# Firearms and Ammunitions: A Sentient Approach to Criminal Investigation

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**Abstract**

Firearms and ammunition have been in use since 100 AD in China. Since then, their approach and advancement have been taking place with passage of time. With guns, ammo has additionally been created to improve its force and utilization. The most prompt weapons conveyed in Europe during the fourteenth century were firearms and hand guns: clear chambers shut down toward one side except for a little touch—opening drilled into the breech end of the drag. The following century saw the advancement of serpentine (matchlock) weaponry which permitted the mechanical bringing down of a seething nitrated rope or breaker into a container of powder neighboring the touch opening. The sixteenth century saw the advancement of wheel-lock arms which used a serrated iron wheel that was caused to pivot by perfect timing against a piece of iron pyrites to deliver a shower of sparkles coordinated toward the blaze container. These headways sometimes constrained the utilization of these guns and ammo in criminal cases and connected this hardware with forensic examination. In this chapter, various sorts of guns and ammo have been depicted. A legal perspective has been depicted for examination purposes with various impacts on the victim and the suspect. This chapter summarizes the history, development, and future prospective of firearms and ammunition while linking it to forensic aspects.

**Keywords**

Firearm · Ammunition · Examination · Advancement · Forensic investigation

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## 10.1 Introduction

Guns, rifles, shotguns, and furthermore automatic weapons and other military gunnery are gadgets which hold a shot or shots that can be dispatched or projected with an incredible power. These firearms are also encountered in some very uncommon violent criminal activities like murder, burglary, police encounters, terrorist activities, homicides, and suicides. These are guns that can be carried easily. Ammunition is any material that is fired or detonated. It can be fired by any weapon. Ammunition can be classified into either exploding type (bomb, missiles, grenades, land mines) or a component of firearm (bullet and warheads) [1]. Guns are utilized in the desperate shooting, usually found in Western nations and in India as well; of late, covert transfer of complex guns has utilized guns in a wide range of cases. Therefore, the number of cases has increased in ballistic division. Ballistics deals with the examination of firearms and ammunition used in committing crimes for investigation and identification. Firearms evidences are very important in criminal investigations and trials. Identification of firearms is pertained through ammunition fired by the particular firearm. It is like finger impression acknowledgment; the imprints made on the cartridge or on the slug by the gun used to shoot the shot are perceived all around. Declarations made by specialists are correspondingly acknowledged as the statements by specialists for fingerprints are excepted. The given affirmations express that no two guns even of a similar make, model, or group made comparable imprints on the discharged ammo like no fingerprints are comparative left by an individual's two distinct fingers. The shot is discharged by the power applied which makes an extension of gases which brings about the copying of the powder charge. A barrel, activity, stock, terminating pin or striker, breech power, chamber, extractor, and ejector are the pieces of gun gathering. The gun has a barrel, an activity, and a stock. The barrel or chamber gives development of gases. Activity is the system of stacking, extraction, and discharge of the cartridges, magazines, and other well-being gadgets. Stock keeps parts in position and provides support for firing purpose. Older firearms usually used black powder as a propellant but modern firearms use smokeless powders. Comparison of firearms and ammunition using comparative techniques like microscopic analysis is very helpful in connecting crime with the individuals. The evidences often found on the crime scene provide aid to recreate the crime scene with the help of firearm discharges and leftover ammunition casings. Also, the firearms left behind may contain some fingerprints which are also considered and recovered for investigations. Gunshot residue (GSR) is also one of the considered factors for investigation of crimes. Wounds formed by firearm can relate the particular firearms. Crime branch laboratories and police agencies with Integrated Ballistic Identification System (IBIS) are very significant in performing automated search for matches for ballistic evidences. But still manual confirmation using microscopic comparison is trusted for firearm examination. These ballistic evidences are most trusted physical evidences to the crimes related to them.

## 10.2 History of Firearms

The concept of firearm started from the tenth century with Chinese fire lances. It was not a car but an addition to the soldier's spear [2]. A barrel of paper or bamboo was filled by gunpowder within it that could be lit once to fire projectile at the enemy. Later, the barrel was made of metal and capacity of holding more gunpowder. Another predecessor of firearms was hand cannon that was also loaded with gunpowder. It had fuse in place of rear which was lit causing to ignite the gunpowder and led the cannonball to propel. Hand cannons were replaced by lighter carriage-mounted artillery pieces and ultimately by the harquebus. During 1420s gunpowder was used to propel missiles from handheld tubes during the Hussite revolt. Musket, a muzzle loading, was among the first firearms to develop. The musket was loaded through muzzle with gunpowder or wadding and then a bullet. Muzzle loaders have to be manually reloaded after each shot. Most of the early firearms were muzzle loading. It had slow rate of firing and slow reloading. The loading was done through muzzle and the weapon had to be pointed upright to pour the powder through muzzle. As an effective method of sealing the breech was developed. The weathered proof, self-contained metallic cartridges, and muzzle loaders were replaced by single-shot breech loaders. Further repeater-type weapons replaced single-shot weapons. Internal magazines were used in firearms made in 1950s during the nineteenth century to load cartridges into the chamber. Spencer and Henry repeating rifles were most revolutionary weapons evolved during the A.S.C.I.I. war. These used fixed tubular magazines. It was placed under the barrel but before it was at the buttstock of the firearm. Fixed magazines allow the use of larger cartridges. They were inserted using stripper clip which was used to transfer cartridges into magazines. Mosin-Nagant, the Mauser Kar 98k, the Springfield M1903, the M1 Grand, and the SKS were the first notable mostly used weapons. Internally magazine firearms, such as the Mauser C96 handgun, were usually but not invariably rifles. Detachable magazines were employed in lateral guns. Lateral firearms used detachable magazines. They were removable from the weapon without disassembling the weapon by pushing it to release from the weapon. After more advancement, ammunition belt feed was used to feed firearms. Composition of belt was formed of canvas or cloth with pockets evenly spaced which allowed belt to feed firearms mechanically. These were later on prone to malfunctioning due to the effect of oil and other contaminants. Designs were improved to permanently connect metal that was made tolerant to exposure to solvents and oils. The M240 and the M134 Minigun were few of them (Fig. 10.1).

## 10.3 Historic Examination of Firearms and Ammunition

In the sixteenth century the invent of rifling in firearms created an idea of the ability of ammunition to be compared. This was not the thought which focused while rifling but only the purpose of rifling was to create accuracy of bullet with respect to target while travelling from the barrel. This gradually created an idea of being utilized for

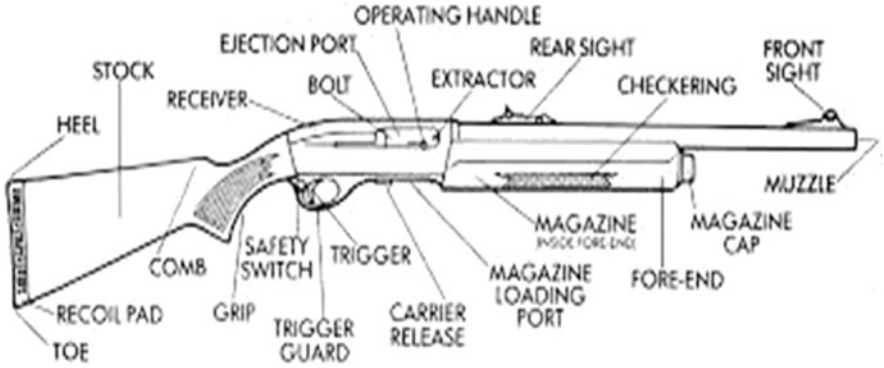


**Fig. 10.1** Different parts of rifle

the purpose of comparison. It would help in relating firearm through which the ammunition had been hurled. The marks created by rifling on the bullet or ammunition indicate the particular barrel of firearm. Gunsmiths used to make unique barrel and bullets which were hand made. In 1835, the first firearm examination took place with successful documentation. It was first documented by a person who was a member of Bow Street Runners in London. He matched a recovered bullet from a victim of murder case, in a mold to confirm the making of a bullet, and found that the person who made the bullet was a perpetrator and he was convicted. With the advancement in manufacturing and automation, the comparison was made difficult. But examination experts postulated microscopic manufacturing differences in barrels which results in different individual identification marks on the fired bullet. This was used for investigation and matching a particular bullet to a barrel through which it was fired. In 1915, Calvin Godard and Phillip O. Gravelle modernized the firearm examination by invention of comparison microscope. It made it easy by simultaneous comparison of two different objects at the same time for the striations present on the bullet and to conclude whether they are matched or not. The implication of this technique resulted in solving the case of Valentine's massacre in 1925, when Godard was asked to collect and examine the evidences to discriminate the killings by the North-side gang or by the police. The examination of the evidences resolved the case, by new ballistic-forensic technique using test fire examination. After this successful testing, Godard was solidified as the father of the firearms examination.

## 10.4 Ballistics and Its Parts

Ballistics can be further divided into three different parts depending upon the projectile movement, target, and its motion.

(a) Internal ballistics

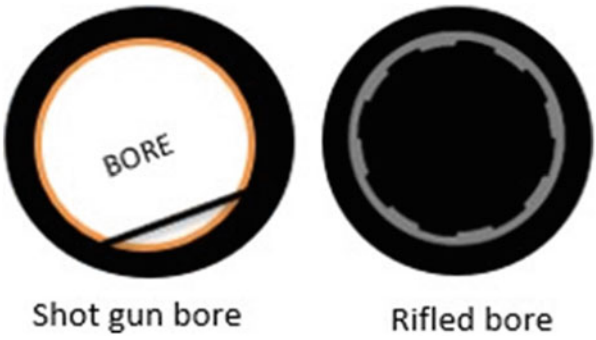


**Fig. 10.2** Internal characteristic of shotgun and rifle

Internal ballistics is identified as the study of movement of the shot from the time the trigger system is actuated till it leaves the muzzle end of the weapon. Internal ballistics overall studies the burning of propellent and nature of the projectile after the gas pressure is formed in the barrel (as shown in Fig. 10.2).

(a) External ballistics
External ballistics manages the shot movement from the muzzle end till it contacts the person in question. External ballistics manages movement, soundness, air opposition, and gravitational draw impacts on the shot [3].

The exact trajectory of the projectile can be known by the below points:

1. Shape of the bullet
2. Velocity of muzzle
3. Gravitational effect
4. Barrel-handling angle

(a) Terminal ballistics
Terminal ballistics deals with the impact caused on the surface of contact. Terminal ballistics is also known as wound ballistics.

There are three ideas by and large held by most regarding the impact of a shot striking an individual. The first is that the projectile "drills" its way through leaving a little section and a similarly little leave opening. The second is that the projectile leaves a little passage opening and a huge leave opening. The third is that when somebody is shot by something besides an air rifle, the effect is sufficient to lift the individual off his or her feet and send him or her flying through the air. Essentially, each of the three ideas are mistaken somehow.

At the point when a shot goes through a living tissue it makes two kinds of wounds: temporary injury and permanent injury. The energy bestowed by the projectile discards the tissue and these tissues' structure briefs injuries which are reestablished because of their flexible nature. Temporary injuries shaped are bigger in distance across than the slug size (as shown in Fig. 10.3). Though the perpetual injuries are shaped by the actual projectile, these injuries are framed on shot track which it covers in the body.

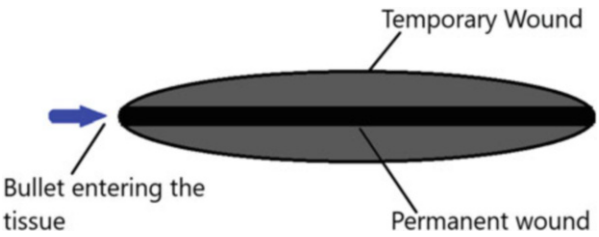


**Fig. 10.3** Diagram of temporary and permanent wounds

## 10.5 Examination of Firearms

When firearm is found at the crime scene it makes it easy to carry out different examinations to recover different evidences. Mostly the specific evidence includes recovery of serial numbers of weapon and fingerprints on firearms. These are very helpful in connecting weapon with criminal. Fingerprints are already known for their individuality and universal identification characteristics. So, in firearms examination it serves as one of the tools. It can relate the criminal to the crime with minimum percentage of error. The method generally used superglue, which is a cyanoacrylate fuming on the surface of the firearm. The firearms are placed in the fume hood where the superglue adheres to the fingerprints in the form of fumes. These are evenly distributed as a result of which it turns the prints white. Later on, these white prints can be treated with fingerprint powders for the enhancement. Sometimes it is difficult to recover prints from the surface of the firearms because of the textured grip and condition in which it is found. Various parts of the firearm can also be examined for the touch. Different firearms have unique and different serial numbers. It indicates the manufacturing and model of the weapon. If the serial number of the weapon is altered or destroyed, it can be recovered. The methods used are magnetic particle inspection and chemical restoration. The magnetic particle inspection uses deformation of the irregularities on the weapon formed due to magnetic resonance. Then the ferrous sulfate binds to the deformed magnetic area and further fluorescent particles can be added for enhancement under UV light. Chemical restoration uses chemical milling. The desired shape could be created. It is a process of removing the small amount of metal corresponding to the serial number that is visible. But it is only applicable to superficial obliterations. Then examiners usually choose an acid that will be used to bring the numbers back slowly. For magnetic materials, Fry's reagent is used and for the non-magnetic material acidic ferric chloride. Magnetic particle inspection was used due to its nondestructive nature, but in case it fails chemical restoration is used for restoration of the serial number. The benefit of recovering the serial number is that it is very useful in tracking the history of the weapon and determination of the owner of the weapon.

### 10.5.1 Examination of Ammunition

Other than whole weapon, bullets and cartridges are most commonly found physical evidences. They can be examined for the comparison and **fingerprint** recovery. Cartridges are used for the examination of unique tool marks like firing pin and ejector marks. These are used for the comparison to know whether the same weapon is used for firing or not. It is done using comparison microscope. Questioned cartridges are compared with the exemplar cartridges for finding if there are any similar marks left during the process of firing. The cartridges are also examined for the recovery of fingerprint left during loading the ammunition into the magazine or chamber. Cartridges can also be swabbed for the DNA left. Bullet is found penetrated into the wall, furniture, or floor at the crime scene or it can be extracted from the body of the victim. It is generally found in damaged condition but if it is handled carefully, lots of information can be extracted out of it. It is best to compare with class and individual characteristics. Class characteristics are same on the bullet fired from same make and model: the number, width, depth, direction and pitch of lands and grooves of the barrel, caliber of the bullet, and rifling twist. These characteristics can be used to link the firearm by which the bullet is fired. Lands and grooves are created when the rifling is made, and direction of the striations is the marks or twist of rifling left in the barrel. The diameter of the barrel is the caliber. More finer details on the bullet contribute to the individual characteristics. They are different and can be never same. It determines the weapon that was used for firing a bullet. The bullet and cartridges found at the crime scene are the required exemplar to be compared. Integrated Ballistic Identification Network (IBIN) and Ballistics Intelligence Service (BIS) record the databases of the compared marks like striation patterns (Fig. 10.4).

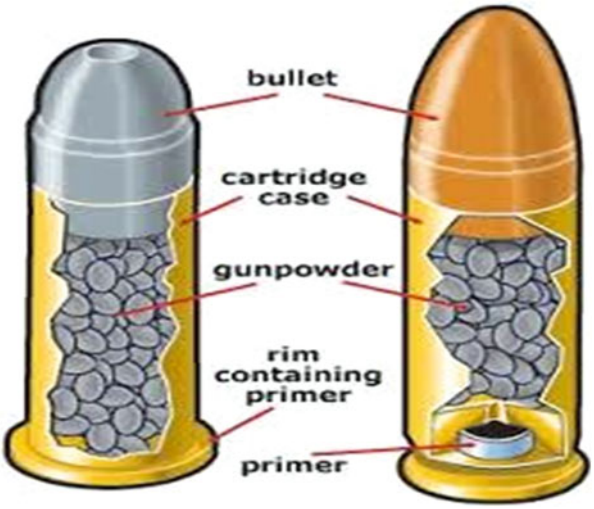


**Fig. 10.4** Different parts of cartridges

## 10.6 Primers and Propellants

### 10.6.1 Primers

In guns and big guns there is the synthetic as well as gadget liable for starting the force burning that will push the shots out of the weapon barrel. In more modest weapons, the groundwork is generally of the main kind and coordinated into the foundation of a cartridge. Primers are the chemical substances which are responsible for creating combustion and igniting the propellant so as to push the projectile out from the barrel.

In 1807 a Scottish clergyman, James Forsythe, found the stun delicate dangerous called mercury blast, HG (ONC). This sort of touchy will explode on the off chance that it is struck or stunned. A sparkle will likewise set if off. By 1850 cartridges were being made that contained mercury explode inside the top of the cartridge as the groundwork. Toward the start, the groundwork was embedded inside the edge of the cartridge. A little pin projected from the rear of the edge. At the point when this pin was struck by the mallet, it struck the preliminary, exploding it. The explosion made the powder inside the cartridge touch off. By 1850, this framework was supplanted by a less complex one wherein the preliminary was embedded into a small cup inside the focal point of the cartridge head. The terminating pin was mounted on the finish of the mallet. At the point when it struck the cup of groundwork, it packed the preliminary and exploded it. The fire created by the explosion got away through an opening in the cup and ignited the fuel. After some time, the structure of preliminary changed, first by potassium chlorate (KCIO) and today by a combination of lead styphnate, antimony sulfide, barium nitrate, and tetracene. At the point when shot buildup is investigated from the hands of a shooter, the analyst searches for particles of antimony, lead, and barium from the groundwork.

### 10.6.2 Cartridge Types

There are three different types of cartridges depending upon the primer arrangement:

### 10.6.3 Pinfire Cartridge

A pinfire cartridge is an old kind of metallic gun cartridge where the preparing compound is touched off by striking a little pin which projects radially from simply over the foundation of the cartridge.

### 10.6.4 Rimfire Cartridge

Rimfire ammo is a kind of gun metallic cartridge whose preliminary is situated inside an empty circumferential edge distending from the foundation of its packaging. At

the point when discharged, the weapon's shooting pin will strike and squash the edge against the edge of the barrel breech, starting the groundwork compound inside the edge, and thusly light the fuel inside the case. The edge of such cartridge is basically an extended and smoothed end part of the case, and the preparing compound is filled from inside into the box hole inside the edge. The case is then loaded up with force powder and closed by the shot. Rimfire cartridges are restricted to low pressing factor types since they require a slim case with the goal that the terminating pin can pulverize the edge and touch off the preliminary (as shown in Fig. 10.3).

### 10.6.5 Centerfire Cartridge

A centerfire cartridge is a gun metallic cartridge whose preliminary is situated at the focal point of the foundation of its packaging. Not at all like rimfire cartridges, the centerfire groundwork is regularly a different part situated into a recessed pit for the situation head and is replaceable by reloading.

Centerfire cartridges have displaced the rimfire assortment in everything except the littlest cartridge sizes. Most of the present handguns, rifles, and shotguns use centerfire ammo.

There are two types of centerfire cartridges:

- Berdan
- Boxer

The two preliminary sorts are practically difficult to recognize by taking a gander at the stacked cartridge; however the (at least two) streak openings can be seen inside a terminated Berdan case and the bigger single opening seen or felt inside a terminated Boxer case (as shown in Fig. 10.5).

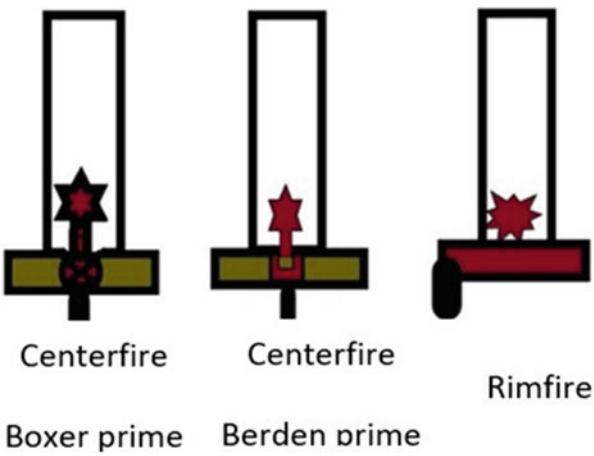


**Fig. 10.5** Comparison of centerfire and rimfire

### 10.6.6 Ricochet

When a bullet is fired from a firearm, it either penetrates the target or changes the direction after an impact. Therefore, ricochet is the change of angle of the projectile after an impact.

#### 10.6.6.1 Impacts of Ricochet

Aside from the reality of adjusting the course of movement of the shot the frequency additionally goes through a changing point of angle of incidence. The direction of slug gets changed after the ricochet and the rocket will lose a lot of its energy which be anything dependent upon 33% of its all-out energy. It will lose its gyroscopic steadiness and tumble in the wake of ricocheting. The reach will diminish which is in opposition to mainstream thinking that a ricocheting projectile will convey farther than one terminated at the rise for greatest reach [4]. The shot may convey some material from the outside of the objective after ricochet. Wounds brought about by ricocheted slugs are curious and of surprising shapes because of various places of striking projectiles subsequent to ricocheting which can be nose forward, side ahead base forward, or some other position.

## 10.7 Classification of Firearms

Firearms are used for different purposes rather than criminal uses on the basis of different characterizations like their size, handling, uses, rifling, and the ways they are loaded. This classification makes it easy to understand what type of firearms are used according to the requirement. Rifled bore is the gun with lands and grooves made in the barrel. The rifling is responsible for the stability of the bullets when fired from the barrel. This increases the range and accuracy of the aim. The canal shaped grooves are made with the number of twists. The depth and width, number of twists, and angle of twist vary with manufacturing. The lands are the raised portion between the grooves corresponding to the number of grooves. The projectile when passed through the barrel rifling provides it with the class characteristics and more finer details are counted as individual characteristics. It includes pistols, revolvers, sporting rifles, service rifles, and machine guns. Smoothbore includes the weapons like signal pistols muzzle-loading guns, the musket, it additionally incorporates the greater part of the improvised firearms. The barrel does not have grooves and lands. Because of the smooth cross section of the barrel, the projectiles used are generally pallets and shots or it uses rifled balls and slugs. Very few shotguns are known with the rifling with two shallow grooves, which are rare. The shots fired cover a wide area as they spread when fired. The diameter of the shotgun defines it. The size of the balls is correlated for the measurement of the bore. If the lead ball weighs one-twelfth of the pound the gun is 12 bore shotguns (Fig. 10.6).

Firearms can also be classified on the basis of their uses. Except for the criminal purpose the firearms are used in sports like shooting sports, which generally involve shotguns. Other than sports, they have great significance in military. Machine guns

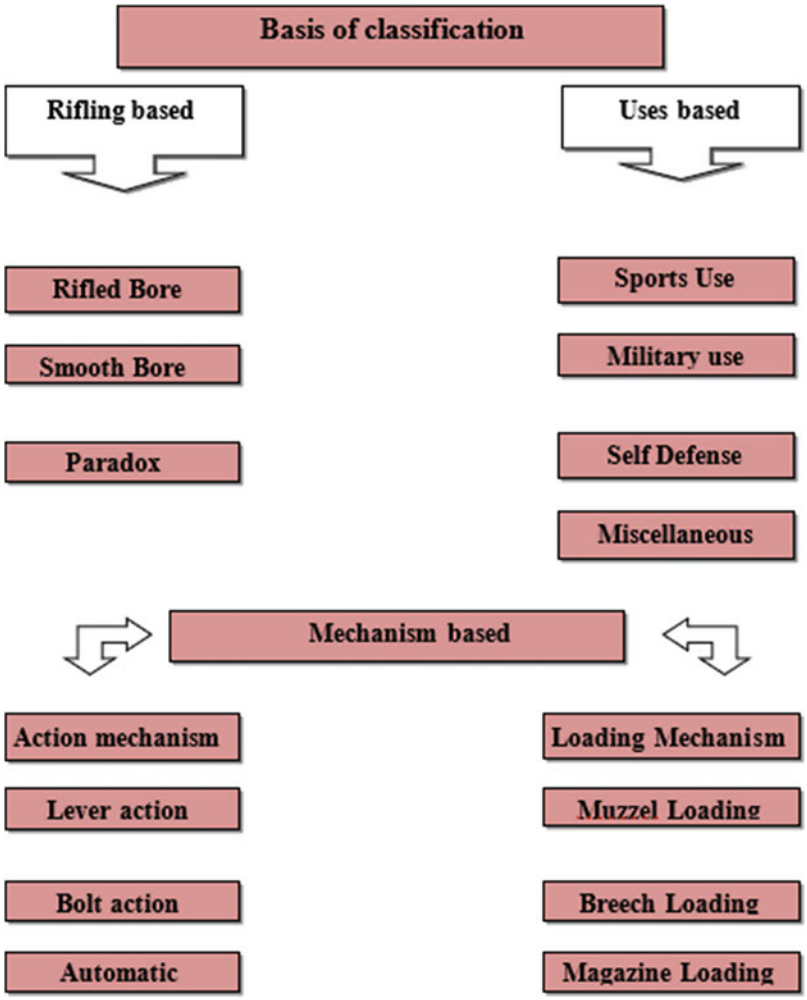


**Fig. 10.6** Classification of firearms

and many other automatic and semiautomatic firearms are used in defense system. They have quick applications and accurate aiming. Self-defense arms like air guns and revolvers are used. The firearms have good recognition specially either in defense or in criminal activities. The mostly used arms in criminal activities include improvised firearms or generally known as country-made firearms. They are also known as zip guns and pipe guns. Their manufacturing does not involve any standard materials and are made by ordinary blacksmith. Most of these are extremely dangerous. The readily available materials are used for their manufacturing. In India, these improvised firearms are at high demand, including in states like Bihar, Uttar Pradesh, Chhattisgarh, and many others. The demand of these firearms is regulated

by many localized criminals as they cannot afford costly manufactured standardized firearms. Repeaters utilizes launch, extraction and further reloading is done in single manual operations. The arms that belong to this class are some shotguns and old bolt action service rifles like 303 rifle. Loading methods vary in different firearms. In case of self-loaders or semiautomatic firearms like pistols and modern service rifles, when fired, the fresh cartridges from the magazine are automatically loaded and the used cartridge is ejected automatically and ready for the second shot. The ejection, extraction, and reloading are repeated until the magazine is exhausted. Submachine guns, machine guns, and some pistols are fully automatic and have a quality of self-loading as well as it goes on firing the first shot as long as the trigger is kept pressed till the magazine is exhausted. Assault rifles can be both automatic and semiautomatic. They are the most misused weapons by terrorists around the world. AK 47 and AK 74 rifles are from this class. According to their loading ability some of the firearms are also breech loading, muzzle loading, and magazine loading. Breech loading and muzzle loading firearms are rarely used, due to advanced loading methods.

## 10.8 Shotguns

A fired firearm is a smooth bore weapon. Width is measured utilizing a bundle of unadulterated lead which finds a way into it precisely and gauges 1/12 of a pound. It is known as a 12-bore fired firearm. Barrel length is little when contrasted with that of a rifle and there might be two barrels next to each other, or one over other. Scope of shot is more modest when contrasted with rifled one.

## 10.9 Rifled Weapons

Aside from smooth bore fired firearms there are a few weapons which do not have smooth bores however: rifled barrels like rifles, guns, and different assault rifles. All rifled guns shoot a solitary projectile at a time. As their barrels are longer they can fire relatively powerful ammo. The rifled barrels are scored. The depressions are cut as twisting from inside the drag. The winding score is gotten by steadily and consistently turning the cutter during the way toward cutting the depressions. This turning is called bend and point of turning is called pitch.

## 10.10 Pistols

The magazine of a gun is encased in its hold. Guns are accessible in various types going from around 5 to 12 mm. Both Colt-type and Smith & Wesson-type guns are accessible. For the most part, guns are self-loader or self-loader types in which pulling of the trigger will bring about the discharging of a cartridge. Launch of the terminated cartridge case just as reloading a new live round is consequently prepared

to fire again on pulling the trigger a second time by the usage of a release. 7.65 mm and 9 mm are instances of automatic guns in which one draw of the trigger will make the gun magazine void consequently as one discharging is trailed by the other inasmuch as cartridges are accessible.

## 10.11 Revolver

Revolvers have a spinning chamber so they are known as gun pistols. Notwithstanding, guns have numerous seminaries just as contrasts with guns. Guns having barrels with six terrains and six scores and left-hand rifling turn are known as Colt type and that one which has five grounds and sections and right-hand contort is known as Smith & Wesson type. There is some space between the barrel and the rotating chamber which is liable for spillage of gases and powder deposits there by lessening its viability. Some of the powder released while firing may be found on the suspect weapon. Pistols are single activity just as twofold activity as single action revolver: In single-activity revolvers, the hammer is positioned manually, which rotates the chamber to bring one of the chambers in accordance with the barrel. The squeezing of the trigger is to deliver the mallet for terminating.

## 10.12 Crime and Investigation

Physical evidences whether visible or invisible play a very important role in criminal investigation. Finding such evidences like ammunition and firearms at the crime scene adds to an aid in crime investigation. Shotguns, rifles, pistols, revolvers, and country-made firearms are preferably used for committing a crime. National Crime Records Bureau (NCRB) of India published statics in 2013 according to which total 7179 people were murdered using licensed and unlicensed firearms [5]. The rate of committing crime is increasing simultaneously. The crimes committed can be a result of psychological effects, intentionally committed or accidental crimes. The firearms and ammunition recovered as an evidence can answer many questions regarding crime [6, 7]:

- Who committed the crime?
- Why it was committed and what were the reasons?
- How was it committed?
- What was the tendency of crime?
- Was the person directly involved?
- What was the psychological condition of the criminal and victim?
- How many people were involved?
- And most specifically what helps to determine the make and model of the weapon?

The sources that carry firearms evidences are the victim, the culprit, the scene of crime, the firearm, and the ammunition.

Projectiles, bullet holes in the body and clothing, deposits and imprints on cloths and skin due to hot gases or fired residues are all examples of firearm injuries in the victim body.

The culprit may carry primer and powder residues. The deposits and residues help in the establishment of culprit with the firearms.

The scene of occurrence carries each and every evidence including the firearms and the fired projectile. The most significant evidences related to firearms cases can be extracted from the scene of occurrence [8–10].

The firearms and the ammunition are the most important evidences which directly relate to the crime. It is not left behind until the case is to be shown in favor of the criminal. If the firearm is left behind it shows that the crime was planned to show the case as suicidal or accidental [11]. They carry fingerprint and other identification marks. Ammunition provides solid material to be tested. It is generally recovered from the house of accused or from the dealer from where the ammunition was purchased [12]. Fired bullet and cartridges can be recovered from the victim or scene. The thumbprints present on the ammunition provide link to criminal.

## 10.13 Types of Crime

The firearms are used in fatal and nonfatal crimes. The frequently occurring crimes that use firearms are:

- Homicides
- Suicides
- Accidental cases
- Rape cases
- Robberies
- Dacoit cases
- Illicit trafficking of firearms and ammunition
- Revenge and conspiracy

Cases of the homicides, suicides, and accidents are the most commonly happening activities. There are different reasons which give rise to these cases [13]. The criminal tendency of a person depends upon the psychological or physical conditions [14]. The physical conditions refer to the economy, physical health, and state of one's relation and psychological conditions refer to the general mental health and the mental tendency of the person to take revenge [15]. Rape cases, robberies, and dacoit cases are committed usually on the gun point. Illicit firearms and ammunition trafficking is vulnerable among many Gulf countries and other countries. It involves the trafficking of mostly small arms used in guerilla warfare. In India, states of Punjab and Jammu and Kashmir are particularly vulnerable to arms trafficking [16]. Under 1959 Arms Act, this illicit trafficking is punishable. According to the Firearm

Act 1959, it is also not permitted to keep any arms without license except low-powerful air gun [17].

## 10.14 Ballistic Examination of Firearm Evidences

Arms and ammunition can be recovered live and fires can be examined for different purposes. These play a significant role in extracting crime-related information and also convincing the court. It is essential to know how and where the evidences can be recovered, how they can be examined, and what these evidences indicate. The ballistics is divided into specific areas of external ballistics, which deals with all the evidences found at the crime scene, and internal ballistics or wound ballistics, which deals with the firearm injuries and also the trajectory of the firearm projectile [18, 19].

Live or fired ammunition like cartridges, bullets, shots, slugs, and pallets are examined for their class and individual characteristics. This examination can link the ammunition to the firearm they are related to. The firearm evidences may also include the penetrated target like glass panels, furniture, and cloths [20]. They can be examined for the patterns formed by fired projectiles and also for the gunshot residues (GSR) [21]. Damaged cartridge cases, damaged bullets, burnt bullets, cartridge cases, smooth barrel marks, buck shots, and pallets are some of the odd identifications that can be used for the identification of the kind of firearms used for firing them [22]. Gunshot residues (GSR) are produced during the firing of a cartridge. It is formed of barrel scrapping, propellants, and primer mixtures. It can be found on the hands of the person who fired a gun. It is found on the target around the projectile holes, including cloths and exposed or affected skin. GSR is found on the inner and outer surface of the firearm and the fired cartridge cases and the projectile involved, and on intermediate targets and articles around the target and the shooter. This can be detected using soft X-ray radiography, dermal nitrate test, Walker's test, Harrison and Gilroy's test, Price's spot test, and scanning electron microscopy [1]. Firing range is one of the important aspects of the forensic ballistics. For the determination of range of fire muzzle pattern, scorching (Fig. 10.7), blackening, tattooing, powder residues, ward distribution, pallet pattern, metal particles, and direction of wound are considered [1, 23]. Firearm injuries are examined by medical doctors and evaluated by firearm experts. Correct evaluation of firearm injury is very effective in the reconstruction of crime scene [24]. It has three parts: entrance wound, exit wound, and internal wound. The shape of wounds may differ; they can be oval, circular, key shaped, ragged, or explosive. They can be of smaller diameter than the diameter of projectile or sometimes have equal diameter or even larger diameter. Exit wounds are often irregular or sometimes circular but dimension is larger than that of entrance wounds. Internal wounds are zigzag due to deflection of projectile or may be multi-channeled due to fragmentation of projectile. The wounding effect of projectile depends upon the target, the velocity, the constructional features, and the range [25, 26]. The threshold velocity of projectile in the skin is 40–50 meters per second and 60 meter per second for the bone penetration.

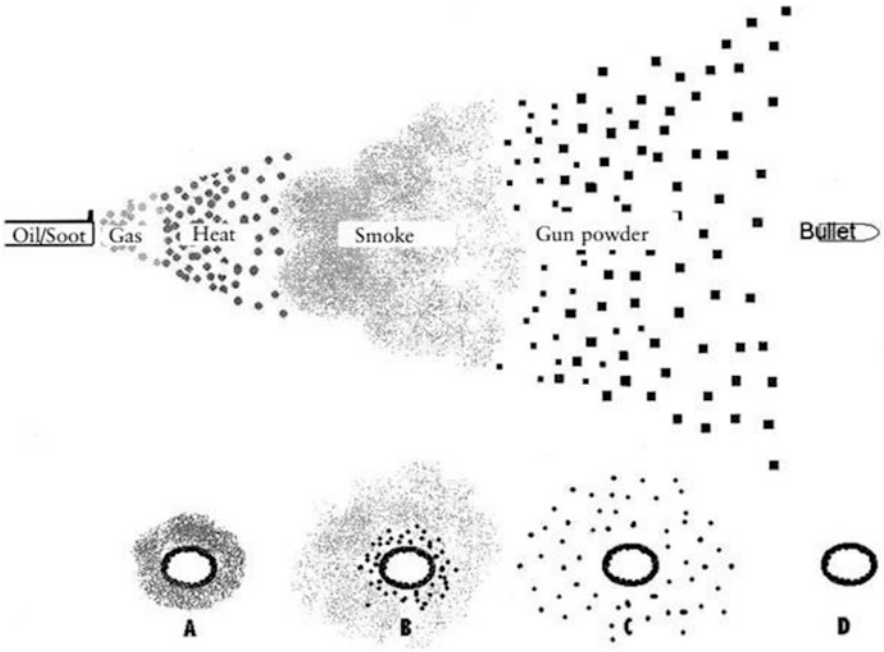


**Fig. 10.7** Particles from firearm

Firearms can be identified either from the extraneous deposits or from the characteristic damage produced by shot. Antemortem and postmortem injuries are examined to strengthen the evidences. Moreover, in recent years with more advancements it has been discovered that the DNA can be obtained from the ammunition that remain unfired or casings that remain after the firing process. DNA can be obtained by swabbing and tape-lifting and can be treated with phenol:chloroform for the extraction, silica-based method, and PCR (Fig. 10.8) [27–29].

### 10.14.1 Range of Fire

Range of fire is the absolute distance between the muzzle end of the firearm and the victim or the target. Determination of range of fire is an important aspect in the field of forensic ballistic investigation. It can be very much helpful in determining the height of the culprit and distance of fire, and gives a relevant connection with the plea of self-defense.

The range of fire can only be estimated if the ammunition or suspected firearm is present, or by observing the type of the wounds, or with the use of crime scene photographs.

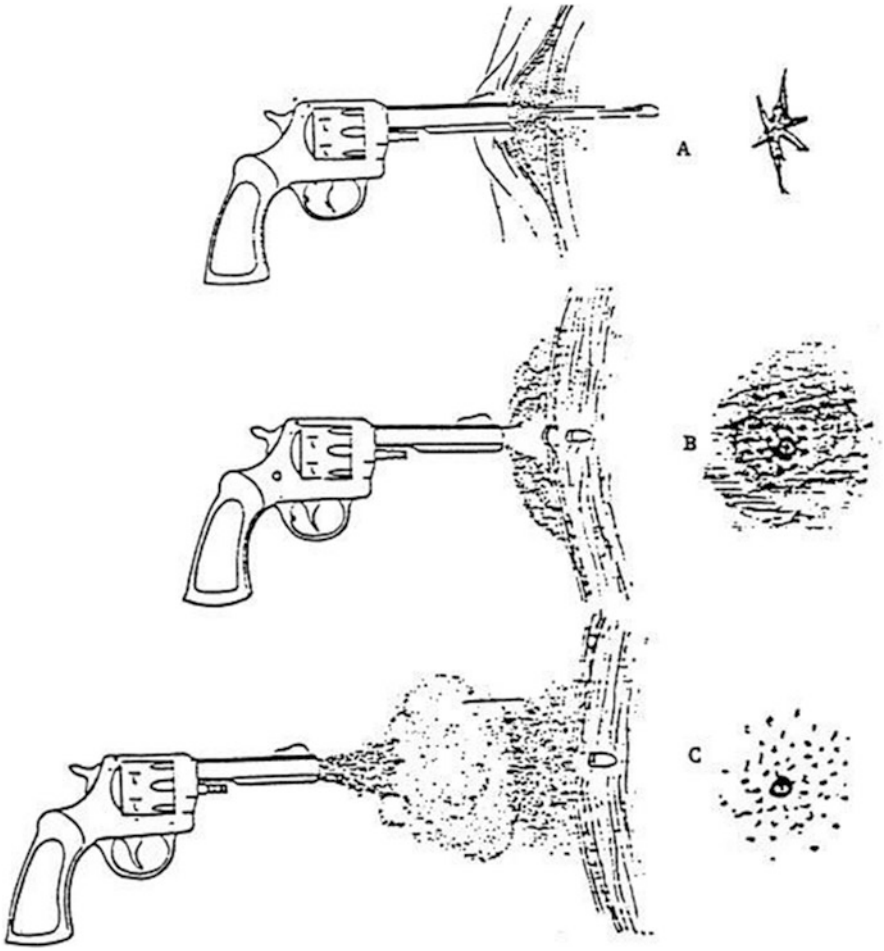


**Fig. 10.8** Gunshot impacts

There are many items which can be found at a crime scene or victims' body that can be further used for the determination of range of firearm and some of them are:

- Muzzle pattern/contact firing
- Powder patterns
- WAD distribution
- Pellet patterns
- Details of entry and exit wounds

### 10.14.2 Muzzle Pattern/Contact Firing

When the muzzle end of the weapon is pressed against the human or animal skin and fired then it leaves a print on the skin. This impression is known as muzzle pattern. The arrangement of muzzle pattern is because of the gases that do not get adequate room to grow inside the objective, and consequently they come out and tear the skin making an opening and framing a star-formed injury with unpleasant edges. When range of firing is zero then none of the pattern is formed on the contact skin [30].

In this case of muzzle pattern, it can be drawn that it could be a case of homicide or when a sleeping person is killed and the ammunition is kept nearby the victim at an adequate distance to deceive the investigating agency [31].

### 10.14.3 Powder Patterns

Whenever a firearm is fired it releases unburnt, burnt, partially burnt, or black powder from the muzzle end. These particles can be found on the victim's body or nearby area and on the body of a victim it forms majorly three types of patterns (as shown in Fig. 10.2):

(a) Burning
(b) Blackening
(c) Tattooing

### 10.14.4 Burning

Burning is caused due to the hot flame gases produced when projectile leaves the muzzle end. Therefore, burning denotes the close range of fire. When hot flames are released from the muzzle, it consists of some gases which come in contact with the air, resulting in scorching of skin.

The range of burning depends upon the length of the barrel as well as the gases produced. In hand revolvers the range is for about some centimeters and similarly in case of rifles it is for some decimeters.

### 10.14.5 Blackening

The deposition of smoke particles in close reach between the entry wound is present in all kinds of powders. That intensity of blackening is maximum in the case of gun powder, less in semi-smokeless powder, and least in smokeless powders with equal quantity and same range. Since smoke particles are light, they lose their speed and are deposited in the material on the way. The range is nearly 2 times the range of burning. Blackening can be separated from burning as it is possible to erase blackening by wipe but this is not the case for burning. In different powders, the

shade of blackening is not the same. For gun powder it is black but for smokeless powders, it is greyish black.

### 10.14.6 Tattooing

Tattooing is the embedding of burnt, semi-burnt, or unburnt particles in the surface of the skin, hence making a tattoo-like print on the skin. These particles are heavier in weight and that is why they cover more distance. Each force of tattooing can be dictated by the nature of the powder charge (as shown in Fig. 10.9).

Tattooing is also known as peppering or stippling.

### 10.14.7 Wad Distribution

Various wads are utilized in a fired weapon ammo to keep the fuel and shot charge in position. In the cartridge implied for guns and rifles conventionally no wads are found as cartridges do not have any wads in them [32]. Wads play out the capacity of fixing the barrel to forestall break of gases yet they are projected alongside the other charge. The wads enter the objective up to 3 meters in the event that they are not impeded, and they dissipate up to 5 meters or more. Distance between the person in question and wad when known and the scope of terminating can be discovered. Assessment of scope of shooting should be possible better by test discharging with the speculated weapons. The climate and wind may change places of wads. Henceforth test terminating technique can give all the more precisely the terminating range.

### 10.14.8 Pellet Patterns

Pellet patterns are majorly seen for the shot guns; the area covered by the spread of pellets is directly proportional to the distance between the muzzle end of the shot gun and the target or the victim.

The spread of pellets depends upon three major factors:

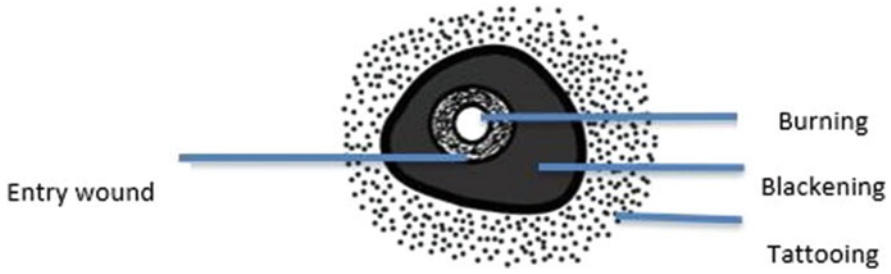


**Fig. 10.9** Powder patterns

- Length of the barrel
- Condition of the firearms

### 10.14.9 Gunshot Residue (GSR)

GSR also known as gunfire residue (GFR) is a residue deposited on the person who handles the firearms; it majorly consists of various discharges such as unburnt particles, burnt particles of propellent or a primer, and cartridge case fragments.

GSR can be majorly found at spots if we see through the forensic aspects:

- At the crime scene
- On the body of the suspect
- On the cloth of the victim

Gunshot residue can act as a game-changer evidence, as it links the suspect, victim, and crime scene. When a person handling the firearm fires the projectile due to the recoiling of the gun the propellent powder or the primer blows from the gun toward the handler. Therefore, traces of GSR can be found on the hands of the suspect and even on the clothes [33].

But if see the victim's area, on which the projectile is fired, the powder can be found on the clothes and majorly antimony, lead, and copper can be detected for establishing the crime.

The GSR can be divided into two parts depending upon its composition:

- Organic GSR components
- Inorganic GSR components

These buildups can be used to distinguish the presence of GSR on the skin and garments of the shooter. A few guns can create bigger measures of GSR and these particles can store deposits on individuals or items in nearness to the underlying release.

| Organic GSR components | Inorganic GSR components |
|---|---|
| • Nitroglycerin<br>• N-nitrosodiphenylamine<br>• 4-Nitrodiphenylamine<br>• Diphenylamine<br>• Ethyl centralite | • Lead<br>• Antimony<br>• Barium<br>• Other heavy metals |

## 10.15 GSR Analysis and Examination

As discussed above GSR can play a major role in connecting the crime with victim and suspect. So, its analysis and examination are also an important task, which can be accomplished with the help of various chemical tests mentioned below:

### 10.15.1 Walker's Test

- This test distinguishes nitrite in the deposits utilizing desensitized photograph bromide paper. The leftover part of this space might be cleaned utilizing another dampened cotton fleece. Both swabs might be set in plastic sacks marked right/left hand (individual's name and address and other description).
- The pack ought to be fixed to make it hermetically sealed. Appropriate inspecting is finished by cleaning around for 30 s with each swab and revolution of the swab to use all surfaces of the cotton tip.
- The swab ought to be scoured against the surface. The unique finger impression design region ought not to be cleaned. Inspecting then again might be done and kept up similarly in order to recognize one hand from the other. This may likewise fill in as a control test.

### 10.15.2 Swabbing Technique

The assortment of buildup particles from the hands of a suspect to have discharged a shotgun can be done by both the strategies of cleaning and washing hands.

The inspecting hardware should comprise a pack with cotton-tipped application swabs saturated with 5% HNO; during examining methods, there ought not to be any immediate contact between the hands of the subject and the sampler.

New elastic gloves ought to be put on prior to taking care of materials. Completely swab a bit of the thumb, pointer, and interfacing space of the correct hand as demonstrated by the concealed part of the past figure.

The swab ought to be eliminated from the bundle, and the cotton tip ought to be soaked with a couple of drops of 5% nitric or hydrochloric acid dropped over it with the assistance of a dropper.

### 10.15.3 Paraffin Test

The test is designed to detect the existence of nitrate buildups, which may be retained on the shooter's hand due to the backblast of gases that escape after the release.

These substances are buildups from smokeless powder, the fuel utilized in present-day cartridges.

The term "paraffin test" is obtained from the paraffin projected strategy, which is utilized to eliminate the buildups from the hands. After expulsion, the cast is tried

with a reagent, either diphenylamine or diphenyl benzidine. A shading response "dull blue spots" shows the presence of nitrate deposits. The chief issue with the paraffin test is its nonspecificity. Countless substances other than explosive deposits contain nitrates and, along these lines, additionally produce a positive response.

### 10.15.4 Dermal Nitrate Test

This test is called one of the basic tests which were first utilized in 1950 and are still being used as a primary test. A cast produced using a dainty layer of wax spread over the hand of the shooter will get GSR. The obtained deposits are treated with diphenylamine broke up in solid sulfuric corrosive. Spots of blue shading appearance would demonstrate the presence of nitrates, showing the presence of GSR. The strategy has lost its dependability as a few materials not containing nitrates give a positive reaction to this test. Walker test has supplanted it, on account of its being more explicit, basic, and advantageous. The test has effectively been clarified.

### 10.15.5 Harrison and Gilroy's Test

It is utilized for the location of metallic components to be specific lead, antimony, and barium. In the instances of shooting by pistols, great outcomes are obtained; however in cases including different guns, the test is temperamental as it regularly comes up short. The outcomes are just subjective and progressed instrumental procedures are to be used for greater dependability and quantitative examination. The subtleties of the test are as follows. A piece of perfect and dry material is treated with one drop of triphenylmethyl arsonium iodide alcoholic arrangement (10%). Antimony if present will be shown by the presence of an orange ring in around 2 min. The test material ought to be dried prior to putting two drops of sodium rhodizonate arrangement in the ring on the test fabric. Red tone, which it creates, will demonstrate lead and barium or both. The fabric needs drying once more. A drop of weakened hydrochloric corrosive (1:20) is put on the red spot on the dried test piece of fabric. No adjustment of shading means that it is barium. The test may be useful in identifying a shooter or a shot opening, but it is disliked by criminological researchers who are aware of the flimsiness of shadings and the interference of three components with one another, and thus use of instrumental techniques for investigation for better and more solid discoveries.

### 10.15.6 Griess Test

The test is utilized to identify nitrite particles in the GSR gathered from various sources or on the surfaces. The test is explicit for GSR since nitrites are not habitually found in everyday life and are extraordinary. Thusly, its location becomes critical and the test gets explicit. The region/surface suspected to convey GSR is

showered with 10% hydroxide arrangement. Whatman channel is dunked in Griess reagent which comprises 3% sulfanilamide, 0.3% N (-naphthyl) ethylene diamide dihydrochloride, both broken down in 5% sulfuric corrosive. The sodden paper is put over the GSR design and gently pressed for about a large portion of a moment. The presence of rose shading spots demonstrates the presence of nitrite particles. The test is well known and generally utilized on the grounds that it is explicit for nitrites [34, 35].

## 10.16 Significance of Firearms Evidences in Criminal Investigation

- Firearms evidences can be used for the establishment of the relationship between the used arm and the user.
- It can be used for the identification of the kind of firearms that were used in committing crime.
- The fingerprints and DNA analysis extracted from the obtained firearm evidences can be used for the identification of the convict.
- There are different classes and individual characteristics of the ammunition that can be examined for the firearm from which they were fired.
- Firearms with different manufacturing have different serial numbers. If they are destroyed for the purpose of misguiding, restoration of the serial number is possible using chemical and mechanical methods to achieve the identification of owner and history of firearm.
- GSR is very useful in the identification of the firearm owner.
- Wound ballistics deals with the examination of firearm injuries that can be used for the determination of velocity, range, and time of the projectile.
- Size and shape of the wound help in the determination of the size of the projectile, distance, and angle at which the projectile is fired.
- These firearm evidences are used for the reconstruction of scene [36].

## 10.17 Conclusion

The examination of firearms and ammunition has been introduced before the tenth century. It was concluded that the firearm evidences play a vital role in criminal investigation. They can establish the relationship between the criminal and the weapon used. With advancement in centuries there has been an increase in the variety of cases which not only involve murder and robbery case but also involve illicit trafficking of the firearms and ammunition. The firearm evidences including ammunition can be identified for their manufacturing and owner. These evidences can be used for the criminal and the type of firearm used in crime. These evidences also help in the reconstruction of scenario. Rand, distance, velocity, and time can also be evaluated with the help of external and internal ballistics.

## References


1. Sharma BR (2002) Firearms in criminal investigation and trials. Universal Law Publishing Company
2. Chase K, Chase KW (2003) Firearms: a global history to 1700. Cambridge University Press
3. Alper M, Glaze L (2019) Source and use of firearms involved in crimes: survey of prison inmates, 2016. US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics
4. Vargas EW, González SV (2020) Firearms and injuries during home robberies in Mexico, 2010–2017. Trends in Organized Crime, 1–24
5. Planty M, Truman JL (2013) Firearm violence, 1993–2011. US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics, Washington, DC
6. Pal A, Pratihari HK (2014) Examination of some country made smooth bore firearms. J Forensic Sci Criminal 2:501–506
7. Cabrera-Barona PF, Jimenez G, Melo P (2019) Types of crime, poverty, population density and presence of police in the metropolitan district of Quito. ISPRS Int J Geoinform 8(12):558
8. Polley D, Mickiewicz P, Vaughn M, Miller T, Warburton R, Komonski D et al (2006) An investigation of DNA recovery from firearms and cartridge cases. J Can Soc Forensic Sci 39 (4):217–228
9. Montpetit S (2020) Obtaining DNA from ammunition: a review. Wiley Interdiscip Rev Forensic Sci 2(2):e1352
10. Hall D, Fairley M (2004) A single approach to the recovery of DNA and firearm discharge residue evidence. Sci Justice 44(1):15–19
11. Moore MD, Bergner CM (2016) The relationship between firearm ownership and violent crime. Justice Policy J 13(1):1–20
12. Singh BP, Singh RP (2005) Shotgun shooting in northern India—a review (1980–1999). Forensic Sci Int 150(1):103–111
13. Nikač Ž International legal framework for combating organized crime. In: International scientific conference "Security, political and legal challenges of the modern world", pp 42
14. Shevchuk V, Kotiuk M (2020) Methods of smuggling of firearms and ammunition in the structure of criminalistic characteristics. Збірник наукових праць ΛΌГОΣ, 8–13
15. Goldsmith A, Halsey M, Bright D (2020) Taking crime guns seriously: a socio-material perspective. Criminol Crim Just, 1748895820971319
16. Zawitz MW (1995) Guns used in crime: firearms, crime, and criminal justice. US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics
17. Upadhyay SK (2001) Crime in India. In: Work product of the 116th international training course. Resource material series, 58
18. Riva F, Champod C (2014) Automatic comparison and evaluation of impressions left by a firearm on fired cartridge cases. J Forensic Sci 59(3):637–647
19. León FP (2006) Automated comparison of firearm bullets. Forensic Sci Int 156(1):40–50
20. Wintemute GJ, Wright MA, Castillo-Carniglia A, Shev A, Cerdá M (2018) Firearms, alcohol and crime: convictions for driving under the influence (DUI) and other alcohol-related crimes and risk for future criminal activity among authorised purchasers of handguns. Inj Prev 24 (1):68–72
21. Warrier V, Shedge R (2020) Advances in firearm serial number restoration. J Indian Acad Forensic Med 42(1):75–76
22. Gagliardi P (2019) The 13 critical tasks: an inside-out approach to solving more gun crime. Lulu.com
23. Pinto, A., Russo, A., Reginelli, A., Iacobellis, F., Di Serafino, M., Giovine, S., & Romano, L. (2019). Gunshot wounds: ballistics and imaging findings. In Seminars in ultrasound, CT and MRI (40, 1, pp. 25-35). WB Saunders, Philadelphia
24. Hopkinson DAW, Marshall TK (1967) Firearm injuries. Br J Surg 54(5):344–353

25. Crawford KR, Mitiukov NW, Busygina EL, Alies MY (2020) Internal ballistics of smoothbore guns. In: IOP conference series: materials science and engineering, vol. 971, no. 4. IOP Publishing, p 042041
26. Kneubuehl BP (ed.) (2011) Wound ballistics: basics and applications. Springer Science & Business Media
27. Bachrach B (2002) Development of a 3D-based automated firearms evidence comparison system. J Forensic Sci 47(6):1253–1264
28. Karger B (2009) Forensic ballistics. In: Forensic pathology reviews. Humana Press, Totowa, pp 139–172
29. DiMaio VJ (2015) Gunshot wounds: practical aspects of firearms, ballistics, and forensic techniques, vol 62. CRC Press, Boca Raton
30. Riva F, Mattijssen EJ, Hermsen R, Pieper P, Kerkhoff W, Champod C (2020) Comparison and interpretation of impressed marks left by a firearm on cartridge cases–towards an operational implementation of a likelihood ratio based technique. Forensic Sci Int 313:110363
31. Changmai P, Bora K, Suresh R, Deb N, Mahanta LB (2019). On the study of automated identification of firearms through associated striations. In: Proc. 31st Int. Symp. Ballistics
32. Pavlovich S The forensic categorisation and recording of manufactured illicit firearms
33. Dziemian AJ, Mendelson JA, Lindsey D (1961) Comparison of the wounding characteristics of some commonly encountered bullets. J Trauma Acute Care Surg 1(4):341–342
34. Wallace JS (2018) Chemical analysis of firearms, ammunition, and gunshot residue. CRC Press, Boca Raton
35. Saferstein R (2007) Criminalistics: an introduction to forensic science. Pearson Prentice Hall, Upper Saddle River, p 73
36. Warlow T (2011) Firearms, the law, and forensic ballistics. CRC Press, Boca Raton
37. Siyech MS (2019) Arms smuggling in India: exploring links between crime and terrorism. In: Studies in conflict & terrorism, pp 1–18
38. Kley VB (2011) US Patent No. 7,926,408. Washington: US Patent and Trademark Office
39. Hudson P (1981) Multishot firearm suicide. Examination of 58 cases. Am J Forensic Med Pathol 2(3):239–242