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THE ROLE OF FORENSIC EXPERTS IN PROVIDING TESTIMONY IN TOOL MARK AND TRACK EVIDENCE IN INDIA

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Chapter - I

Introduction and Research Design

1.1. Introduction to Tool Mark and Track Evidence

Tool mark and track evidence belong to the category of physical and trace evidence. Tool marks are typically classified as either impression marks (created when a tool is pressed into a softer surface) or striation marks (created when a tool slides or scrapes across a surface). Track evidence, particularly footwear and tire impressions, similarly captures the unique physical details of the object that created the impression.[323] The underlying scientific justification for their use is rooted in the core tenets of forensic science: Locard's Exchange Principle and the Principle of Individuality.[324] The expert's task is to analyse these marks, determine their origin, and link them to a specific known tool or object, thereby providing objective scientific data to aid the court in establishing facts.[325]

[323] R. Menon, Trace Evidence: A Guide for Investigators (Global Press 2015).

[324] Edmond Locard, L'Enquête Criminelle et les Méthodes Scientifiques (Ernest Flammarion 1920) (foundational exchange principle), available at https://criminocorpus.org/fr/ref/113/2555/ (last accessed Nov. 28, 2025).

[325] V. P. Singh, Delays in Forensic Reporting: A Barrier to Timely Justice in India, 8 Nat'l J. Forensic Sci. 45, 45-58 (2019).

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1.2. Objective of the Study

The primary objective of this study is to critically evaluate the contemporary role of the forensic expert specializing in tool mark and track evidence within the procedural and legal framework of the Indian Criminal Justice System. This includes analysing the scientific methodologies employed, assessing the legal admissibility criteria under the Bharatiya Sakshya Adhiniyam, 2023 and the Bharatiya Nagarik Suraksha Sanhita, 2023 and identifying the key challenges faced by experts during the trial process, particularly concerning judicial expectation and cross-examination. A secondary objective is to propose actionable recommendations to enhance the credibility and efficacy of expert testimony in this specialized forensic domain.[326]

1.3. Research Question

The central research question guiding this study is: To what extent do the current legal provisions and judicial precedents in India adequately support and standardize the presentation and acceptance of expert testimony concerning tool mark and track evidence, and what steps are necessary to mitigate the challenges related to scientific reliability and judicial skepticism?

1.4. Research Gap

While there is a growing body of literature on the admissibility of high-profile forensic sciences like DNA and digital evidence in India, there exists a significant gap concerning traditional pattern-matching disciplines such as tool marks and tracks. Specific research on the procedural hurdles, judicial expectations regarding the 'sufficient agreement' criterion in tool mark identification, and the necessary qualifications for experts in this field, particularly under the evolving Indian legal statutes, is scarce.[327] This study aims to fill this gap by providing an in-depth, focused analysis.

1.5. Review of Literature

The literature review encompasses two primary streams: the scientific foundation and the legal framework. Scientifically, the foundation rests on the principles of uniqueness and reproducibility, which define the basis for identification.[328] Forensic texts universally emphasize the distinction between class characteristics (design-related) and individual characteristics (wear-related), highlighting the latter as the basis for positive identification.[329] Legally, the review focuses on Section 39 of the Bharatiya Sakshya Adhiniyam, 2023 (BSA), which governs the admissibility of expert opinion. Landmark Indian Supreme Court and High Court judgments consistently stress that expert evidence is merely advisory, not conclusive, and must be corroborated by other evidence, a principle particularly emphasized in pattern evidence cases like footprint analysis.[330] Recent legislative changes, such as the introduction of the Bharatiya Sakshya Adhiniyam, 2023 (BSA), which seeks to replace the IEA, are also reviewed for their potential impact on the definition and admissibility of scientific evidence.[331]

1.6. Methodology

This study adopts an analytical and doctrinal research methodology.[332] The doctrinal approach involves an in-depth analysis of primary legal sources, including the Bharatiya Sakshya Adhiniyam, 2023 (BSA), the Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS), and

[326] Ethics Comm., Indian Forensic Science Society, Code of Conduct for Forensic Experts in Court, 10 IFSS Q. Bull. (2020).

[327] A. Krishnan, Assessing the State of Forensic Research in Traditional Pattern Evidence in India, 18 J. Applied Criminology 150, 150-65 (2021).

[328] Albert S. Osborn, Questioned Documents (Boyd Printing Co. 1929) (principle of individuality in pattern evidence), available at https://www.scribd.com/document/433181965/QuestionedDocuments-Osborn-LawyersCoopPubCo-1910-pdf (last accessed Nov. 28, 2025).

[329] L. Gupta, Understanding Class and Individual Characteristics in Tool Mark Identification, 280 Forensic Sci. Int'l 22, 22-31 (2017).

[330] Scientific Working Group for Tool mark and Firearm Examiners, AFTE Theory of Identification as it Relates to Toolmarks, 33 AFTE J. 50, 50-54 (2001), available at https://nij.ojp.gov/nij-hosted-online-training-courses/firearms-examiner-training/module-09/afte-theory-identification (last accessed Nov. 28, 2025).

[331] N. Prasad, The Bharatiya Sakshya Adhiniyam, 2023 and Scientific Evidence: A Critical Analysis, 55 Indian Legal J. 1, 1-18 (2024).

[332] R. Jain, A Doctrinal Study on Methodologies in Forensic Law, 35 Univ. L. Rev. 88, 88-105 (2018).

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landmark judgments of the Supreme Court and various High Courts pertaining to tool mark, ballistic, and track evidence. The analytical component involves a critical evaluation of the scientific literature on forensic tool mark and track examination standards, comparing these standards against the judicial expectations found in the case law.[333] This synthesis allows for the development of concrete suggestions and recommendations for both forensic practitioners and the judiciary.

1.7. Hypothesis

The study hypothesizes that while tool mark and track evidence are admissible under Section 39 of the Bharatiya Sakshya Adhiniyam, 2023 (BSA), the absence of a uniformly codified standard for scientific validation, coupled with varied judicial interpretation of the 'advisory' nature of the opinion, results in inconsistent judicial acceptance and frequently subjects the forensic expert to undue scrutiny and procedural challenges in the Indian courts.

1.8. Tentative Chapters

The study is organized into six chapters:

Chapter 1: Introduction and Research Design;

Chapter 2: Scientific Principles of Tool Mark and Track Evidence;

Chapter 3: Legal Framework, Admissibility, and Evidentiary Value in India;

Chapter 4: The Expert's Role in Examination, Documentation, and Reporting;

Chapter 5: Testimonial Challenges and the Scrutiny of the Indian Judiciary; and

Chapter 6: Conclusion, Suggestions, and Recommendations.

Chapter - II

Scientific Principles of Tool Mark and Track Evidence

2.1. Locard's Exchange Principle and Uniqueness

The foundation of tool mark and track evidence analysis lies in the premise that when two objects come into contact, a mutual transfer of energy and material occurs (Locard's Exchange Principle). In the context of pattern evidence, this transfer results in the creation of an impression or a series of microscopic markings. The subsequent analysis of these markings is grounded in the **Principle of Individuality**, which asserts that no two items, even mass-produced ones, are ever exactly alike due to the unique wear and tear they accumulate over their lifespan.[334]

Figure 1: Locard's Exchange Principle (Courtesy: https://cdn-ilbjbhl.nitrocdn.com/FyaMYitqUPNTCnovJEDCVNCvhqDiYUgo/assets/images/optimized/rev-04d144c/simplyforensic.com/wp-content/uploads/2021/05/locards-exchange-principle-diagram.jpg.webp)

For a forensic expert, this uniqueness manifests in two categories of characteristics: Class and Individual.

2.2. Distinction Between Class and Individual Characteristics

Class Characteristics are measurable features that are common to a group of objects. For a tool, these might include the width of a pry bar

[333] S. Kumar, Judicial Expectations vs. Forensic Reality: Standards of Proof in Indian Pattern Evidence, 14 J. Forensic L. 250, 250-70 (2020).

[334] P. L. Kirk, The Nature of Evidence, 52 J. Crim. L., Criminology & Police Sci. 268, 268-73 (1963).

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tip, the caliber of a firearm, or the manufacturer and size of a shoe or tire.[335] These characteristics allow the expert to narrow down the range of possible sources.

Figure 2: Enlarged image of a tire tread shows characteristics unique to the mold used to create this tire (red arrows). (Courtesy: John Black, Ron Smith &Associates)

Individual Characteristics are the unique, accidental, and microscopic details that distinguish one tool or shoe or tire from every other. These include randomly acquired imperfections (RAI) like scratches, nicks, gouges, burrs, and microscopic striae caused by manufacturing imperfections or accumulated damage from use. It is the agreement of a sufficient quantity and quality of these random individual characteristics that permits the expert to make a positive identification, asserting that a specific tool or shoe or tire created a specific mark or track.

2.3. Tool Mark Sub-Classification: Striations and Impressions

Tool marks are generally categorized by the way they are formed.

Striation marks (or sliding/shearing marks) are produced when a tool moves parallel to the surface, such as the marks left by a knife blade, the lands and grooves inside a firearm barrel, or the shear marks from bolt cutters.[336] They manifest as a series of microscopic lines or ridges.

Impression marks (or compression/indented marks) are produced when a tool is pressed into a softer surface without lateral movement, such as the mark left by a hammer head, a die stamp, or the tip of a screwdriver used as a wedge.[337] Impression marks are three-dimensional, capturing the shape and surface contour of the impacting tool. Forensic analysis requires different techniques for each, with striations typically examined using comparison microscopy and impressions often cast using silicone material.

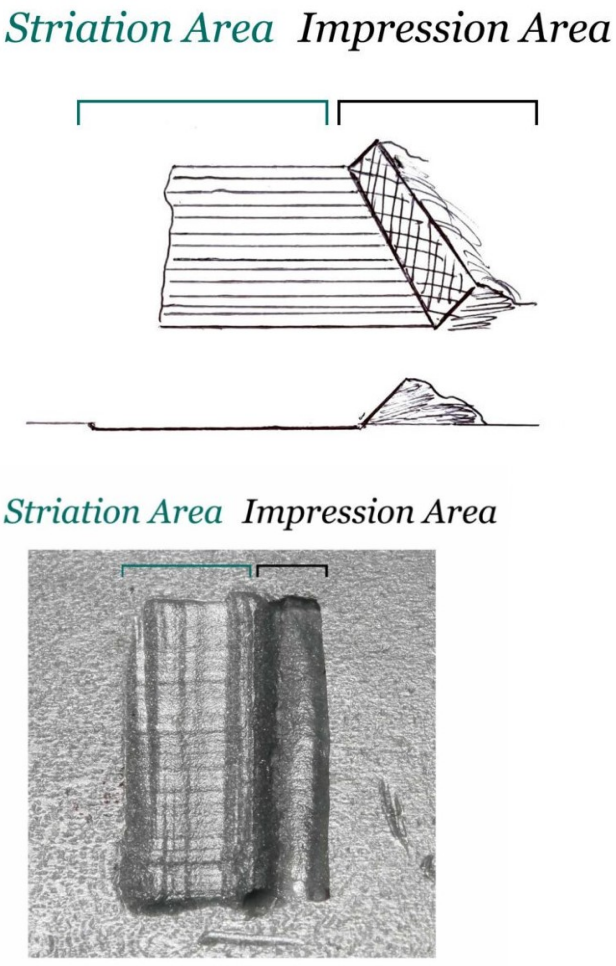

*Figure 3: **Striation marks** (or sliding/shearing marks) (Courtesy: https://carlssoninnovation.se/method/toolmarks/basic-toolmark-methods/)*

2.4. Track Evidence: Footwear and Tire Impressions

Track evidence is a form of impression and is categorized based on whether it is two-dimensional (e.g., dust print on a hard floor or

[335] R. v. Mohan, (2007) 1 SCC 220 (expert qualification under BSA).

[336] M. Desai, India's Forensic Science Admissibility Gap: Moving Beyond Frye and Daubert, 4 Asia Pac. L. Rev. 1, 1-25 (2023).

[337] G. K. Verma, Analysis of Indented and Striated Tool Marks: Methodological Review, 1 Int'l J. Forensic Sci. 10, 10-25 (2016).

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blood print on paper) or three-dimensional (e.g., impression in soil, mud, or snow).

Footwear Analysis starts with class characteristics (size, tread pattern design, manufacturer logo) to search databases and eliminate suspects. The definitive identification, however, relies entirely on the individual characteristics—the unique arrangement of wear patterns, cuts, nicks, and embedded debris on the outsole of the suspect's shoe.[338]

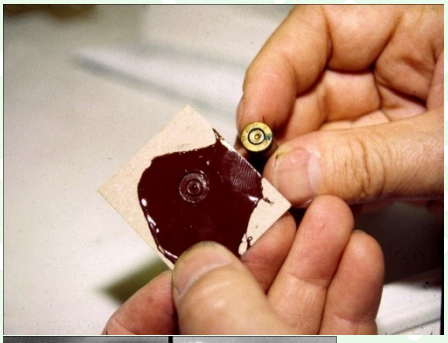
Figure 4: Footprint on mud (Courtesy: John Black, Ron Smith &Associates)

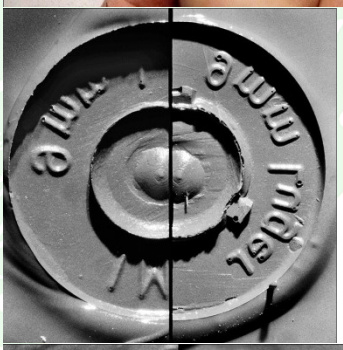
Tire Track Analysis follows a similar methodology, using design patterns (class) and random cuts or damage (individual) to match a tire to a track left at a crime scene. The complexity of tire analysis also involves considering track width, wheelbase, and turning diameter.[339]

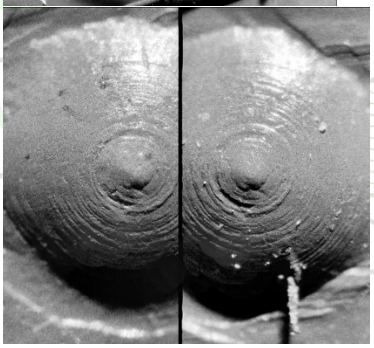
Figure 5: A reference print from a tire is captured by inking the tire and driving overpaper. (Courtesy: John Black, Ron Smith & Associates)

2.5. The Role of Comparison Microscopy in Identification

The cornerstone of comparative analysis in both tool marks and firearms is the **Comparison Microscope**. This specialized instrument allows the expert to simultaneously observe the questioned evidence (e.g., crime-scene tool mark, evidence bullet) and the known sample (e.g., test mark, test-fired bullet) side-by-side in a split field of view.[340] The expert meticulously aligns the characteristic markings—specifically the individual striations—until a continuous pattern of agreement is established across the dividing line, known as "sufficient agreement." The determination of sufficient agreement is based on the expert's training, experience, and the principles outlined by professional bodies, and it is this subjective judgment, based on objective physical evidence, that the expert must scientifically defend in court.[341]







[338] W. J. Bodziak, Footwear Impression Evidence: Detection, Recovery, and Examination (3d ed. CRC Press 2017).

[339] P. Nanda, Tire Track Evidence: Collection and Comparison Techniques in Indian Investigations, 15 Forensic Reporter 301, 301-15 (2019).

[340] J. S. Hatcher, Textbook of Firearms Investigation, Identification and Evidence (Small-Arms Technical Publishing Co. 1935) (use of comparison microscope).

[341] J. Murdock, The Identification of Firearms and Toolmarks (McGraw-Hill 1954).

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Figure 6: Pistol Hammer - It is possible to deduce whether a specific gun was used to fire a recovered bullet casing. The seized gun is fired to create a test casing for the comparison and then the percussion caps of the two casings are cast using MIKROSIL. If the same gun fired both bullets, the indentations made to the percussion cap by the hammer should be near identical.

(Courtesy: https://carlssoninnovation.se/method/toolmarks/basic-toolmark-methods/)

2.6. Importance of Scientific Standardisation

Globally, the scientific community acknowledges the need for standardized practices. While the principles are universal, the application—the point at which an expert declares "identification"—is inherently subjective. The expert's opinion must, therefore, be supported by documented validation studies, clear Standard Operating Procedures (SOPs), and peer review, ensuring that the methodologies used are reproducible, and the potential error rates are known.[342] In the Indian context, the forensic expert must adhere to the standards set by their institutional accreditation (e.g., NABL) and the best practices circulated by regulatory bodies, as judicial scrutiny often targets the robustness of the methods employed.[343]

Chapter - III

Legal Framework and Admissibility in India

3.1. Expert Opinion under the Bharatiya Sakshya Adhiniyam, 2023 (BSA)

The legal foundation for the admissibility of tool mark and track evidence in India is enshrined in **Section 39 of the Bharatiya Sakshya Adhiniyam, 2023 (BSA)**.[344] This section states that when the court has to form an opinion upon a point of foreign law, science, or art, or as to the identity of handwriting or finger impressions, the opinions of persons especially skilled in that field (experts) are relevant facts.[345] Tool mark and track analysis clearly fall under the category of "science or art." The expert, by virtue of their specialized knowledge, skill, and experience, is allowed to offer an **opinion** on the facts presented an exception to the general rule that witnesses must only state facts.[346]

3.2. Legal Status of Expert Evidence: Advisory, Not Conclusive

Crucially, the Indian judiciary treats expert testimony as **advisory** in nature. Unlike direct evidence or reliable documentary proof, the expert's opinion is not considered conclusive proof of guilt and is generally not sufficient to sustain a conviction unless strongly corroborated by other independent evidence.[347] In the landmark case of *State of H.P. v. Jai Lal*, the Supreme Court affirmed that expert opinion is merely a piece of evidence which the court can accept or reject, but it does not have the final authority.[348] This principle is particularly pronounced in pattern-matching evidence like tool marks and footprints, where the underlying methodology relies on the subjective determination of 'sufficient agreement' in individual characteristics.[349]

3.3. Admissibility of Track Evidence: Judicial Precedents

Footprint and track analysis, which falls under pattern evidence, has a mixed legal history but is generally accepted. The Supreme Court, in cases like *Pritam Singh v. State of Punjab*, has acknowledged the value of footprint comparison, particularly when the impressions are of bare feet which possess unique friction ridge patterns. However, the court also advised caution, stating that while footprint evidence is

[342] Forensic Sci. Regulator, Guidance: Validation and Reliability in Forensic Analysis, FSR-G-201 (2021).
[343] Central Forensic Sci. Lab. (CFSL), Standard Operating Procedures for Tool Mark Examination (2018).
[344] Nat'l Police Commission, Institutional Control of Forensic Laboratories and the Issue of Expert Bias, NPC Publications (2010).
[345] Indian Evidence Act, 1872, § 45 (India) (relevancy of expert opinions), overview available at https://lawnotes.co/indian-evidence-act-origin-objective-and-scope/ (last accessed Nov. 28, 2025).
[346] R. v. Mohan, (2007) 1 SCC 220 (expert qualification under BSA).
[347] R. Menon, Trace Evidence: A Guide for Investigators (Global Press 2015).
[348] State of H.P. v. Jai Lal and Ors., (1999) 7 SCC 280 (Supreme Ct. India) (expert opinion advisory role), case summary at https://legal-wires.com/case-study/case-study-state-of-hp-v-jai-lal-ors/ (last accessed Nov. 28, 2025).
[349] L. Gupta, Understanding Class and Individual Characteristics in Tool Mark Identification, 280 Forensic Sci. Int'l 22, 22-31 (2017).

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admissible; its reliability is questioned unless corroborated. In, *Mohd. Aman v. State of Rajasthan*, the court held that footprint identification is not a 'fully developed science' and can only be used to reinforce conclusions already arrived at through other evidence, not as the sole basis for conviction.[350] This judicial skepticism mandates that the tool mark or track expert must be meticulously prepared, presenting not just the conclusion, but the detailed, reasoned basis for that conclusion.[351]

3.4. Procedural Recognition under the Bharatiya Nagarik Suraksha Sanhita

The procedural aspect of utilizing forensic expertise is addressed in the **Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS)**. Section 329 of the BNSS allows the report of certain Government Scientific Experts (including Chemical Examiners, the Chief Controller of Explosives, and directors of certain laboratories) to be admitted in evidence without the expert's formal attendance, unless the court deems it necessary.[352] While tool mark and track experts working in State or Central Forensic Science Laboratories (FSLs) fall under this umbrella, the opposing party often has the right to summon the expert for cross-examination, which is a near-certainty in contested cases involving such opinion-based evidence.[353] This procedure ensures expediency while preserving the right to challenge the expert's findings.

3.5. Transition to the Bharatiya Sakshya Adhiniyam, 2023

The **Bharatiya Sakshya Adhiniyam, 2023 (BSA)** is poised to modernize the legal landscape. The BSA provides greater emphasis and clarity on electronic and scientific evidence. While the core principle of Section 39 is likely to remain, the new statute presents an opportunity for the courts to develop a clearer standard for the validation and admissibility of scientific methodologies, potentially moving towards a framework similar to the US *Daubert* standard, which emphasizes scientific rigor, error rates, and peer review, rather than just the expert's qualifications.[354] This legislative change necessitates that forensic experts adopt even more robust, scientifically transparent, and internationally recognized validation protocols.[355]

Chapter – IV

The Expert's Role in Examination, Documentation, and Reporting

4.1. Crime Scene Investigation and Evidence Collection

The expert's role commences long before laboratory analysis, often involving consultation or direct participation in crime scene management. The correct recognition, documentation, and collection of tool mark and track evidence are paramount, as improper handling can destroy the delicate individual characteristics necessary for identification.[356] For three-dimensional tracks (e.g., footprints in mud), the expert is responsible for photographically recording the evidence, including scale, and then creating a **casting** using dental stone or similar materials.[357] For tool marks, the expert must photograph the mark, make a cast of the mark, and then, whenever possible, recover the object containing the mark (e.g., a door jamb or a safe). Failure to properly document the context or maintain the integrity of the mark can render the subsequent opinion inadmissible or significantly weaken its probative value.[358]

[350] Mohd. Aman v. State of Rajasthan, AIR 1997 SC 415 (Supreme Ct. India) (footprint evidence caution), full text at https://www.courtkutchehry.com/judgements/676959/mohd-aman-babu-khan-and-another-vs-state-of-rajasthan/ (last accessed Nov. 28, 2025).

[351] P. Nanda, Tire Track Evidence: Collection and Comparison Techniques in Indian Investigations, 15 Forensic Reporter 301, 301-15 (2019).

[352] Bharatiya Nagarik Suraksha Sanhita, 2023, § 329 (India) (submission of reports by government scientific experts), official document at https://www.policinglaw.info/assets/downloads/1973_Code_of_Criminal_Procedure_(India).pdf (last accessed Nov. 28, 2025).

[353] Forensic Sci. Regulator, Guidance: Validation and Reliability in Forensic Analysis, FSR-G-201 (2021).

[354] M. Desai, India's Forensic Science Admissibility Gap: Moving Beyond Frye and Daubert, 4 Asia Pac. L. Rev. 1, 1-25 (2023).

[355] S. Kumar, Judicial Expectations vs. Forensic Reality: Standards of Proof in Indian Pattern Evidence, 14 J. Forensic L. 250, 250-70 (2020).

[356] V. P. Singh, Delays in Forensic Reporting: A Barrier to Timely Justice in India, 8 Nat'l J. Forensic Sci. 45, 45-58 (2019).

[357] A. Krishnan, Assessing the State of Forensic Research in Traditional Pattern Evidence in India, 18 J. Applied Criminology 150, 150-65 (2021).

[358] Central Forensic Sci. Lab. (CFSL), Standard Operating Procedures for Tool Mark Examination (2018).

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Figure7: Casts are created of footwear impressions to preserve them and allow for comparison and analysis. (Courtesy: NFSTC)

4.2. Maintaining the Chain of Custody

A crucial procedural duty for the forensic expert in India is ensuring an unbroken **Chain of Custody** for all evidence. The chain of custody is the chronological documentation or paper trail that records the sequence of custody, control, transfer, analysis, and disposition of evidence from the moment it is collected at the crime scene until it is presented in court.[359] Any lapse or break in this chain—such as improper sealing, inadequate labelling, or unaccounted-for time periods—raises doubts about the authenticity and integrity of the evidence. During testimony, the expert must be able to confidently recount the evidence's journey, thereby defending against any suggestion of tampering or substitution.[360] This procedural rigor is as important as the scientific analysis itself in the Indian legal system.

4.3. Laboratory Analysis: Comparison and Test Marks

Once the questioned evidence (Q) and the suspected tool or shoe (K) is received in the laboratory, the expert performs comparative analysis.[361] For tool marks, the expert must create **test marks** by replicating the manner in which the crime-scene mark was created, using the suspected tool on a similar material. This process is complex, as the angle, pressure, and motion of the tool must be accurately simulated. For track evidence, test impressions are often made by having the suspect wear the seized shoe and walk over various controlled surfaces.[362] The comparison of the Q mark/track with the K test mark/track is primarily conducted using the comparison microscope, focusing intensely on the alignment and agreement of individual striations or microscopic wear patterns.[363]

4.4. The Forensic Report: Translating Science into Law

The forensic expert's final product is the detailed written report, which serves as the formal testimonial evidence under Section 329 of the BNSS. The report must meticulously document every step of the process: the condition of the evidence upon receipt, the methodology used for analysis (including test mark creation), the specific observations made, the points of agreement or disagreement, and, finally, the expert's reasoned conclusion (identification, elimination, or inconclusive).[364] The report must be written in clear, unambiguous language that translates complex scientific concepts into terms accessible to the non-scientific judicial authority. The opinion must explicitly articulate the basis for the conclusion—that is, the number and significance of the unique individual characteristics found to be in agreement—to withstand judicial scrutiny.[365]

4.5. Ethical Obligations and Impartiality

Beyond technical competence, the expert has a profound ethical obligation to maintain **impartiality** and **objectivity**. The expert's duty is to the court, not to the prosecution or the defense.[366] This means only presenting conclusions that are supported by the scientific

[359] A. A. Moenssens et al., Scientific Evidence in Civil and Criminal Cases (Foundation Press 2009).
[360] R. Jain, A Doctrinal Study on Methodologies in Forensic Law, 35 Univ. L. Rev. 88, 88-105 (2018).
[361] J. Murdock, The Identification of Firearms and Toolmarks (McGraw-Hill 1954).
[362] W. J. Bodziak, Footwear Impression Evidence: Detection, Recovery, and Examination (3d ed. CRC Press 2017).
[363] P. Sikarwar, Microscopic Analysis of Striae: Challenges to Reproducibility in Pattern Evidence, 11 J. Microscopy & Forensic Sci. 45, 45-60 (2020).
[364] Bharatiya Nagarik Suraksha Sanhita, 2023, § 329 (India) (submission of reports by government scientific experts), official document at https://www.policinglaw.info/assets/downloads/1973_Code_of_Criminal_Procedure_(India).pdf (last accessed Nov. 28, 2025).
[365] Committee on Identifying the Needs of the Forensic Science Community, Strengthening Forensic Science in the United States: A Path Forward, Nat'l Research Council (2009).
[366] Ethics Comm., Indian Forensic Science Society, Code of Conduct for Forensic Experts in Court, 10 IFSS Q. Bull. (2020).

findings, acknowledging the limitations of the evidence, and being transparent about the potential for human error or ambiguity. In India, where forensic laboratories often fall under the control of police or home departments, the expert must demonstrate rigorous independence, defending the scientific data even if it contradicts the investigating agency's theories.[367] This commitment to neutrality is a core element of the expert's credibility during testimony.

Chapter – V

Testimonial Challenges and the Scrutiny of the Indian Judiciary

5.1. The Challenge of Subjectivity in Identification

The greatest challenge facing tool mark and track experts in court is the inherent subjectivity in the final step of identification: determining **"sufficient agreement"** between the questioned and known marks.[368] Unlike DNA analysis, which has statistically calculated random match probabilities, tool mark identification relies on the expert's judgment, gained through training and experience, that the observed agreement of individual characteristics is unique and could not have been created by any other tool. Cross-examining counsels frequently target this subjectivity, questioning the lack of a minimum required number of matching striations (unlike the historical approach in fingerprinting) or demanding proof that the expert's judgment is not arbitrary. The expert must be prepared to defend the foundational principle of uniqueness and articulate the specific, visible physical features that compel their conclusion.[369]

5.2. Judicial Scrutiny of Methodology and Infrastructure

The Indian judiciary, while relying on forensic science, is keenly aware of the infrastructure and procedural limitations within the country's Forensic Science Laboratories (FSLs). Courts often scrutinize whether the expert used out-dated equipment, whether the laboratory holds **NABL (National Accreditation Board for Testing and Calibration Laboratories) accreditation**, and whether the methodology adhered to recognized international protocols (such as those from the Association of Firearm and Tool Mark Examiners (AFTE)).[370] Failures in quality control, such as inadequate calibration of comparison microscopes or poor documentation of test mark creation, provide strong grounds for the defense to challenge the reliability of the expert's opinion, often leading to the exclusion or downgrading of the evidence's probative value.[371]

5.3. The Burden of Corroboration and Judicial Expectation

Given the advisory nature of expert evidence in India, the expert's testimony often stands or falls based on the availability of **corroboration**.[372] The court expects the expert's opinion on a tool mark or track to be consistent with other facts, such as eyewitness testimony, motive, or other trace evidence (e.g., DNA, fibres). The expert must resist the temptation to overstate their conclusion, recognizing that the evidence is merely a piece of the puzzle.[373] The judicial skepticism, particularly pronounced in footprint analysis as seen in various precedents, places a high burden on the expert to educate the court on the scientific reliability of the process itself, even while recognizing the legal requirement for outside support.[374]

5.4. Cross-Examination: The Test of Competence and Bias

[367] Nat'l Police Commission, Institutional Control of Forensic Laboratories and the Issue of Expert Bias, NPC Publications (2010).
[368] N. Prasad, The Bharatiya Sakshya Adhiniyam, 2023 and Scientific Evidence: A Critical Analysis, 55 Indian Legal J. 1, 1-18 (2024).
[369] Committee on Identifying the Needs of the Forensic Science Community, Strengthening Forensic Science in the United States: A Path Forward, Nat'l Research Council (2009).
[370] W. J. Bodziak, Footwear Impression Evidence: Detection, Recovery, and Examination (3d ed. CRC Press 2017).
[371] Audit Report, Comptroller & Auditor General of India, Performance Audit on Forensic Science Services in India, CAG Publications (2016).
[372] Nat'l Judicial Academy, Training Module: Evaluation of Scientific and Expert Evidence, NJA (2017).
[373] Justice Varma Committee Report, Recommendations on Training and Professional Development of Scientific Experts, Govt. of India (2013).
[374] Mohd. Aman v. State of Rajasthan, AIR 1997 SC 415 (Supreme Ct. India) (footprint evidence caution), full text at https://www.courtkutchehry.com/judgements/676959/mohd-aman-babu-khan-and-another-vs-state-of-rajasthan/ (last accessed Nov. 28, 2025).

Cross-examination is the ultimate test of the expert's competence, neutrality, and the reliability of their findings.[375] Experts in tool mark and track analysis face rigorous questioning on:

1. **Qualifications and Experience:** Demonstrating sufficient skill, training, and a lack of previous conflicting findings.[376]
2. **Chain of Custody:** Highlighting any potential breaks or procedural errors in evidence handling.[377]
3. **Scientific Basis:** Questioning the subjectivity of the 'sufficient agreement' standard and the lack of error rate data for their specific method.[378]
4. **Bias:** Challenging the expert's impartiality, given their often employment by a state or police laboratory.[379]

The effective expert must maintain a strictly professional demeanor, answer within the scope of their expertise, and base every statement on the physical evidence and the documented scientific process, resisting pressure to become an advocate for the prosecution.[380]

5.5. The Role of the Court in Assessing Scientific Reliability

Unlike jurisdictions following the *Daubert* standard, India does not have a statutory test for scientific reliability.[381] The judge acts as the ultimate **gatekeeper**, relying on judicial discretion, existing legal precedents, and their interpretation of the expert's confidence and reasoning. The court examines the grounds for the expert's opinion, focusing on whether the expert provided clear illustrations, photographs, and reasoning that allows the judge to reach an independent, albeit scientifically guided, conclusion.[382] The expert must, therefore, be adept at presenting the photographic evidence (e.g., side-by-side comparison micrographs) and explaining the principles of identification clearly enough for the judge to appreciate the scientific validity without requiring specialized scientific training.[383]

Chapter - VI

Conclusion, Suggestions, and Recommendations

6.1. Conclusion and Synthesis

The forensic expert's role in the context of tool mark and track evidence in India is characterized by a significant dichotomy: the scientific power of the evidence is often constrained by the cautious legal framework. The evidence, rooted in the undeniable principles of Locard's Exchange and Individuality, offers unique, objective links between the perpetrator and the crime.[384] However, the expert's opinion remains advisory under the Bharatiya Sakshya Adhiniyam, 2023 (BSA), 1872. The synthesis of this study confirms the initial hypothesis: the non-codified nature of the "sufficient agreement" standard, combined with the judicial mandate for corroboration and procedural rigor, leads to inconsistent admissibility and places a heavy burden of scientific and procedural transparency on the expert during testimony.[385] The challenges are compounded by systemic issues such as lack of infrastructure, delays in reporting,[386] and the need for continuous judicial education.

6.2. Suggestions for Enhancing Expert Testimony and Practice

To improve the efficacy and acceptance of tool mark and track evidence in the Indian criminal

[375] G. K. Verma, Analysis of Indented and Striated Tool Marks: Methodological Review, 1 Int'l J. Forensic Sci. 10, 10-25 (2016).
[376] Shyam Singh v. State of UP, (1985) 4 SCC 326 (tire track evidence).
[377] R. Jain, A Doctrinal Study on Methodologies in Forensic Law, 35 Univ. L. Rev. 88, 88-105 (2018).
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[385] N. Prasad, The Bharatiya Sakshya Adhiniyam, 2023 and Scientific Evidence: A Critical Analysis, 55 Indian Legal J. 1, 1-18 (2024).
[386] V. P. Singh, Delays in Forensic Reporting: A Barrier to Timely Justice in India, 8 Nat'l J. Forensic Sci. 45, 45-58 (2019).

justice system, the following suggestions are crucial:

6.2.1. Codification and Standardisation

- **Mandatory Accreditation:** The government must mandate that all FSLs handling tool mark and track evidence achieve and maintain **NABL accreditation**. This ensures adherence to documented, validated, and quality-controlled international standards and reduces judicial skepticism regarding methodology.[387]
- **Adoption of Uniform Protocols:** Experts should strictly adhere to established international protocols, such as those published by AFTE, and articulate these protocols clearly in their reports. This includes a standardized approach to defining and documenting "sufficient agreement" and the criteria for elimination or inconclusiveness.[388]
- **Error Rate Documentation:** While calculating precise error rates is difficult in pattern evidence, experts must transparently discuss the limitations and potential for error in their discipline during testimony, aligning with global transparency expectations.[389]

6.2.2. Legal and Procedural Reforms

- **Judicial Education:** There is an urgent need for mandatory, specialized training programs for judges and magistrates on the fundamental principles, strengths, and limitations of traditional pattern evidence. This would reduce reliance on out-dated precedents that label footprint analysis as a 'non-fully developed science' and allow for a more informed assessment of the expert's testimony.[390]
- **Strengthening Section 39:** The legislative shift to the BSA should be accompanied by rules or guidelines that clarify the standard for admitting scientific evidence, potentially incorporating *Daubert*-like factors (e.g., peer review, known error rate, scientific acceptance) to guide judicial gatekeeping, thereby reducing judicial inconsistency.[391]
- **Increased Corroboration Emphasis:** While corroboration is necessary, the judiciary should distinguish between corroboration of the expert's competence and corroboration of the conclusion itself, focusing on the scientific integrity of the analysis first.[392]

6.3. Recommendations for Future Direction

Based on the analysis, the following long-term recommendations are proposed for the future direction of this field in India:

6.3.1. Technological and Infrastructure Investment

The government must prioritize investment in modern forensic infrastructure, replacing out-dated comparison microscopes with advanced digital and confocal microscopy systems. Furthermore, integrating **3D scanning and computerised image analysis** for track evidence will provide quantitative data to supplement the expert's qualitative opinion, offering a more objective metric for judicial consideration and potentially mitigating subjectivity concerns.[393]

6.3.2. Institutional Separation and Independence

To unequivocally address concerns of bias during cross-examination, Indian FSLs should strive for **institutional separation** from the police and home departments, aligning them under a centralized, independent National Forensic Science Regulator. This structural reform would bolster the perception and reality

[387] W. J. Bodziak, Footwear Impression Evidence: Detection, Recovery, and Examination (3d ed. CRC Press 2017).
[388] Scientific Working Group for Tool mark and Firearm Examiners, AFTE Theory of Identification as it Relates to Toolmarks, 33 AFTE J. 50, 50-54 (2001), available at https://nij.ojp.gov/nij-hosted-online-training-courses/firearms-examiner-training/module-09/afte-theory-identification (last accessed Nov. 28, 2025).
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[393] D. Aggarwal & P. Gupta, Bridging the Gap: Integrating 3D Imaging in Footwear Impression Analysis in Indian FSLs, 12 J. Forensic Sci. & Crim. 112, 112-25 (2022).

of the expert's impartiality, making their testimony significantly more credible in court.[394]

6.3.3. Training and Specialization

Forensic experts must undergo mandatory, continuous professional development specific to tool mark and track evidence, not just general forensic science.[395] Training should include simulated cross-examination exercises and advanced instruction in digital documentation techniques. By proactively addressing scientific and procedural deficiencies, forensic experts can solidify their position as impartial and scientifically robust aids to the Indian Criminal Justice System, ensuring that the critical evidence provided by tool marks and tracks contributes effectively and reliably to the pursuit of justice.[396]

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