Indian Journal of Forensic Medicine and Pathology
Volume 16, Number 1, January-March 2023.
DOI: https://dx.doi.org/10.21088/ijfmp.0974.3383.16123.2

ORIGINAL ARTICLE

Firing Pin Micro-Printing for Identification of Firearm

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ABSTRACT

Any device of any kind that is built or modified to discharge a projectile of any kind using the force of an explosive or other types of energy is considered to be a firearm. The three basic components of a firearm are the breech, barrel, and stock. The firing pin and hammer are part of the breech. The firing is initiated when the hammer strikes the firing pin, which then forcefully impacts the percussion cap at the base of the cartridge containing the primary explosive substance. During this procedure, the firing pin leaves distinct markings on the percussion cap that help determine if the purported handgun can be positively or unfalsifiably identified during test firing. These markings, however, can occasionally be purposefully damaged or removed in order to lead the investigation officer or ballistic expert astray. Firing pin markings won't be useful for identification in these circumstances. The conceptual work in the current study involves using micro laser printing to engrave the serial number of firearms on the firing pin's surface as well as precise markings at the firing pin's tip. These carefully etched markings will make it easier to identify factory made weapons in shooting incident instances. However, the main goal of this effort was to increase the significance of firing pin marks for the identification and linkage of the fired cartridge case and firearm. Although there are other ways for identification, such as breech marks, extractor marks, chamber marks, etc.

KEYWORDS | Firearm; Firing Mechanism; Firing Pin; Micro-Printing; Identification; Ballistic Expert.

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Received on: *21.10.2022*

Accepted on: *18.12.2022*

How to cite this article:
Vikhyaat Kumar, Bhoopesh Kumar Sharma, Megha Walia, et al./Firing Pin Micro-Printing for Identification of Firearm. Indian J Forensic Med Pathol.2023;16(1):17-23.

INTRODUCTION

Forensic ballistics is the branch of forensic science that deals with shooting incidents and examination of firearms and related evidences for the purpose of justice. A ballistic expert works on matching, and identification of empty cartridge cases and bullets to identify and link the alleged firearm.[1] In instances involving weapons and ammunition, a ballistic expert is a forensic scientist who works for the criminal justice system and provides testimony in accordance with it in court.[2]

Firearms and ballistic matching play a crucial role in criminal investigations because "every firearm tells a tale." The details required to tell their story can be found on a gun's exterior and interior as well as on the used ammunition. This information is further utilized to support

ensuing investigations and legal actions.[3] For instance, a ballistic comparison can demonstrate that a firearm was used in a murder case as well as other crimes committed abroad, which is already a sign of the weapon's routing.[4]

A firearm is a device of any description designed or adapted to discharge a projectile of any kind by the action of explosive or other forms of energy. Any firearm usually has three basic parts i.e. breech, barrel, and stock. The breech part consists of a firing pin and a hammer. During firing, the hammer strikes the firing pin and further firing pin strikes forcefully on the percussion cap located at the base of the cartridge that bears the primary explosive material to initiate the firing. During this process, the firing pin leaves specific markings (Fig. 1) on the percussion cap that aids in the positive or negative identification of the alleged firearm during test firing.[5] However, these markings sometimes may be disturbed or destroyed deliberately by using any tool to misguide the investigation officer or ballistic expert. In such cases firing pin markings will not serve the purpose of identification.[6]

Fig. 1: Showing the Comparison of firing pin marks under Stereoscopic microscope, Created after firing over the percussion cap on 0.32 caliber cartridges.

When the fired cartridge is examined then the examiner looks for certain marks those imprinted as a result of the firing pin striking the percussion cap (primer cap) or rim of the cartridge in rim fire cartridges.[7] On the other hand, when a cartridge is discharged in any firearm, very high pressure gases are generated inside the cartridge and forces the cartridge head back against the head of the breech block of the gun, imprinting the impression on the brittle material, often brass or germanium on the breech face, this creates an individual breech face markings at the base of the cartridge.[8] Similarly, the marks that are created when cartridge cases are ejected from the action block of a firearm are called ejector marks. Furthermore, the standard factory made firearms seldomly leave chamber marks on the fired ammunition when the chamber has some defects than it imprints its marks on the cartridge these types of marks are called chamber marks.[9]

However, these markings sometimes may be disturbed or destroyed deliberately to misguide the investigation officer or ballistic expert. In such cases firing pin markings will not serve the purpose of identification.[10] This conceptual work of creating specific markings at the tip of the firing pin of a firearm and engraving the serial number of the firearm on the surface of

the firing pin through micro-printing process have assisted in the identification of firearms in shooting incident cases of factory made firearms.

LITERATURE

Eight fractal dimension features and eleven geometric moment features were recovered from firing pins from five handguns of the Parabellum Vector SPI 9 mm type by Norazlina Razak et al. (2020) using the system feature fusion of fractal dimension. Five different machine learning approaches were used to classify all the features. The outcome demonstrates that the neural classifier had a 99.3% classification accuracy rate. An excellent result for automatic firearm detection is obtained when fractal dimension approaches, geometrical moments, and neural networks are combined.[11]

The position and direction of a firearm at the moment of discharge are critical, according to Valentina Manzalinia et al. (2020). The study examined the cartridge cases that were discharged from three different revolvers with three different spatial orientations (vertical upwards, horizontal, and vertical downwards). Surface topography analysis and optical microscopy were utilized to quantify the firing pin impression and define its depth and form. The direction of the rifle had a significant impact on the size and depth of the firing pin impression: rounds fired upwards produced the deepest impression, while those discharged downwards left the smallest. This behavior was attributed to the changing shape of the firing pin-primer cup contact as well as the varied pressure applied by the primer as the weapon's orientation changed. This notion has shown that a sufficient morphological and topographical analysis technique may be constructed to ascertain whether a revolver shot was fired while the weapon was held horizontally, upwards, or downwards.[12]

In comparison research by Suresh R. (2017), four 0.22 rim fire cartridges from a known source were used, and following a test fire, two of them were stereo microscopically inspected. The characteristic marks were caught by the digital camera, and the results were then acquired by performing a comparative analysis of the striations utilizing various tools and a computer system. The results were crucial in locating a specific handgun. This study was completely based upon comparison of the photomicrographs that has already been done by several researchers before.[13] The study was limited for only two types of cartridges, whereas more study is needed in this area to link a particular firearm with the alleged cartridge cases.

Guns have been marked with a code by David H. and colleagues in 2008. If the code inscribed on the spent cartridge casing can be connected to a specific firearm in a database, the job of forensic scientists and police investigators can be greatly expedited. With the present direct-writing procedure, three alternative encoding formats may be applied to a single firing pin: an alphanumeric code, a gear code, and a radial bar code. Previously, this technology only allowed for the laser machining of a single alphanumeric code on the firing pin's face.[14]

The "Kanade Lucas Tomasi" (KLT) equation was utilised by Zeno G. et al. (2001) to apply a rapid signature-based pre-selection technique. Authors utilised this method to compare the computed points' positions. In this way, when paired with the third scale of the trous wavelet, 11 of the 49 photographs from their study were in the top spot. In large part, whether or not correct matches are found in the top ranking position depends on how prominent the markings are. The top 5% of the total database, where all of the photographs were found, was used. This procedure is easy to complete and can be done quickly such that comparisons can be made in only a few seconds.[15] In order to achieve higher accuracy levels, authors recommend conducting additional study in this field with more computed points.[16,17]

MICROPRINTING, PROCEDURE AND APPLICATIONS AS A NOVEL FEATURE

The major challenge face by the ballistic experts during the examination of firing pin marks under comparison or stereo microscope, are the identification of damaged or destroyed

firing pin marks after or before firing on the percussion cap of the cartridge case. Though identification and linkage of the fired cartridge case with the alleged firearm are still very much possible with the aid of other markings such as breech face, ejector, extractor markings, etc., however, many times these markings can also be damaged to an extent by various means, making it further difficult for the expert to perform a positive examination.[18,19]Also, it is very much evident from the previous studies that in most of the cases, the firing pin marks are primarily considered as an identification tool by the forensic experts.[20]

The present concept was to engrave a specific pattern on the firing pin's tip along with a serial number of the firearm on the firing pin's surface to provide a more sophisticated, accurate, and specific identification of the firearm from the fired cartridge case (Fig. 2). This will also help the investigators further in cases where the complete firing pin of the firearm is damaged or changed to misguide the investigator. Any such change can easily be pointed out by examining the serial number on the changed firing pin to serve as a strong clue of tampering with evidence.

Fig. 2: Image of the specially designed firing pin engraved with micro-printed numbers with an enlarged view.

A specific spiral pattern was engraved with the help of micro-printing during the manufacturing process of the firing pin, and at the time of firing, when the firing pin strikes the percussion cap of the cartridge during firing, that specific pattern will be imparted on the percussion cap making it easy and specific for identification without much labor as shown in Fig. 3.

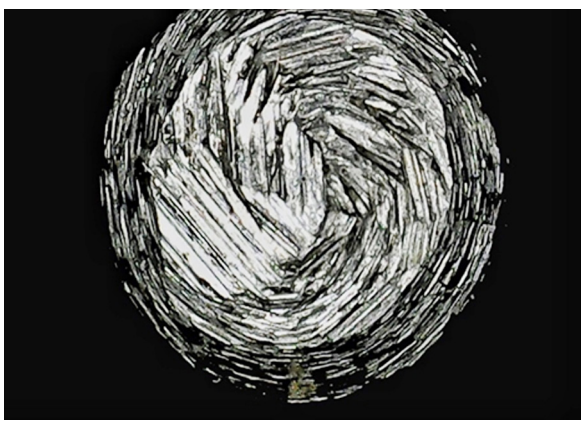

Fig. 3: The engraved markings at the tip of firing pin with the aid of Micro-Printing shown in magnified view under stereomicroscope.

MATERIALS AND METHODS

The main aim of the study was to:

- To design and inscribed a specific pattern at the tip of the firing pin with the help of Micro-laser Printing
- To conceptualize the micro-printing of the firearm serial number on the surface of the firing pin.
- To study the effectiveness of the concept in easy identification of the firearm with the help of stereomicroscope.

For the experiment an imitated firing pin of the dimension firing pin of 3.375 inches in length and diameter of 0.078 inch, the tip of the firing pin was 0.039 inches as shown in figure 3 was created with the help of an ironsmith with a special engraving on the tip of the firing pin and the surface using Micro-Laser Printing method. The ironsmith was provided with pre-design markings that need to be engraved with the help of micro-laser printing at the tip of the firing pin. The created marks were then imprinted on a hard metaling surface (aluminum and steel) and soft clay dough imitating the percussion cap of the cartridge case. The obtained marks were then analyzed using stereoscopic microscope under 50x magnification and by using a hand digital microscope.

RESULTS AND DISCUSSIONS

During the careful examination under stereomicroscope a clear, identifiable, and specific marks pertaining to the specific firing pin were observed on the hard metallic surface as well as on the soft dough clay surface (Fig. 4).

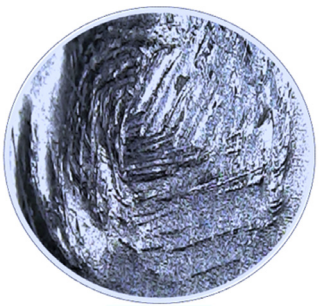

Fig. 4: The markings imprinted on the hard steel surface by the micro-printed firing pin and then examined under stereomicroscope.

From the experiment it became evident that on the harder steel and aluminum surfaces, exactly similar striations were imprinted those were engraved at the tip of imitated firing pin. Under stereomicroscope similar striation patterns were encountered and photographed and then compared with the markings created on different surfaces and it was found the concept of engraving the firing pin was quite successful and can definitely aid in more accurate and positive identification of the firearm in shooting incident cases. The marks were repeatedly imprinted on various hard surfaces as shown in fig. 5, then compared under stereomicroscope with a magnification of 50x. However, the marks imprinted on wooden surface was not as clear as on the other hard metallic surfaces (Fig. 6).

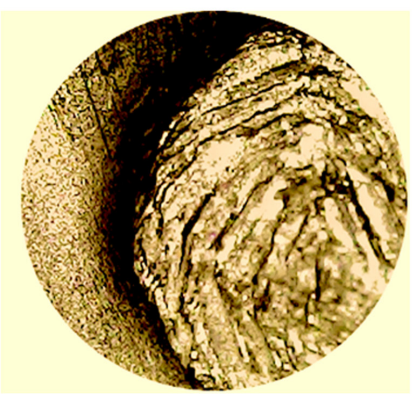

Fig. 5 and **Fig. 6:** The markings imprinted on the hard brass surface and wooden surface respectively.

CONCLUSION

In literature it was observed that there is no such phenomenon described to provide a complete identification of firing pin within a firearm as well as on the fired cartridge case. Till date, the examination is done with the aid of a comparison microscope in respect to specific markings caused by a particular firing pin of a firearm on the fired cartridge percussion cap. In this regard, a specific mechanism is needed to provide a more specific and accurate identification on the basis of firing pin marking that can link a fired cartridge case with an alleged firearm as well as which can help in identification with accuracy in cases where country made firearms are used as weapon of offence. Also, there have been instances as per the literature, where the firing pin of a firearm has been damaged/changed before the forensic examination. This problem can be addressed well when the serial number of a particular firearm will be inscribed over the firing pin along with a specific marking (that will be discussed in this concept) on the tip of the firing pin. This will definitely overcome the issues related to the examination and linkage of a firearm in a shooting incident. Forensic examiners after examination and identification can create a database of the same for further references. Also, if during manufacturing of the firearm this database is maintained, then this will be an additional proactive measure to combat the crime as well as a reactive measure to identify the shooter or the firearm. Additionally, the firing pin serial number will be provided in the license book to the license holder, which will make it further secure to prevent any improvisation in the firearm. This will be a proactive step taken by the firearm manufacturers and the license issuers to prevent the criminal activities and also tampering of the evidence later on.

Conflict of Interest: *Nil*

Source of Funding: *Nil*

Acknowledgement: *Nil*

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