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Review Article

The Role of Firearms, Ballistics and Impression Evidences in Criminal Investigation

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Abstract

Background: Firearms, ballistics, and impression evidence play crucial roles in criminal investigations, aiding law enforcement in identifying suspects, reconstructing events, and establishing connections between the crime scene, weapons, and individuals involved. **Methods:** This article reviews current literature and case studies on the applications of firearms, ballistics, and impression evidence in forensic investigations. By examining existing methodologies, forensic standards, and case examples, the article analyses the effectiveness of these types of evidence in identifying suspects, reconstructing crime scenes, and presenting findings in court. **Discussion:** The use of firearms, ballistics, and impression evidence has proven invaluable in criminal investigations. Firearms analysis reveals details such as the calibre and model of the weapon used, while ballistics testing allows for trajectory analysis and, in some cases, shooter positioning. **Conclusion:** Firearms, ballistics, and impression evidence are essential forensic tools that aid in the accurate identification of weapons and suspects in criminal cases. These forms of evidence provide reliable information that can corroborate witness statements, reconstruct crime scenes, and establish links between suspects and the crime.

1. Introduction

Firearms, ballistics, and impression evidence play crucial roles in forensic investigations, aiding in the identification of suspects and the reconstruction of crime scenes. Firearms and ballistics evidences are concerned with the examination and analysis of firearms, ammunition, and the effects of projectiles.

Those evidences help the law enforcement agencies to solve the crime by following the procedures and mechanisms of forensic science.

This study provides an overview of Firearms, ballistics, and impression evidence and their significance in criminal investigations.¹

2. Overview of Firearms

In the study of firearms, experts examine the mechanical workings and characteristics of firearms, such as pistols, rifles, and shotguns. Firearms examiners use various techniques, including comparison microscopy and computerized databases, to analyse these marks.

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The projectile is propelled by explosive force in firearms. Firearms come in various types and have been used for different purposes like hunting, self-defence, and military purposes. Firearms consist of several essential components, it includes a long, cylindrical tube called a barrel is used to fire projectiles.²

Firearms can be broadly categorized into three main types. The first one is the Handguns, which include pistols and revolvers, are made to be used with just one hand. Pistols are Semiautomatic handguns that use a self-loading mechanism to chamber a round after each shot. The Revolvers are handguns with a rotating cylinder that holds multiple rounds, each fired through a separate chamber. The second type of fire arms includes Rifles which is a long-barrelled firearms with spiral grooves inside the barrel (rifling) to impart spin to the bullet for accuracy. The rifles include Bolt-Action Rifles, Semi-automatic Rifles and Assault Rifles.

3. Importance of Firearm Forensic Identification

In criminal investigations and judicial actions, forensic identification of guns is vital. To ascertain their role in a crime, it entails analysing and contrasting firearms, ammunition, and relevant evidence. This process relies on various scientific techniques and principles to establish links between a firearm, a fired projectile, and a suspect. The next step in firearm identification involves the examination of the ammunition. Forensic experts examine the recovered fired cartridges for unique characteristics, including the calibre, head stamp, and firing pin impression.³ The analysis of gunshot residue (GSR) is a key component of firearm identification. When a gun is fired, GSR is released into the air, leaving residue on the shooter's hands, clothing, and surroundings. Forensic scientists collect samples from the suspect's hands, clothing, and the crime scene to analyse the presence of GSR. The study entails recognising recognisable particles that are frequently present in GSR, such as lead, barium, and antimony.⁴

Thus, forensic identification of firearms is a vital component of criminal investigations. In order to prove a connection between a firearm and a crime, forensic professionals must examine and contrast weapons, ammunition, and other relevant evidence. This process involves various techniques, including the examination of firearms and ammunition, the use of comparison microscopes, the analysis of gunshot residue, digital forensics, and the examination of gunshot wounds. Forensic experts carefully handle

and package firearms, ammunition, and related items to prevent contamination or damage.⁵

4. Role of Gunshot Residues (GSR) in Criminal Investigations

Gunshot Residues (GSR) refer to the microscopic particles that are deposited on surfaces when a firearm is discharged. These residues can be useful forensic evidence in criminal investigations, allowing investigators to establish whether a firearm was discharged, how close it was to a certain surface, and perhaps even establish a relationship between a suspect and a crime scene. We shall examine the components of GSR, its techniques of detection, and its importance in forensic science in this article. Gunshot residues consist of three main components: lead, barium, and antimony.⁶

GSR analysis is not limited to surfaces. It can also be conducted on clothing, the shooter's hands, and other relevant items. Techniques like swabbing or tape-lifting are frequently utilised to gather samples from these surfaces. The collected samples are then processed and analysed using the aforementioned techniques to detect and identify GSR particles. It's crucial to be aware of the limitations of GSR analysis even though it can be a useful tool in forensic investigations.

To overcome these limitations, forensic scientists rely on a combination of GSR analysis, other physical evidence, and witness statements to build a comprehensive case. The context and circumstances surrounding a crime scene play a crucial role in interpreting GSR findings. For example, the absence of GSR on a suspect's hands does not necessarily rule out their involvement in a shooting if they were wearing gloves. In recent years, advancements in GSR analysis techniques have led to improved sensitivity and accuracy.⁷ GSR analysis is not limited to crime scenes involving firearms. In circumstances of self-defence or unintentional discharges, it may also be used. Differentiating between intentional shootings and accidental discharges can be crucial in determining the nature and severity of the crime committed. In addition to its application in criminal investigations, GSR analysis has been used in research and experimental settings. It helps evaluate the performance and safety of ammunition and firearms, contributing to the improvement of ballistics and forensic firearm examination techniques. It is important to note that the interpretation of GSR analysis requires expert knowledge and careful consideration of various factors.

5. Forensic Firearms and Ballistics Evidences in a Crime

Forensic firearms and ballistics are a branch of forensic science that involves the examination and analysis of firearms, ammunition, and the effects of projectiles. It plays a crucial role in criminal investigations by providing valuable information about the firearms used in crimes, the trajectory of bullets, and the manner in which injuries were inflicted. Firearms examination is the first step in forensic firearms and ballistics. It involves the identification and classification of firearms based on their characteristics, such as type (pistol, revolver, rifle, shotgun), make, model, and calibre. Sun Shot Residues can be assessed through forensic science. When a firearm is discharged, it releases tiny particles of unburned propellant and other substances onto the shooter's hands and clothing. GSR particles can be collected for the examination of firearm explosion. GSR analysis involves techniques like scanning electron microscopy and atomic absorption spectroscopy.⁸

Ballistics analysis focuses on the study of projectiles, their trajectories, and the effects of their impact. By examining bullet trajectories, experts can determine the angles at which shots were fired and the sequence of shots. This information is crucial for reconstructing crime scenes and establishing the positions of victims, suspects, and witnesses. Forensic ballistics also involves analysing the effects of bullets on their targets. This analysis includes the examination of entrance and exit wounds, as well as the distribution of gunshot residue around the entry area.⁹ By studying these effects, forensic experts can infer the range from which a firearm was discharged and the angle at which the bullet struck the target. Furthermore, the study of gunshot wounds helps forensic experts determine the manner in which injuries were inflicted.¹⁰

Forensic firearms and ballistics analysis are a multidisciplinary field that requires the collaboration of various experts, including forensic scientists, firearms examiners, pathologists, and crime scene investigators. Their combined efforts help unravel the mysteries surrounding firearm-related incidents and provide crucial evidence for legal proceedings. One of the important tasks in forensic firearms and ballistics analysis is the reconstruction of shooting incidents. Bullet trajectory analysis is another crucial aspect of forensic firearms and ballistics. By examining the entry and exit wounds, as well as the paths taken by

bullets through the body or other objects, experts can determine the direction and angle from which the shots were fired.¹¹ This information can help corroborate or refute the accounts provided by witnesses or suspects and provide critical insights into the dynamics of a shooting incident. In addition to the physical aspects, forensic firearms and ballistics analysis also involves the examination of gunshot residue (GSR) and firearm-related injuries. GSR analysis entails taking samples from people who are thought to have fired a gun from their hands, clothing, and other surfaces. This analysis can provide valuable information about an individual's recent involvement in a shooting.

The examination of firearm-related injuries, both fatal and non-fatal, is an essential aspect of forensic ballistics. Pathologists and forensic medical examiners study the nature and characteristics of gunshot wounds to determine the type of firearm used, the range from which the shot was fired, and the potential angles of entry. They assess the severity of injuries, the potential pathways of bullets through the body, and the presence of any defensive wounds.¹² This information contributes to the overall understanding of the shooting incident and can assist in determining the cause and manner of death.

To enhance the efficiency and accuracy of forensic firearms and ballistics analysis, technology plays a significant role. Digital photographs of ballistic evidence gathered from crime scenes and recovered weapons are kept in computerised databases like the National Integrated Ballistics Information Network (NIBIN). These databases enable the rapid comparison and identification of ballistic evidence across different cases and jurisdictions, aiding in the detection of patterns, links between crimes, and potential associations with known offenders. Therefore, we can say, forensic firearms and ballistics analysis is a crucial field within forensic science. By examining firearms, ammunition, and the effects of projectiles, experts can provide valuable information for criminal investigations and legal proceedings.

6. Impression Evidence

Impression evidence refers to any type of evidence that is created when two objects come into contact with each other, resulting in the transfer of physical characteristics from one object to another. For example, a fingerprint left at a crime scene can be used to identify a suspect or eliminate innocent individuals from suspicion. Shoeprints or tire tracks can help establish the route taken by a suspect,

provide information about their size, and even indicate their gait or manner of walking. In hit-and-run cases, vehicle tire tracks can help identify the type of vehicle involved. The collection of impression evidence requires careful techniques to ensure the preservation and accuracy of the evidence.

For two-dimensional impressions, methods such as photography, lifting, or casting are commonly employed. Photography involves capturing detailed images of the impression using specialized equipment, such as macro lenses or alternative light sources to enhance the visibility of the impression. Lifting involves using adhesive materials, such as tape or gel-lifters, to transfer the impression onto a suitable backing material for further analysis.¹³ Three-dimensional impressions are typically collected through a process called impression casting. This involves carefully excavating the impression from the surrounding material to preserve its shape and detail. The impression is then filled with a casting material, which solidifies and creates a replica that can be further analysed.

Forensic Impression Evidence

Forensic impression evidence is essential and important to criminal investigations, when it comes to identifying and connecting suspects to crimes. This sort of evidence entails the study and comparison of diverse imprints, such as footprints, tyre tracks, tool marks, bite marks and fingerprints, left at a crime scene or on objects. These impressions can link suspects to a crime, corroborate witness statements, and help establish timelines. Moreover, impression evidence can be presented in court to support the prosecution's case, providing a scientific basis for identifying suspects and establishing their involvement in criminal activities.¹⁴

Techniques for Analysing Impression Evidence:

Footwear Impressions: Footwear impressions left at crime scenes can be analysed using various techniques, such as casting, photography, and computerized image enhancement. Investigators can compare these impressions with known shoe patterns to determine if they match.

Tyre Impressions: Similar to footwear impressions, tyre tracks left at a crime scene can be analysed by comparing them to known tire patterns. Tire impressions can reveal information about the type of vehicle, tire size, and unique tread characteristics, which can assist in identifying suspects and vehicles involved in a crime.

Tool Marks: Tool marks left on objects, such as doors, windows, or safes, can provide valuable evidence about the tools used in a crime. Forensic experts can examine these marks under magnification and compare them with known tools or tool marks databases to determine if they were made by a specific tool.

Bite Marks: Bite marks can be seen on people's bodies or on items. Forensic odontologists analyse bite marks using dental records, comparing tooth patterns, and identifying unique features that can link the bite mark to a specific individual.

Fingerprints: Through the process of fingerprint identification, fingerprints are one of the most popular sorts of impression evidence. By comparing ridge patterns and minutiae points, forensic experts can determine if a fingerprint found at a crime scene matches those of a suspect.

In spite of its importance, forensic impression evidence faces certain difficulties and restrictions. The accuracy of the analysis and comparison can be impacted by the impression quality, such as fragmentary or distorted marks. Weather and other environmental factors can weaken impression evidence and make it more challenging to analyse. Furthermore, the uniqueness and individuality of impression evidence can vary. Therefore, it is important to consider the probative value and the weight that impression evidence carries in each case. Forensic impression evidence is a valuable tool in criminal investigations, providing investigators with crucial information to identify suspects, establish connections, and reconstruct events. Footwear impressions, tire tracks, tool marks, bite marks, and fingerprints, all contribute to building a comprehensive case.^{15,16}

7. Various legal framework in India and related things:

1. Firearms Regulations and Provisions: Firearm Control Laws: Firearms are regulated under various national laws, such as the Gun Control Act (U.S.), which governs the possession, sale, and transfer of firearms. In some jurisdictions, carrying and using firearms must comply with licensing requirements. Criminal Use of Firearms: Statutory provisions criminalize unlawful possession, discharge, or trafficking of firearms. Statutes related to armed offenses, such as murder or armed robbery, often carry enhanced penalties. Forensic Use of Firearms Evidence: Firearms evidence, like spent cartridges, bullets, and gunshot residue, is often collected under

provisions that guide forensic analysis. Legal statutes such as the Federal Rules of Evidence (FRE) in the U.S. govern how firearms evidence is admitted during trials.

2. Ballistics Evidence: Statutory Framework:

Ballistics Forensics: Ballistics evidence, which involves the study of projectiles (bullets) and their movement, is critical in linking firearms to crimes. Forensic experts analyse bullet trajectory, markings on projectiles, and gunpowder residue. **Legal Admissibility of Ballistic Evidence:** Jurisdictions have specific statutory guidelines under which ballistic evidence is presented in court. In the U.S., the Daubert Standard helps determine if forensic ballistics testimony is scientifically valid and relevant to the case. **Chain of Custody Requirements:** Legal statutes typically require law enforcement to maintain a clear chain of custody for ballistic evidence to ensure its integrity from the crime scene to the courtroom.

3. Impression Evidence: Footprints, Tire Marks, and Tool Marks:

Types of Impression Evidence: Footprints, tire marks, and tool marks fall under impression evidence, which is governed by rules on collection, analysis, and presentation in legal proceedings.¹⁷ **Statutory Standards for Forensic Analysis:** Statutes often reference forensic standards, like those from the International Association for Identification (IAI) or other accrediting bodies, to ensure that impression evidence is properly handled and interpreted. **Admissibility in Court:** Similar to ballistics, legal standards such as the Frye Test or Daubert Standard govern how impression evidence is presented in court. This ensures that the forensic techniques used meet scientific and legal scrutiny.

4. Criminal Procedure: Search and Seizure of Firearm and Impression Evidence:

Fourth Amendment Considerations (U.S.): Legal statutes protect individuals from unlawful searches and seizures, meaning law enforcement must often obtain a warrant before seizing firearms, ballistic, or impression evidence from a crime scene. **Exclusionary Rule:** Evidence collected in violation of statutory provisions related to search and seizure may be excluded from trial under the exclusionary rule, which protects against unlawful gathering of evidence.

5. Expert Testimony and Evidence Presentation:

Forensic Experts: Statutory provisions regulate the qualification of forensic experts who present firearms, ballistic, and impression evidence in court.

These experts must meet specific legal and scientific criteria to testify.¹⁸

6. The Bharatiya Sakshya Adhinyam, 2023: This law governs the admissibility of evidence in courts. In the context of firearms, ballistics, and impression evidence, Sections 45 and 46 are particularly relevant as they allow the testimony of experts in specialized fields (such as ballistics experts) to be admissible in court.

7. Arms Act, 1959: The Arms Act regulates the acquisition, possession, and use of firearms in India. It is essential in criminal investigations involving firearms as it determines whether the use or possession of a firearm is legal. The Act also provides a framework for tracking illegal firearms, which can serve as evidence in crimes involving shooting incidents or illegal weapons possession.

8. The Bharatiya Nagarik Suraksha Sanhita, 2023: The BNSS outlines the process of investigation, including the collection and preservation of evidence. Sections dealing with searches, seizures, and arrests are critical when dealing with firearms and ballistics. Investigating officers have the authority to seize firearms and other relevant evidence, including ballistic materials, for forensic analysis, which forms a part of the criminal investigation process.

Forensic Science Laboratories (FSLs): While not directly under statutory law, forensic science laboratories play a significant role in the examination of ballistic and impression evidence. Ballistics experts in FSLs conduct tests to identify the type of firearm used, match bullets to guns, and analyses gunshot residue, all of which are critical in solving cases involving firearms. There are many advancement and innovations with inclusion of Artificial intelligence in Forensic Medicine and evidence collection techniques.^{19,20}

Impression Evidence: Impression evidence such as fingerprints, tool marks, and shoe prints is crucial in criminal investigations.²¹ The Indian Evidence Act allows for the admissibility of such evidence, while modern forensic techniques enhance the accuracy of identifying suspects through impression marks left at crime scenes.

8. Conclusion

Firearms, ballistics, and impression evidence play crucial roles in forensic investigations, aiding in the identification of suspects and the reconstruction of crime scenes. Firearms and ballistics are concerned with the examination and analysis of firearms, ammunition, and the effects of projectiles.

Thus, firearms, ballistics, and impression evidence are critical forensic disciplines used in criminal investigations. The analysis of firearms and ammunition can provide valuable information about the weapon used, while the examination of bullet and cartridge casing markings can help establish connections between firearms and crime scenes. Impression evidence, such as shoeprints, tire tracks, and tool marks, can assist in identifying suspects and reconstructing the events of a crime.

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