A REVIEW: CASE STUDIES INVOLVING GLASS EVIDENCES

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Abstract:

This paper reviews forensic case studies highlighting the pivotal role of glass evidence in criminal investigations. Focusing on five diverse cases, it explores how meticulous forensic analysis of glass can uncover crucial details, such as the direction of impact, the sequence of events, and potential sources of contact. The paper outlines the primary methods used in forensic glass analysis, including refractive index measurement, elemental analysis and density gradient techniques. Each method's role in establishing connections or exclusions is evaluated in the context of the cases presented. This study highlights the forensic value of glass evidence in linking suspects to crime scenes and reinforces the need for precision to avoid misinterpretation and investigative delays.

Key Words: Glass, Glass evidence, Glass Fracture, Case Study, vehicular crime

Introduction:

Glass evidence plays an increasingly critical role in forensic science, especially in cases involving burglary, vehicular crimes, and violent assaults. As an omnipresent material in modern environments, glass fragments can be transferred between individuals, objects, and crime scenes, thus providing potential links between suspects and criminal activities. Forensic glass analysis allows investigators to determine attributes such as the origin of the glass, impact direction, and specific characteristics that can be matched or differentiated across samples. The inherent variability in glass composition due to manufacturing processes provides forensic scientists with valuable discriminating factors, enabling them to link glass fragments to specific locations or items.

We present a case series where the victims were exposed to traumatic events that left behind glass fragments as critical evidence, allowing investigators to reconstruct events and establish connections between suspects and crime scenes.

This paper delves into five case studies where forensic glass analysis played a crucial role, detailing the methodologies employed to draw conclusions and illustrating how these analyses were instrumental in uncovering truth in criminal proceedings. Techniques such as fracture pattern analysis, refractive index measurement, scanning electron microscopy with energy-dispersive X-ray spectroscopy, density assessments and trajectory analysis for fragmentation have emerged as standard practices in forensic laboratories worldwide. Each method contributes unique insights into the properties and origins of glass, which, when accurately applied, can substantiate the connection between a suspect and a crime scene.

By reviewing these case studies, this paper underscores the importance of glass evidence found at crime scene while advocating for the continual advancement of analytical techniques to enhance accuracy and reliability in forensic investigations.

Methodology:

The forensic analysis of glass evidence involves multiple techniques, each contributing unique information that aids in the identification and comparison of glass fragments. The main methodologies reviewed here include:

1. Refractive Index (RI) Measurement

RI measurement is one of the most extensively used techniques in forensic glass analysis. It quantifies how light changes direction as it passes through a glass fragment, which is a critical distinguishing property among different types of glass.

- **Techniques and Instrumentation**: The most common tool for RI measurement in forensics is the Glass Refractive Index Measurement (GRIM) system, which utilizes a hot-stage microscope to precisely determine RI values by gradually heating the glass and observing the match point with a surrounding liquid.
- **Precision and Reliability**: Studies indicate that the RI of a glass sample can often distinguish between different sources, especially when combined with other physical or chemical data. However, the accuracy of the technique depends on the ability to control environmental factors like temperature, which affects RI values.
- **Case Example:** In a motor vehicle accident involving substantial physiological trauma to the victim, RI analysis was instrumental in linking the source of the glass which had penetrated into the left occipital lobe[3].

2. Elemental Analysis

Elemental analysis provides a "fingerprint" of glass by determining its chemical composition, which varies by manufacturer and type.

- **Energy-Dispersive X-Ray:** EDX is commonly used for elemental analysis of glass fragments. By bombarding the sample with electrons, EDX identifies elements based on their emitted X-ray spectra. EDX is suitable for distinguishing between glass types but can be limited by surface contamination.
- **Scanning Electron Microscope:** SEM is a strong instrument which gives high-resolution images of a sample's surface. It works by directing an electron beam across the surface of the sample. As the electrons interact with the material, they produce different signals, such as secondary electrons, backscattered electrons, and X-rays.

3. Physical Comparison and Pattern Analysis

- **Fracture Pattern Analysis**: Fracture patterns on glass can reveal information about the force and direction of an impact, which can be crucial in reconstructing events such as shootings or explosive incidents.
- **Density Assessment**: Glass Density is analysed using a density gradient column. Fragments settle at matching density points, compared to reference samples, aiding forensic identification and comparison.
- **Trajectory Analysis**: Trajectory Analysis reconstructs projectile path using angles and impact points. Tools like LASERs visualize paths, helping identify shooter's position, discharge height and events for crime scene reconstruction.

Results and Discussion:

The application of forensic glass analysis techniques has proven essential in many case studies, illustrating the forensic significance of glass evidence. Here, we examine notable cases where glass analysis was pivotal in solving crimes:

Case Studies:

Case study – 1

Fire in the Hole (Lucien C. BS. Haag, March 2012)

In this recent shooting case, a man was fatally wounded in the front passenger seat of a Lincoln Navigator. The shot was fired by a police officer positioned near the vehicle's front right fender or side mirror. The officer claimed the victim was aiming a weapon, justifying the shot, while witnesses alleged the victim's hands were raised in surrender. The primary forensic challenge was to determine the victim's arm position at the time of the incident.

Forensic experts focused on forward and backward fragmentation patterns to reconstruct the victim's position when the bullet penetrated the passenger window. Key findings included:

- **Forward and Backward Fragmentation:** The bullet passed through the tempered glass of the front passenger window before hitting the victim. The angle of the impact caused a specific forward and backward dispersion pattern of glass fragments. Backward fragmentation, with shards directed into the vehicle, resulted in "pseudostippling" on the victim's left forearm, showing where glass particles impacted the skin, similar to a stippling effect from gunpowder.
- **Trajectory and Fragment Path Analysis:** The angle of the window, tilted inward by about 20 degrees, influenced the downward trajectory of glass particles into the vehicle. This trajectory meant that glass particles would primarily affect areas below the bullet's path, impacting the victim's left arm and shoulder region while leaving the right arm below the path of fragmentation.
- **Autopsy and Forensic Analysis:** Autopsy findings showed pseudostippling on the left forearm, but none on the right. This detail, combined with trajectory analysis, indicated that the victim had his right arm below the path of glass fragments, consistent with a position where he might have been holding an object rather than having his hands raised.

The distribution of glass fragments and the lack of injury to the right arm suggested that the victim's arms were not raised. The pseudostippling pattern supported the officer's account that the victim's arms were in a position consistent with handling a weapon at the time of the shot. Consequently, the forensic findings concluded that the victim was likely in a posture where he could have been perceived as posing a threat to the officer. This case underscores the importance of forward and backward glass fragmentation analysis in reconstructing events and determining positions in shooting incidents.

Figure- 1

Impact of Glass on Bullet

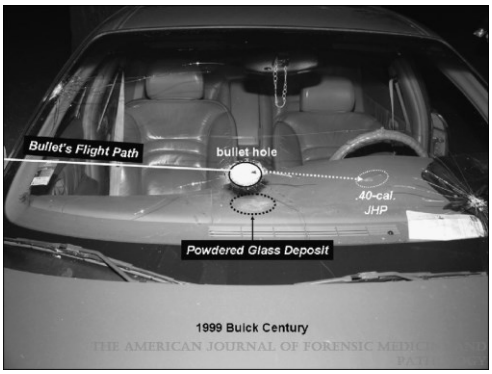

Figure- 2

A shot passing through windshield

Figure- 3
A: A stand-in representing the decedent in the Lincoln Navigator, illustrating the shooter's version of the subject's position at the time of firing his .38 Special revolver.
B: A stand-in for the decedent in the Lincoln Navigator, reflecting the position of the subject at the moment of the shooting, as described by other occupants of the vehicle.

Case study – 2
Glass Penetrating Skull Injury mimicking Projectile Injury (Ryan Blumenthal, 2022)

This case centres on a fatal motor vehicle accident involving a 29-year-old male driver in May 2021. The vehicle overturned and collided with a wall, causing fatal head trauma. A notable complication in the case arose due to a small glass shard that penetrated the left occipital region of the victim's skull, mimicking a projectile wound. This unusual injury raised questions about the cause, and without the glass fragment embedded in the wound, it could easily have been mistaken for a gunshot wound or similar projectile injury.

The forensic analysis of the glass fragment was essential in distinguishing the trauma as accidental rather than ballistic. Various glass analysis methods were employed to verify the glass source, study the fracture pattern, and clarify the injury's origin:

- **Microscopic Examination:** This helped analyse the size, shape, and edges of the glass fragment, revealing fracture characteristics like hackle marks, striations, and break patterns. These findings indicated a blunt force impact rather than a high-velocity projectile, supporting the conclusion that the injury was accidental.
- **Refractive Index (RI) Measurement:** The Refractive Index of the glass fragment was compared to the car's windshield or window glass to confirm its source. The unique RI properties of automotive glass were crucial in identifying the shard as originating from the vehicle.
- **Density Gradient Analysis:** By determining the density of the glass shard and comparing it with other glass samples from the vehicle, analysts confirmed that it matched the type of glass used in the car's windshield, thereby linking it directly to the accident scene.
- **Elemental Analysis (EDS or ICP-MS):** This technique helped identify the elemental composition of the glass. Windshield glass has distinct elemental properties due to specific manufacturing processes, enabling analysts to confirm it as automotive glass.
- **Fracture Pattern Analysis:** Analysts examined the radial and concentric fractures on the glass. Unlike the distinct patterns of high-velocity impacts, the fractures from this incident showed irregular patterns characteristic of a blunt force accident, helping to differentiate it from a ballistic injury.

Detailed forensic glass analysis provided critical insights, allowing examiners to determine that the fatal injury was due to accidental trauma rather than a projectile. This case highlights the importance of thorough forensic analysis in accurately interpreting unusual injuries.

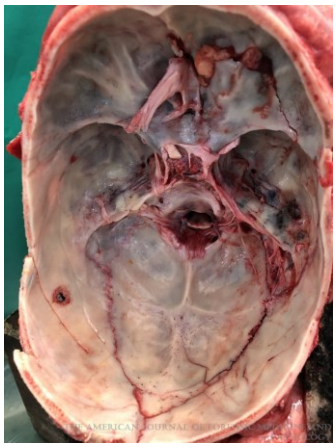

Figure- 4

A tiny glass fragment that entered the left occipital area of the skull.

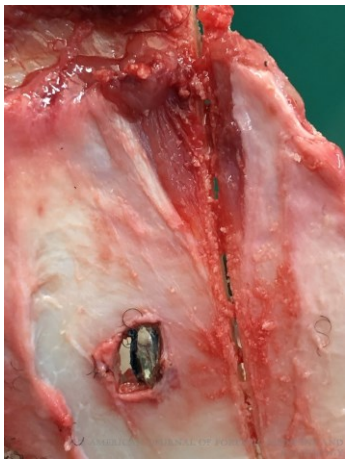

Figure- 5

This bone defect exhibits inward beveling.
A small glass fragment is observed at the centre of the wound.

Case study – 3
The Hit-and-Run Case of Susan Nutt (Tatiana Trejos, Waleska Castro, Jose r. Almirall,2010-17-19; Panadda, C. Ratchapak and P. Nathinee,2018)

In February 1987, 19-year-old Craig Elliott Kalani was killed in a hit-and-run incident while walking his dog in his neighbourhood in northwest Oregon. His body was discovered later that night, and police found glass fragments near the scene & in Craig's pockets. This evidence became a crucial lead in the investigation.

The police began searching for a vehicle that was involved in the hit-and-run. They located a car owned by Susan Nutt that had damage from a hit-and-run collision. To link the vehicle to the crime, investigators needed to match the fragments of glass found at the scene to Susan's car.

Forensic experts first performed a physical match of the glass fragments to the damage on Susan's car. Later, a more detailed elemental analysis was carried out, revealing that the glass fragments from both the crime scene and Susan's car was composed of the same 22 chemical elements. This analysis confirmed that the glass fragments came from Susan's car.

Based on this evidence, Susan Nutt was convicted in connection with the hit-and-run death of Craig Kalani. She received a sentence of up to five years in prison, followed by a five-year probation period.

This case demonstrates how forensic techniques, including physical matching and chemical analysis, can be used to link evidence to a suspect in criminal investigations.

Case study – 4
The Jigsaw Case (J. M. Curran, T. N. Hicks, J. S. Buckleton, 2000)

A suspected hit and run case involving a dead cyclist was found on a poorly lit local road in July, 1972. Various evidences including large glass fragments and the victims' clothes were recovered from the crime scene. Few days later, a glass sample was recovered from a suspect's car.

The large glass fragments showed a characteristic pattern for headlamps and in some a serial code was seen. A "jigsaw fit analysis" was done to match the glass fragments with each other. On examination with a comparison microscope, the edges of the glass fragments formed during the breaking matched with the fragments that have been fitted with the jig saw analysis.

The serial codes of the glass fragments discovered earlier were found to be characteristic of a certain type of car similar to that of the suspect's car. But since matching was not possible, a physiochemical test was done that revealed that it was from the same car.

The glass fragments from the victim's clothes were subjected to similar analysis and the likelihood ratio justified the hypothesis that it had originated from the suspect's car which led to the conclusion that the car was connected to the hit and run case.

Case study – 5
Determination of Headlamp State (P. Baudoin, R. Lavabre, 1996; R. Goebel, 1975)

In November, 1979, two cars collided to each other after dark. The driver of the car who drove into the other testified that he hadn't seen the other car owing to its headlights being switched off which was immediately disputed. In order to check the viability of the statement, the bulbs were sent to the laboratory.

The determination of the dispute could be made by whether the glass envelope was broken during the collision or in case of no breakage, the experts determine any deformations or presence of any specific coating on the tungsten filament.[7] The presence of dark blue, reddish violet coating[8] due to reaction of tungsten with oxygen or a fragment of melted glass indicates that the bulb was turned on during the collision. On examination the following observations were made:

- Stereo-Magnifying Glass: Glass envelope was found broken
- A single object of 1mm melted onto the filament was noticed which was detected spectroscopically via Scanning Electron Microscope.

These conclusions proved that the headlight was on during the collision. Absence of the tungsten oxides could be attributed to the fact that it could be lost during packing or transporting of the damaged bulb.

Conclusion:

This review of forensic case studies emphasizes the critical role that thorough and accurate analysis of glass evidence plays in criminal investigations. Across the cases presented, meticulous examination of glass fragments—whether through refractive index measurements, elemental profiling, or density comparisons—proved essential in linking suspects to crime scenes and reconstructing sequences of events. These findings underscore the need for forensic practitioners to apply established glass analysis techniques consistently and with precision to avoid misinterpretations, as illustrated by the case where flawed analysis led to investigative complications.

We hope that these insights will encourage enhanced training, stricter adherence to methodological standards, and increased awareness within the forensic community, ultimately strengthening the reliability and impact of glass evidence in criminal justice.

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