CHAPTER 3

SCANNING ELECTRON MICROSCOPY IN DISCRIMINATING BETWEEN RICOCHET OR DIRECT BULLET HITTING THE TARGET- A CASE REPORT
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Introduction.

The study of bullet ricochet phenomenon is an essential part in the evaluation of the scene of crime in case of shootout incidents. The ability to assess the ricochet marks and creases at a shooting scene as to the direction of travel of the bullets that produced them aids to the investigator in reconstructing the events associated with the incident. An understanding of the relationships between angles of impact and ricochet angles for various substrates permits the investigator to analyze various scenarios as to their possibility or impossibility. The bullet impact site was reconstructed by removing the surrounding bone and realigning the bony fragments through a photographic study using an operating microscope and matching the bullet to the bone impact signature (O’ Brian C et al., 1991). In the detection of bone and bone plus bullet particles in back spatter from close range shot to head, used SEM-EDX to identify the back spatter bone particles on the weapons suspected to be involved and also identified the weapon which is actually involved in the offence (Burnett Br, 1991). SEM-EDX can be a useful tool for rapid screening of soil samples, especially in combined with investigation of other attributes of soil traces such as color, fabric and the composition, shapes and surface textures of individual articles are aggregates within the soil traces (Kenneth Pye and Debra croft, 2007). SEM-EDX is used in the analysis and discrimination of forensic soil (Salih Cenjiz et al., 2004). SEM coupled with EDXA is also used in the characterization of GSR particles of lead free ammunition (Mathew J Went and Michael J Went, 2007). The efficiency of the filtration process for concentrating small population of gunshot residue particles
detection was studied by using SEM EDX (Zeichner et al., 1989). SEM-EDX is used in the analysis of GSR particles which are modified by target impact (Bryan Burnett M.S., 1989) and also in detecting GSR particles found at the bottom of the discharged bullet (Bergmen P et al., 1988).

**Pasquale Poppa** et al., 2011, have studied the effects of burning head of pigs with several types of lesions (blunt trauma, sharp force, and gunshot lesions) on soft tissues and bones, both from a morphological and chemical point of view. Results showed that the charring process does not completely destroy signs of lesions on bones, which can often be recovered by cleaning bone surface from charred soft-tissue residues. Furthermore, neutron activation analysis test proved that antimony may be detectable and it is also found on gunshot entry wounds at the final stages of charring process.

**Giovanni Cecchetto et al., 2012,** have evaluated and compared the amount and differential distribution of GSR utilizing micro computed tomography (micro CT) in the analysis of fresh and decomposed gunshot wounds.

**Alberto Amadasi** et al., 2012, have studied the area of each entrance wound and was analyzed before and after the carbonization process via a scanning electron microscope (SEM) equipped with an energy dispersive X-ray analyzer (EDX). In each sample, metallic residues composed of lead, barium, and antimony were found. These metallic residues were thus preserved even after exposure to the extremely high temperatures reached within the oven, especially with unjacketed bullets, although the particles seem to be more irregular in shape as a result of the heating process. Finally it is concluded that, the gunshot residues survive extremely high temperatures and can be detected via SEM/EDX even in cases of charred tissues.
Margherita Neri et al., 2007, have studied a microscopic quantitative method based on the use of sodium rhodizonate to verify the presence of residues and their distribution on the cutis of gunshot wounds under confocal laser scanning microscopy. In all skin specimens the area of each histological section was directly measured by an image analysis system. Both the number and the size of powder particles were measured. The distribution of gunshot residues (GSR) in the epidermal and sub epidermal layers was also analyzed.

Anteje Berendes et al., 2006, have studied the heavy-metal-free ammunitions becoming more and more popular, it is necessary to find methods to visualize patterns of those elements in gunshot residues (GSR) that are not accessible by chemographic colouring tests. The recently introduced millimetre X-ray fluorescence analysis (m-XRF) spectrometer is used. A comparison of several methods applied in GSR investigation shows the advantages of the m-XRF method.

L. Garofano et al., 1999, have studied and confirmed that in the majority of cases occupational samples cannot be falsely identified as gunshot residue, it also demonstrates that people with automobile-related jobs (i.e. mechanics, automobile electricians, tyre repairmen) can be exposed to particles composed of barium and antimony which, in some cases, may be hard to distinguish from irregular, flattened and flaky-looking gunshot residue. The risk of a “false-positive” result is particularly high when automatic research systems and tape-lift collection are used without further investigation based on particle morphology.

Audrey Farrugia et al., 2010, have studied the Ricochet of a bullet in the spinal canal is well known by neurosurgeons but relatively not a common event in usual medico-legal autopsy practice. This article is presenting a homicide case of a
penetrating gunshot injury of the lumbar spine through the T12-L1 inter vertebral foramen, with active movement of the projectile within the spinal canal to the L5-S1 level.

Molina et al., 2007, have analysed the gunshot residue particles on the shooters hands in suicides by scanning electron microscopy.

Turkova and M Kotrly, 2008, are illustrating the use of SEM with EDS that make possible to observe topography surface and morphology of the samples and examination of chemical components.

M.E.Taylor, 1973, has studied some applications of scanning electron microscopy (SEM) of forensic interest are outlined including the examination of fibres, hair, paint, timber and metal particles. An SEM with X-ray analysis facilities has been evaluated and its ability to provide analytical data as well as topographical details in a minimal examination time is demonstrated.

Schyma et al., 1997, have experimented gunshots with 9 mm calibre ammunition (9 mm Luger) using a part dummy made of textile, pig skin and gelatine as the target. After ricocheting off a concrete floor tile with impact angles of 15° or 20°, the deformed projectiles penetrated the gelatine block to a depth of between 21 and 37 cm. The ricochet angles varied between 5° and 11°. None of the bullets mushroomed after ricochet; a few bullets even over penetrated. The ricocheted projectiles sprayed a substantial amount of copper particles onto the textile, and metallic fragments were also deposited along the bullet path.

W. Johnson, 1998, had made the study about the ricochet of non spinning projectiles from water.
Haag Lucien C, 2007, have studied the bullets destabilized by ricochet or as the result of an impact with some intervening object experience a yawing to tumbling motion in flight. As a result, they often produce atypical entry wounds, but, as will be demonstrated in this article, this is not a certainty and such bullets can produce normal-appearing entry wounds. It is these wounds that are more difficult to recognize as the consequence of a ricocheted or deflected bullet at the time of autopsy. With few exceptions, ricocheted or deflected bullets also acquire characteristic damage and trace evidence inclusions that often survive the wound production process. A careful inspection of such bullets at the time of recovery will usually reveal such ricochet damage.

G Zadora et al., 2003, have illustrated the importance of Scanning electron microscopy with energy dispersive X-ray spectrometry (SEM–EDX) to classify and discriminate evidence material because they can simultaneously examine the morphology and the elemental composition of objects.

In the review of literature (1-22) demonstrated about the pattern of wounds caused by ricocheted or deflected bullets. But so far there is no study is reported regarding how to discriminate between ricochet bullet and direct bullet hitting the target using SEM-EDX. In this context the present study (M. Kiran Kumar et al., 2009) is planned with an attempt to discriminate between whether the fired bullet is ricocheted one or a direct one.

The objective of the study is

1. SEM-EDX analysis to distinguish between ricocheted or direct bullet is hitting the target.
Case History

A group of youngsters appeared to have gathered for a late night party organized in a pub. They were enjoying the party sitting across a table. Just behind their table family members were sitting across in another table and having their dinner. Under the influence of alcohol one among the group of youngster uttered a few words looking at the family lady. That appeared to be enraged her husband to involve in a heated argument with the group. Under provocation and anger he was reported to be fired a bullet through his .32 revolver. One among the youngster had a bullet injury and the injured was shifted to hospital for medical treatment. A few days after the incident, the accused confessed with his licensed weapon. Later, upon interrogation the accused had made a statement that he did not fire the victim directly instead, he fired the bullet inside the pub in air. He stated further that ricocheted bullet might have been hit the victim.

Material and Methods.

Examination of the Scene of Crime (Pub)

The spot, that is the front room of the pub where the firing was said to be taken place was examined. The room was searched thoroughly for evidence using high concentrated forensic search light but there was no ricocheted or direct dent/hole mark was noticed either on the floor, ceiling, side walls or on surrounding furniture at the scene of crime.

A .32 calibre revolver, fired cartridge cases and live cartridges recovered from the accused and one jerkin along with the bullet were recovered from the victim during medical examination. These exhibits along with the injury report were referred to the forensic laboratory for ballistics examination.
During the examination of the bullet said to be recovered from the victim was found to be .32 calibre lead bullet. The bullet was found to be having rifling marks with a slight deformation at its nose position. Further, the examination of the jerkin reported to be that of the victim has shown a bullet hole when viewed it under the stereomicroscope at high magnification. Later the bullet hole portion of the jerkin was carefully cut and subjected to SEM analysis for the surface morphology and EDXA for the elemental profiling of the adhered foreign particles.

![Fig-1 EDXA spectrum of the bullet hole portion of the jerkin](image)

Further, the recovered bullet was scanned at various positions with the SEM under different magnification. While scanning, the deformed nose position of the bullet, the secondary electron images under 600 magnification and 30 KV accelerating voltage of electron at an working distance 22.7 mm (Fig-2) had shown the deposition of some white particles. The EDXA elemental profile of the white particles found on the deformed nose portion of the bullet is shown in the Fig-3.
Results and discussion.

The bullet hole portion of the jerkin that was subjected to EDXA analysis for the elemental profile had shown only the presence of Lead (Pb) with Kα intensities (KeV) Lα intensity at 10.5517 (Fig-1). Similarly, the elemental profile of the white particles that are deposited on the recovered bullet indicates the presence of carbon, oxygen, lead, phosphorous and calcium. The respective Kα and Lα intensities (KeV) of the elements in that order are 0.2774, 0.5249, 10.5517, 2.0134 and 3.6905 (fig-3).
The presence of phosphorous and calcium on the deformed nose portion of the bullet is suspected to be having the bone origin of the victim. In order to verify and confirm this, the standard bone was scanned using SEM–EDXA under the same operating condition as that of the specimen to acquire the image (Fig-4) and elemental profiling. The elemental profile of the standard bone (Fig-5) indicates the presence of the major elements that were almost identical with that of the white particles found deposited on the deformed nose portion of the bullet. The weight percent of the elements obtained for the specimen and standard bone are tabulated (Table –1).

![Fig-4 Scanned image of standard bone particles.](image-url)
Fig-5 EDXA spectrum of the standard bone particles

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Elements</th>
<th>Weight percent of the elements</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Bullet hole portion of the Jerkin</td>
<td>Deformed nose portion of the bullet</td>
</tr>
<tr>
<td>1</td>
<td>Carbon</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Oxygen</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>Calcium</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>Phosphorous</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>Lead</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Silica</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>Sodium</td>
<td>--</td>
</tr>
</tbody>
</table>

Table-1 The weight percent of the elements obtained for the bullet hole portion of the jerkin, deformed nose portion of the bullet and standard bone piece.
The elemental profile obtained for bullet hole portion of the jerkin shows the presence of only lead indicating that the hole is caused due to the passage of lead bullet. Further, on comparison of the profiles obtained for white particles identified by the secondary electron image at 600 magnification on the deformed nose portion of the bullet and the standard bone piece are finally confirming that the white particles found on the bullet are having the origin of the bone of the victim.

Conclusions.

The secondary electron images (M E Taylor, 1973) of the bony particles that are present on the deformed nose portion of the bullet and secondary electron image of the standard bony particles matches exactly with respect to all the surface characteristics which is consistent with the study made earlier (Burnett Br, 1991) i.e they have detected the bone and bone plus bullet particles on the bullet shot in close range. Also he states that SEM- EDX is used in the whole analysis. With this background the present study reveals that the elemental composition (M E Taylor, 1973) of some white particles found deposited on the deformed nose portion of the bullet shows that it contains elements like Calcium, Phosphorus and lead. Similarly the elemental profiling of the standard bony particles also contains elements like Calcium, Phosphorus along with Carbon, Oxygen, Silica and Sodium. This confirms that the white particles that were found on the deformed nose portion of the bullet appear to be containing the bony particles of the victim. Haag and Lucien C, 2007 have thoroughly studied about the ricocheted bullets and they state that the bullet destabilized by ricochet or as a result of an impact with some intervening object experiences a yawing to tumbling motion in flight. Further it states that ricocheted or deflected bullet also acquires characteristic damage and trace evidence inclusions that often survive the wound production process. A careful inspection of such bullet at the
time of recovery will usually reveal such ricochet damage (Haag and Lucien C, 2007) which had prompted a clue for the present case investigation (M. Kiran Kumar et al., 2009). It was found in the present case investigation report (M. Kiran Kumar et al., 2009) that the victim was sustained with an injury at the upper portion of the left chest region. Further the crime scene examination in the spirit of literature (Alberto Amadasi et al., 2012) report that in the present investigation there was neither the ricocheted nor direct dent/hole mark was noticed inside the pub (M. Kiran Kumar et al., 2009). There is also a literature (Schyma et a., 1997) involving a similar kind of case that helped to make use of SEM EDX analysis in the present case and found that there was deformed nose portion of the bullet but indicating that it was not containing any foreign materials like soil (Kenneth Pye and Debracroft 2007 and Salicenjiz et al, 2004), paint, glass, wood particles that can be originated from the floor, window, ceiling, door, side walls or from the surrounding furnitures. Finally taking the support of the earlier literature (Turkova and M Kotrly, 2008) it is concluded in the present investigation that the bullet fired from the .32 calibre revolver of a family man might have hit the victim youngster sitting in the pub directly and that was ruling out the possibility of ricocheted bullet injury (M. Kiran Kumar et al., 2009).

Summary

A victim was shot using a .32 calibre revolver that might have been injured (Giovanna Cecchetto et al., 2012 and Margherita et al., 2007) at the upper portion of the left chest region. A few days after the incident, the accused had confessed with his licensed weapon. Later, upon interrogation the accused had made a statement that he did not fire the victim directly instead, he fired the bullet inside the pub in air (W
Johnson, 1998). He stated further that ricocheted bullet might have been hit the victim (Haag and Lucien C, 2007). Therefore there was a challenge before the Forensic Ballistician to scientifically establish whether the directly fired bullet or ricocheted one was causing the injury. The study was pursued here (M. Kiran Kumar et al., 2009) through SEM-EDXA analysis involving secondary electron image, elemental profile analysis of the hole portion (Turkova and M Kotrly, 2008 and M E Taylor, 1973) of jerkin of the victim and particles deposited on the nose portion of the bullet that were recovered from the injured body of the victim and their image comparisons with a standard bone particles (G. Zadora et al., 2003). The data obtained from the study (M. Kiran Kumar et al., 2009) are establishing that the bullet fired from the .32 calibre revolver might have hit the victim directly (Schyma et al., 1997) and this empirical support is ruling out the possibility of ricochet bullet hit injury.

The results of this study are published in Trade Science Inc, 2009, ACAIJ 8(1) 2009 pp 01-04 (23).
References


17. Turkova, M. Kotrly, 14th European Microscopy Congress, 2008, pp 635-636


