

THE SCIENCE BEHIND FIREARM AND TOOL MARK EXAMINATION

BY **NANCY RITTER**

Study finds less than 1.2 percent error rate in matching bullets fired from Glock semiautomatic pistol barrels to the actual firearm.



The NIJ-funded study described in “Study Identifies Ways to Improve ATF Ballistic Evidence Program” looked at the operation of the National Integrated Ballistic Information Network (NIBIN), not at the underlying science of firearm and tool mark examination. This forensic science — sometimes referred to by laypeople as “ballistics” — is concerned with the validity of matching a fired bullet to a particular firearm.

So what is the current state of the science of firearm and tool mark examinations? Are these examinations accurate, reliable and valid?

First, the basics: Firearms have numerous metal parts. During the manufacture of a firearm, the machining process leaves unique, microscopic markings (called tool marks) on some of these parts. When most firearms are fired, these tool marks are transferred to the discharged (“spent”) cartridge casings and bullets. This evidence can

be collected from the scene of a crime, such as a homicide or shooting, and firearm and tool mark examiners can compare them with a test-fired firearm that, for example, has been confiscated from a suspect.

Since 2009, NIJ has funded research to determine the accuracy and reliability of firearms examinations — that is, whether a fired bullet (sometimes referred to as a spent projectile) was ejected from a particular firearm or the probability of finding unique patterns on casings that are shared by spent ammunition from the same firearm. NIJ’s most recent findings, released in February 2014, established an error rate of less than 1.2 percent in matching bullets fired from Glock semiautomatic pistol barrels to the actual firearm.

The study — a collaboration between a Florida International University statistician and the Miami-Dade Police Department, which has been studying Glock barrels since 1994 — was designed to answer two basic questions:

Left photo:
9mm full metal jacket
bullet that was fired
from a Glock 19 with a
polygonally rifled barrel*

- Will trained firearm and tool mark examiners looking at bullets fired through consecutively manufactured firearm barrels that contain the same barcode-like pattern be able to correctly identify the firearm that fired the bullet?
- What role does an examiner's level of experience play in accurately identifying the firearm that fired an unknown (or "questioned") bullet?

The experiment looked at bullets fired from 10 consecutively manufactured Glock barrels. Here's the interesting part: During the manufacturing process, specific Glock barrels are imprinted with a barcode-like pattern called the Enhanced Bullet Identification System (EBIS). The idea behind this study was that even though these barrels were consecutively made and cut with the same EBIS pattern, their "signatures" (or tool marks) should still be different. Consecutively manufactured barrels, as the final report states, "represent the best possibility for the production of two firearms that could produce non-distinguishable markings," since the same tools and machining processes were used, back to back, on one barrel after another.

Here's how the experiment worked: One hundred and fifty test sets — with an "open set" design, in which the participants had no expectation that all unknown bullets should match known test sets — were sent to 165 firearm and tool mark examiners in 41 states, the District of Columbia and internationally. This sample was the largest ever used for this type of experiment. Sneha Gulati, with the Department of Mathematics and Statistics at Florida International University, analyzed the results.

The Findings

The examiners correctly matched the spent bullet to the barrel that fired it 98.8 percent of the time.

The study also found that examiners with less than 10 years of experience did not reach different conclusions than examiners with more than 10 years of experience; that is, there was no significant difference between these two groups in their ability to correctly identify which bullets were fired from which consecutively manufactured Glock barrels.

The researchers stated:

Through examination of the individual striations/impressions, the signature can be positively identified to the firearm/tool that produced it. Such tool mark identifications are made to a practical certainty ... Practical impossibility cannot be expressed in mathematical terms. As a result of extensive empirical research and validation studies such as this one ... an opinion can be justifiably formed that it is a practical impossibility that another firearm will be found that exhibits as much individual microscopic agreement with test tool marks as the questioned tool marks that have been identified.

It is very important to note, of course, that there are many other types of firearms that have not been studied in this same way, particularly using consecutively manufactured barrels. That said, Gerry LaPorte, Acting Director of NIJ's Office of Investigative and Forensic Sciences, noted that the findings from this study support the scientific foundation of forensic firearm and tool mark identification through the evaluation of the repeatability and uniqueness of striations of unknown bullets.

"The Glock study provides empirical data to strengthen the foundation of firearms identification, which was among the issues raised in 2009 by the National Academy of Sciences in *Strengthening Forensic Science in the United States: A Path Forward*," he added.

Read the full Glock report, *An Empirical Study to Improve the Scientific Foundation of Forensic Firearm and Tool Mark Identification Utilizing Consecutively Manufactured Glock EBIS Barrels With the Same EBIS Pattern*, at [NCJRS.gov](https://www.ncjrs.gov), keyword: 244232. The report includes an extensive review of past studies that have looked at the science of firearm and tool mark identification.

Ongoing Firearm and Tool Mark Examination Research and Development

NIJ is also funding two ongoing studies that could inform the scientific foundation of firearm and tool mark examination as a forensic investigative tool:

- Cadre Research Labs is working on rapid three-dimensional ballistic imaging and matching using a novel gel-based sensor that, when touched, conforms to an object's surface and renders a three-dimensional profile in roughly two minutes. This research includes five "deployment studies" that will gather feedback on the system's functionality, interface and usability from firearm and tool mark investigators with the Oakland Police Department; the San Francisco Police Department; the Contra Costa County Office of the Sheriff; the Walnut Creek Bureau of Alcohol, Tobacco, Firearms and Explosives; and the Illinois State Police.
- NIJ awarded a competitive grant to the National Institute of Standards and Technology to create an open-access ballistics reference database — containing a wide range of two- and three-dimensional data for bullets and cartridge cases — that researchers and vendors will be able to use to improve pattern recognition, or "matching," algorithms. This type of research database has already been created in the field of biometrics (including, for example, fingerprints), leading to advancements in image-based matching algorithms. To stimulate similar technological advancements in pattern-matching algorithms for firearms and tool marks, the ballistics database will include a large diversity of breech face, firing pin and bullet land impressions of test fires, providing crucial data for testing the robustness of matching algorithms.

Findings from these studies are expected by 2016.

About the Author

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* Photo taken by Peter Diaczuk, an adjunct instructor of criminalistics in the Department of Sciences at John Jay College of Criminal Justice, CUNY.

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