Firearms & Tool Marks

Forensic Science
Introduction

Structural variations and irregularities caused by scratches, nicks, breaks, and wear may permit the criminalist to relate:

• A bullet to a gun
• A scratch or abrasion mark to a single tool
• A tire track to a particular automobile

Individualization, a goal of in all areas of criminalistics, frequently becomes an attainable reality in firearm and tool mark examination.
What is Ballistics?

- A firearm is a weapon capable of firing a projectile using a confined explosive.
- Ballistics is the study of bullets and firearms.
- Ballistics can answer questions like:
  - What type of firearm was used?
  - What was the caliber of the bullet?
  - How many bullets were fired?
  - Where was the shooter standing?
  - What was the angle of impact?
  - Was firearm used in a previous crime?
Type of Firearms

Handguns

• **Pistol** – a handheld firearm

• **Revolver** – has a revolving cylinder that turns as the gun is fired

• **Semiautomatic** – fires *one shot per pull* of the trigger; the empty cartridge ejects and the next cartridge advances automatically (features a removable magazine)

• **Fully-automatic** – a firearm that *fires repeatedly* and for as long as the trigger is held down
Ballistics Evidence

• The shell is marked by contact with the weapon’s firing pin and loading mechanisms

• Forensic scientists compare impressions on the bullets to markings on the weapon to try and determine a match
  • “rifling” grooves on bullets
  • (more later…)
Caliber (or calibre) is the internal diameter of the firearm’s barrel, or the diameter of the projectile it fires.

• A small bore rifle with a diameter of 0.22 inches is a .22 caliber.
• Some bullets have a metric caliber rather than an inch caliber, such as the 10 mm caliber.
Small Arms Ammunition

- Bullet
- Case
- Propellant
- Primer
Function: The part of the cartridge which exits the muzzle and strikes the target.

Composition:
Lead alloyed with tin and/or antimony with/without copper or copper alloy "gilding" (less than 0.0002 inches thick).
Metal jacketed with lead or steel core and jacket of copper-zinc, copper-nickel or aluminum (0.0165 to 0.03 inches thick).
Shapes:

Lead bullets - roundnose, wadcutter, semi-wadcutter, hollowpoint; generally all have cannelures or grooves.

Metal-jacketed -

1. full jacketing in military ammunition
2. partial jacketing in hunting rifle and semi-automatic pistol ammunition: semi-jacketed soft point, semi-jacketed hollow point, silver-tip (aluminum).
Three Main Shapes

Round Nose  Hollow Point  Wadcutter
Round Nose – Solid Point
Maximum penetration
Cheapest shape to manufacture
Easily loads into chambers
Hollow Point

Spreads or mushrooms on impact

Causes additional damage to target

Inhibits penetration
Wad Cutter
Used exclusively as a practice load
Minimizes penetration
Rips a hole in target paper which is visible by the shooter
Three Basic Compositions of Bullets

Lead

½ Jacketed

Jacketed (Full metal jacket)
Uses:

Lead bullets - traditionally only for revolvers and .22 caliber rimfire ammunition; copper gilding in .22 caliber high-velocity rimfire ammunition.

Metal-jacketed bullets - traditionally for semi-automatic pistols and high velocity rifles.
Lead
Cheap
Dense
Soft
Easy to mold
½ Jacketed
A lead bullet coated with copper half way up the exposed portion of the bullet

Used primarily for hollow points
Copper improves exit velocity
Lead promotes mushrooming
Jacketed
A lead bullet completely coated in copper

- Copper improves exit velocity and accuracy of the trajectory.
- Used to hold the shape of the bullet in an effort to maximize penetration
The Greiss test converts nitrites to an orange-red color.

Sodium rhodizonate reacts with traces of lead to make purple spots.
Griess Test

The Griess test is a chemical analysis test which detects the presence of organic nitrite compounds. The *Griess diazotization reaction* on which the Griess reagent relies was first described in 1858 by Peter Griess.
Primer

Function:
Explodes on compression, igniting the propellant.

Composition:
Commonly lead styphnate, barium nitrate, antimony sulphide.
Typically centerfire ammunition contains all 3 elements (lead, barium antimony) but rimfire ammunition sometimes contains only lead or lead and barium.

Considered in elemental trace tests to determine if a person fired a weapon.
Location:

Centerfire - centrally-placed primer assembly comprising primer cup (struck by firing pin), primer, anvil with flash holes.

Rimfire - No primer assembly. Primer spun into rim of cartridge case (rim struck by firing pin) and in contact with propellant.
Propellant

Function:
BURNS TO PRODUCE LARGE VOLUMES OF GASES UNDER PRESSURE.

Composition:
BLACK POWDER (CHARCOAL, SULPHUR, POTASSIUM NITRATE), NOW OBSOLETE. SMOKELESS POWDER (NITROCELLULOSE WITH/WITHOUT NITROGLYCERINE) IS MOST COMMON IN MODERN ROUNDS.

Shape:
SHEETS OF SMOKELESS POWDER CUT INTO DISC, Flake OR CYLINDER SHAPES. ALTERNATIVELY PRODUCED AS BALL AND FLATTENED BALL SMOKELESS POWDER (AS IN WINCHESTER BRAND PROPELLANTS) WHICH MAY BE COATED WITH SILVER-BLACK GRAPHITE.
Cartridge case or shotshell casing examinations can determine the caliber or gauge, the manufacturer, and whether there are any marks that may be of value for comparison.

The microscopic characteristics of evidence cartridge cases and shot shell casings can be examined to determine whether they were fired in a specific firearm.
Cartridge Case

Function:
Expands and seals chamber against rearward escape of gases.

Composition:
Usually brass (70% copper 30% zinc); Also plastic and paper in shotgun shell tubes.
Cartridge Case

Shape:

straight (pistol ammunition)
bottleneck (rifle ammunition)

Extractor flange:

   The configuration of the cartridge base; rimmed, semi-rimmed, rimless, belted, rebated

Headstamp:

   Manufacturer’s identification imprinted or embossed on cartridge case
Rifling is a helical machined surface inside the barrel that has unique microscopic characteristics as a result of the manufacturing process.

Rifles and handguns (but not shotguns) have rifled barrels.
The raised metal between the grooves is the lands. In the US, caliber is measured between opposing grooves. Elsewhere, it is measured between opposing lands.

Some markings have "class characteristics" indicative of the make and model of the firearm.

Other markings have "individual characteristics" which reflect imperfections peculiar to a particular firearm and may allow its specific identification.
Bullet Striations

Also known as tool marking; when a hard object is brought into forceful contact with a softer object, the softer object will be marked.

This is what happens when a soft bullet engages the hard rifling in the interior of a barrel.

Bullet jackets are typically made of some softer metal such as a lead or copper while rifle barrels are commonly steel.
Bullet Identification Characteristics

Number of lands and grooves (usually 4 to 6 but range from 2 to 22).

Diameter of lands and grooves.

Width of lands and grooves.

Depth of grooves.

Degree of twist (twist is the number of inches of bore required for one complete rifling spiral).

Direction of rifling twist (commonly right/clockwise, less commonly left/counterclockwise e.g. Colt).
Pattern Matching

The process of determining whether or not the striated toolmarks on two objects, such as fired bullets, correspond.

This is a somewhat subjective process based on the observations and experience of the examiner.
CMS Criteria for Identification

In three dimensional toolmarks, at least two different groups of at least three consecutive matching striae must appear in the same relative position.

In three dimensional toolmarks, at least one group of six consecutive matching striae must be in agreement in an evidence toolmark when compared to a test toolmark.

In two dimensional toolmarks, at least two groups of at least five consecutive matching striae must appear in the same relative position.
Glock Rifling is an Exception

Some weapons (e.g. Glock pistols) do not make usable striation pattern on fired bullets because they use polygonal rifling instead of conventional rifling.

One group of eight consecutive matching striae in agreement would be considered a matching evidence toolmark from this type of rifling.
Initial Examination of a Fired Bullet

Determination of general rifling characteristics for the firearm that fired it through bullet inspection.

Narrows the possible makes and models of firearm that could have fired the bullet.

An initial examination for **trace evidence** that might be destroyed in the course of bullet testing.

- Textile fibers, traces of paint, or bits of concrete and brick from intermediate targets
- Pattern of the badge embossed on its nose
If the bullet is not deformed, its diameter can be measured with a micrometer.

Lead and lead-alloy bullets are larger in diameter than full metal jacket or semi-jacketed bullets of the same nominal caliber.

If the bullet is severely deformed, its possible caliber(s) may be determined by weighing it.

The weight of the bullet will rarely pinpoint its caliber but will serve to eliminate a number of calibers. For example, a 72-grain bullet may be .32 caliber but it cannot be .22 caliber.
Fired standards – Bullets fired from firearms having known rifling characteristics.

Generally simpler to compare each questioned bullet to a set of fired standards than to other collected bullets at the scene.
Determining Class Characteristics

Class characteristics of firearms can also be determined from expended cartridges:

- Caliber
- Shape of firing chamber
- Location of the firing pin
- Size of extractors and ejectors (if any)
- Size and shape of the firing pin
- Geometrical relationship of the extractor and ejector
Determining Class Characteristics

Care should be exercised in inferring the general class characteristic of a weapon.

- A shotgun can be converted into a rifle
- Sub-caliber cartridges can be wrapped so they fit in larger barrels

Determine if the weapon’s class characteristics are consistent with those found on the fired bullets or cartridges.

The weapon must be test fired to obtain bullets and cartridges for comparative microscopic examination IF it operates properly and if the weapon can be safely fired.
A comparison microscope consists of two compound microscopes connected by an optical bridge.

Two specimens are viewed side by side to simplify comparison.
Bullet Comparison

Jacketed and semi-jacketed bullets may not expand sufficiently to fill the groove of the rifling.

Skid marks are marks parallel to the axis of the bullet, made when the bullet initially enters the rifling edges. Surfaces of the lands will scrape along the bullet surface before the bullet is fully gripped by the rifling.

The term skid mark is also applied to marks near the nose of a bullet caused by contact with the forcing cone in the barrel of a revolver.
Slippage marks are made on a bullet when it slips along the tops of the lands instead of being firmly gripped by the rifling.

They are the result of the barrel being worn or having been bored out and may also result if a sub-caliber bullet is fired in a weapon.

Slippage marks are hard to replicate in test firings.
Firing pin impressions and breech block markings on the primer (also called bolt-face signatures) should be compared first because they can only be produced by firing a cartridge in a firearm.

Chambering, extractor, ejector, and magazine marks may be made by loading a cartridge in a weapon without firing it.
Possible Conclusions from Analysis

Positive identification – The class characteristics are consistent and individual characteristics match. This means that the likelihood that a firearm other than the firearm submitted for examination fired the questioned bullet or cartridge is very unlikely.

Negative identification - The questioned bullet or cartridge was not fired in the submitted weapon. The class characteristics did not match.

Inconclusive - There was too little information on which to base a conclusion or that while the class characteristics matched, sufficient individual characteristics to declare a match could not be found.
How Reliable are Bullet Identifications?

The National Research Council set up a Committee to investigate forensic methods and released a report in January 2009. They found that the basic premises of firearms and toolmark identification had not been scientifically established.

Additional research is recommended to better support the contention these are unique methods.
National Integrated Ballistic Information Network (NIBIN)

In this program, ATF administers automated ballistic imaging technology for NIBIN Partners: Federal, State and Local law enforcement agencies.

NIBIN allows NIBIN Partners to submit digital images of the markings made on spent ammunition recovered from a crime scene or a crime gun test fire.

The images are then correlated (in a matter of hours) against earlier entries via electronic image comparison. If a high-confidence candidate for a match emerges, the original evidence is compared via microscope to confirm the match or NIBIN “hit.”
Since 1979, ATF’s annual appropriations have prohibited the expenditure of funds for consolidating or centralizing Federal firearms licensee acquisition and disposition records.

Therefore, NIBIN cannot be used to capture or store ballistic information acquired at the point of manufacture, importation, or sale; nor can it be used to capture purchaser or date of manufacture or sale information.
Typical database entry data include:

1. Type of breech block marking.
2. Size, shape and location of extractor marks.
3. Size, shape and location of ejector marks.
4. Size, shape and location of firing pin marks (the most important identifying marks in rimfire cartridge cases).
DRUGFIRE is a database that links firearms evidence from serial shooting investigations used in firearms laboratories in the United States.

Of the 65,000 processed homicide and murder cases, 5,200 have been solved using DRUGFIRE.

Examiners from across the country can compare and link evidence obtained in the form of spent cartridges and other ammunition casings.
Other Firearms Evidence

Fingerprints may be found on casings but usable prints are rarely found on the firearm.

Obliterated and/or altered firearm serial numbers can sometimes be restored.

Firearms can be test fired to obtain known specimens for comparison to evidence ammunition components such as bullets, cartridge cases, and shotshell casings.
Other Firearms Evidence

Shot Pellets, Buckshot, or Slugs

- Examinations of shot pellets, buckshot, or slugs can determine the size of the shot, the gauge of the slug, and the manufacturer.

Wadding

- Examinations of wadding components can determine the gauge and the manufacturer.
Firearm Residue

- **Gunshot residue (GSR)** – tiny particles expelled from a firearm when it is fired

- When a firearm is discharged, the bullet, unburned and partially burned particles of gunpowder, and smoke are propelled out the barrel toward the target

- If the muzzle of the weapon is close, these products will be deposited onto the target

- The distribution of gunpowder particles and other residues around a bullet hole allows for an estimation of the distance from which a handgun or rifle was fired
Residue

• When garments are taken to the crime laboratory, the surfaces are examined microscopically for the presence of gunpowder residue.

• The powder-residue pattern on the victim’s clothing or skin is compared to test patterns the suspect weapon makes when fired at varying distances from a target.
Residue

Distance Determination: Contact shot

- Holding the gun **in contact with and up to 1 inch** from the target creates a **star-shaped (stellate) tear pattern** around the bullet hole entrance, rimmed by a smoke-like deposit of vaporous lead.
Residue

Distance Determination: 6-18 inches

- A halo of vaporous lead (smoke) deposited around a bullet hole normally indicates a discharge of 12 to 18 inches or less.

- Scattered specks of unburned and partially burned powder grains without any accompanying soot are often observed at distances up to 25 inches (and occasionally farther).
Residue

Distance Determination: > 3 ft

- More than 3 feet will not usually result in deposits of powder residue
- There may be a dark ring around the hole, known as a bullet wipe
Residue

Distance Determination: Shotguns

• Distance determinations for shotguns are also made by comparing crime scene evidence to test fire patterns. Generally, the more spread out the shot, the farther the distance of the shooter.

Generally, the spread increases 1 inch for each yard of distance (based on 12 gauge shotgun)
Revealing Powder Residues

- Infrared photography can enhance the contrast of vaporous lead and powder particles around a bullet hole.
- The **Griess test** can detect invisible gunpowder residues.
- Chemically treated, gelatin coated paper is ironed onto the target.
- Nitrite particles from gunpowder are revealed by the chemical reaction.
Residue

Primer Residue on Hands

• Firing a weapon also propels residues back toward the shooter

• Traces of these residues are often deposited on the shooter’s firing hand, and detection can determine whether an individual has recently fired a weapon

• Examiners measure the amount of barium and antimony on the suspect’s hands, particularly the thumb web, the back of the hand, and the palm
**Trajectory**

- **Trajectory** is the path of the propelled bullet.

- From the angle of trajectory, investigators can trace the path back to the shooter
  - For example: if a trajectory angle is downward, the position of the shooter was above his or her target.

- **Ignoring gravity**, a straight line can be drawn between two reference points such as:
  - Holes in windows and walls
  - Entrance and exit wounds on a victim
Gravity and Trajectory

- Two forces are acting on a fired bullet
  - forward force of the gunshot
  - downward force of gravity

- In a long distance shot, the line of sight to the target must be adjusted to compensate for the effect of gravity

- Wind speed and direction can also affect this adjustment
Tool Marks and Other Impressions

Tool Marks

A tool mark is any impression, cut, gouge, or abrasion caused by a tool coming into contact with another object.

- **Abrasion mark** – a mark produced when a surface slides across another surface.
- **Cutting mark** – a mark produced along the edge as a surface is cut.
- **Indentation mark** – a mark or impression made by a tool on a softer surface.
Tool Marks and Other Impressions

Tool Marks

• A careful examination of the impression can reveal important class characteristics, such as the size and shape of the tool

• It is the presence of minute imperfections on a tool that individual characteristics

• The shape and pattern of such imperfections are further modified by damage and wear during the life of the tool
Collecting Tool Mark Evidence

• When practical, the entire object or the part of the object bearing the tool mark should be taken to the crime lab.
  • Maintain chain of custody

• Under no circumstances should the crime scene investigator attempt to fit the suspect tool into the tool mark!
  • Any contact between the tool and the marked surface may alter the mark
  • This action will at least raise serious questions about the integrity of the evidence
Tool Marks and Other Impressions

Collecting Tool Mark and Impression Evidence

• Before any impression is handled, it must be photographed (including scale).

• If the impression is on an easy to move item, such as glass, paper, or floor tile, the evidence is transported intact to the laboratory.

• If the surface cannot be submitted to the laboratory, the investigator may be able to preserve the impression:
  • Example: lifting a fingerprint
  • Example: making a cast of a shoe or tire impression
  • Example: chemical enhancement of latent bloody shoe impressions
Points of Comparison

- The comparison microscope is used to compare crime scene tool marks with test impressions made with the suspect tool.

- A sufficient number of points of comparison, or the uniqueness of such points, will support a finding that:
  - both the questioned and test impressions originated from the same source, OR
  - The suspect tool could NOT have made the mark.

- New computer software and websites may be able to assist in making shoeprint and tire impression comparisons.

- Also, bite mark impressions on skin and foodstuffs have proven to be important evidence in a number of homicide and rape cases.