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A Forensic-Based Empirical Study to Analyze the Empty Case Ejection Patterns Type 56 Assault Rifle

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Abstract

Empty case locations and dispersions on the ground differ according to the type of firearms and are affected by an array of factors. Post-ejection pattern testing is the most effective method to understand the cartridge ejection patterns on the ground for a specific gun and ammunition combination. However, limited scientific research information is available in the existing literature which explores the ejection patterns of rifles, or attempts to study how this readily available evidence can be constructively used for scene reconstruction. This empirical research explored the empty case ejection patterns of an AK-family rifle: Type 56. Although the dispersion patterns were inconsistence in general, the experiment proposed a method to narrow down the shooter's approximate location based on the identified center point of the ammunition cluster and post ejection test results of the rifle used in the shooting. The research also highlights the reasons for the inconsistencies seen in dispersion patterns of this rifle type based on the observations made during the research.

Keywords: Assault rifle; Forensic based; Ejection patterns; Critical information; Physical evidence; Spent cartridges; Weapon position; Gun and ammunition; Crime scenes

Introduction

The location of the shooter in a shooting incident is critical information that an investigator needs for scene reconstruction of a shooting event. However, this becomes challenging when the shooter's location during an incident is not available or unknown. In such circumstances, investigators can make use of physical evidence available in the scene to help determine the shooter's approximate location with empty case location of ground (spent cartridges) being one such relevant evidence. The significance of this evidence type increases when the azimuth line or direction of fire is known [1] Although recent research has highlighted the unreliability of this evidence type alone as an accurate indicator of the shooter's location [2] the importance of this readily available evidence type cannot be totally ignored. It can still be productively applied to determine the approximate location of the shooter, alone or when considered alongside other evidence collected as part of a shooting investigation. Empty case locations and dispersions on the ground differ according to the type of the firearm, and are affected by eight main factors: weapon design and condition, ammunition type, weapon position and movements, shooter's individual performances, type of the terrain and the presence of obstacles [3]. Therefore, post-ejection pattern testing has been considered as the most reliable method to understand the ejection patterns, empty case dispersion on the ground, and associated tool imprints of a particular gun and ammunition combination of a shooting incident [3] Existing research knowledge on the subject is also referred to during investigations and in courts during shooting related trials. Although research has been published explaining the inherent ejection patterns and empty case dispersion patterns of different handguns [4-6], limited scientific research currently explores the empty case dispersion patterns of rifles. Additionally, no scientific research studies have attempted to study how this readily available physical evidence can be productively employed to assist in determining the tentative location of the shooter in a rifle shooting incident or understand why rifles have such inconsistency empty case dispersions. This empirical research explores the empty case ejection patterns of an AK-family rifle; Type 56 and derives conclusions that might productively assist in Type 56 (Chinese Made) related shooting incident reconstructions. An AK-family rifle was selected for the study due to recent and continuous reporting of these rifle types in crime scene shooting incidents worldwide. AK rifles are also known as “a tool of modern terror” and the rifle of choice for mass shooting [5] and has become a frequently encountered weapon type by shooting investigators around the world.

Materials and Method

The experimental method included the firing of an AK variant assault rifle (Chinese made T-56 Mk-II) under different conditions and recording the empty case dispersion patterns on the ground using a pre-arranged rectangular co-ordinate system covering 625 ft2 split into 1 ft x 1 ft grid squares as shown in (Figures 1 & 2) Standard BALL ammunition (Chinese FMJ bullet with steel case) was used for the experiment as BALL ammunition are frequently used in crime scene shooting in comparison to other types. The ground used for the experiment was flat grassland with soft soil. The test was conducted in two phases; the first phase involved firing of an AK rifle mounted on a fixed and stable platform placed on the 0 point of the grid system (Figure 1). Phase 1 aimed to observe the empty case locations of the rifle, keeping all the known variables (weapon type, ammunition, weapon’s position, weapon’s angle, ground condition, shooter (fixed gun), grip, and height of the gun controlled. During phase 2, two competent shooters of differing heights (Shooter 1 - 5 ft 2 inches and Shooter 2 - 5 ft 7 inches) were positioned in the same place and asked to fire the same rifle in the standing position and three different gun angles. Shooters were asked to fire single shots allowing 10 to 15 seconds for a second person to mark the empty case location on ground using a flag. (Table 1) presents a descriptive summary of firing sequences, including firing methods, angles, and the number of shots fired in each phases of the experiment and a pictorial illustration of the experimental arrangement of phase 1 and 2 is illustrated in (Figures 1-3) respectively presents the firing angles of phase 2. The ejection port of the rifle was kept exactly above the 0 point of the X and Y coordinates during the firing, and a plumb bob hooked to the trigger guard of the rifle aligned the ejection slot to the 0 point (Figure 4). An adjustable angle indicating bar was kept at the shooter’s side to align the rifle to the angles specified by the Angle Indicating Bar (Figure 5). A third person continuously observed the angles of the rifle during the firing to make sure that the shooter is firing in the correct angle indicated by the indicating bar. Recorded empty case locations were exported to Microsoft Excel graphs as data points of X and Y coordinates. The final resting point of the empty case was marked, and no bouncing of ejected empty cases observed due to the height of grass. Distance from the firing point (0 point of the grid) to resting point of the empty of the ground and angle formed by the line joining the empty case to the shooter and X-axis were measured for each empty case location and recorded.

Table 1: Summary of firing sequence/angles and number of shots fired in phases 1 and 2.

Phase	Method/ Shooter	Angle of the Shot (degrees)	Ref	No of Shots Fired
1	Rifle mounted on a fixed platform	90	Figure 1	60
2	Shooter 1	90	Figure 3	10
		70		10
		110		10
	Shooter 2	90		10
		70		10
		110		10

Figure 1: Phase 1 – AK rifle mounted on a fixed and stable platform placed on the 0 point of the grid system.

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Figure 2: Phase 2 - Grid network and placement of the shooters who fired the same rifle in three firing angles.

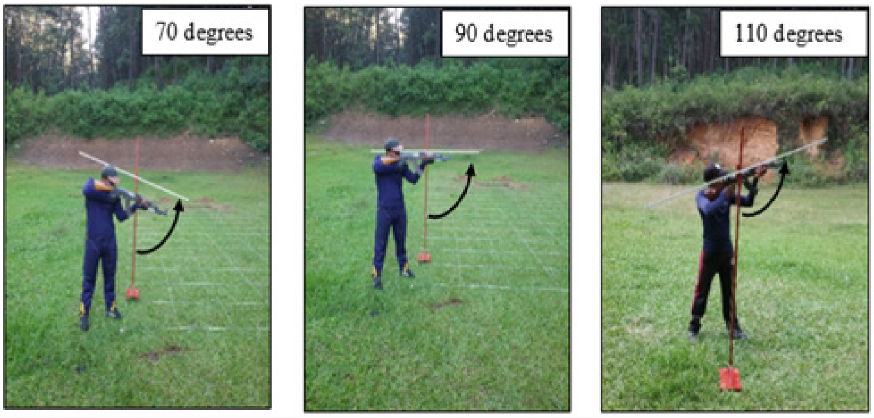

Figure 3: Firing angles of phase two: 70, 90, and 110 degrees.

Figure 4: Plumb bob hooked to trigger guard of the rifle was used to align the ejection port of the rifle to the 0 point of the grid system.

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Figure 5: Angle indicating bar was kept at the side of the shooter for accurate alignment of the rifle to different angles.

Results and Discussion

The ejected empty case locations on the ground in phase 1 showed a significant inconsistency in the results. This proved that even when all known variables are kept controlled, unknown factors influence empty cases to eject and land with inconsistence dispersion patterns. (Figure 6 & Table 2) below present a summary of the test results in phase 1. Two shooters performed phase 2 of the test and fired the same weapon from three different angles. (Figure 7 & Table 3) represent the overall results from phase 2 testing. The relative inconsistency of ejected empty case locations was noted to be very similar to the results from phase 1. However, when comparing the minimum, maximum, average distances and standard deviations in relation to where empty cases landed from firing locations, the firer and firing angles seem to influence the dispersion patterns. This confirms the findings by [2] in which human factors; firearm`s position and grip, were identified as main factors having profound effects on spent cartridge case ejection patterns. Therefore, dispersion patterns by the shooter and different firing angles were separately considered and analyzed to understand this situation further.

Table 2: Summary of the ejection test results of phase one.

Distance to empty case location from the shooter (mounted gun)	The Average Distance	16.8 ft
	Max distance	22.4 ft
	Minimum distance	7.3 ft
	Standard Deviation	4.3 ft

Table 3: Summary of the ejection test results in phase 2.

	Measurements	Shooter 1	Shooter 2
Distance to empty case location from the shooter	The average distance from the shooter	19.8 ft	17.9 ft
	Max distance from the shooter	25.3 ft	22.9 ft
	Min distance from the shooter	8.4 ft	6.2 ft
	Standard Deviation	4.4 ft	3.9 ft

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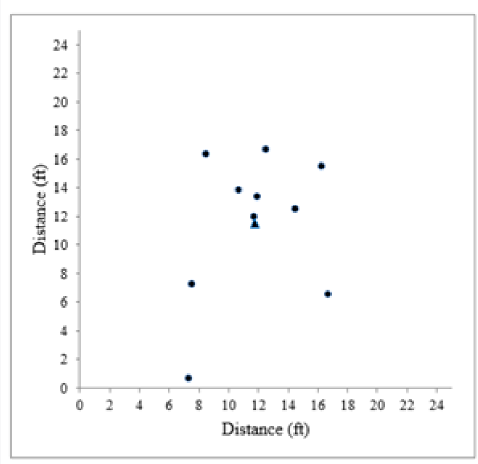

Figure 6: Empty case locations with all known variables kept control (Blue triangle indicates the average distance from the shooter; 16.8 ft).

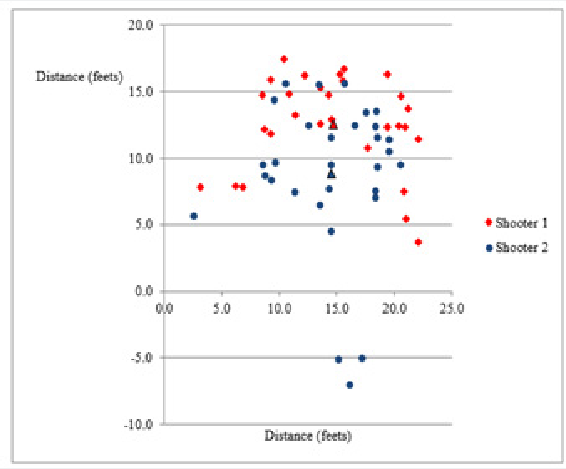

Figure 7: Empty case locations of 60 shots fired by two firers with the same rifle in three angles; 70, 90, and 110 degrees. Red triangle indicates the average distance of empty case locations of shooter 1 (19.9 ft) and blue triangles indicates average distance of empty case locations of shooter 2 (17.9 ft).

The angle of the barrel and shooter (Figures 8-10) summaries the empty case locations of 10 shots fired by individual shooters in phase 2 at 70, 90, and 110 degrees, using the same rifle and (Table 4) presents a summary of results for comparison. The dispersion patterns typically showcased inconsistency, with the average point impact with the ground shown to have values ranging from 17 to 22 feet from the firer. The recorded overall results demonstrated a significant variation of dispersion patterns even when the change of each variable was considered independently, and other known variables such as ammunition type and weapon were kept controlled. However, the average distances recorded from the shooter's location in phase 1 and 2 (16.8 ft, 19.8 ft and 17.9 ft) were identified as the center point of the respective ammunition clusters on ground and suggestive of a method to identify the shooter's approximate location with a post ejection testing of the rifle used for the shooting. An empty case cluster, general azimuth line of firing and the rifle used for the shooting must be available for the proposed method and the sequence of the proposed method is given below (Table 3-5):

I. Conduct a post ejection testing of the Type 56 rifle used for the shooting with 10 shots and mark the empty case location on ground.

II. Identify and mark the center point of the empty case cluster (May use a similar method highlighted at IDMF (2019) or Naval Ordinance and Gunnery (2019).

III. Measure the distance from the center point of the empty case cluster to the test shooter's location.

IV. Apply the recorded distance in the post ejection test to reconstruct the approximate location based on the ammunition cluster in the scene and available azimuth line of firing

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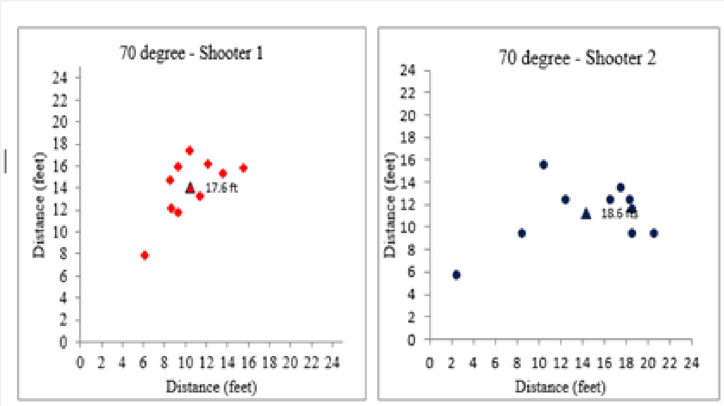

Figure 8: Dispersion of empty cases of two shooters in 70 degrees. The triangle followed by its measurement shows the average distance from the shooter.

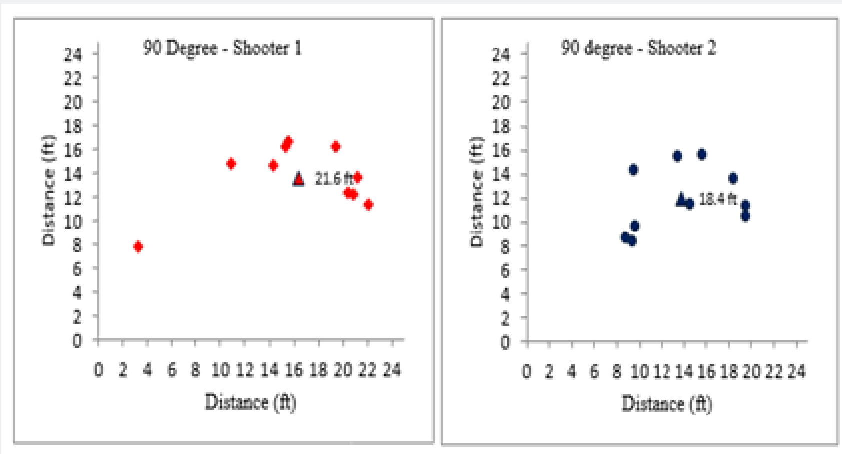

Figure 9: Dispersion of empty cases of two shooters in 90 degrees. The red triangle followed by the measurement shows the average distance from the shooter.

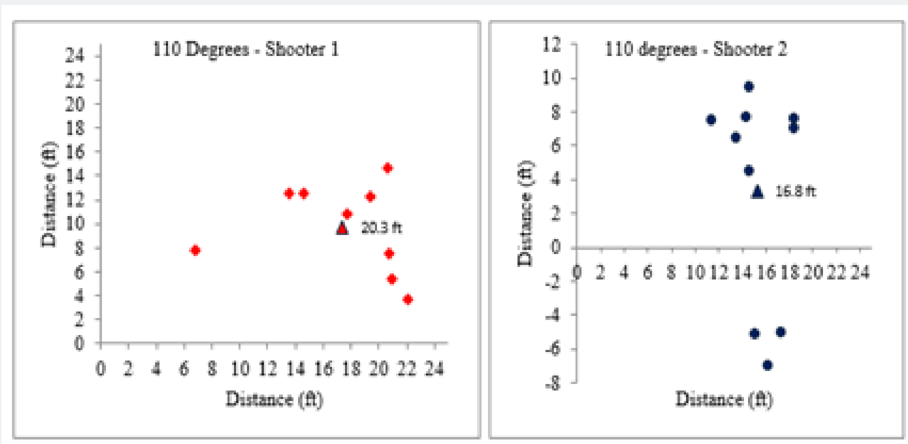

Figure 10: Dispersion of empty cases of two shooters in 110 degrees. The triangle followed by the measurement shows the average distance from the shooter.

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Table 4: Summary of the ejection test results of phase 2.

Shooter	Firing Angle (Degree)	Min distance (ft)	Max distance (ft)	Average Distance (ft)	Standard Deviation (ft)
Shooter 1	70	15	22.1	17.6	3.4
	90	8.4	25.3	21.6	4.8
	110	10.3	25.2	20.3	3.8
	Average			19.8	
Shooter 2	70	6.2	22.6	18.6	4.9
	90	12.3	22.9	18.4	4
	110	13.6	19.8	16.8	1.9
	Average			17.9	

Table 5: Summary of results of 10 mock tests conducted with two other Type 56 rifles.

Rifle	Distance Reported from the Centre Point of 10 Empty Case Clusters to the Firers Location (Ft)					Average Distance (ft)	Standard Deviation (ft)
MK II	27.8	29.2	28.8	28.5	29.6	28.5	0.9
	27.9	30.5	27.5	28.3	27.7		
MK 1	25.8	25.7	25.6	24.8	25.9	26.2	0.7
	27.2	26.9	26.2	26.9	27.2		

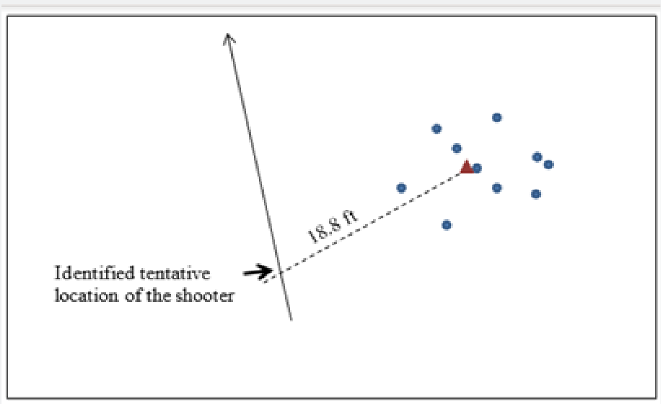

Figure 11: An example reconstruction of the shooter's approximate location using the new method.

An example is given at (Figure 11) where 18.8 ft was identified as the distance from the center point of the ammunition cluster to the shooter's location during an ejection testing of a Type 56 rifle. In order to further validate this method, 10 x mock tests were conducted on the same test ground, using another 2 x rifles (Type 56 MK II and Type 56 MK I). The recorded 10 distance from the identified center points of the ammunition cluster of 10 empty cases to the shooter's location is shown at (Table 5) below. The recorded results indicated that there is a greater possibility of using this method for AK related shooting incident reconstruction in similar conditions and the center points of each rifle`s empty case clusters have a significant reconstructive value in determining the shoot`s approximate location. Although general distances reported were different to rifle types (MK II and MK I), close values reported under each rifle category in 10 tests proved the consistency of the results in each rifle type and applicability of the proposed method in a real case scenario. However, the reported standard divination also must be noted, and the results must be presented as an approximate value. The mock tests also highlighted that even in same family rifles with identical firing and ejecting mechanisms have different ejecting phenomenon which may be due to the effect of unknown variables including the working condition of the rifles.

Tool Imprints on Empty Cases

A tool mark was observed in all empty case bodies used for the experiment. It revealed that these marks are a result of the empty case body hitting against the edge of the ejection port (receiving

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cover) during its first turning moment for ejecting. The heights of these cutting marks ranged from 22 mm (+/- 1mm) from the base of the empty cases, and 90 percent of the marks of the empty cases were reported within the above measurement. Different depths and sizes of these cutting marks indicated various speeds and orientations in which the empty case body hit against the receiving cover. The reason for these cutting marks and their different heights/ depths were explored and realized after studying the ejecting mechanism of this rifle type. When the front of the empty case passed the front edge of the ejecting slot, its base is held firmly held by the extractor. This causes the empty case to rotate around the base where the extractor is holding the rim for a very short time [7,8]. Due to different position of the empty case when it's hit the ejector and subsequently with the edge of the receiving cover, cutting mark is produced in same height of the empty case. A 10 percent difference in measurement heights may also occur due to the different speeds of the piston rod. The same ejection phenomenon with regards to the rotating empty case is explained by [9] in M16A1 rifles. (Figure 12) illustrates these cutting marks on empty cases. Based on the results and observations of the experiment, in addition to the 8 main factors highlighted by [3] the following additional factors have been considered in this research, which independently or jointly will have an effect on the inconsistency of the dispersion patterns of Type 56 ejected cases:

Figure 12: Cutting marks on ejected empty cases with different cutting depths and sizes.

a. Empty case`s rotating moment prior to hitting the ejector and subsequent hit against the edge of the receiving cover.

b. During weapon cycling, the inbuilt clearance between the piston and gas tube walls induce gas leak from the gaps differently, producing different pressure levels to the piston head in each shot. This pressure difference influences the speed of the rear-moving bolt with the empty case and subsequently affects the ejecting speed/directions of the empty cases.

c. Gas leaking from the gas connecting pipe between barrel and gas tube may cause the additional pressure differences to the piston mechanism mentioned above.

d. The AK gun mechanism involves a comparatively long piston stroke with more clearance between moving parts than seen in handguns. Therefore, frictional forces between the moving parts also tend to differ from shot-to-shot-creating speed variations in ejection stroke. This was obvious during slow-motion playbacks of some of videos referred where moving bolts on the railing slightly move even sideways due to free space.

e. Powerful rearwards movements allow the empty cases to eject and travel longer distances than with handguns. Different air resistance and thus drag experienced by the empty case in air along with wind effects during this comparatively long ejection distance also may have an impact leading to greater inconsistency in the resultant dispersion patterns (Figure 11 & 12).

Conclusion

Following a range of firing experiments involving an AK variant assault rifle (Chinese made T-56 Mk-II with standard Chinese BALL ammunition and steel case) under different conditions, the empty cases landed to the right of the shooter with an average distance of 18.8 feet with 3.8 feet standard deviation.. The repeated tests from another 2 rifles from Type 56 family recorded average distances of 28.5 ft and 26.2 ft respectively. Ninety-four percent of the empty cases of the tested Type 56 guns were ejecting right and front to the maximum distance of 29.6 feet, whereas only 6 percent were located at the right and rear of the shooter. Average distances of empty cases recorded highlighted that empty case dispersion patterns on ground is specific to the individual rifle. The recorded average distance (centre point of the cluster) values in this experiment are seen foremost in reconstructive aspects in which the shooter's approximate position could be decided when the rifle used for shooting, azimuth line of firing and an empty case cluster is available. Research proposed a reconstruction method

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to identify the shooter`s approximate location using the centre point of an empty case cluster on ground. However, the proposed method can only be applied for the scenarios where the shooting ground is similar to experimental ground with no re-bouncing or rolling of empty cases and shooter is believed to fire minimum 10 shots on a same azimuth line of fire. This research revealed that in addition to the known factors for empty case ejection in semi-automatic pistols, several additional factors such as length of the stroke, varying frictional forces between parts, gas leaking and different gas pressures to exerting on the piston head, loose play between parts, and rotating moment and different position of the empty case prior to contacting the ejector, contact of the empty case body with the receiving cover and long distances travelled in air could also have a considerable influence over the empty case dispersion patterns of Type 56 rifles. In the future it will certainly be worthy to compare these results with other models of AK variant rifles and 7.62 x39mm ammunition types with slight different bullet and cartridge case configurations to determine how accurately shooter position estimations can be made across a wider range of AK firearms as well as other rifle types .

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