CP. A method for studying knife tool marks on bone. J Forensic Sci. 2011 Jul; 56(4):967-71. Doi: 10.1111/j.1556-4029.2011.01741.x. Epub 2011 Apr 11. PMID: 21480893.
12. Bernardi C, Nogueira L, Cabusat-Mailliet C, Carle G, Alunni V, Quatrehomme G. Analysis of false starts lesions on human bones produced by two hand saws with high TPI. Int J Legal Med. 2020 Mar; 134(2):613-618. Doi: 10.1007/s00414-020-02251-x. Epub 2020 Jan 21. PMID: 31965235.
13. Nogueira L, Quatrehomme G, Rallon C, Adalian P, Alunni V. Saw marks in bones: A study of 170 experimental false start lesions. Forensic Sci Int. 2016 Nov; 268:123-130. Doi: 10.1016/j.forsciint.2016.09.018. Epub 2016 Sep 28. PMID: 27721038.
14. Kumar, Sachil & Saxena, Geetika & Gautam, Archana. (2021). Forensic Analysis and Interpretation of Tool Marks. 10.5772/intechopen.98251.

