

Bullet Fingerprinting Analysis by Digital Comparison Microscope



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Abstract

The firearm can be linked to the projectiles on the basis of the striation marks formed due to the irregularities present on the surface of barrel. This can be accomplished by using comparison microscope. No two firearms, even those of the same make and model and made consecutively by the same tools, will produce the same markings on a bullet or a cartridge. On the other hand, bullets fired through the same rifled barrel and cartridge cases fired in the same gun may be expected to show an identity of markings which is peculiar to this particular firearm and to no other. These markings serve to identify a particular rifled barrel because that barrel has an individuality possessed by no other barrel. In this study, 20 samples were examined under digital comparison microscope in which fired suspected samples were compared to the crime bullets by conducting test firing. Class characteristics like direction of twist and individual characteristics like striation marks were compared using comparison microscope. It was found that the caliber of the received samples were 7.65mm and 0.315"/8mm. By comparing the striation marks the sample was declared match or no match, leading to firearm linkage

Keywords: Digital comparison microscope; Bullet; Striation marks; Firearm linkage; Bullet fingerprinting

Introduction

The comparison of marks on fired bullets and spent cartridge cases is a useful way for firearms examiners to make a positive association between fired ammunition and a specific firearm or to exclude a suspected gun. [1] The forensic identification of ballistics specimens relies on the detection, recognition and ultimate matching of markings on the surfaces of cartridges and projectiles made by the firearms [2] (Figure 1). The need for firearm identification systems by police services continues to increase with greater accessibility to weapons in the international contexts [3]. The characteristic markings on the cartridge and projectile of a bullet fired from a gun can be recognized as a fingerprint for identification of the firearm [4]. Forensic ballistics imaging has the capacity to produce high resolution digital images of cartridge cases and projectiles for matching to a library of ballistics images [5] (Figure 2). However, the reliance upon imaging technologies makes identification of ballistics specimens both a demanding and exacting task, where the control of the error of measurement in the imaging technique must not allow compromise of integrity of the identification process (Figure 3). The analysis of marks on bullet casings and projectiles provides a precise tool for identifying the firearm from

which a bullet is discharged [3-6]. The characteristic markings of each cartridge case and projectile are released ready for analysis when the gun is fired. More than thirty different features within these marks can be distinguished, which in combination produce a "fingerprint" for identification of the firearm [7]. This forensic technique has wide application in the world of forensic science, and would play a vital part in legal evidence in the case where firearms are involved. Projectile bullets fired through the barrel of a gun will exhibit extremely fine striation markings, some of which are derived from minute irregularities in the barrel, produced during the manufacturing process (Figure 4 & 5). The examination of these striations on landmarks and groove marks of the projectile is difficult using conventional optical microscopy. However, digital imaging techniques have the potential to detect and identify the presence of striations on ballistics specimens. The discipline of firearm and tool mark identification is based on two empirical hypotheses. The first hypothesis is the consistency/reproducibility of markings which originates from the same firearm or tool. The second hypothesis is the existence of differences between markings originating from two different firearms or tools [7-12].



Figure 1: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 2: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 3: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 4: Showing Comparison Between Crime Bullet and Suspected Bullet.

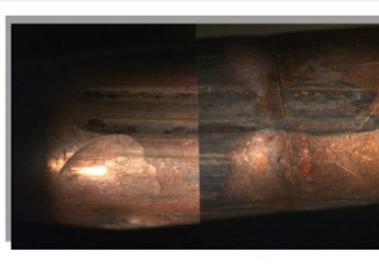


Figure 5: Showing Comparison Between Crime Bullet and Suspected Bullet.

Materials and Methods

Present study was done on 20 fired bullet/bullet fragment with rifled and unrifled firearm brought for firearm linkage in Ballistics Division of Central Forensic Science Laboratory (CBI), New Delhi. Test firing with the available firearm was carried out and at least two bullets from each barrel or at least two test specimens were collected, marked for recognition (Figure 6). Debris from bullets/bullets fragments was removed. Bullet/bullet fragment having biological fluids/residue were handled

with gloves, eye wear, and rinsed in hypo chlorate solution prior to any other examination. Swabs, moistened with methanol, lightly wiped over the surface, taking care not to damage individual characteristics. Stubborn residue were removed by placing the item in an ultrasonic cleaner, rinsed with methanol and allowed to dry (Figure 7). After the initial treatment with crime bullets/bullets fragments were examined for rifling marks-class characteristics under the comparison microscope. The following parameters were ascertained (Table 1):



Figure 6: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 7: Showing Comparison Between Crime Bullet and Suspected Bullet.

Table 1: Showing Microscopic Examination of The Bullet Leading to Firearm

Sample no.	No. of crime bullet	Striation Marks	No. of suspected Firearm	Caliber of Suspected Firearm	No. of Test Fires	Microscopic Examination	Remarks	Conclusion
1	2	IRREGULAR	1	7.65 MM	3	Two 7.65mm fired bullet (marked BC/1 and BC/2) contained in parcel no.2 were compared with three 7.65mm test fired bullet (marked BT/1 to BT/3) which were test fired from 7.65mm country made pistol (W/1) contained in parcel no. 1for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that one 7.65mm bullet had been fired from 7.65mm country made firearm.	MATCH
2	2	IRREGULAR	2	7.65MM	3	Two 7.65mm fired bullet (marked BC/1 and BC/2) contained in parcel no.3 were compared with six 7.65mm test fired bullets(marked BT/1 to BT/6) which were test fired from 7.65mm country made pistol (marked W/1 and W/2) contained in parcel no.1 and 2 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that one 7.65 mm bullet (BC/1) had been fired from 7.65mm country made Firearm (W/1)	MATCH

3	1	IRREGULAR	1	7.65MM	3	One 7.65mm crime bullet (BC/1) contained in parcel no.2 were compared with three 7.65mm test fired bullets (marked BT/1 TO BT/3), which were test fired in the laboratory from 7.65mm country made pistol(W/1) contained in parcel no.1 for their characteristic striation marks , which were found similar.	After examination Under digital comparison microscope, it is Concluded that7.65mm bullet (BC/1) contained in parcel no. 2 had been fired from 7.65mm country made Pistol W/1).	
4	3	IRREGULAR	3	7.65MM	3	Three 7.65mm fired bullet (marked BC/1toBC/3) contained in parcel no.3 were compared with nine 7.65mm test fired bullets (marked BT/1to BT/9) which were test fired from 7.65mm country made pistol (marked W/1, W/2 and W/3) contained in parcel no.1,2 and 3 for their characteristic striation marks	After examination under the digital comparison microscope, it is concluded that one 7.65mm bullet (BC/3) had been fired from 7.65mm country made firearm (W/2).	MATCH
5	3	IRREGULAR	0	7.65MM	0	Two7.65mm fired bullets (marked BC/1 to BC/3) contained in parcel No. 1 to 3 respectively were examined under the digital comparison microscope for their characteristics striations marks.	After examination under the digital comparison microscope, it is concluded that two 7.65mm bullets (BC/1 and BC/3) contained in parcel no. 1 and 3 had been fired from single 7.65mm country made firearm	MATCH
6	3	IRREGULAR	2	7.65mm	3	Three 7.65mm fired bullet (marked BC/1toBC/3) contained in parcel no.3 compared with six 7.65mm test fired bullets (marked BT/1to BT/6) which were test fired from 7.65mm country made pistol (marked W/1 and W/2) contained in parcel no.1and 2 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that two 7.65mm bullets (BC/1 and BC/2) contained in parcel no. 3 had been fired from 7.65mm country made firearm (W/2).	MATCH
7	4	IRREGULAR	0	7.65mm	0	Four 7.65mm fired bullets (marked BC/1 to BC/4) contained in parcel No. 1 to 4. respectively were examined under the digital comparison microscope for their characteristics striations marks.	After examination, under the digital comparison microscope, it is concluded that two 7.65mm bullets (BC/3 and BC/4) contained in parcel no. 3 and 4 had been fired from single 7.65mm country made firearm.	MATCH

8	2	IRREGULAR	2	7.65mm	3	Two 7.65mm fired bullet (marked BC/1 and BC/2) contained in parcel no.3 compared with six 7.65mm test fired bullet (marked BT/1 to BT/6) which were test fired from two 7.65mm country made pistol (marked W/1 and W/2) contained in parcel no. 1 and 2 for their characteristic striation marks.	After examination under digital comparison microscope, it is concluded that one 7.65mm bullet (BC/2) had been fired from 7.65mm country made firearm (W/2).	MATCH
9	2	IRREGULAR	1	7.65 MM	3	Two 7.65mm fired bullet (marked BC/1 and BC/2) contained in parcel no.2 compared with three 7.65mm test fired bullets (marked BT/1 to BT/3) which were test fired from 7.65mm country made pistol (W/1) contained in parcel no.1 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that one 7.65mm bullet (BC/1) had been fired from 7.65mm country made firearm (W/1).	MATCH
10	4	IRREGULAR	2	7.65 MM	3	Four 7.65mm crime bullet (marked BC/1 to BC/4) contained in parcel no.2 compared with six 7.65mm test fired bullets (marked BT/1 to BT/6) which were test fired in the laboratory from 7.65mm country made pistol (marked W/1 and W/2) in contained in parcel no.1 and 3 for their characteristics striation marks, which were found similar	After examination under digital comparison microscope, it is concluded that 7.65mm bullet (BC/1) contained in parcel no. 2 had been fired from 7.65mm country made pistol (W/1).	MATCH
11	2	IRREGULAR	1	0.315"/8MM	3	Two 0.315"/8mm fired bullet (marked BC/1 and BC/2) contained in parcel no.1 compared with three 0.315"/8mm test fired bullets (marked BT/1 to BT/3) which were test fired from 0.315"/8mm country made pistol (W/1) contained in parcel no.2 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that one 0.315"/8mm bullet (BC/1) had been fired from 0.315"/8mm country made firearm (W/1).	MATCH
12	2	IRREGULAR	2	0.315"/8MM	3	Two 0.315"/8mm fired bullets (marked BC/1 to BC/2) contained in parcel No. 1 compared with six .315"/8mm test fired bullets (marked BT/1 to BT/6) which was test fired from country made pistol (marked W/1 and W/2) contained in parcel no. 2 and 3 for their characteristics striations marks.	After examination under the digital comparison microscope, it is concluded that two 0.315"/8mm bullets (BC/1) contained in parcel no. 1 had been fired from single 0.315"/8mm country made firearm (W/1)	MATCH

13	2	IRREGULAR	1	0.315"/8MM	3	Two 0.315"/8mm fired bullets (marked BC/1 and BC/2) contained in parcel No. 1 compared with three .315"/8mm test fired bullets (marked BT/1 to BT/3) which was test fired from country made pistol (W/1) contained in parcel no. 2 for their characteristics striations marks	After examination under the digital comparison microscope, it is concluded that two 0.315"/8mm bullets (BC/1) contained in parcel no.1 had been fired from 0.315"/8mm country made firearm (W/1).	MATCH
14	3	IRREGULAR	3	0.315"/8MM	3	Three 0.315"/8mm fired bullets (marked BC/1 to BC/3) contained in parcel No. 1 compared with nine .315"/8mm test fired bullet (BT/1 to BT/9) which was test fired from country made pistol (marked W/1, W/2 and W/3) contained in parcel no. 2, 3 and 4 for their characteristics striations marks	After examination under the digital comparison microscope, it is concluded that two 0.315"/8mm bullets (BC/2) contained in parcel no. 1 had been fired from single 0.315"/8mm country made firearm (W/3).	MATCH
15	2	IRREGULAR	1	0.315"/8MM	3	Two 0.315"/8mm fired bullet (marked BC/1 to BC/2) contained in parcel no.2 compared with three 0.315"/8mm test fired bullets (marked BT/1 to BT/3) which were test fired from 0.315"/8mm country made pistol (W/1) contained in parcel no.1 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that one 0.315"/8mm bullet (BC/2) had been fired from 0.315"/8mm country made firearm (W/1).	MATCH
16	3	IRREGULAR	2	0.315"/8MM	3	Three 0.315"/8mm fired bullets (marked BC/1 to BC/3) contained in parcel No. 1 compared with six .315"/8mm test fired bullet (BT/1 to BT/6) which was test fired from country made pistol (marked W/1 and W/2) contained in parcel no. 2 and 3 for their characteristics striations marks.	After examination under the digital comparison microscope, it is concluded that two 0.315"/8mm bullets (BC/1 and BC/3) contained in parcel no. 1 had been fired from single 0.315"/8mm country made firearm (W/2).	MATCH
17	4	IRREGULAR	3	0.315"/8MM	3	Four 0.315"/8mm fired bullets (marked BC/1 and BC/2) contained in parcel No. 1 compared with nine .315"/8mm test fired bullet (BT/1 to BT/9) which was test fired from country made pistol (marked W/1, W/2 and W/3) contained in parcel no. 2, 3 and 4 for their characteristics striations marks.	After examination under the digital comparison microscope, it is concluded that two 0.315"/8mm bullets (BC/2 and BC/4) contained in parcel no. 1 had been fired from 0.315"/8mm country made firearm (W/3).	MATCH

18	2	IRREGULAR	2	0.315"/8MM	3	Two 0.315"/8mm fired bullets (marked BC/1 to BC/2) contained in parcel No. 1 compared with six .315"/8mm test fired bullets (marked BT/1 to BT/6) which was test fired from country made pistol (marked W/1 and W/2) contained in parcel no. 2 and 3 for their characteristic striations marks.	After examination under the digital comparison microscope, it is concluded that 0.315"/8mm bullet (BC/1) contained in parcel no. 1 had been fired from 0.315"/8mm country made firearm (W/2).	MATCH
19	2	IRREGULAR	3	0.315"/8MM	3	Two 0.315"/8mm fired bullet (marked BC/1 and BC/2) contained in parcel no.4 compared with nine 0.315"/8mm test fired bullets (marked BT/1 to BT/9) which were test fired from 0.315"/8mm country made pistol (marked W/1, W/2 and W/3) contained in parcel no.1, 2 and 3 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that one 0.315"/8mm bullet (BC/2) had been fired from 0.315"/8mm country made firearm (W/2).	MATCH
20	4	IRREGULAR	3	0.315"/	3	Four 0.315"/8mm fired bullets (marked BC/1 to BC/4) contained in parcel No. 4 compared with nine 0.315"/8mm test fired bullets (marked BT/1 to BT/9) which were test fired from 0.315"/8mm country made pistol (marked W/1, W/2 and W/3) contained in parcel no.1, 2 and 3 for their characteristic striation marks.	After examination under the digital comparison microscope, it is concluded that two 0.315"/8mm bullets (BC/1 and BC/3) contained in parcel no. 4 had been fired from single 0.315"/8mm country made firearm.	MATCH

a) Direction of rifling (right/left)

b) Number of lands and grooves

c) Groove width/land width

d) Twist of rifling



Figure 8: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 9: Showing Comparison Between Crime Bullet and Suspected Bullet.

Compared class characteristic data with the available data and ascertained the probable types of firearm involved. Comparison of class characteristic rifling marks on test fired bullets with crime bullets under comparison microscope with specific reference to number of lands and grooves, direction/angle of rifling, land width as well as groove width whether similar or otherwise or insufficient. If class characteristics on test and crime bullets are similar, then examine and compare individual characteristics. Fragmented bullet even having only one land and groove for tallying class characteristics should

also be compared with test bullets for individual characteristic marks. Examine and compare individual characteristic marks present on all lands and grooves on test bullets in case of rifled firearm and striation marks on test bullets/specimen in case of unrifled firearms and identify similar individual characteristic marks on them. Compared inter-se individual characteristic marks present on crime bullet/bullet fragment whether similar or otherwise or insufficient to ascertain number of firearms involved. Photomicrographs showing individual characteristic matching were taken, duly labeled, and marked (Figure 8 & 9).



Figure 10: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 11: Showing Comparison Between Crime Bullet and Suspected Bullet.

Results and Discussion

Markings on twenty successively fired bullets and expended cartridge cases were examined under digital comparison microscope. The fired samples were compared to the crime bullets by conducting test fires. Class characteristics like direction of twist and individual characteristics like striation marks were compared using comparison microscope (Figure 10). Markings among different manufacturers of ammunition differed significantly even between consecutively fired bullets. From an analysis of striation marks on landmarks, the surfaces of the bore near the breech end area were eroded within twenty fired rounds which is in accordance to [13] Diameter, weight and/or velocity of bullets will affect the reproducibility of striations on landmarks. A smaller number of striations were observed on the small diameter bullets. It was found that the caliber of the received samples were 7.65mm and 0.315"/8mm. By comparing the striation marks the sample was declared match or no match, which led to firearm linkage. When comparisons were made between firearms and fired ammunition the results can read as follows: Exhibit (bullet) was identified as having been fired from Exhibit 2 (firearm) (Figure 11). This conclusion is reached

after all class characteristics agree and a sufficient correlation between individual characteristics is found. Exhibit (bullet) was not fired from Exhibit 2 (firearm). These conclusions are reached if class characteristics don't match [14].

A bullet is slightly larger in diameter than the bore diameter of the barrel in which it is designed to be fired. The bore diameter is the distance from one land to the opposite land in a barrel. As a result, a rifled barrel will impress a negative impression of itself on the sides of the bullet. The rifling pattern in the barrel that fired a particular bullet can be determined by counting the number of groove or land impressions around the circumference of the bullet. Then, by holding the nose of the bullet pointing away from you, the direction the impressions run away from you (either to your left or right) determines the direction of twist. If the rifling impression pattern on the bullet matches the rifling pattern in the barrel of the questioned firearm, the next step is to measure the rifling impressions on the bullet (Figure 12-15). No two firearms, even those of the same make and model and made consecutively by the same tools, will produce the same markings on a bullet or a cartridge. When bullets are compared to standards from a given barrel the pitch to the rifling

impressions can be a means to eliminate the bullet as having been fired from the firearm. If the angle disagrees with the angle found on standards, then the comparison will be a negative one based on those class characteristics. The problem with this is that it is hard to accurately measure the pitch. Unless there

is a noticeable difference in the pitch, it can be difficult to use this class characteristic as a means of elimination. As a result, firearm examiners rarely measure the rifling impression pitch (Figure 16).

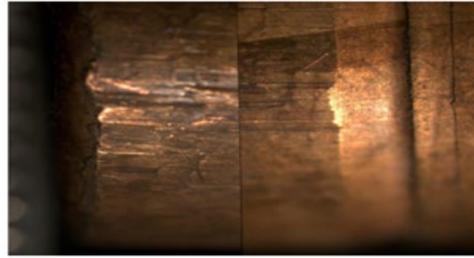


Figure 12: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 13: Showing Comparison Between Crime Bullet and Suspected Bullet.

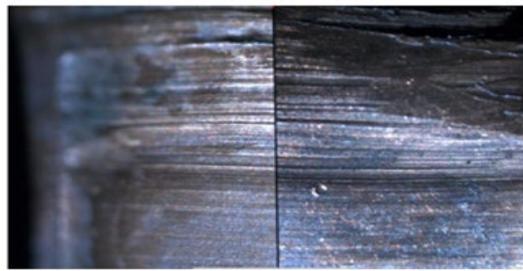


Figure 14: Showing Comparison Between Crime Bullet and Suspected Bullet.

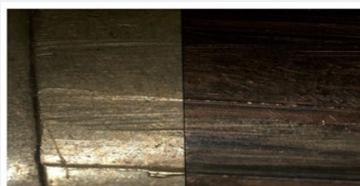


Figure 15: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 16: Showing Comparison Between Crime Bullet and Suspected Bullet.

Conclusion

Markings on twenty successively fired bullets and expended cartridge cases were examined. Markings among different manufacturers of ammunition differed significantly even between consecutively fired bullets. This study shows that there are identifiable features on the surfaces of bullets that can link them to the barrel that fired them [15]. Exhibit (bullet) was identified as having been fired from firearm (Figure 17-20). This conclusion is reached after all class characteristics agree and a sufficient correlation between individual characteristics is found. 20 samples were examined under digital comparison microscope

in which fired suspected samples were compared to the crime bullets by conducting test firing [16-19]. Class characteristics like direction of twist and individual characteristics like striation marks were compared using comparison microscope. It was found that the caliber of the received samples were 7.65mm and 0.315"/8mm. By comparing the striation marks the sample was declared match or no match, leading to firearm linkage [20-25]. Results of this study have provided the forensic science community with additional supportive documentation in the field of firearm and tool mark identification, especially as it pertains to the identification of bullets fired from consecutively rifled barrels [15].



Figure 17: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 18: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 19: Showing Comparison Between Crime Bullet and Suspected Bullet.



Figure 20: Showing Comparison Between Crime Bullet and Suspected Bullet.

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