INDENTATION MARK EVIDENCE IN INDIAN CRIMINAL TRIALS: ADMISSIBILITY, RELIABILITY, AND JUDICIAL EVALUATION

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ABSTRACT

Indentation mark evidence is considered a crucial element in forensic toolmark examination and has grown in significance in a variety of criminal cases, including property crimes, violent crimes, and forgery. However, in Indian courts, where the problem of indentation marks is treated haphazardly and frequently inconsistently, its significant significance in crime scene reconstruction and connecting equipment to criminals is still up for question. In the context of the evolving Indian criminal justice system, particularly under the Bharatiya Sakshya Adhiniyam (BSA), 2023, this study offers a thorough doctrinal and forensic examination about the admissibility, reliability, and judicial appraisal of the evidence of indentation marks. Using the most advanced forensic methods, the study establishes the scientific foundation for the creation, categorisation, and comparison of markings. The legal framework that must be updated for the admission of such evidence is then covered, with particular attention on Sections 39, 40, and 63 of the BSA, 2023 as well as key court rulings that establish the requirements for expert testimony in India. To highlight the common issues with the fundamental subjectivity and uncertainty in toolmark analysis, a comparison with the U.S. and U.K. jurisdictions is conducted. The study highlights a number of important issues related to examiner bias, methodological constraints, the lack of standardised procedures, and the risk of experts exaggerating their findings. The study highlights the urgent need for unified guidelines, improved forensic training, laboratory accreditation as a requirement, and the development of judicial understanding as the next steps to address the issue by identifying the significant gaps in scientific validation and the judicial examination. In order to bring Indian criminal trials into compliance with international standards and the fundamental tenets of a fair trial and due process, the paper concludes with some strategic recommendations aimed at enhancing the evidentiary value, procedural rigour, and scientific reliability of indentations.

Keywords: Indentation Marks, Toolmark Evidence, Forensic Science, Bharatiya Sakshya Adhiniyam (BSA), Expert Testimony, Criminal Trials,

Judicial Evaluation, Admissibility, Reliability.

I. Introduction:

When it comes to using scientific methods to prove and corroborate facts, forensic science has advanced significantly and is now one of the most significant sources for the courts. Among the various forms of analysis being done in the field, the examination of toolmarks and indentations has proven to be quite beneficial in situations involving property damage, assault, forced entry, and tampering. The three-dimensional impressions made when a softer surface is compressed by a harder tool are known as indentation marks. They are referred to as silent witnesses because they occasionally offer a precise and quantifiable connection between a particular tool or instrument and the location of a crime.

Every tool used in a crime leaves a distinct record on the surface of the substance it comes into contact with, whether it is biological material, metal, plastic, or wood. The resulting markings include both individual characteristics, that is, microscopic features exclusive to a certain tool caused by wear, damage, or manufacturing flaws, as well as class characteristics, which are shared by tools of the same make and type. In order to provide a professional opinion regarding the correspondence, the forensic examiner must compare the recovered markings with the test impressions created by a suspect tool. Despite being a classic forensic profession, toolmark examination has not yet achieved scientific agreement over its acceptability and rigour, and this issue is still up for dispute worldwide.

Although the courts in India readily accept indentation mark evidence as expert opinion, the lack of unified judicial reasoning and standardised forensic dependability have led to inconsistent treatment of this evidence in court. Judges frequently let expert testimony without closely examining the scientific approach that underpins it, leading to a state of confusion and potentially a lack of awareness of justice. Unlike DNA profiling, indentation mark analysis relies primarily on the examiner's subjective opinion due to the lack of a uniform statistical model to quantify match probability[1]. One of the primary concerns of the worldwide findings, particularly the 2009 U.S. National Academy of Sciences (NAS) Report, which questioned the

[1] See generally Ass'n of Firearm & Toolmark Exam'rs (AFTE), Theory of Identification (2013) (setting forth the methodology where identification relies on "sufficient agreement," a qualitative assessment)

scientific validity of pattern-matching forensic techniques, was subjectivity[2].

The evidence of indentation marks has significant investigative and evidential significance in spite of these criticisms. In property crimes, such as marks on a safe or window frame that provide an indication of the method of entry, it is frequently the only trace evidence. Marks left by knives or weapons on bones or other surfaces can reveal important details about the kind of weapon used, its angle, and the dynamics of the force utilised in violent crimes. Indian courts are in a difficult position where they must balance the methodological subjectivity with the investigative merits. The fundamental question is whether the evidence satisfies the new legal framework's requirements for admission, reliability, and relevance. The revised legal basis for the inclusion of expert opinions has been established by the Bharatiya Sakshya Adhiniyam, 2023 (BSA), specifically section 39[3]. Judges' comprehension and interpretation of this new statute is crucial and continues to be an active field of research in legal reasoning, particularly with regard to the degree of effect an expert's opinion should have, the level of certainty required, and the knowledge required.

II. Scientific Foundations and Methodological Constraints:

A thorough understanding of the scientific principles governing the production and interpretation of indentation marks is still necessary for an appropriate judicial evaluation. Indentation, abrasion, and cutting marks are the three main categories of toolmarks. Indentation marks that deal with the compressive displacement of material are the only focus of the current study project.

A. Creation and Categorisation:

When a tool applies force in a perpendicular or nearly perpendicular manner to a softer substrate, an indentation mark is created. The resulting imprint highlights the tool's drawbacks. The mark is primarily determined by the following factors:

Material properties include the elasticity and hardness of the substrate and the tool.

[2] Saul M. Kassin et al., The Fallibility of Forensic Science: Systemic Misconceptions and the Need for Reform, 10 J. Crim. L. & Criminology 206, 212–15 (2013) (discussing the findings of the 2009 NAS Report). See also President's Council of Advisors on Sci. & Tech. (PCAST), Report on Forensic Science in the Criminal Courts 3–4 (2016) (further questioning the foundational validity of toolmark analysis

[3] Bharatiya Sakshya Adhiniyam, No. 47 of 2023, Section 39 (India)

Force and Angle: The quantity and direction of force delivered. Tool Condition: The particular microscopic defects accumulated throughout the production and use of a tool.

Identification depends on the forensic classification:

Class characteristics are characteristics shared by all members of a set of tools.

Subclass Characteristics: The manufacturing pattern traces shared by a small number of tools. False connections may be made if these are misinterpreted.

Individual Features: Unique flaws produced at random (burrs, dents, and nicks). These are the reasons to conclude that the mark was formed by a specific tool.

B. Analytical Methods and Documentation:

Accurate documentation is the initial stage in the admissibility process. Typically, it involves the following:

Casting: If the original item cannot be removed, this technique creates a high-fidelity model using materials like Mikrosil or polysiloxane to precisely replicate the imprint. High-resolution photography employs unique illumination from the side or the same angle to enhance contrast and reveal the object's depth and minute details.

Advanced Imaging: Using techniques such as 3D profilometry, confocal microscopy, or focus variation microscopy to provide quantifiable digital surface maps for comparison, which lessens reliance on visual evaluation[4].

The methods for comparison include:

Comparative microscopy is a traditional method that uses a dual-stage microscope to view and compare test impressions and the disputed mark.

AFTE's perspective on conducting a qualitative assessment of "sufficient agreement"[5] between the various qualities is known as "pattern matching."

[4] Jay A. Siegel, Forensic Science: The Basics 309–10 (CRC Press 2016) (describing the use of 3D techniques in toolmark analysis)
[5] Ass'n of Firearm & Toolmark Exam'rs (AFTE), Theory of Identification (2013)

Quantitative analysis provides a shift to objective measures by using software and algorithms to create numerical similarity scores from 3D data.

C. Discussions on Scientific Limitations and Reliability:

The accuracy of indentation analysis is limited by a number of factors:

Subjectivity: Two separate examiners may reach different results based on their subjective experiences because the "sufficient agreement" requirement lacks a numerical threshold.

Variability: Depending on the surface, the impact angle, and the amount of friction used, the same tool can produce noticeably varied markings.

Error Rates: In contrast to DNA analysis, large-scale independent validation studies are not used to standardise or quantify the known or possible error rate for toolmark identification.

Bias: Examiners may experience confirmation bias if they are aware of the suspect tool's relationship to the crime scene prior to beginning the study[6].

These restrictions are frequently noted in international publications (PCAST, 2016) and call for a careful, critical, and prompt assessment by the jurors[7].

III. The Legal Framework in India: The BSA, 2023:

The evidence of the indentation marks has been submitted into court by Bharatiya Sakshya Adhiniyam (BSA), 2023, which has previously overturned the Evidence Act, 1872. Although the legal framework has changed, the fundamentals of expert testimony remain the same.

A. Statutory Basis:

BSA Section 39[8] The principles of expert testimony are maintained by the new law. "When the Court has to form an opinion upon a point of foreign law or of science or art, or as to identity of handwriting or finger impressions, the opinions upon that point of persons specially skilled

[6] Saul M. Kassin et al., The Fallibility of Forensic Science: Systemic Misconceptions and the Need for Reform, 10 J. Crim. L. & Criminology 206, 219 (2013) (discussing the dangers of confirmation bias in forensic pattern matching)
[7] President's Council of Advisors on Sci. & Tech. (PCAST), Report on Forensic Science in the Criminal Courts 3–4 (2016)
[8] Bharatiya Sakshya Adhiniyam, No. 47 of 2023, Section 39 (India)

in such foreign law, science or art, or in questions as to identity of handwriting or finger impressions are relevant facts," according to BSA, 2023 Section 39. By all measures, the study of indentation markings is "science" or "art" since it is a particular area of forensic research. Therefore, a "expert" whose judgement is recognised under section 39 is a qualified forensic examiner who specialises in tool marks or impressions.

B. Expert Opinion's Corroborative Nature:

According to Indian law, expert testimony is merely an opinion and not a fact. This key idea remains the same under the BSA.

Not a Single Conviction: Expert testimony is typically insufficient on its own to convict if there is only weak direct or circumstantial evidence, and it should be viewed as seconding proof, particularly in fields that depend on matching patterns like indentation analysis.

Judicial Duty of Scrutiny: Judges must carefully consider the expert's logic. The court must identify the "grounds upon which the opinion is founded," much as it did in seminal rulings that are still relevant under the new legislation such as Murari Lal v. State of Madhya Pradesh[9]. The judge must ensure that the methods employed are reliable and that the result is supported by the evidence.

C. Electronic Records' Admissibility:

The BSA, 2023 also establishes specific requirements for the admissibility of electronic evidence, which is crucial for the examination of indentation marks in the modern world. The BSA's Section 63[10] addresses the admissibility of electronic records as evidence. Following the certification standards of Section 63 (formerly Section 65B of the Indian Evidence Act) is essential since toolmark documentation is typically completed using 3D digital scans, high-resolution photos, and computer-aided comparison charts. The expert must ensure that the digital evidence is accompanied by a certificate attesting to the accuracy, security, and protocol of the electronic records' creation, storage, and retrieval.

[9] Murari Lal v. State of Madhya Pradesh, AIR 1980 SC 531, ¶ 4 (India) (holding that expert opinion, standing alone, is generally not sufficient for conviction and requires judicial scrutiny of the grounds)
[10] Bharatiya Sakshya Adhiniyam, No. 47 of 2023, Section 63 (India)

D. Challenges and Judicial Assessment under BSA:

Even though the BSA establishes the framework for the courts to accept expert testimony, the courts nevertheless struggle to assess the following:

Who is an expert? There is no indication in the BSA regarding the requirements for expert status. When evaluating an expert's competency, the courts will take into account the expert's training, work history, and publications.

Standard of confidence: The judge will be extremely critical of the expert's terminology and will specifically caution against using terms that are not supported by science in the field of toolmark analysis, such as "absolute" or "100" confidence.

Methodology Validation: It is the judges' duty to ascertain whether the analytical techniques employed by the forensic science lab (such as 3D imaging and AFTE criteria) are widely recognised and have been reproduced under controlled conditions.

IV. Comparative Jurisprudence on Admissibility Standards:

In order to create strong judicial standards in India, the knowledge of other common law systems is essential.

A. The Daubert Standard in the United States:

The Daubert Standard is the standard used in the United States to evaluate expert witnesses. It requests that trial judges assess the evidence's scientific reliability based on the following criteria:
Testability: the ability or history of testing an idea or method.

Peer Review and Publication: has the approach been examined? The existence and magnitude of the known or potential error rate.

General Acceptance: the extent to which the relevant scientific community accepts the procedure.

In accordance with this rule, U.S. courts have progressively accepted toolmark evidence while also frequently restricting the scope of the expert's conclusions, forbidding the claim of

complete identification and permitting testimony to be based on measured probability rather than just the expert's experience. This standard was established in Daubert v. Merrell Dow Pharmaceuticals.[11]

B. United Kingdom:

Reliability and Scientific Validation Based on the Criminal Practice Directions and the Codes of Practice of the Forensic Science Regulator, the UK employs a reliability-centered approach. These state that expert testimony needs to be based on reliable and quantifiable methods. The experts must clearly state their limitations and degree of confidence in their judgements in order to testify in their favour; If applicable, disclose the method's associated error rate; Provide an exhaustive methodology and a comprehensive audit trail (chain of custody). This approach is reinforced in cases like R v. T[12]. The UK approach is more focused on scientific rigour and openness, which may be shown to be a very applicable model for the Indian scenario than Daubert's rigorous checklist.

V. Standards, Protocols, and Scientific Guidelines for Analysis:

The dependability of indentation evidence is inextricably linked to the quality of the laboratory processes, their verifiability, and the criteria that have been followed.

A. The Value of the Chain of Custody:

Given the fragility of microscopic impressions, the BSA requires an uninterrupted and meticulously documented chain of custody to demonstrate the exhibit's integrity and authenticity. Evidence may not be accepted in court if it is handled incorrectly, folded, or placed in a way that causes additional degradation. This principle is fundamental to the Code of Criminal Procedure, 1973[13].

B. International Standards and Scientific Methods:

Only validated techniques are used in forensic labs. The techniques are:

[11] Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579, 593–94 (1993)
[12] R v. T, [2011] 1 Cr. App. R. 9, [90] (Eng.) (criticizing forensic evidence based purely on subjective experience without validation)
[13] Code of Criminal Procedure, 1973, No. 2 of 1974 (India)

Electrostatic Detection Device (ESDA): This is the most crucial tool for retrieving and making the weakest indented writing visible.

Stereomicroscopy/Comparison Microscopy: This is used to compare distinctive features side by side at a high magnification.

3D Surface Mapping: This technology significantly reduces subjectivity by providing quantifiable and objective surface topography.

Indian FSLs typically adhere to their internal protocols these days. To achieve national standardisation and boost the judiciary's trust in the process, the DFT Technical Procedures for identification and ASTM E2290-07 for indented writing must be adopted[14].

VI. Critical Analysis: Subjectivity, Bias, and Judicial Gaps:

There are disadvantages to using indentation mark evidence, primarily because of contentious structural problems that need for judicial involvement.

A. The Subjectivity and Error Debate:

The subjectivity of the pattern matching procedure continues to be the primary criticism. Critics contend that the discipline is more reliant on the examiner's experience and subjective assessment than on empirical measurements because the word "sufficient agreement" is intrinsically non-quantifiable. The following are the outcomes of this variability:

Absence of Quantifiable Error Rates: In order for the courts to determine the likelihood of a match in an impartial manner, extensive, independent competency testing and error rate studies are required.

Confirmation bias is the psychological propensity for an expert who knows the suspect's tool to look for confirming traits rather than non-confirming traits.

B. The Issue of Judicial Inertia and Overclaiming:

The potential for experts to overstate their level of certainty is a significant problem in the

[14] ASTM E2290-07, Standard Guide for Examination of Indented Writing (ASTM Int'l 2019)

courtroom. In court, experts occasionally utilise phrases like "definitive matches" or "unique identification" that are not supported by science. The decision-maker may be greatly impacted by such an exaggeration. Due to judicial inertia, which occurs when the court takes the expert's opinion as passive rather than challenging it, judges in the majority of Indian courts lack specialised scientific expertise. A dependability level that differs between countries is the result of the incapacity to implement the BSA with the required rigour.

C. Integrity of Technology (BSA, Section 63):

There are new concerns associated with the increasing reliance on digital enhancement and 3D reconstruction, including:

Digital Artefacts: the possibility that features not seen in the original mark could be added or improved by image processing.

Compliance with Section 63[15]: Important evidence may be deemed inadmissible if the required certificate, which outlines the whole chain of procedure for electronic records (digital image, 3D scan), is not provided.

VII. Suggested Systemic Reforms for Enhanced dependability:

The Indian legal and forensic system should make the following significant adjustments in order to reorder the evidence of indentation marks and their dependability to the forces of constitutional due process:

The Development of the Technical National Protocol: Create a single, consistent national operating procedure (NOP) for the study of indentations and marks that uses 3D profiling and requires the technical body to document measurement data and photo evidence.

The Accreditation and Quality Assurance: Strict enforcement of a government FSL's required accreditation under an internationally recognised standard (such as ISO/IEC 17025[16]) is necessary. Regular audits, competency evaluations, and quality management system

[15] Bharatiya Sakshya Adhiniyam, Section 63

[16] B. R. Sharma, Forensic Science in Criminal Investigation & Trials 128–30 (Universal Law Publishing 2020) (discussing the need for mandatory laboratory accreditation, typically to ISO/IEC 17025, for ensuring reliability in India)

authentication will result from this.

Judicial Scientific Literacy: The National Judicial Academy and State Judicial Academies should create compulsory and repeated training sessions for judges and magistrates regarding the limitations of pattern-matching forensics emphasizing concepts such as bias, error rates, and the needed standard of validation.

Codified Testimony Guidelines: The Supreme Court has to set rules that will not allow the experts to make claims of unique individualization in absolute terms but rather expressing conclusions as likelihood or measured probability while pointing out the limits of the methodology.

Creating a Reliability Framework: India should investigate the possibility of implementing a codified reliability-based judicial test, akin to a modified Daubert test, for the admission of expert testimony under the BSA. This would go from merely requiring relevance to requiring scientific validity as a prerequisite for the evidence's admission.

VIII. Conclusion:

A crucial but problematic area of forensic science is the existence of indentation mark evidence. Its application in the Indian criminal justice system is contingent upon the judges' capacity to evaluate the subjectivity and methodological constraints of such evidence. Although Section 39 of the Bharatiya Sakshya Adhiniyam, 2023 provides statutory grounds for admitting such evidence, the actual challenge is how to uphold the highest scientific standards.

To transform the indent case from one that may be subjective to one that is undeniable in terms of trustworthiness, systemic reforms focused at standardisation, accreditation, and judicial education are required. Ultimately, this evidence must be a powerful corroborating weapon that not only strengthens the prosecution's case but also keeps the accused from being found guilty on the basis of an overly scientific or inadequately examined expert opinion.The underlying goal remains the fulfillment of a fair trial and due process[17].

[17] See Selvi v. State of Karnataka, (2010) 7 SCC 263, ¶ 260 (India) (emphasizing the right to a fair trial and due process as enshrined in the Indian Constitution)

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