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Recognizing the Impreciseness in Determining the Range of Fire from Tattooing Acquired with Improvised Firearms

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Abstract: The confiscation of improvised firearms among armed robbers and antisocial participants in a range of illegal activities has surged drastically. They prefer to get improvised weaponry in a clandestine way due to their ease of availability and low cost. Each improvised firearm has a distinct effect on the target due to the lack of suitable standards and comprehension.

When the shooting range must be estimated, GSR facilitates the disposition of cases in forensic ballistics. Since improvised handguns are used in the majority of reported occurrences, the range determination and its ramifications should be explored. The goal of this study was to use tattooing as a criterion to measure the range of fire with 7.65mm improvised guns. The results demonstrated that the firing range is related directly to the tattooing dispersion and simultaneously inversely proportional to the intensity of tattooing created.

Tattooing dimensions were inconsistent throughout the trials with the same gun within the same range, like 5×4 cm and 13×12.5 cm. For each of the three distinct ranges (10, 20, and 30 cm), the dimensional values were repeated in between 10×11cm and 12×12cm. As a result, determining a precise range of firing of homemade weaponry by measuring the dimension of tattooing generated was practically impossible. More research on improvised weaponry should be done so that this issue may be addressed.

***Keywords**: Improvised handguns, 7.65mm ammo, Gunshot Residues, Range of Firing, Tattooing*

Highlights

- 7.65mm improvised firearms were used for test firings.
- Test firings were completed from three different ranges of 10cm, 20cm and 30cm.
- Results demonstrated that analysis of the dimensions of tattooing cannot be used as a parameter for the determination of a precise range of fire for improvised firearms.
- The average values can be used for comparison of range, but shows deviation.

I. INTRODUCTION

A pistol is a portable gun that affects the objects by launching one or more projectiles propelled by booming high pressure energy generated by the combustion of propellant within an ammunition cartridge [1,2]. The statistics show that tiny arms have been significantly more lethal than nuclear bombs because they have been used in the majority of murders. India is one among the nations with strong laws that prohibits the residents from owing a firearm. The Indian Arms Act of 1959 set the rules for the law. Revolvers and semi-automatic pistols are the two most prevalent forms of handguns. Standard weapons and country-made firearms (improvised, desi katta) are the two main types of firearms in India [1]. **Figure 1** depicts the comparative remarks on regular standard guns and improvised guns.

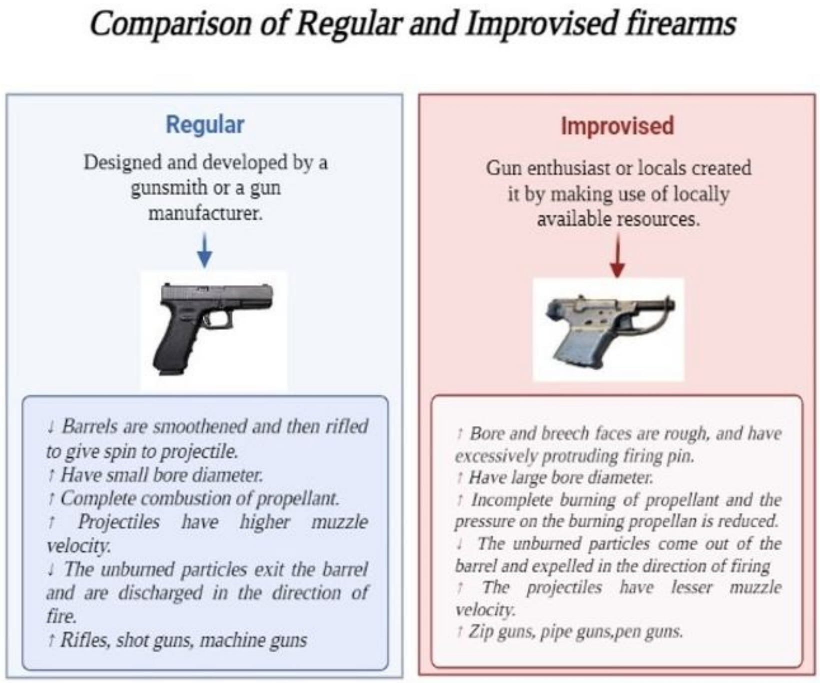


Figure 1. The comparative remarks on regular standard guns and improvised guns

Country-made firearms are typically recovered from criminals, armed dacoits, terrorists, antisocial individuals and poachers engaged in a variety of illicit acts. The ballistics of the conventional firearm and the improvised weapon differ in a number of ways. Pipe guns, zip guns, and slam guns are a few names for improvised weapons. They are produced using the materials that are already on hand. The quality of improvised firearms ranges from low-end weapons that are dangerous for the user to high-end weapons utilised in cottage industries. On the other hand, regular firearms are those created by a gunsmith or a firearm designer. The barrel, stock, lock, and action are the few pieces that both conventional and homemade rifles must have in order to discharge a bullet. Even though these components are found in both rifles, their fabrication results in different ballistics for each one. Due to the high cost of factory-made weapons and the difficulty of obtaining a license, criminals prefer to get country-made firearms in a clandestine manner, resulting in a thriving firearms trade in the nation. Homemade firearms are firearms designed and built illegally by local blacksmiths or manufacturers from readily accessible materials such as iron pipes, steel tubes, sanitary or water pipes, automobile steering pipes, and so on. The size and shape of a barrel, the calibre of the weapon, and other aspects of an improvised firearm are all determined by the tools available. Because of poor weapon production, the mechanism of an improvised firearm differs from that of any other firearm. It is most effective only at a short range. These homemade guns have a completely unexpected wounding impact [3].

Almost every gun is built on the same basic idea. Each time you pull the trigger, a bullet is shot, and the energy from the cartridge is used to activate the mechanism, allowing the next cartridge to be fired right away [1,4]. To fire a projectile down a barrel, explosive pressure is exerted behind it [1,5]. In cartridge-firing weapons, the firing pin struck by the hammer impacts the cartridge primer, which ignites the gunpowder within [1,6]. When a firearm is fired, large amount of Gunshot Residue (GSR) particles are released along with the bullet [7]. The weapon's muzzle is held far enough away from the body to prevent soot from being deposited there, yet unburned or burned particles spread to create tattooing close to the wound. However, because Desi Katta is manufactured improperly and illegally, one shouldn't assume anything while calculating the distance. Instead, one should test-fire the bullet in a ballistic laboratory. When compared to an unlicensed weapon, a standard firearm's projectiles have a higher muzzle velocity. The country-made firearm has rough surfaces on the breech faces and bore surfaces, which causes numerous microscopic abnormalities. GSR is largely made up of burned, semi-burnt and unburnt particles from the primer combination as well as lubricants, grease and metals from the cartridge and from the rifle itself [8]. The country-made firearms feature a large-diameter bore. Gases from the propellant spill past the projectile in the barrel as a result, lowering the pressure on the burning propellant. These unburned fragments emerge from the barrel and are ejected towards the firing direction [6]. In the forensic analysis of firearms, GSR makes it simple to dispose of scenarios in which the firing range must be determined.

GSR may be used to locate entry and exit holes, as well as to determine whether or not a person has discharged the firearm. The angle of discharge, shooting distance, bullet type, barrel condition and weapon state are all factors that determine how GSR appears on the target [9]. Because of the irregularity and rough construction of country-made guns, it is difficult to evaluate the quantity of GSR obtained by shooting from a certain range [10]. Unburned or semi-burned powder particles may infiltrate the epidermal layer of the skin of the target, causing tattooing. The tattooing is a permanent mark that cannot be erased by washing or shaving [10–13].

Examination of domestically produced weapons can disclose a lot about their contemporary design and operation mechanisms. As time goes on, manufacturers apply new techniques to firearms to improve their quality and make them more dependable for the consumers. The quality of locally produced firearms would be lower than those produced in factories, even if the local craftsman is skilled at creating weapons that are safe to use. Since improvised firearms are used in majority of reported occurrences, the range determination and its ramifications should be explored. The goal of this study was to utilise tattooing as a criterion to measure the range of fire with 7.65mm improvised firearm. For detection and analysis of GSR, cloth is used as a target instead of skin, as it can hold the particles for a prolonged time.

II. MATERIALS

A. *Ammunitions*

Live cartridges of calibre 7.65mm were consumed during the test firing. The cartridges were obtained from case properties, which were manufactured by K.F. (Kirkee Factory, Pune).

B. *Bullet Recovery Box*

The cotton fabric target was stapled over a cardboard measuring 38 × 31 cm in size. The target was attached to the bullet recovery box, which was located 109 cm above the ground.

C. *Country-made Firearms*

Country-made pistol samples (chambered for 7.65mm cartridges) were taken from case properties received in the Forensic laboratory. Each gun was discharged thrice at three different distances from the target: 10 cm, 20 cm and 30 cm.

D. *Target White Cloth*

For detection and analysis of GSR, white cloth was used as a target instead of skin, as it can hold the particles for a prolonged time. The cotton fabric target was stapled over a 38 × 31 cm piece of cardboard. The white linen was tugged tightly enough to erase creases without being strained.

III. METHODOLOGY

A. *Test Firing*

The tests were carried out at the indoor firing range of ballistics section of Forensic laboratory, with country-made handguns chambered for 7.65mm rounds. Test firing involved a series of steps, starting from target fixation to removing the target from the bullet recovery box after firing. All the firing trails were done by experienced professionals with proper precautions.

1) *Target Fixing*

The test firings were done on white cloth stapled to a cardboard piece, which was then fixed into a bullet recovery box. The white cloth was stretched and stapled at the corners, thereby avoiding any wrinkles or misshape, so that the GSR could be collected without any loss. The sample number was noted on the top edge of the white cloth.

2) *Firearm Mounting*

The selected 7.65mm improvised firearms obtained from the case materials were checked for any barrel blockage or dysfunction. The firing pin and trigger condition of the firearm were examined. The firearms were mounted on an immovable firing stand (figure 2) in order to avoid further accidents. The mount was placed in front of the bullet recovery box so that the fired bullets could be easily recovered.

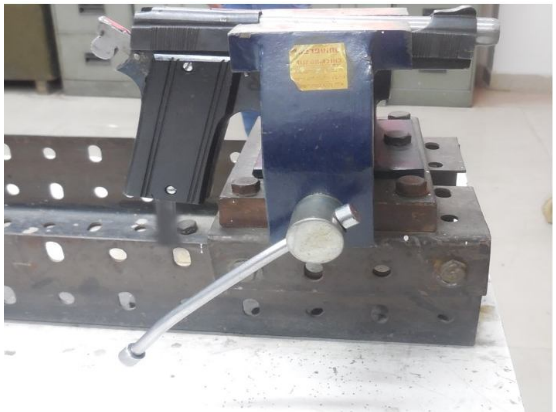


Figure 2. Firearm mounted on an immovable firing stand for test firing

3) Firings

The mounted firearms were prepared for firing. A small nylon rope was inserted through the trigger guard and held in the hands of the shooter, so by pulling the rope, the shooter could pull the trigger and the shots would be released. The shooter from the laboratory had followed certain safety protocols before firing. The professionals had worn goggles and earpieces. Then, after confirming the safety measures, the rope was pulled thereby the firearm got discharged. Each gun was then fired three times from three different ranges, such as 10 cm, 20 cm and 30 cm from the target (total 9 rounds).

4) Removing Firearm from the Stand

The rope inside the trigger guard was taken out, and the firearm was immediately removed from the stand after firing.

5) Collecting Target from Bullet Recovery Box

The target white cloth containing bullet holes and GSR was then removed from the bullet recovery box carefully, so that the particles embedded in the cloth would not get disturbed. The collected cloth was then covered with a paper cover to prevent further smudging and loss of particles.

6) Recovering Fired Bullets

The fired deformed bullets were collected from the bullet recovery box. Bullets were deformed due to the impact on the target. The bullets were collected and packed separately with the sample number. The bullets were embedded with certain marks after firing. These packed samples and collected bullets were sent for analysis.

B. Analysis

The samples, fired bullets and firearms were analysed carefully.

1) Measuring Firearm Parameters

The selected firearm used for firing was carefully examined. The length of the barrel of the gun and the barrel diameter were measured using measuring scale and vernier calliper. The internal surface of the barrel was examined for identifying deformities.

2) Sample Analysis

The target cloth recovered from the bullet recovery box with GSR was carefully handled. The dimensions of tattooing found on the cloth were measured with a measuring scale without disturbing the powder pattern on the sample. Thereafter, the bullet hole in the target was examined. Before and after the analysis, the target cloth was packed separately with paper.

C. Data Interpretation

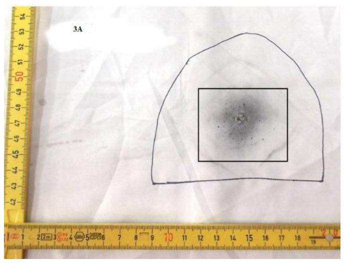
A comparative study of tattooing obtained with the analysed data was done. The triplet data for each firearm from each shooting distance was taken so as to reduce the sampling error. Data comparison was done in two categories. Different firearms fired within the same range of fire, and the same firearm fired within different ranges.

IV. RESULTS AND DISCUSSION

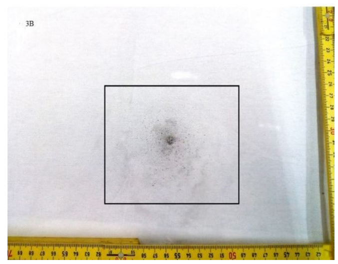
The obtained data was analysed in two categories, such that the data gained from the triple trail of each firearm at three different ranges can be compared with the data of different firearms of the same calibre. The obtained data is categorized into three sections depending upon the range of fire.

A. Tattooing Comparison at a 10cm Firing Range

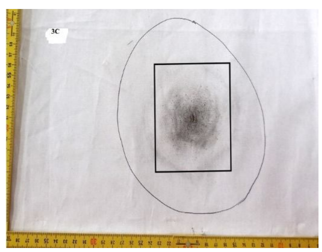
Four firearm samples were used for test firing (S1, S2, S3, and S4). Each firearm was fired three times from a 10 cm range. The tattooing obtained on the target surface shows great variations. Sample 1 has a barrel length of 9.8cm and a barrel diameter of 8mm and also has multiple holes on the surface, through which GSR particles escape after firing. Because of these imperfections in the barrel, each time the firearm is discharged, GSR particles escape differently. As a result, the pattern of tattooing on the target varies. During the first trail (S1A), the tattooing was concentrated around the bullet hole and was less dispersed. The dimension of the tattooing was about 5cm×4cm. When the same firearm was discharged for the second time (S1B) under similar conditions and without moving the position, the tattooing dimension was increased to 11cm×10cm and became more dispersed than the first sample. During the third trail (S1C), the dimension and dispersion of tattooing again showed great differences from the first two trails. The dimension was 7.5cm×7.5cm. Also, the bullet holes showed great variation in dimension when the same firearm was fired thrice from the same range. Figure 3 depicts the variations in the tattooing pattern acquired from sample 1 at a 10 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 10 cm range is given in figure 7.



3A



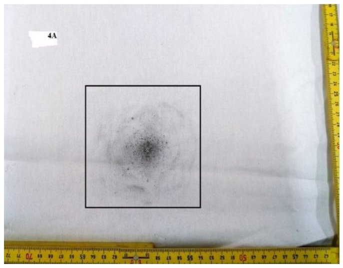
3B

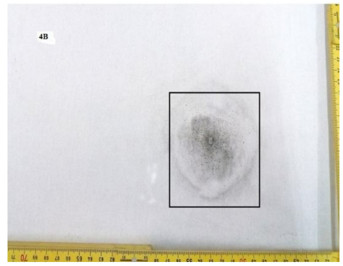


3C

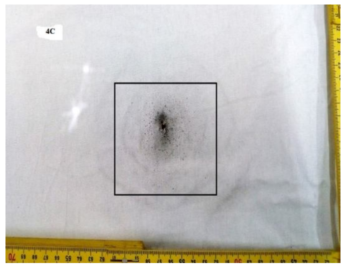
Figure 3. (3A) Tattooing obtained with first firearm sample in first trail at 10 cm range is in the rectangular box. The blackening obtained is marked inside the triangular shape for reference. The case details are masked. (3B) Tattooing obtained with first firearm sample in second trail at 10 cm range is shown in the rectangular box. (3C) Tattooing obtained with first firearm sample in third trail at 10 cm range in the rectangular box. The blackening obtained is marked inside the circular shape for reference

Sample 2 (S2) had a barrel length and a barrel diameter of 10cm and 8mm, respectively. Like S1, S2 also had some imperfections on the barrel surface, through which GSR escaped. During trail one (S2A), the dimension of tattooing was 14cm×10cm and was dispersed away from the bullet hole, which is 0.6cm×0.6cm. But when the same firearm was fired for the second time (S2B), the dimension of tattooing was changed to 9cm×7.5cm with a bullet hole of 0.9cm×0.8cm. The third trail (S2C) with the same firearm within the same range was given tattooing with a dimension of 11cm×10.5cm, which was mostly dispersed away from the bullet hole. **Figure 4** depicts the variations in the tattooing pattern acquired from sample 2 at a 10 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 10 cm range is given in figure 7.





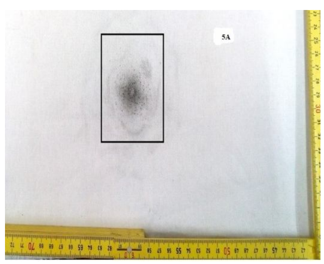
4A **4B**

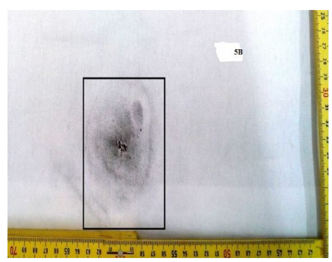


4C

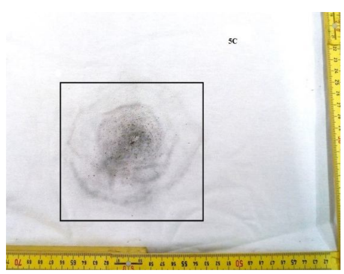
Figure 4. (4A) Tattooing obtained with second firearm sample in first trail at 10 cm range. (4B) Tattooing obtained with second firearm sample in second trail at 10 cm range in the rectangular box. (4C) Tattooing obtained with second firearm sample in third trail at 10 cm range.

The third sample (S3), with a barrel length of 11cm and a diameter of 7.5mm, also had multiple holes and imperfections like S1 and S2. Therefore, the proper deposition of GSR on target didn't take place. Therefore, tattooing showed different patterns and dimensions. So the values obtained during the trials had inconsistencies. 7cm×6cm, 10cm×8cm and 14cm×10.5cm were the values gained during the first (S3A), second (S3B) and third (S3C) trails, respectively. **Figure 5** depicts the variations in the tattooing pattern acquired from sample 3 at a 10 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 10cm range is given in figure 7.





5A **5B**



5C

Figure 5. (5A) Tattooing obtained with third firearm sample in first trail at 10 cm range in the rectangular box. (5B) Tattooing obtained with third firearm sample in second trail at 10 cm range in the rectangular box. (5C) Tattooing obtained with third firearm sample in third trail at 10 cm range in the rectangular box

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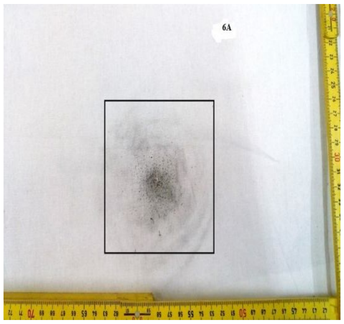
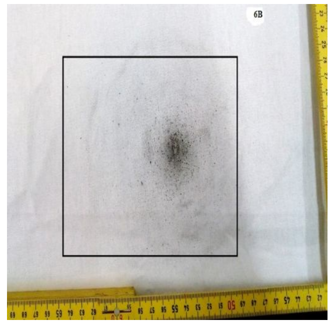
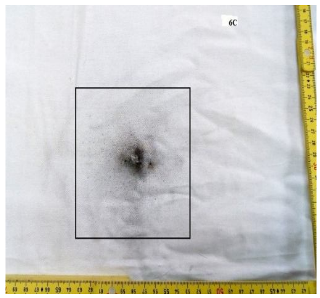
Unlike the first three samples, the fourth sample (S4) had a barrel length of 8.5cm and a diameter of 7.9mm and had no imperfections or holes on its barrel surface. Hence, proper deposition of GSR was expected on the target surface. But during the three trails, S4A, S4B and S4C, the dimensions obtained were 10.5cm×10cm, 18cm×15cm and 11cm×11cm, respectively. Unlike the tattooing obtained from the first three samples, the tattooing from the fourth sample was dispersed more and scattered far from the bullet holes, and had least intensity. **Figure 6** depicts the variations in the tattooing pattern acquired from sample 4 at a 10 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 10 cm range is given in figure 7.





6A **6B**



6C

Figure 6. (6A) Tattooing obtained with fourth firearm sample in first trail at 10 cm range in the rectangular box. (6B) Tattooing obtained with fourth firearm sample in second trail at 10 cm range in the rectangular box. (6C) Tattooing obtained with fourth firearm sample in third trail at 10 cm range in the rectangular box

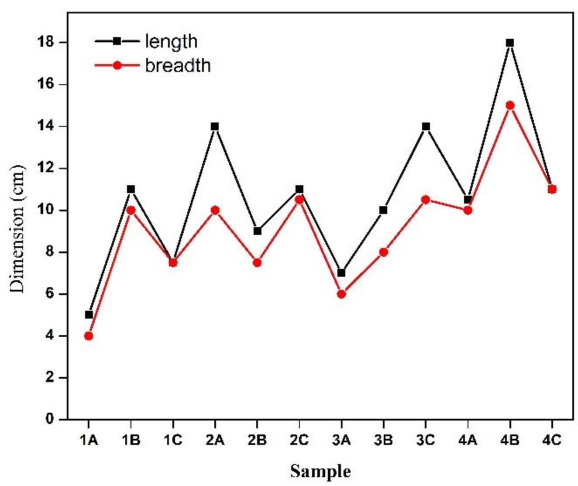


Figure 7. Representation of dimensions obtained at 10 cm range

At 10cm range, the lowest dimension obtained was 5×4 cm and the highest value was 18× 15 cm. The average value for the dimension of tattooing formed with four samples was calculated and shown in table 1.

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Table 1. Displays the average tattooing dimension and standard deviation of the samples, at three different firing ranges of 10cm, 20cm and 30cm.

Firing range (Cm)	Sample	Average of triplet values (Cm × cm)	Mean value (Cm × cm)	Standard Deviation (Cm × cm) (±)
10	S1	7.8×6.3	10.6×8.9	2.21 × 2.39
	S2	11.3×9.3		
	S3	10.3×8.1		
	S4	13.1×12		
20	S1	9×8.5	11.8×10.9	1.91 × 1.62
	S2	12.5×11.6		
	S3	12.8×11.6		
	S4	13.1×12		
30	S1	11.4×11.1	15.7×14.1	3.47 × 2.42
	S2	19.6×17		
	S3	15×14		
	S4	17.1×14.6		

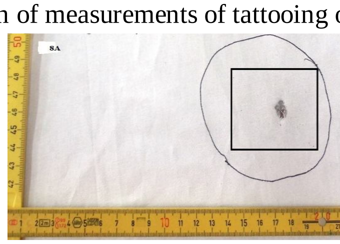
From the mean table, the standard deviation of the data was calculated using the equation; Standard deviation S.D (σ) = $\sqrt{\frac{\sum (x_i-\bar{x})^2}{n-1}}$, where

x_i = individual value, $\bar{x}$ = mean value, n = number of samples

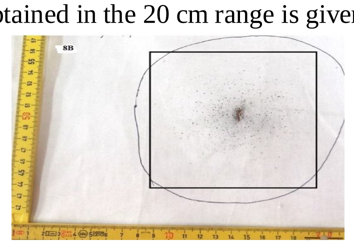
At a 10 cm range of fire, the dimension values of tattooing of samples show a standard deviation of ± 2.21 cm×2.39 cm.

B. Tattooing Comparison at a 20cm Firing Range

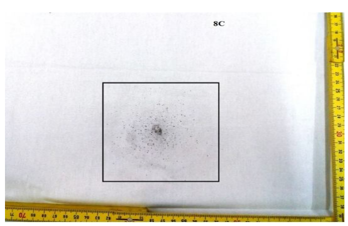
The same four samples, S1, S2, S3 and S4, which were fired at a 10 cm range, were used for firing at a 20 cm range of fire. Each firearm's peculiarities were explained earlier. When S1 was fired three times, three different dimensional values were obtained. 5cm×4cm was the dimension of tattooing obtained during the first trail S1A and was intensely concentrated around the bullet hole. Followed by the second and third trails, S1B and S1C, the deposition of particles on the target was scattered with a dimension of 13cm×12.5cm and 9cm×9cm. Figure 8 depicts the variations in the tattooing pattern acquired from sample 1 at 20cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 20 cm range is given in figure 12.



8A



8B



8C

Figure 8. (8A). Tattooing obtained with first firearm sample in first trail at 20 cm range in the rectangular box. (8B). Tattooing obtained with first firearm sample in second trail at 20 cm range in the rectangular box. (8C). Tattooing obtained with first firearm sample in third trail at 20 cm range in the rectangular box

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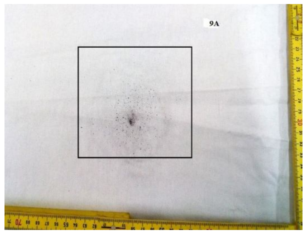
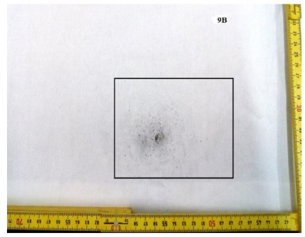
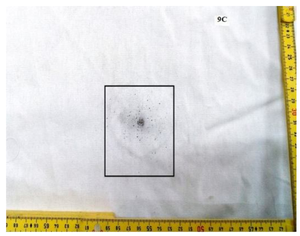
The second sample, S2, upon firing, showed inconsistent values for tattooing dimensions. 16cm×15cm, 12cm×12cm and 9.5cm×8cm, were the values obtained for three trails S2A, S2B and S2C respectively. The particle deposition on the target surface was more scattered or dispersed when compared to sample 1. **Figure 9** depicts the variations in the tattooing pattern acquired from sample 2 at 20cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 20 cm range is given in figure 12.



9A



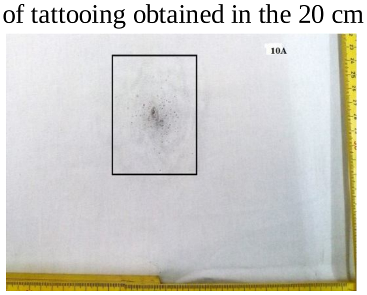
9B



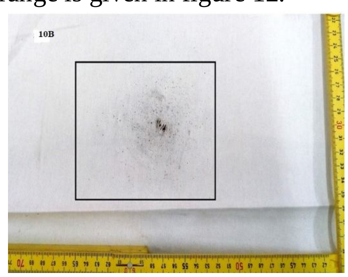
9C

Figure 9. (9A) Tattooing obtained with second firearm sample in first trail at 20 cm range in the rectangular box. (9B) Tattooing obtained with second firearm sample in second trail at 20 cm range in the rectangular box. (9C) Tattooing obtained with second firearm sample in third trail at 20 cm range in the rectangular box

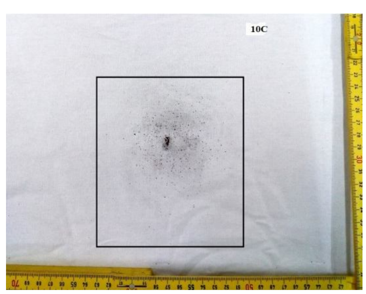
When the third sample, S3, was used, the values for tattooing dimension values showed great variation. 8cm×7cm, 13cm×11cm and 17.5cm×17cm were the values for the three trails, S3A, S3B and S3C, accordingly. And the particles were dispersed completely**.** **Figure 10** depicts the variations in the tattooing pattern acquired from sample 3 at 20cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 20 cm range is given in figure 12.



10A



10B



10C

Figure 10. (10A) Tattooing obtained with third firearm sample in first trail at 20 cm range in the rectangular box. (10B) Tattooing obtained with third firearm sample in second trail at 20 cm range in the rectangular box. (10C) Tattooing obtained with third firearm sample in third trail at 20 cm range in the rectangular box.

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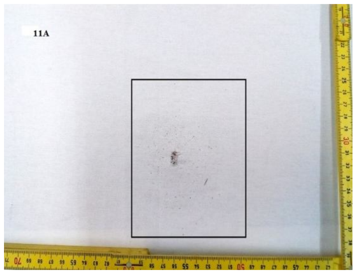
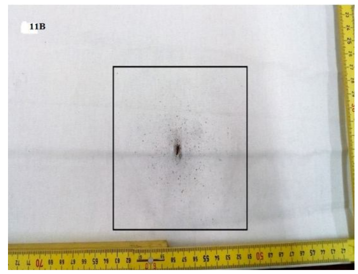
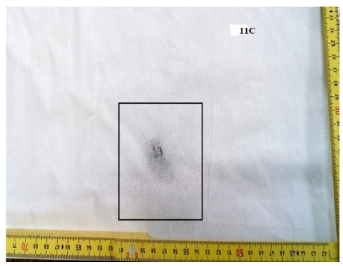
The fourth sample, S4 upon discharge, gave values for the dimensions of tattooing as 13.5cm×10cm, 16cm×15cm and 10cm×11 cm for first (S4A), second (S4B) and third (S4C)trail respectively. All the three samples, S2, S3 and S4, gave a dispersed pattern of tattooing other than sample 1 (S1), which was mostly concentrated around the bullet hole. **Figure 11** depicts the variations in the tattooing pattern acquired from sample 4 at 20cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 20 cm range is given in figure 12.



11A



11B



11C

Figure 11. (11A) Tattooing obtained with fourth firearm sample in first trail at 20 cm range in the rectangular box. (11B) Tattooing obtained with fourth firearm sample in second trail at 20 cm range in the rectangular box. (11C) Tattooing obtained with fourth firearm sample in third trail at 20 cm range in the rectangular box

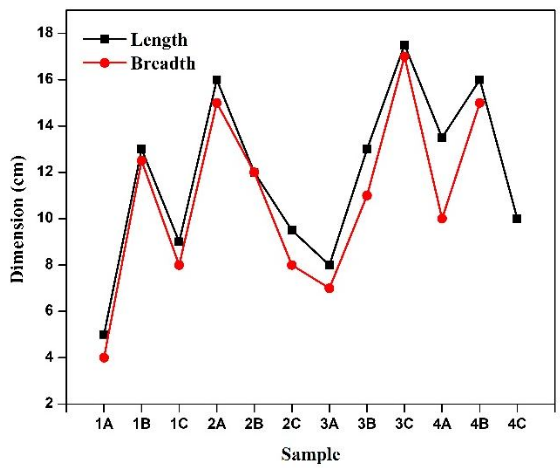


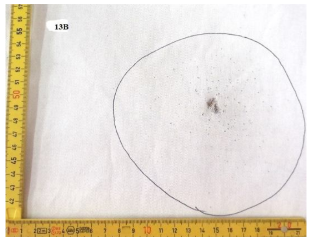
Figure 12. Representation of dimensions obtained at 20 cm range

At 20cm range the lowest dimension obtained was 5×4 cm and the highest value was 16×15 cm. The average value or the dimension of tattooing formed with four samples was calculated and shown in table 1.
At 20 cm range of fire the dimension values of tattooing of samples show a standard deviation of ±1.91cm×1.62cm.

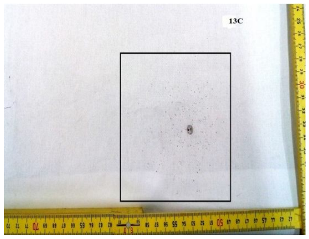
C. Tattooing Comparison at a 30cm Firing Range

The same firearms used for firing at 10 cm and 20 cm were selected for firing at the 30 cm range. Each firearm's peculiarities were explained earlier. Each firearm sample was fired thrice without moving the firearm from the stand. Sample 1 (S1) gave dimensions of tattooing of 7.3cm×6cm, 16cm×16 and 11cm×11.5cm for the first (S1A), second (S1B) and third(S1C) trails, respectively.

Figure 13 depicts the variations in the tattooing pattern acquired from sample 1 at a 30 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 30 cm range is given in figure 17.



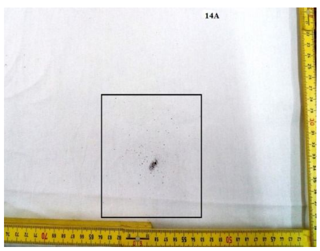
13A **13B**

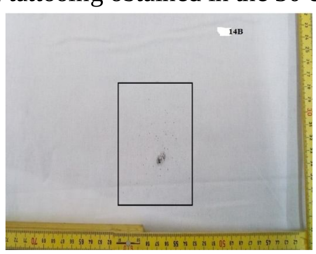


13C

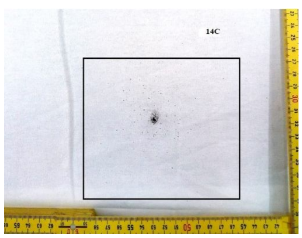
Figure 13. (13A) Tattooing obtained with first firearm sample in first trail at 30 cm range in the box. (13B) Tattooing obtained with first firearm sample in second trail at 30 cm range in the box. (13C) Tattooing obtained with first firearm sample in third trail at 30 cm range in the box

Sample 2 (S2) gave a more dispersed pattern of tattooing than sample 1. These particles were scattered away from the bullet hole. The different dimensional values for tattooing upon three different trails obtained were 22cm×19cm, 16cm×14cm and 21cm×18cm for S2A, S2B and S2C, respectively. **Figure 14** depicts the variations in the tattooing pattern acquired from sample 2 at a 30 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 30 cm range is given in figure 17.





14A **14B**



14C

Figure 14. (14A) Tattooing obtained with second firearm sample in first trail at 30 cm range in the rectangular box. (14B) Tattooing obtained with second firearm sample in second trail at 30 cm range in the rectangular box. (14C) Tattooing obtained with second firearm sample in third trail at 30 cm range in the rectangular box

When the measurements for the third sample (S3) were taken, it was evident that particles were dispersed more and had the least intensity. 11cm×9cm, 15cm×14cm and 19cm×19cm were the values obtained for the first (S3A), second (S3B) and third trail (S3C), respectively. Figure 15 depicts the variations in the tattooing pattern acquired from sample 3 at a 30 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 30 cm range is given in figure 17.

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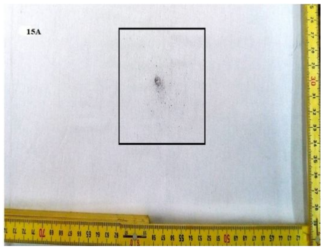
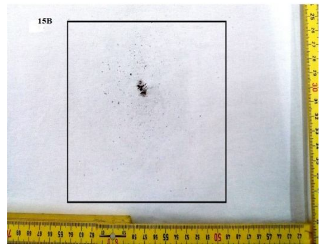
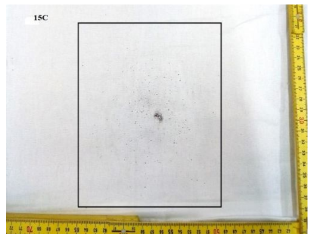


15A



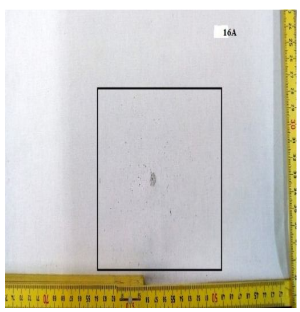
15B



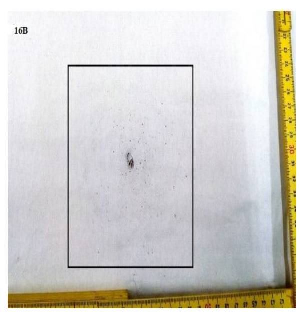
15C

Figure 15. (15A) Tattooing obtained with third firearm sample in first trail at 30 cm range in the rectangular box. (15B) Tattooing obtained with third firearm sample in second trail at 30 cm range in the rectangular box. (15C) Tattooing obtained with third firearm sample in third trail at 30 cm range in the rectangular box

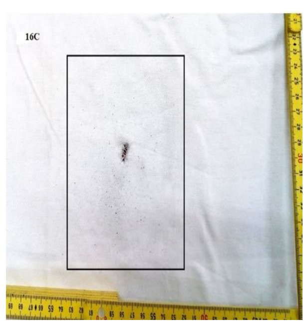
Sample 4 (S4) when used for firing gave particle deposition more dispersed and had dimensions of 15.5cm×14cm, 19cm×14cm and 17cm×16cm for trail S4A, S4B and S4C, respectively, for tattooing. Figure 16 depicts the variations in the tattooing pattern acquired from sample 4 at a 30 cm firing range. Also, the graphical representation of measurements of tattooing obtained in the 30 cm range is given in figure 17.



16A



16B



16C

Figure 16. (16A) Tattooing obtained with fourth firearm sample in first trail at 30 cm range in the rectangular box. (16B) Tattooing obtained with fourth firearm sample in second trail at 30 cm range in the rectangular box. (16C) Tattooing obtained with fourth firearm sample in third trail at 30 cm range in the rectangular box

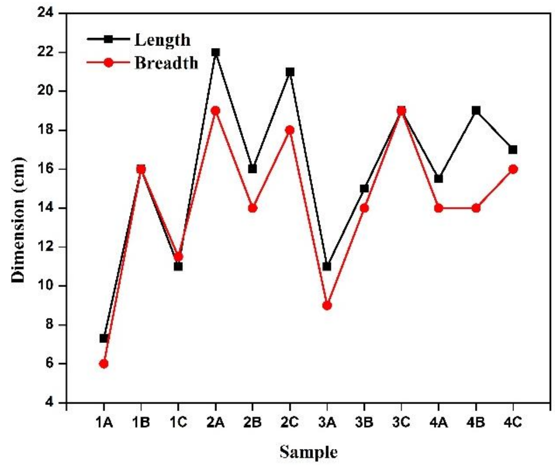


Figure 17. Representation of dimensions obtained at 20 cm range

At 30cm range the lowest dimension obtained was 7.3×6 cm and the highest value was 22×19 cm. The average value for the dimension of tattooing formed with four samples was calculated and shown in table 4. In the 30 cm range of fire, the dimension values of tattooing of samples show a standard deviation of ±3.47 cm×2.42 cm.

According to a study by Agrawal. S. *et al*. (2019), on the blackening effect produced by an improvised firearm of 7.65mm calibre on the target, they concluded that blackening cannot be used as a parameter for determining the range of fire in improvised firearms. During their work, they have come across inconsistent values for the dimension of blackening from three different ranges. These inconsistent values were obtained due to improper making and assembling. Also, observe that the intensity and dimension or area covered by blackening is inversely proportional to the range of fire. When the range of fire was increased from 10 cm to 30 cm, the blackening intensity decreased significantly and the pattern concentrated around the bullet hole only. The average values for the dimension of blackening decreased from 5.894cm×5.728cm to 2.976cm×2.74cm when the range was increased from 10cm to 20cm and when the range was further increased to 30cm, the dimensions were decreased to 0.274cm×0.264cm [8].

The data and graphical analysis revealed that the tattooing pattern or particle deposition created on the target surface by improvised firearms of the same calibre (7.65mm) is unpredictable. For each of the three distinct ranges (10, 20, and 30 cm), the dimensional values were repeated in between 10×11cm and 12×12 cm. As a result, determining the precise range of firing of homemade weaponry by measuring the dimension of tattooing generated was practically impossible. The same firearm fired from the same range of fire itself showed different patterns and dimensions of tattooing. Although average readings can be used to estimate the firing range, when compared to average values, real values exhibit a great deal of diversity. As a result, test firing values cannot be used for range estimation. This difference in tattooing might be caused by the material of the firearm, the length of the barrel of the firearm, firing pin defects, and so on. The internal bore diameter of the firearms used ranges between 7.5cm and 8.1 cm. The barrel of the firearm used has certain deformities, such as holes on its surface, through which GSR particles escape. As most of the country made firearms are manufactured without professionalism, the effect of firing with such firearms cannot be predicted. According to research by Ditrich H., the ring of tattooing discharged from the muzzle is modified by barrel length, calibre and velocity. The gunshot residue on the target is determined by the distance between the muzzle and the commencement of the vortex [14–20]. From the analysed data, it is clear that up to a certain range, the range of firing is directly proportional to the dispersion of GSR particles and inversely proportional to the intensity of tattooing. Beyond the limit, the tattooing would be absent on the surface. While examining the fired bullets collected from the bullet recovery box, it is clear that upon firing the same firearm from the range of fire on the same target, bullets were deformed differently. The blackening and tattooing cannot be used as a parameter for determining the range of fire in the case of improvised firearms, as they provide inconsistent values. This is because country-made firearms are manufactured without professionalism, the effect of firing with such firearms cannot be predicted.

V. CONCLUSIONS

The primary goal of this research was to determine whether the shooting range of 7.65mm country-made guns can be identified based on the tattooing generated on the target surface. Each firearm was fired thrice from a measured range of 10 cm, 20 cm and 30 cm from the target.

From the analysed data and graphical analysis, it was clear that the pattern of tattooing formed on the target shows no consistency. For each of the three distinct ranges (10, 20 and 30 cm), the dimensional values were repeated in between 10×11cm and 12×12cm. As a result, determining the precise range of firing of homemade weaponry by only measuring the dimension of tattooing generated was practically impossible. The same firearm, which was fired from the same range of fire shows different dimensions and patterns of tattooing. Also, when comparing different country made firearms of the same calibre which were fired from the same range of fire showed multiple inconsistent values. During the examination of firearms it was identified that the sample firearms had different dimensions in barrel length and barrel diameter. In addition to that, several irregularities on the firearm barrel were noticed. So this difference in tattooing might be caused by the material of the firearm, the length of barrel of the firearm, firing pin defects, and so on. As most of the country made firearms are manufactured without professionalism, the effect of firing with such firearms cannot be predicted. From the analysis, it is clear that a precise range of fire cannot be measured for country-made firearms by only measuring the tattooing area. An approximate range of fire could be determined from the average values. More research on improvised weaponry should be done so that this issue may be addressed.

VI. ACKNOWLEDGEMENT

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