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From Barrel to Bench: A Critical Study of Bullet Trajetory Analysis in Crime Scene Reconstruction And Judicial Decision – Making in India

M. Ragavi

II Year LL.M, Dept Of Crime and Forensic Law, The Tamilnadu Dr.Ambedkar Law University, Chennai

ABSTRACT

Forensic ballistics is a critical tool in criminal investigations, providing scientific methods to reconstruct firearm-related crime scenes. Bullet trajectory analysis, a key sub-discipline, allows investigators to determine the shooter's position, angle and distance of firing, and the nature of the shooting distinguishing homicide, suicide, or accidental discharge. Despite its scientific reliability, Indian courts have shown variable acceptance of trajectory evidence, often treating it as corroborative rather than conclusive, and at times prioritizing eyewitness or medical testimony.

This study, titled "From Barrel to Bench: A Critical Study of Bullet Trajectory Analysis in Crime Scene Reconstruction and Judicial Decision-Making in India," examines the reliability, admissibility, and judicial interpretation of trajectory analysis. Using a doctrinal approach, the research analyzes high-profile cases such as State of Madhya Pradesh. v. Paltan Mallah, (2005), Ram Narain Singh v. State of Punjab, Sohrabuddin Sheikh Encounter Case (2018), and Sukhwant Singh v. State of Punjab (1995)to explore how courts weigh ballistic evidence in criminal adjudication.

The findings indicate that trajectory analysis is scientifically robust and invaluable for reconstructing crime scenes; however, its judicial impact is moderated by conflicting expert opinions, lack of standardized protocols, and the advisory status of expert testimony under Section 39 of Bharathiya Nyaya Sanhita. High-profile cases demonstrate its potential when corroborated with other evidence.

The study concludes with recommendations for standardized forensic procedures, judicial training in ballistics, digital trajectory modeling, and better collaboration between medical and ballistic experts, to enhance the evidentiary weight of bullet trajectory analysis in India.

Keywords: Forensic Ballistics, Bullet Trajectory, Crime Scene Reconstruction, Judicial Decision-Making, High-Profile Cases, India

1. INTRODUCTION

The connection between Forensic science and Judicial reasoning has become an essential part of modern criminal justice. Among the various branches of forensic investigation, Bullet Trajectory analysis holds special significance because it helps to scientifically recreate the events of a shooting. The phrase *"from*

barrel to bench" effectively captures this process where a bullet's journey from a firearm eventually becomes a piece of evidence in the courtroom.[1]

In India, Forensic Ballistics has grown into an indispensable field for investigators and courts alike. By examining the Angle of fire, Distance, Impact, and Bullet path, experts can determine how a shooting occurred and whether it was an act of self-defense, murder, or a staged encounter.[2] This kind of evidence often becomes crucial in cases where witness testimonies are inconsistent or unreliable.

Despite its potential, the use of bullet trajectory analysis in India still faces several obstacles. These include limited forensic infrastructure, lack of uniform standards, and insufficient training for investigators and experts.[3] Moreover, courts sometimes treat scientific opinions with caution due to doubts about their accuracy or procedural handling.[4] These issues highlight the need for better collaboration between scientific experts and the legal system so that forensic findings can be both technically sound and legally credible. This research paper critically explores the movement of ballistic evidence from the crime scene to the courtroom and studies how scientific findings influence judicial decision-making in India. It examines major judgments, case studies, and forensic methods to assess how effectively Indian courts use ballistic science in evaluating criminal responsibility. The ultimate aim is to strengthen the link between forensic accuracy and legal justice, ensuring that science truly serves the cause of truth.

2. CONCEPT AND SCIENTIFIC BASIS OF BULLET TRAJECTORY

A bullet trajectory is the three-dimensional path a projectile follows from the muzzle to where it stops or strikes. Although often sketched as a straight line in lay diagrams, its true path is a curved arc shaped by several interacting physical and ballistic factors. Understanding those factors and how forensic analysts measure and model them is essential for reliable crime-scene reconstruction.

2.1 STAGES OF BALLISTICS

Ballistics, the scientific study of projectiles, is generally divided into three main phases: internal, external, and terminal ballistics. Each phase plays a critical role in understanding the complete motion of a bullet and its forensic implications during crime scene reconstruction.

Internal Ballistics

Internal ballistics examines everything that happens inside the firearm from the moment the trigger is pressed until the bullet exits the barrel. This phase involves several key processes: the trigger's activation mechanism, the firing pin striking the primer, the ignition of the propellant, and the rapid build-up of high-pressure gases that propel the bullet forward. The bullet then accelerates down the barrel, engaging the rifling grooves, before finally exiting the muzzle. Several factors influence internal ballistics, including the type and burn rate of the propellant, the pressure within the chamber (which can exceed 50,000 psi), the bullet's design, and the barrel's geometry. These elements collectively affect the muzzle velocity, stability, and potential forensic markings left on the bullet, which can later help identify the firearm used.[5]

[1] R.K. Sharma, *Forensic Science in Criminal Investigation and Trials* 25 (Universal Law Publ'g Co. 2021).
[2] B.R. Sharma, *Forensic Ballistics in Criminal Justice* 78 (LexisNexis 2019).
[3] Nat'l Crime Records Bureau, *Crime in India Report 2022* (Ministry of Home Affairs, Gov't of India).
[4] N.B. Goud, Scientific Challenges in Firearm and Ballistic Analysis in India, *Indian J. Forensic Sci.*, vol. 12, no. 2, 45 (2020).
[5] Richard Saferstein, Criminalistics: An Introduction to Forensic Science 240–45 (12th ed. 2018).

External Ballistics

Once the bullet leaves the barrel, it enters the realm of external ballistics, which studies its behavior in flight toward the target. The bullet does not travel in a straight line; gravity, air resistance, and environmental factors like wind all affect its trajectory. Additionally, the bullet's spin, shape, and velocity play a crucial role in its stability and path.

Understanding external ballistics is essential for forensic investigations, as it allows experts to estimate the shooter's position, range, and angle of fire. By analyzing flight patterns and potential deflections, investigators can reconstruct the circumstances of a shooting more accurately.[6]

Terminal Ballistics

The final stage, terminal ballistics, focuses on what happens when the bullet reaches its target. This includes penetration, deformation, fragmentation, or ricochet, as well as the resulting damage such as wounding patterns, shockwaves, and cavitation in tissues.Terminal ballistics also examines how bullets behave when impacting different materials like bone, glass, or wood. By studying these interactions, forensic experts can trace bullet paths through the body or objects, assess the lethality of the firearm, and gather crucial evidence for crime reconstruction.[7]

In summary, each stage of ballistics offers unique insights. Internal ballistics reveals firearm and ammunition characteristics, external ballistics allows trajectory reconstruction, and terminal ballistics shows the bullet's effect on the target. Together, these phases provide a comprehensive understanding of shootings, assisting forensic experts in reconstructing crime scenes with scientific precision.

2.2 GOVERNING PHYSICAL FACTORS

In forensic ballistics, a detailed understanding of the physical factors that govern a bullet's flight is essential for reconstructing shooting incidents. Variables such as muzzle velocity, firing angle, gravity, air resistance, and ricochet collectively determine the path a bullet follows from the firearm to its point of impact. Careful analysis of these parameters allows experts to accurately infer the shooter's position, intent, and the sequence of events.[8]

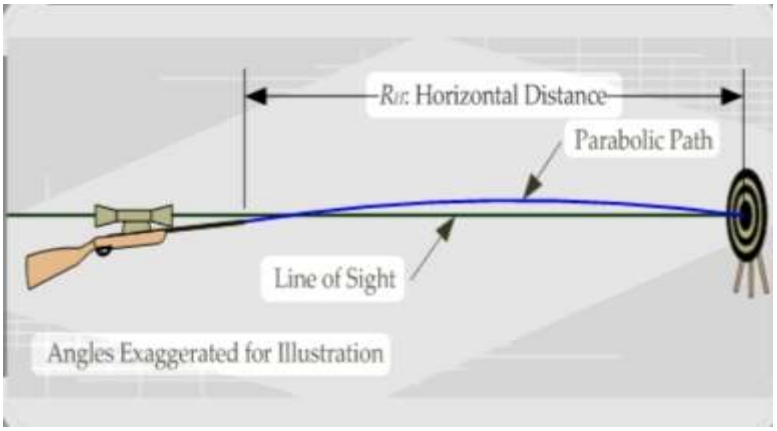

Image courtesy: www.britannica.com

Muzzle Velocity

Muzzle velocity denotes the speed at which a bullet exits the firearm barrel and represents the initial kinetic energy propelling the projectile. Higher muzzle velocities produce flatter trajectories and longer

[6] John James & Jon Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques 210–15 (4th ed. 2013).
[7] Julian S. Hatcher, Hatcher's Notebook 120–30 (3rd ed. 2000).
[8] B.R. Sharma, supra note 1, at 135

effective ranges, whereas lower velocities result in more pronounced gravitational drop. Factors such as barrel length, propellant type, and bullet mass influence velocity. In forensic investigations, estimating muzzle velocity provides critical information regarding shooting distance, ammunition type, and the bullet's residual energy upon impact.It is usually expressed in meters per second (m/s) or feet per second (fps).[9]

Angle of Fire

The firing angle is instrumental in determining whether a bullet travels upward, downward, or horizontally. Forensic investigators employ laser trajectory kits and precise angular measurement tools to reconstruct these angles. Upward trajectories may indicate a shooter positioned below the target, such as on stairs or lower ground, whereas downward angles suggest elevated firing positions like rooftops or balconies. Accurate determination of firing angles contributes to reconstructing the relative positions of the shooter and target.[10]

Gravity and Air Resistance

After leaving the barrel, bullets are influenced by gravity, which pulls them downward, and air resistance, which decelerates their motion. Together, these forces shape the bullet's trajectory. Environmental conditions including wind, temperature, and humidity can also produce measurable deviations, particularly in long-range or outdoor shootings. Forensic analysts incorporate these variables to determine the bullet's origin and account for trajectory deviations caused by drop or drift.[11]

Parabolic path

The parabolic path is the curved trajectory a bullet follows after being fiired, caused by the combined effects of muzzle velocity (forward force) and gravity (downward pull).The bullet moves forward and downward simultaneously, forming a parabola.[12]

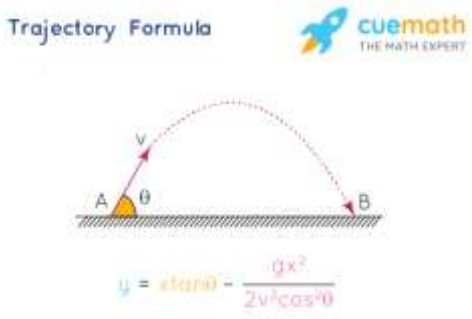

Image courtesy: www.rifleshootermag.com

Key Characteristics of a Parabolic Path

1. Symmetrical Curve: The path of the bullet is roughly symmetrical — the bullet rises and falls at equal angles (in ideal conditions).

[9] https://crimelab.phoenix.gov/QTDocuments/1690. accessed on oct 13,2025
[10] https://www.flinnsci.com/api/library accessed on oct 13, 2025
[11] https://lidarmag.com/2023/07/22/lidars-revolution-of-forensic-ballistic-trajectory-analysis/ accessed on oct 13,2025
[12] https://www.sciencedirect.com/science/article/abs/pii/S0379073816301268 accessed on oct 13,2025

2. Maximum Height (Apex): The highest point of the curve, depending on muzzle velocity and firing angle.
3. Range: The total horizontal distance covered before the bullet hits the ground or target.
4. Impact Point: The bullet's final position, determined by angle, gravity, and air resistance.[13]

Example

If a shooter fires a bullet upward at an angle of 20°, the bullet will rise, reach its highest point, and then descend in a curved path until it strikes the target or the ground. Forensic experts can measure entry points, bullet impact height, and distance to recreate this parabolic motion, identifying whether the shot came from ground level or an elevated position. The parabolic path is the fundamental characteristic of a bullet's flight. It reflects the combined influence of muzzle velocity, firing angle, and gravitational pull. Forensic experts use this understanding to reconstruct shootings accurately, identify firing positions, and provide scientifically grounded interpretations of ballistic evidence in criminal investigations.[14]

Ricochet

A ricochet occurs when a bullet strikes a hard surface and bounces off or deflects, instead of penetrating or embedding in it. The bullet changes its original direction after impact but continues to travel, usually with reduced speed and altered shape.Ricochets can also leave markings or residue from the surface material on the bullet, which become valuable forensic clues.[15]

Example:

A bullet fired at a 15° angle hits a concrete wall and bounces off, striking a nearby vehicle. Forensic experts can measure the impact marks and deflection angle to determine the bullet's original path and the shooter's position.

Ricochet marks, deflection angles, and bullet deformation enables accurate crime scene reconstruction and aids in distinguishing between direct and indirect fire.[16]

3. TECHNIQUES OF BULLET TRAJECTORY RECONSTRUCTION

The scientific examination of bullet trajectory lies at the intersection of physics and forensic investigation. Each shooting leaves behind a silent map a pattern of bullet holes, ricochets, and impact marks that narrate how the event unfolded. Forensic experts rely on a range of analytical techniques, both traditional and technologically advanced, to decode this evidence and reconstruct the events of the shooting with precision.[17]

3.1 String and Rod Method

The string and rod method is among the oldest and most widely used techniques in forensic trajectory analysis. Investigators insert a thin metal rod or taut string through the bullet hole or defect in an object such as a wall, glass pane, or vehicle door to trace the bullet's line of travel. When several bullet paths are reconstructed, the extended lines are projected backward to identify the probable location of the shooter. Despite its simplicity, this method can yield accurate preliminary findings, particularly in indoor scenes where environmental factors are minimal. However, it is also prone to human error, especially when bullet holes are irregular or when secondary ricochet marks exist. For this reason, investigators

[13] https://www.assajournal.com/index.php/36/article/view/840 accessed on oct 13,2025
[14] Id.
[15] https://www.researchgate.net/figure/Trajectory-of-a-ricocheting-bullet accessed on oct 13,2025
[16] Id.
[17] https://educationinteractive.com.au/wp-content/uploads/2019 accessed on oct 14,2025

often pair the string method with precise measurements and photographic documentation to maintain the scientific integrity of their reconstruction.[18]

3.2 Laser Trajectory Kits

Modern forensic practice has gradually shifted toward the use of laser trajectory kits, which project narrow beams of light through bullet holes to represent the bullet's original path. The visible beam makes it easier to visualize the trajectory and document it for later analysis or courtroom presentation.

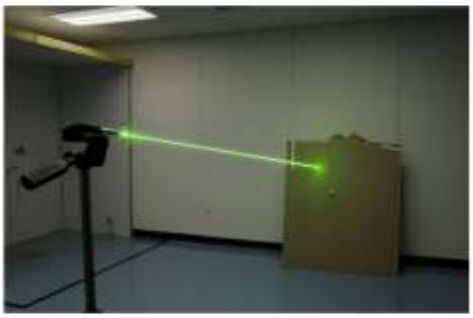

Image courtesy : https://fastercapital.com

Unlike strings or rods, lasers offer the advantage of maintaining a straight, unobstructed line of projection. This allows investigators to determine not only the shooter's approximate position but also whether multiple shots originated from the same or different firing points. In addition, lasers can be combined with digital cameras to produce highly accurate photographic overlays.[19]

In India, however, access to such kits is often limited to central or metropolitan forensic science laboratories. Many state-level or district units continue to rely on manual methods due to cost constraints and lack of trained personnel.[20]

3.3 Photogrammetry and 3D Scanning

The development of 3D scanning and photogrammetry has revolutionized bullet trajectory analysis. These technologies employ laser scanners or high-resolution cameras to capture the geometry of a crime scene in three dimensions. The resulting digital model allows forensic experts to map bullet paths, measure distances, and calculate angles with remarkable accuracy.

By integrating bullet hole data with 3D coordinates, investigators can create a dynamic digital reconstruction that can be rotated and examined from any perspective. This method minimizes subjective interpretation and provides an objective record that can be preserved indefinitely for judicial review.[21] In complex scenes such as outdoor shootings or those involving multiple shooters 3D trajectory mapping helps visualize the relationship between the victim, shooter, and environment. Indian forensic institutes such as the National Forensic Sciences University (NFSU) have begun introducing training modules in digital reconstruction to strengthen the accuracy of firearm-related investigations.[22]

[18] B.R. Sharma, Forensic Science in Criminal Investigation and Trials 311 (5th ed. 2020).
[19] R. Saferstein, Criminalistics: An Introduction to Forensic Science 144 (12th ed. 2020).
[20] National Forensic Sciences University, Forensic Ballistics Training Manual 22 (2022).
[21] J.S. Sodhi & A. Sharma, Forensic Ballistics in Crime Investigation 178 (Central Police Academy 2019).
[22] Id.

3.4 Computer-Based Simulation

Another modern advancement involves computer-based trajectory simulation software, such as FARO Zone 3D or CrimeZone. These programs allow investigators to input physical data bullet hole locations, entry angles, impact points, and dimensions of the scene to generate an interactive, virtual reconstruction.Such software not only illustrates possible shooter positions but also permits the testing of different hypotheses (for instance, whether the shot could have originated from a particular window or vehicle). The digital reconstruction can be replayed or projected in court, assisting judges and juries in visualizing the sequence of events.[23] In India, while adoption is still in its infancy, metropolitan police units like Delhi and Maharashtra have initiated pilot projects integrating 3D simulations in high-profile cases involving alleged encounters and gang-related shootings.[24]

3.5 Integration of Traditional and Digital Techniques

While digital technology has greatly improved the accuracy of trajectory reconstruction, a hybrid approach often yields the best results. Initial assessment using traditional methods such as rods and strings helps locate bullet holes and estimate firing angles on-site. These measurements can then be digitally captured through 3D scanning and analyzed via simulation software. This integrated process ensures that physical evidence collected at the scene is accurately represented in the digital model. Moreover, it enhances transparency, allowing both investigators and courts to rely on verifiable, reproducible data.[25]

3.6 Documentation and Visualization

Accurate documentation is the backbone of forensic credibility. Each trajectory should be photographed with scale markers, scene sketches, and coordinate data. Laser beams or strings must be visible in photographs to show the direction of fire. Advanced visualization tools now allow investigators to overlay these images onto 3D models or maps, creating demonstrative exhibits that can be easily understood in court. Judicial officers, who may not be versed in physics or ballistics, often find such visual evidence persuasive and easier to comprehend than technical reports. In Ram Narain Singh v. State of Punjab, the Supreme Court acknowledged that forensic visualization assisted in corroborating the prosecution's account of the shooting direction.[26]

Therefore, while trajectory reconstruction is invaluable, it must be complemented by corroborative evidence such as gunshot residue (GSR) tests, bloodstain pattern analysis, and autopsy findings to produce a scientifically holistic reconstruction.[27]

4. INVESTIGATIVE SIGNIFICANCE OF BULLET TRAJECTORY ANALYSIS

Every bullet fired from a gun becomes an unspoken witness to the event. Through careful trajectory reconstruction, investigators can extract valuable information about how a shooting occurred, where the shooter stood, and even whether the act was intentional or accidental. In India, where eyewitness testimonies are often unreliable or contradictory, trajectory evidence provides an objective framework to interpret the physical events of a shooting.

4.1 Locating the Shooter's Position

One of the foremost purposes of trajectory analysis is to determine the origin of fire the point from whi-

[23] Id
[24] Sanjay v. State (NCT of Delhi), 2017 S.C.C. OnLine Del 10722.
[25] Sharma, supra note 1, at 316.
[26] Ram Narain Singh v. State of Punjab, A.I.R. 1975 S.C. 1727.
[27] Id

ch the bullet was discharged. By extending the reconstructed trajectory lines backward, experts can approximate the shooter's position and elevation. For example, when bullet holes on a wall indicate a downward angle of entry, it may suggest that the shooter fired from a higher location, such as a staircase, balcony, or vehicle. Conversely, upward angles often indicate that the shooter was positioned below the target. This spatial reconstruction helps establish whether the shooter was standing, kneeling, or even prone during the incident.[28]

4.2 Determining the Number and Sequence of Shots

Trajectory analysis also enables investigators to determine the number of shots fired and their sequence. By mapping distinct bullet paths, forensic experts can infer whether multiple shots originated from a single firearm or from different weapons. This is particularly crucial in gang-related or encounter situations where multiple shooters may have been involved. Forensic reconstruction can reveal whether the bullets were fired simultaneously or in rapid succession, and whether the firing pattern was deliberate or defensive.[29]

4.3 Establishing the Nature of the Incident

Trajectory evidence can help classify a shooting as homicidal, suicidal, or accidental by interpreting the direction and angle of fire in relation to the victim's wounds and scene context.

- Suicidal shootings usually involve an upward or inward trajectory, as the firearm is held close to the body and angled toward vital organs or the head.
- Homicidal shootings typically present multiple entry angles or downward trajectories, indicating external attack.
- Accidental discharges often exhibit irregular or ricocheted paths, inconsistent with deliberate aiming.

Trajectory analysis also assists medical examiners during postmortem examination by correlating the entry and exit wounds with the angle of the bullet path, helping confirm or reject alleged positions of the victim at the time of shooting.[30]

4.4 Testing the Credibility of Witness Statements

Eyewitness testimony can be heavily influenced by confusion, bias, or fear, especially in violent shooting situations. Trajectory reconstruction acts as an independent test of truth, validating or disproving witness statements. If a witness claims that the shooter fired from the left side of the victim, but the bullet entered from the right, trajectory findings can instantly expose inconsistencies.[31]

Thus, when properly documented and scientifically presented, trajectory analysis strengthens judicial fact-finding by transforming physical evidence into a logical narrative of the shooting event.

4.5 Reconstructing Multi-Shooter and Complex Incidents

In multi-shooter situations, such as crossfires or encounters involving both police and suspects, trajectory mapping becomes indispensable. Each reconstructed bullet path can be color-coded or labeled to indicate its source weapon or probable shooter. The intersection points and convergence zones of multiple trajectories reveal whether the firing occurred from a single direction or multiple angles. In forensic terms, this allows investigators to separate offensive from defensive fire, identify protected positions, and even determine whether a victim was moving or stationary during the attack.[32] Such

[28] B.R. Sharma supra note 2 at 326 (5th edition)
[29] Id.
[30] R. Saferstein, Criminalistics: An Introduction to Forensic Science 144 (12th ed. 2020).
[31] State of maharastra vs Damu (2000) 6 SC 269
[32] J.S. Sodhi & A. Sharma, Forensic Ballistics in Crime Investigation 184 (Central Police Academy 2019).

reconstructions often serve as crucial evidence in judicial inquiries into alleged "fake encounters," where trajectory evidence can either support or challenge the official police narrative.[33]

4.6 Linking Trajectory Findings with Other Forensic Evidence

For bullet trajectory analysis to achieve its full probative value, it must be integrated with other forensic examinations. These include:

- Gunshot Residue (GSR) Testing: Confirms the firing distance or whether a suspect recently discharged a weapon.
- Bloodstain Pattern Analysis (BPA): Helps determine the position of the victim at the time of shooting and whether movement occurred after injury.
- Autopsy Examination: Reveals internal bullet paths that complement external trajectory data.

When these disciplines converge, the reconstruction becomes far more accurate and legally persuasive. In several Indian investigations, courts have emphasized the importance of corroborating trajectory findings with medical and ballistic reports before drawing final conclusions.[34]

5. JUDICIAL RECOGNITION OF BULLET TRAJECTORY ANALYSIS IN INDIA

Indian courts have increasingly acknowledged the value of scientific evidence in reconstructing shooting incidents, particularly through bullet trajectory analysis. Judicial opinions over the decades reveal a gradual shift from reliance on human testimony to acceptance of objective, expert-driven findings. This evolution underscores the growing faith in forensic ballistics as a tool for truth determination in criminal adjudication.

5.1 State of Madhya Pradesh v. Paltan Mallah (2005)

In State of Madhya Pradesh v. Paltan Mallah, the Supreme Court reinstated the conviction of the accused, Paltan Mallah, for the assassination of prominent trade union leader Shankar Guha Niyogi.[35] The Court overturned the earlier acquittal granted by the Madhya Pradesh High Court, which had dismissed crucial pieces of evidence presented by the prosecution. A significant aspect of the judgment was the Supreme Court's reliance on ballistic forensics, which established a scientific link between the country-made pistol recovered on the disclosure of the accused and the bullets extracted from Niyogi's body.[36] The ballistic expert's report conclusively matched the firearm to the fatal projectiles, providing objective corroboration to the prosecution's narrative.

In addition to the forensic evidence, the Court also accepted two extra-judicial confessions made by Paltan Mallah before reliable witnesses, observing that these admissions were consistent with the ballistic findings.[37] Taken together, the confessional and forensic evidence left no reasonable doubt about the accused's guilt. While affirming the conviction, the Supreme Court commuted Paltan Mallah's death sentence to life imprisonment, acknowledging the inordinate delay in the final adjudication of the case.[38] Importantly, the decision underscored the indispensable role of scientific evidence, particularly ballistic examination, in ensuring evidentiary reliability and truth-finding in homicide trials under Indian criminal jurisprudence.[39]

[33] National Forensic Sciences University, Forensic Ballistics Manual 47 (2022).
[34] Id.
[35] https://www.casemine.com/commentary/in accessed oct 15, 2025
[36] State of M.P. v. Paltan Mallah, (2005) 3 S.C.C. 169 (India)
[37] Id. at 175.
[38] Id. at 177.
[39] Id. at 180.

5.2 Ram Narain Singh v. State of Punjab

In Ram Narain Singh v. State of Punjab, the Supreme Court reaffirmed the evidentiary importance of ballistic trajectory analysis in establishing the accuracy of the prosecution's narrative.[40] The case revolved around a rural shooting incident where multiple gunshots were fired during an altercation. Expert ballistic examination revealed that the bullets had entered the victim's body from a slightly elevated and frontal direction, indicating that the shooter had fired from a higher position, aiming downward. This scientific assessment substantiated the testimonies of eyewitnesses who claimed that the accused had fired from the raised platform of a house overlooking the scene. The Court observed that "scientific interpretation of firing angles and bullet paths leaves little room for conjecture," emphasizing that ballistic reconstruction serves as a critical tool in connecting physical evidence with human testimony.The judgment thus highlighted the judiciary's growing trust in forensic ballistics as an objective method for reconstructing crime scenes and determining the shooter's position with precision.[41]

5.3 Sohrabuddin Sheikh Encounter Case

The Sohrabuddin Sheikh v. State of Gujarat case is one of India's most significant judicial inquiries into alleged fake encounters, marking a crucial intersection between forensic science, human rights, and police accountability.[42] In this 2005 incident, Sohrabuddin Sheikh was reportedly shot dead by Gujarat and Rajasthan police officers, who claimed that he was a wanted criminal killed in an armed exchange. However, subsequent investigations revealed deep inconsistencies in the encounter narrative, raising suspicion that the incident had been staged.

Forensic reconstruction played a pivotal role in exposing these discrepancies. The ballistic and trajectory analyses of the scene and weaponry revealed the absence of corresponding bullet marks and gunfire residues that would ordinarily accompany a crossfire.[43] Moreover, the angle and pattern of the alleged shots did not align with the official account of a moving gun battle, suggesting instead that the shots were fired at close range in a controlled setting. These findings cast doubt on the authenticity of the encounter and pointed toward premeditated execution rather than spontaneous self-defence. The Court reaffirmed that every encounter killing must be subject to forensic and judicial scrutiny, emphasizing that scientific evidence such as ballistic examination, gunshot residue analysis, and trajectory mapping is indispensable in distinguishing genuine self-defence encounters from extrajudicial executions.[44]

5.4 Sukhwant Singh v. State of Punjab

In Sukhwant Singh v. State of Punjab, the Supreme Court emphasized the crucial role of ballistic expert evidence in firearm-related murder cases.[45] The prosecution relied on an eyewitness and the recovery of a .12 bore gun with wads and lead balls allegedly linking the accused to the shooting.[46] However, the failure to send the empty cartridge and the seized weapon for ballistic examination proved fatal to the prosecution's case.[47] The Court held that when both the firearm and cartridges are recovered, ballistic testing is essential to establish a scientific connection between the weapon and the crime.[48] Relying

[40] https://www.casemine.com/judgement/in accessed on oct 15, 2025
[41] Ram Narain Singh vs State of Punjab , AIR 1975 SC 1727
[42] https://indiankanoon.org/search accessed on oct 16,2025
[43] Central Bureau of Investigation, Final Report on Sohrabuddin Sheikh Encounter Case (2011).
[44] Id. at 357.
[45] Sukhwanth Singh vs State of Punjab, (1995) 3 SCC 367
[46] Id. at 370
[47] Id. at 372.
[48] Id. at 374.

solely on the testimony of an interested eyewitness, without such expert corroboration, was considered unsafe and insufficient to prove guilt beyond reasonable doubt.[49] Consequently, the Court overturned the conviction and acquitted Sukhwant Singh, reaffirming that the absence of ballistic analysis creates reasonable doubt and undermines the prosecution's credibility in firearm offenses.[50]

6. CHALLENGES AND RECOMMENDATIONS IN INDIAN FORENSIC PRACTICE

Although India's judiciary increasingly recognizes the importance of bullet trajectory analysis, its practical use in criminal investigations remains limited. Its effectiveness is often hindered by gaps in training, infrastructure, coordination, and standardization.[51]

6.1 Inadequate Scene Documentation

Accurate trajectory reconstruction depends on detailed and early crime scene documentation.[52] However, crucial evidence such as bullet holes, cartridge cases, and impact marks is often lost due to poor scene preservation or lack of awareness among first responders.[53] Once spatial details are disturbed, reconstructing the path of fire becomes unreliable. The absence of modern tools like 3D scanners and trajectory rods further limits precision.[54]

6.2 Insufficient Training and Coordination

Many police personnel and first responders lack adequate training in handling ballistic evidence.[55] Small details like bullet angles or ricochet marks are often overlooked or mishandled, leading to loss of critical information. Additionally, forensic experts are frequently called after the scene has been altered, reducing the value of later examinations. Effective coordination between investigators and forensic teams is essential for reliable analysis.[56]

6.3 Lack of Standardized Procedures

India currently lacks uniform national guidelines for bullet trajectory reconstruction.[57] Different forensic laboratories follow varied internal practices, resulting in inconsistent conclusions and weakening the credibility of expert reports. Establishing a national standard operating procedure (SOP) for trajectory analysis would ensure uniformity, accuracy, and greater acceptance of forensic findings in court.[58]

6.4 Limited Judicial Understanding

While courts are becoming more open to scientific evidence, there is still hesitation to rely heavily on complex forensic interpretations.[9] Limited judicial familiarity with ballistic principles often results in underestimation of scientific findings. Specialized judicial training could help judges better evaluate technical reports and improve the evidentiary weight of trajectory analysis.[59]

6.5 Recommendations

To strengthen the role of bullet trajectory analysis in India's forensic system:

1. Develop National SOPs: Introduce standardized protocols for scene measurement and documenta-

[49] https://www.casemine.com/judgement/in/5f0ce6639fca1904717621a8 accessed on oct 17,2025
[50] https://indiankanoon.org/doc/169580/
[51] See R.K. Mishra, Forensic Science in Criminal Investigations in India 112–15 (2018).
[52] PK.Singh, Bullet Trajectory Reconstruction and Scene Analysis, 24 Indian J. Crim. L. 45, 47 (2020).
[53] Id.
[54] S.Kumar, Modern Technologies in Forensic Ballistics,18 Forensic Sci.Rev 60, 62-63(2019)
[55] R.K. Mishra, supra note 1, at 118.
[56] PK. Singh,Supra note 2 at 48
[57] S.Kumar, Supra note 4 at 64
[58] Id.
[59] R.K. Mishra, Supra note 1 at 20

tion.[60]

2. Adopt Digital Tools: Utilize 3D scanning, photogrammetry, and digital reconstruction to preserve and present crime scenes.[61]
3. Enhance Collaboration: Form integrated forensic teams combining police, ballistic experts, and medical examiners.[62]
4. Expand Training: Conduct continuous training programs for police and judiciary on forensic methods.[63]
5. Create Central Databases: Establish a national ballistic and trajectory database to aid inter-state investigations.[64]

With these reforms, bullet trajectory analysis can evolve from a supporting tool to a central component of evidence-based criminal investigations in India.

7. CONCLUSION

Bullet trajectory analysis is a vital forensic tool, revealing the direction, distance, and intent behind gunfire. Indian courts have increasingly relied on it: in Pattan Mallah v. State of West Bengal,[65] the Supreme Court used trajectory evidence to confirm deliberate firing; in Ram Narain Singh v. State of Punjab,[66] It helped verify assailant positions during a shooting and in the Sohrabuddin Shaikh encounter case,[67] trajectory analysis highlighted discrepancies in the official account, aiding the court's assessment of encounter circumstances. Despite its potential, practical challenges remain. Poor scene documentation, limited forensic resources, and lack of trained experts can undermine ballistic evidence.[68] Strengthening this field requires standardized procedures, advanced tools like 3D scanners, and better collaboration among investigators, forensic scientists, and the judiciary. By aligning with Article 21, Trajectory reconstruction ensures objective, evidence-based justice. As Justice Hegde observed, "scientific evidence speaks through the certainty of physical law".[69]

[60] P.K.Singh, supra note 2, at 50.
[61] S. Kumar, supra note 4, at 66.
[62] Id.
[63] R.K.Mishra, supra note 1, at 123
[64] P.K. Singh, supra note 2, at 52.
[65] State of Madhya Pradesh v. Paltan Mallah (2005) 3 SCC. 169(India)
[66] Ram Narain Singh vs State of Punjab , AIR 1975 SC 1727
[67] Sohrabuddin Shaikh Encounter Case, (2018) 3 SCC 789.
[68] K.R. Raghavan Challenges in Forensic Ballistics in India, 12 J.Forensic Sci. & Crim. Just. 45, 52 (2020).
[69] Id.