IBIS Acquisition and Correlation of Ejection Port Marks from Ten Consecutively Manufactured Glock Pistols

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ABSTRACT

The acquisition of the ejection port marks on 30 cartridge cases with the IBIS BULLETTRAX (Integrated Ballistics Identification System) was investigated. All cartridge cases came from the test firing of ten consecutively manufactured Glock 17 pistols. Increasing the number of surfaces and marks available for the comparison process with the IBIS TRAX-HD3D will inevitably enhance the reliability of the correlation, and moreover, the potential for ballistic identification. The reproducibility and uniqueness of these ejection port marks were also studied. These marks are not always reproducible and variation does exist in their shape and location.

Introduction

In the examination of firearms, one of the classic studies is to perform microscopic comparison on marks produced by firearms or firearm parts which have been consecutively manufactured. Numerous studies have been conducted in the past to prove that in the manufacturing process of firearms, marks can be produced in a unique way and be further used as individual characteristics **[1, 2]**. Individual characteristics are "marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage. They are unique to that tool to the practical exclusion of all other tools" **[3]**.

In this article, the reproducibility and uniqueness of ejection port marks will be investigated. Ejection port marks are dynamic marks created during the ejection process of the cycle of fire. During ejection, the cartridge case can hit the edge of the ejection port (the working surface) of the slide and striations can be created when interacting with the metal surface, which is granular **[4, 5]**. In the case of Glock pistols, this granular texture on the ejection port comes from the chemical surface treatment used on several metal parts to make them more corrosion resistant **(see Figure 1) [6]**.

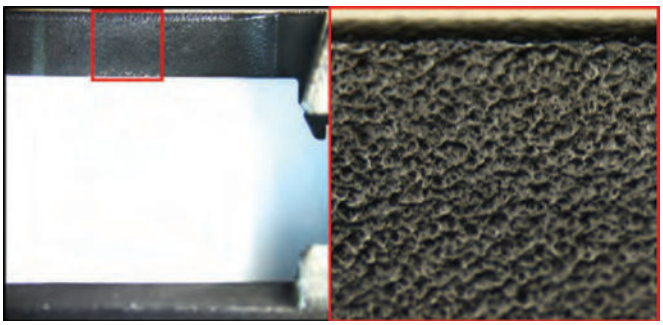

Figure 1: Ejection port of a Glock 17 pistol (4th generation). Left side shows the edge of the port and right side shows the grainy metal surface of the red area with higher magnification.

Ejection port marks can have both class (i.e. general shape) and individual characteristics (i.e. striations) and can be evaluated and considered as useful data for the identification process **[5, 7, 8, 9]**. Moreover, they can have different general shapes and are not produced by all firearms. Indeed, it depends on many variables such as the manufacturer, model, and caliber of the firearm. However, studies have shown that Beretta **[5]** and

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Glock **[7]** pistols typically produce ejection port marks in a fairly consistent manner.

In one of the cases examined in the authors' laboratory, ten semi-automatic Glock pistols with consecutive serial numbers were received. Taking advantage of such an opportunity, the authors decided to study ejection port marks present on cartridge cases fired from these firearms.

The objectives of this study were to:

- Verify the reproducibility and uniqueness of Glock ejection port marks on ten consecutively manufactured pistols;

- Evaluate the possibility to acquire cartridge cases with the IBIS BULLETTRAX system;

- Use acquired ejection port marks to make IBIS correlation with the Correlation Server;

- Compare all Glock ejection port marks with the IBIS MATCHPOINT and make identifications.

Materials and Methods

The ten firearms used in this study were fourth generation 9mm Luger caliber Glock 17 pistols that were manufactured consecutively (personal communication in May and September 2021 with Glock U.S. Headquarters; unreferenced,

Random numbering of cartridge cases	Glock pistols	Type of ejection port marks
2	A	Triangular shape
15	A	Triangular shape
27	A	N/A
9	B	Triangular shape
13	B	Rectangular shape
18	B	Rectangular shape
8	C	Triangular shape
11	C	Rectangular shape
25	C	Triangular shape
5	D	Rectangular shape
24	D	Triangular shape
28	D	Triangular shape
6	E	Triangular shape
12	E	N/A
26	E	Rectangular shape
17	F	Triangular shape
21	F	Rectangular shape
30	F	Triangular shape
3	G	Triangular shape
10	G	Triangular shape
23	G	Triangular shape
7	H	Triangular shape
16	H	Triangular shape
22	H	Triangular shape
4	I	Triangular shape
14	I	N/A
19	I	N/A
1	J	N/A
20	J	Triangular shape
29	J	Rectangular shape

Table 1: Random numbering for each Glock cartridge case with their type of ejection port marks.

see "Acknowledgements"). For each firearm, the serial number was consistent on the frame, slide, and barrel. Each pistol was received new in factory condition and in its own original labeled case containing all the Glock accessories.

Each pistol was test fired three times in a conventional manner with Federal brand cartridges (nickel-plated primer and brass cartridge case). Every fired cartridge case set was recovered and retained in a labeled envelope. In order to limit cognitive biases during the comparison process, a random number was assigned to each cartridge case **(see Table 1)**. A Leeds Forensic Systems comparison microscope, LCF3 Olympus SZX16, was used for manual microscopic comparison. The acquisition of the ejection port marks was performed by the IBIS BULLETTRAX and the comparison was made using the IBIS MATCHPOINT. The IBIS TRAX-HD3D system was operated with version TRAX 3.1 SP1 / DB 5.1.1.

Two different methods were employed to acquire the marks with the IBIS BULLETTRAX. In the first method, the acquisition of cartridge cases was made according to the same procedure as used for bullets **(see Figure 2, left side)**. Given that ejection port marks originate only on a small region of the fired cartridge cases, a targeted acquisition was performed in order to acquire only the ejection port mark. In the second method, cartridge cases were rotated for the acquisition at a 90-degree angle to the normal position, so that the striations were positioned in the same direction as on bullets **(see Figure 2, right side)**. To avoid diluting the IBIS database with non-case-related samples, all the cartridge case exhibits of this study were saved under the IBIS event type "Quality Control". This means that exhibits were only correlated between themselves and not with the whole database. The IBIS Correlation Server was then used to make correlations between exhibits. After the correlation, exhibits were classified by general "Rank Sort" and then compared on IBIS MATCHPOINT.

Results and Discussions

Analysis of Fired Cartridge Cases Using A Comparison Microscope

Out of the 30 fired cartridge cases discharged from the ten different Glock pistols examined, 25 of them exhibited ejection port marks. During the examination using the comparison microscope, two types of ejection port marks were observed: either a triangular-shaped mark situated on the fired cartridge case's mouth or a rectangular-shaped mark situated a few millimeters below the fired cartridge case's mouth **(see Figure 3)**. **Table 1** shows a summary of all 30 cartridge cases test fired from the Glock pistols, with the indication of the type of ejection port marks. These pistols were marked by letters from A to J for anonymity purposes. Out of the 25 ejection port marks, 18 were triangular-shaped and seven were rectangular-shaped. Both types of marks can be observed on cartridge cases fired from the same Glock pistol. As a result of microscopic analysis, it can be stated that the presence and the shape of Glock ejection port marks are not always reproducible from Glock to Glock with consecutive serial numbers and present variations within cartridge cases fired by the same pistol.

However, in Finklestein et al. **[7]**, all 19 Glock pistols tested (eight different models and three different calibers) left a peculiar and recognizable complete triangular-shaped mark on each cartridge case's mouth. Their conclusions were that these marks: "were not accidentally produced, were not dependent on the ammunition manufacturers, contained both class and individual characteristics and could be further used to give a positive comparison". Back in 2005, the year in which this study was published, only the first three generations of Glock pistols were available. The production of 4th generation Glock pistols began in 2009 **[10, 11]**. From the present study, ejection port marks on Glock 17 (4th generation) pistols are

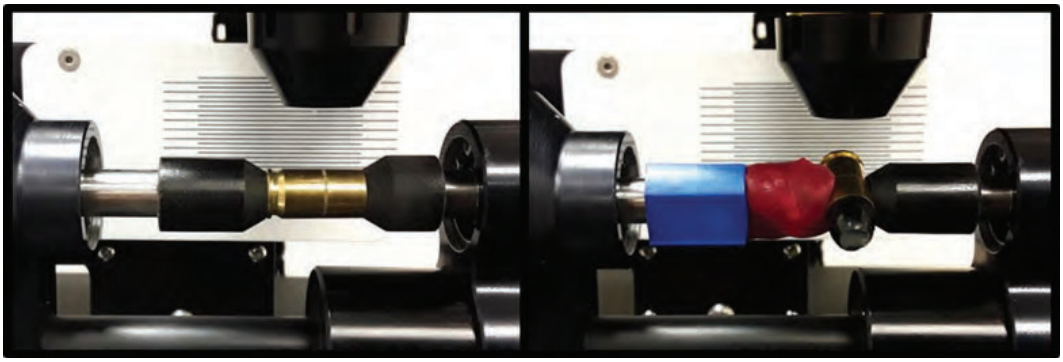

Figure 2: Acquisition setup on the IBIS BULLETTRAX system for ejection port marks. On the left side, first acquisition method according to the normal acquisition procedure for bullets and on the right side, second acquisition method with a 90-degree angle rotation to the normal acquisition procedure.

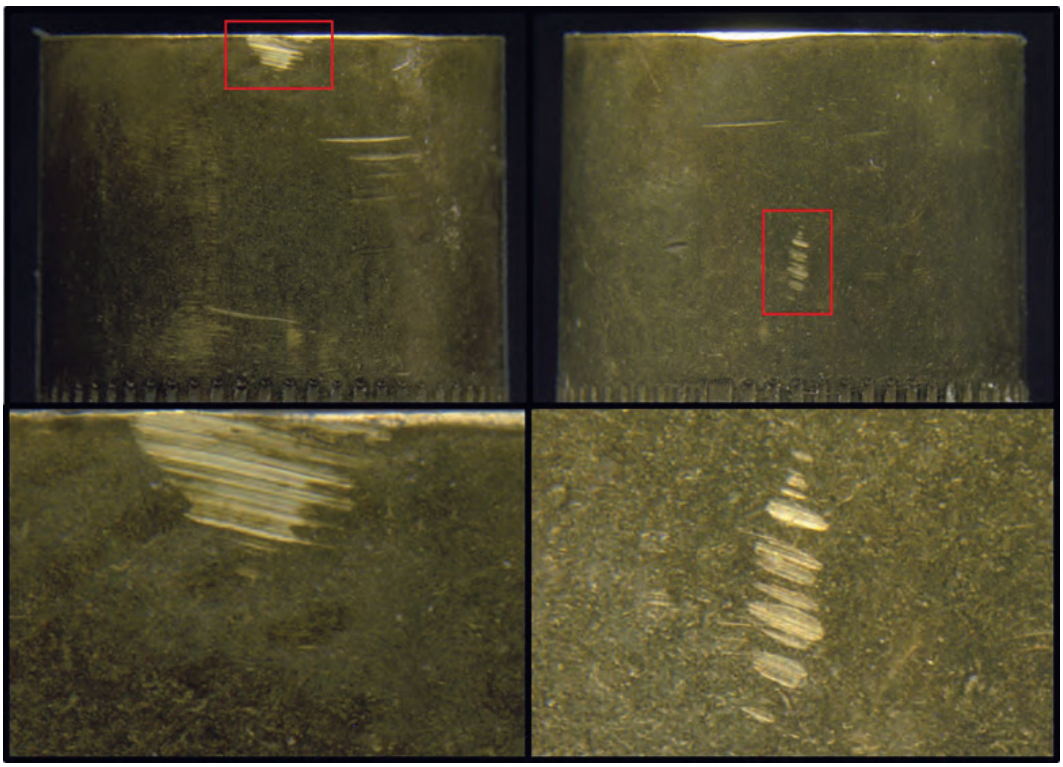

Figure 3: Ejection port mark on two different cartridge cases fired from the same pistol (Glock pistol E). On the left side, a triangular-shaped mark and on the right side, a rectangular-shaped mark with their respective close-ups below.

definitely not always reproducible and there is also variation in the general shape.

Dimension and location of the ejection port marks are variable and depend on how the fired cartridge case will strike the ejection port. In other words, it will depend on the point of impact and the angle of impact between the fired cartridge case and the ejection port. This led us to present two main hypotheses that could explain this high level of variation between studies:

- Glock slide design (4th generation vs older generations);
- Shooting method and recoil damping.

Comparison of Fired Cartridge Cases Using A Comparison Microscope

A microscopic comparison was performed on each fired cartridge case to determine if the ejection port marks can be used to determine if they originated from the same source pistol. A total of 21 associations were theoretically possible depending on the number of cartridge cases that had ejection port marks and the firearm used to fire them. The ejection port marks were then classified under this range of conclusions: identification or inconclusive.

Identification means that there is an agreement in all discernable class characteristics and sufficient agreement in individual characteristics to conclude that the marks originated from the same source **[3]**. For the purposes of this study, inconclusive means that there is agreement in the class characteristics, and some agreement in individual characteristics, but insufficient for identification. It is important to specify that this range of conclusions is only used to associate the ejection port marks to each other. All other marks (i.e. firing pin, breach face marks, etc.) were not considered in the comparison process. The methodology used for comparison was pattern matching.

After analyzing and comparing the ejection port marks using the comparison microscope, it was found that the triangular-shaped marks are the easiest to compare because of the amount of striae available for comparison. However, triangular-shaped marks and rectangular-shaped marks can also be linked together, but with some difficulty. Indeed, the two types of marks are not exactly at the same height on the fired cartridge case, so that there is only a small part of the two marks overlapping, which considerably reduces the amount of

features that can be compared. Unfortunately, sometimes the association is not possible because the marks do not overlap at all. One of the variables associated with the creation of ejection port marks is the unpredictability of the exact area or surfaces along the edge of the ejection port that will make contact with the expended cartridge case to create the mark. Some pistols may be very consistent and reproducible in this action, and others less so.

Finally, 14 associations were physically possible according to location, shape, dimension and quantity of striations available on the ejection port marks. Among them, seven were classified as identification and seven as inconclusive. For the other marks, there was no overlap and therefore no possibility of association. **Figure 4** shows a comparison using the microscope of two ejection port marks classified as an identification and the microscope comparison summary is shown in **Figure 5**.

In addition to the comparison performed to assess the reproducibility and variability of the ejection port marks, a uniqueness analysis was performed. To do this, each cartridge case with an ejection port mark was compared with all other cartridge cases fired from the various pistols. As a result, none of the ejection port marks were mis-identified as having originated from pistol slides that were not used to create them, which demonstrates their uniqueness. Additionally, the granular surface texture **(Figure 1)** of the edge of the ejection ports appears random; therefore, no subclass influences would be expected in the resultant marks.

Correlation Results for the First Acquisition Method

By using the first acquisition method as described previously, a total of 35 acquisitions were performed with the IBIS BULLETTRAX system and then correlated by the IBIS Correlation Server. In some cases, an additional acquisition had to be done to acquire the whole mark. Of these 35

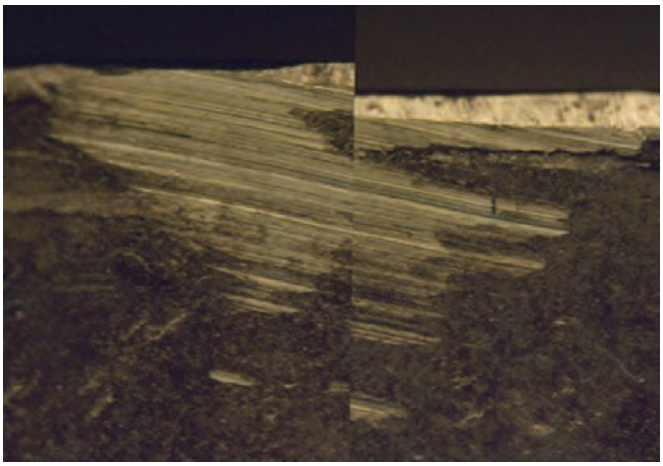

Figure 4: Comparison using microscope of two ejection port marks classified as an identification.

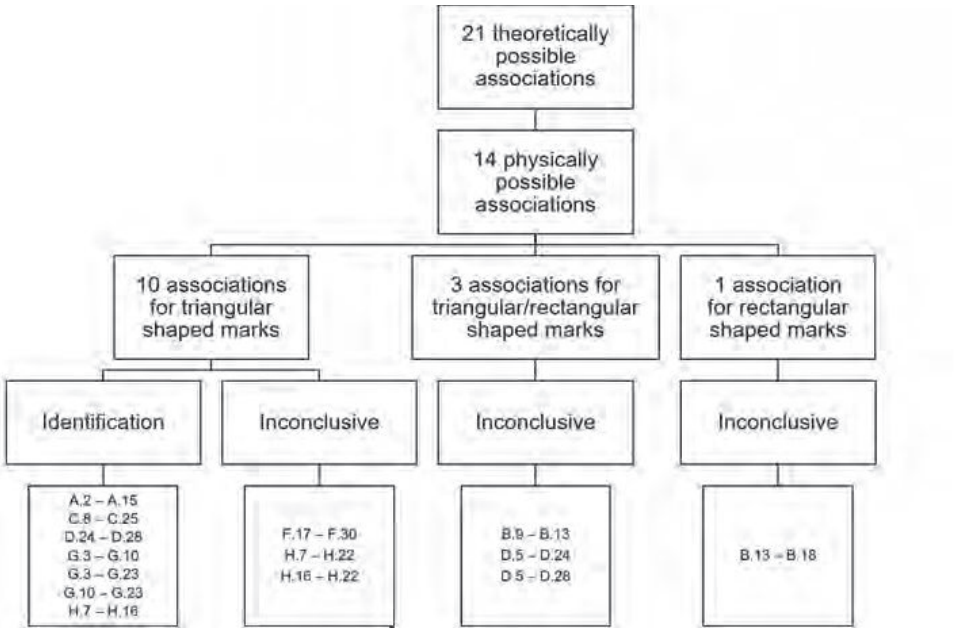

Figure 5: Summary of associations made by analysis using comparison microscope.

acquisitions, only 19 were related to one or more exhibits by the IBIS Correlation Server. After verification, none of the results were correct.

A comparison with IBIS MATCHPOINT was performed without considering the statistical correlation. When visually comparing ejection port marks, striations are vertically oriented and cannot be rotated 90-degrees to be juxtaposed horizontally, as shown in **Figure 6**. The IBIS MATCHPOINT does not allow comparing striations in that orientation, making the comparison process practically impossible to perform. Even if there were many identifications easy to confirm visually with IBIS MATCHPOINT, the IBIS Correlation Server had no success with these vertical striations. It seems that IBIS algorithms are not designed to compare vertical lines together because striations on standard bullets are mostly arranged in a horizontal orientation.

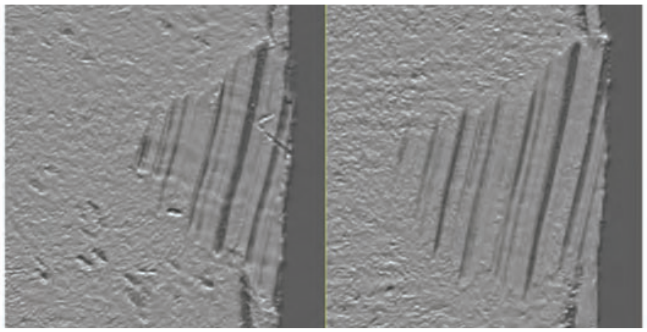

Figure 6: Comparison using the IBIS MATCHPOINT between a reference exhibit and a test exhibit with the first acquisition method.

Correlation Results for the Second Acquisition Method

To overcome the issue of the vertical orientation of the striations, a second acquisition method was performed by physically placing each cartridge case rotated at 90-degrees in order to get the striated ejection port marks in an orientation similar to the land impression in bullets. This also makes the acquisition of the whole mark possible in a single operation. With this method, the IBIS Correlation Server was able to correlate the acquisitions and make a general "Rank Sort" classification for all the exhibits. Then, all classified exhibits were analyzed and compared with IBIS MATCHPOINT. With this new acquisition method, ejection port mark striations of each exhibit can be juxtaposed horizontally, as it is the case with bullet striations, making the comparison more convenient. **Figure 7** shows the comparison between two exhibits which were acquired using the second acquisition method. Out of the 14 possible associations previously confirmed using the comparison microscope, four were classified as identification

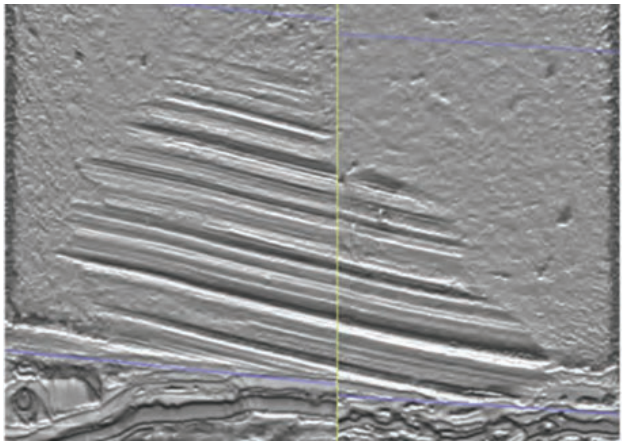

Figure 7: Comparison using the IBIS MATCHPOINT between a reference exhibit and a test exhibit with the second acquisition method.

and ten as inconclusive. The summary of the comparison using the second acquisition method is shown in **Figure 8**.

Finally, **Table 2** summarizes the results obtained with the three different methods (i.e. comparison using microscope, first and second acquisition methods using IBIS MATCHPOINT). A higher number of identifications was achieved using a comparison microscope. It shows that comparison using a standard light comparison microscope is more convenient than on the IBIS BULLETRAX system due to the large manipulation flexibility (i.e. positioning and light source) and real-time imaging analysis of exhibits. However, the IBIS MATCHPOINT still allows proper comparison of the ejection port marks acquired using the second acquisition method.

Conclusions

The ejection port marks of 30 cartridge cases discharged from ten consecutively manufactured Glock 17 (4th generation) pistols were analyzed. Analysis using a comparison microscope reveals that ejection port marks (presence and shape) are not always reproducible from Glock to Glock and there is significant variability within a group of cartridge cases fired in the same pistol. However, due to their uniqueness, the ejection port marks are relevant marks that can be used to assist in the identification process.

One of the limitations of using IBIS BRASSTRAX comes from the limited number of acquired surfaces on fired cartridge cases (i.e. firing pin, breech face, and ejector). Incorporating an additional surface to acquire usable data with the IBIS BULLETTRAX (i.e. cartridge case body) will enhance the reliability of the correlation and, moreover, the potential for ballistic identification. This study shows that fired

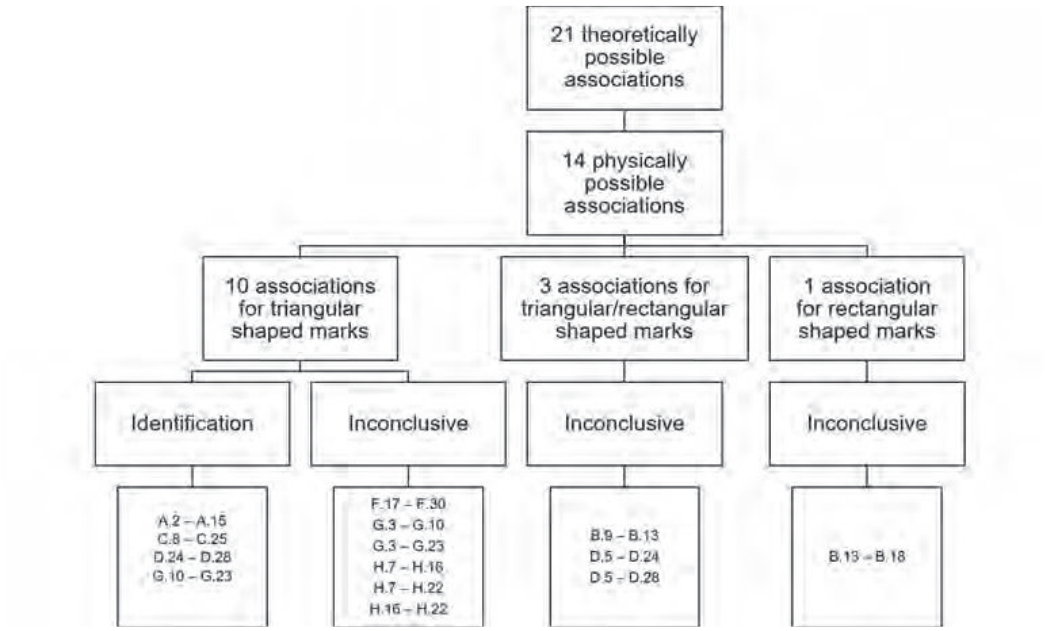

Figure 8: Summary of associations made by analysis using the IBIS MATCHPOINT.

	Identification	Inconclusive
Comparison microscope	7	7
First acquisition method: acquisition according to normal procedure	0	0
Second acquisition method: acquisition with a 90° angle	4	10

Table 2: Summary of associations made using the comparison microscope and the two acquisition methods using the IBIS TRAX-HD3D system.

cartridge cases can be successfully acquired with the IBIS BULLETTRAX system. However, to obtain proper correlation results, the acquisition must be done with the striations oriented horizontally, as in a standard bullet acquisition. The correlation results of ejection port marks acquired by IBIS BULLETTRAX system showed that this new technique is promising and could be deployed among IBIS users. An ejection port mark's database could be shared to improve match potentials on cartridge cases, particularly in cases where firing pin and breech face impressions failed to produce many individual characteristics. Moreover, the possibility of using an IBIS system to acquire other relevant marks on cartridge cases, such as chamber and extractor marks, could also be explored in order to have a more complete signature of the

exhibit. Ultra Electronics Forensic Technology confirmed that when ejection port mark striations are in the same orientation as on bullets, their algorithms are performing the same as they would for bullet exhibits (personal communication in September 2020 with Ultra Electronics Forensic Technology; unreferenced, see "Acknowledgements"). However, the new QUANTUM 3D IBIS system is now designed to acquire marks on a cartridge case's body and should be capable of facilitating this acquisition process **[12]**.

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