J Forensic Sci, September 2009, Vol. 54, No. 5
doi: 10.1111/j.1556-4029.2009.01107.x
Available online at: www.blackwell-synergy.com

TECHNICAL NOTE

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An Investigation into Whether or Not the Class and Individual Characteristics of Five Turkish Manufactured Pistols Change During Extensive Firing

ABSTRACT: In order to assess whether or not the class and individual characteristics of a firearm change over time, five different makes of Turkish self-loading pistol were tested and were each fired a large number of times. The class and individual characteristics were identified for each pistol and the first fired cartridge case was compared with the subsequent consecutive 250th fired cases for each pistol. It was found that there were slight changes in some of the individual and class characteristics; however, this was not statistically significant and did not affect the ability of the firearms examiner to match the first fired case to the last fired case for each firearm tested.

KEYWORDS: forensic science, ballistics, pistol, cartridge case, class characteristics, individual characteristics, firing pin impression, extractor mark, ejector mark, breech face mark

When a cartridge is fired and the case extracted and ejected, various parts of the firearm come into contact with the case. As the metal of the cartridge case is softer than that of the firearm in which it has been fired, these parts of the firearm can leave marks on the cartridge case. Fine marks are left on parts of the firearm as a result of its manufacturing process. These are unique to the firearm and are referred to as "individual characteristics." For example, striae on the breechface of the firearm can be produced during the hand filing of the breech surface. In addition, individual characteristics are imparted to other parts of the firearm, including the firing pin, ejector, and extractor, from the tools that have been used to make these parts (1). These individual characteristics are transferred to the cartridge case when it is fired in the firearm. In addition to individual characteristics, the overall shape, size, and orientation of the firing pin impression, extractor and ejector marks can provide vital information when trying to identify the type of firearm that has fired a particular cartridge case and are referred to as "class characteristics" (2). Unlike the unique individual characteristics, class characteristics are similar between firearms of the same make and model.

Connecting a particular fired cartridge case to a specific firearm can be an integral part of a forensic investigation. In addition, the examination of a fired cartridge case for class characteristics may allow an identification of the type, make, and model of firearm that has been used (3). After a firearm has been discharged during a shooting incident, the fired cartridge case is collected by the crime scene investigators and submitted to the laboratory for analysis. If a suspect firearm is also seized, provided the class characteristics of that weapon are similar to those found on the seized fired cartridge case, the firearm is test fired at the laboratory and control cartridge cases are generated for comparison purposes (4). The control test fires will be compared with the seized cartridge case in order to determine whether or not the suspect firearm had been used to fire the cartridge case recovered from the crime scene. If, however, a suspect firearm is not recovered, the seized cartridge case is screened against and then placed onto an Open Case File (OCF) index. It will be retained on this index for many years for routine screening against suitable items subsequently submitted to the laboratory. Similarly, if a firearm is submitted, the control test fires generated are also screened against the OCF in order to identify any prior use. Any connection found with the OCF allows intelligence to be given to the investigating officers with regards to linked crime scenes or firearm seizures.

However, if the firearm used in this shooting incident is not recovered for a very long time, it is conceivable that there may have been considerable use of this firearm over this period. This may alter the individual characteristics being transferred to cartridge cases fired in the firearm. If there are significant changes in these individual characteristics, it is possible that the firearm may not be connected to the fired cartridge case held on the OCF. It is therefore extremely important to assess the degree of change in the individual characteristics over a period of extensive firing and to what extent this change will affect the conclusions reached by the firearms examiner.

Previous studies in this area have found that there are no significant differences in individual characteristics on consecutively fired cartridge cases (5–10). However, none of these investigations have dealt with Turkish manufactured self-loading pistols.

In this study, five different pistols of Turkish manufacture were selected and examined. The specific makes and models were selected, as they are some of the best selling in Turkey. The pistols were each fired a number of times, varying between 1,000 and 5,000 times depending on the pistol being tested. The first 10 and then subsequent consecutive 250th fired cartridge cases were collected, numbered, and retained for comparison purposes. The first

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Received 9 Aug. 2008; and in revised form 12 Sept. 2008; accepted 28 Sept. 2008.

10 cartridge cases were used to determine the class and individual characteristics of each firearm and the subsequent 250th fired cartridge cases were compared with the first fired cartridge case for each firearm. In addition, the firing pin impression diameter and the width and length of the extractor mark were measured in order that any change in these class characteristics could be identified.

Materials and Methods

In this study, five different 9 mm Parabellum caliber self-loading pistols were selected; the Canik 55, the Kanuni 16, the Sarsılmaz Kılınç 2000, the Yavuz 16, and the Şahin 08. These pistols were new and had been obtained directly from their manufacturer. Each pistol was fired a number of times; the Canik 55 1,000 times, the Kanuni 16 2,000 times, the Sarsılmaz Kılınç 2000 2,500 times, the Yavuz 16 3,500 times and the Şahin 08 5,000 times. Therefore a total of 14,000 cartridges were fired. Each pistol was not cleaned during the course of this investigation. The cartridges selected had been manufactured by the Turkish Mechanical and Chemical Industry Corporation (MKE).

The comparisons were carried out on Leica Stereo and Leica DMC comparison microscopes and the images were captured using a Leica DC 200 digital camera (Leica Microsystem Company, Wetzlar, Germany).

After firing, each consecutive 250th cartridge case was numbered and retained for comparison purposes. The first 10 cartridge cases for each pistol were also numbered and retained and were then compared with each other in order to identify, assess, and photograph the class and individual characteristics present (11). The class characteristics assessed were the overall shape of the firing pin impression and the style of the marks within this impression, the overall style of the breechface marks, the shape of the ejector, and the length and width of the extractor marks. The individual characteristics identified and assessed included those within the firing pin impression, breechface marks, extractor marks, and the ejector marks, depending on the pistol in question.

The nominated class and individual characteristics on each consecutive 250th cartridge case for each pistol was compared with the first cartridge case fired in that particular pistol. It was noted whether or not these characteristics were present on each consecutive 250th case and whether or not they had changed.

The firing pin impression diameter and extractor mark width and length were measured on the first 10 cartridge cases for each pistol using the 3D Ballistic Computer Analyses Systems (Balistika®) (12). The average (x) and the standard deviation (σ) of these measurements were calculated. The same characteristics were measured for each consecutive 250th cartridge case fired in each pistol and compared with the mean and standard deviation values calculated for the first 10 cartridge cases fired in each pistol.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{1}{n}(x_1 + \cdots + x_n).$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(X_i - \bar{X})^2}{N-1}}$$

Results

The overall shape of the firing pin, the style of the marks within the firing pin impression, the style of the breechface marks, and the shape of the ejector marks for each pistol are shown in Table 1.

Canik 55 Self-Loading Pistol

When the first cartridge case was compared with the last, the class characteristics were similar and there was no significant difference. The values of the firing pin diameter and the width and length of the extractor mark of the 250th, 500th, 750th, and 1,000th fired cartridge cases are shown in Table 2 alongside the mean and standard deviation values calculated from the first 10 fired cartridge cases. The specific individual characteristics assessed for comparison purposes for this pistol were marks within the firing pin impression and ejector and breechface marks. These marks had not significantly altered between the first, 250th, 500th, and 1,000th fired cartridge cases (Fig. 1).

Kanuni 16 Self-Loading Pistol

When the first cartridge case was compared with the last, the class characteristics were similar and there was no significant difference. The values of the firing pin diameter and the width and length of the extractor mark of the 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, and 2,000th fired cartridge cases are shown in Tables 3 and 4 alongside the mean and standard deviation values calculated from the first 10 fired cartridge cases. The specific individual characteristics assessed for comparison purposes

TABLE 1—*The shape of characteristics marks of cartridge cases.*

Pistol Make	Shape of Firing Pin	Marks of f/p Shape	Marks of Breech Face	Ejector Marks
Canik 55	Hemisphere	Hemisphere	Parallel	Irregular
Kanuni 16	Hemisphere	Smooth	Parallel	Triangular
Sarsılmaz Kılınç 2000	Hemisphere	Smooth	Parallel	Triangular
Yavuz 16	Hemisphere	Circular	Parallel	Triangular
Şahin 08	Hemisphere	Circular	Smooth	Irregular

TABLE 2—*The measured values of the Canik 55 first 10 and subsequent consecutive 250th fired cartridge cases and ($x \pm \sigma$) values.*

S.N.	1	2	3	4	5	6	7	8	9	10	x	σ	250	500	750	1,000
F.P.D.	1,590	1,490	1,540	1,430	1,410	1,530	1,730	1,610	1,590	1,520	1,544	0,093	1,630	1,490	1,630	1,490
E.M.W.	0,810	1,190	1,180	0,870	1,170	0,950	1,050	0,880	0,690	0,760	0,955	0,184	0,990	1,010	0,990	1,010
E.M.L.	1,310	1,780	1,380	2,020	1,410	1,810	2,010	1,600	2,210	1,310	1,684	0,329	1,360	1,390	1,360	1,390

S.N.: shot number; F.P.D.: firing pin impression diameter, mm; E.M.W.: extractor mark width, mm; E.M.L.: extractor mark length, mm.

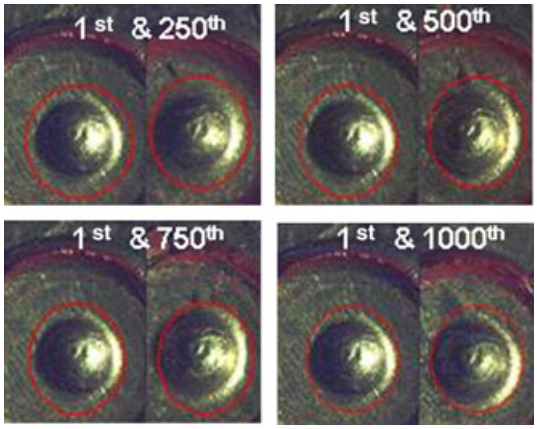

FIG. 1—*Firing pin impression of the Canik 55.*

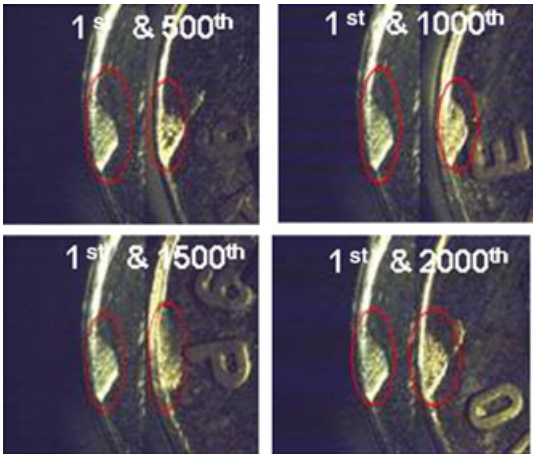

FIG. 2—*Ejector mark of the Kanuni 16.*

for this pistol were marks within the ejector, breechface marks, and firing pin cut-out drag marks. The marks had not significantly altered between the first, 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, and 2,000th fired cartridge cases (Fig. 2).

Sarsılmaz Kılınç 2000 Self-Loading Pistol

When the first cartridge case was compared with the last, the class characteristics were similar and there was no significant difference. The values of the firing pin diameter and the width and length of the extractor mark of the 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, 2,000th, 2,250th, 2,500th, and 3,000th fired cartridge cases are shown in Tables 5 and 6 alongside the mean and standard deviation values calculated from the first 10 fired cartridge cases. The specific individual characteristics assessed for comparison purposes for this pistol were the breechface marks and marks within the ejector and firing pin impression. The marks had not significantly altered between the first, 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, 2,000th, 2,250th, 2,500th, and 3,000th fired cartridge cases (Fig. 3).

Yavuz 16 Self-Loading Pistol

When the first cartridge case was compared with the last, the class characteristics were similar and there was no significant difference. The values of the firing pin diameter and the width and length of the extractor mark of the 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, 2,000th, 2,250th, 2,500th, 3,000th, 3,250th, and 3,500th fired cartridge cases are shown in Tables 7 and 8 alongside the mean and standard deviation values calculated from the first 10 fired cartridge cases. The specific individual characteristics assessed for comparison purposes for this pistol were marks within the firing pin impression and ejector and the breechface marks. The marks had not significantly altered between the first, 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, 2,000th, 2,250th, 2,500th, 3,000th, 3,250th, and 3,500th fired cartridge cases (Fig. 4).

Şahin 08 Self-Loading Pistol

When the first cartridge case was compared with the last, the class characteristics were similar and there was no significant difference. The values of the firing pin diameter and the width and length of the extractor mark of the 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, 2,000th, 2,250th, 2,500th, 3,000th, 3,250th, 3,500th, 3,750th, 4,000th, 4,250th, 4,500th, 4,750th, and 5,000th fired cartridge cases are shown in Tables 9 and 10 alongside the mean and standard deviation values calculated from the first 10 fired cartridge cases. The specific individual characteristics assessed for comparison purposes for this pistol were firing pin cut-out drag marks and detail within the ejector and extractor marks. The marks had not significantly altered between the first, 250th, 500th, 750th, 1,000th, 1,250th, 1,500th, 1,750th, 2,000th, 2,250th, 2,500th, 3,000th, 3,250th, 3,500th, 3,750th, 4,000th, 4,250th, 4500th, 4,750th, and 5,000th fired cartridge cases (Fig. 5).

TABLE 3—*The measured values of the Kanuni 16 first 10 fired cartridge cases and ($x \pm \sigma$) values.*

S.N.	1	2	3	4	5	6	7	8	9	10	x	σ
F.P.D.	1,278	1,240	1,171	1,247	1,199	1,234	1,173	1,125	1,397	1,184	1,225	0,075
E.M.W.	1,290	1,097	1,237	0,945	1,090	0,970	1,232	1,087	1,123	1,019	1,109	0,115
E.M.L.	1,897	1,976	2,007	1,829	1,768	1,745	1,803	1,765	1,880	1,448	1,812	0,156

TABLE 4—*The measured values of the Kanuni 16 subsequent consecutive 250th fired cartridge cases.*

S.N.	250	500	750	1,000	1,250	1,500	1,750	2,000
F.P.D.	1,224	1,236	1,274	1,167	1,299	1,234	1,173	1,225
E.M.W.	1,129	1,165	1,066	1,093	1,115	1,019	1,201	1,062
E.M.L.	1,829	1,911	1,794	1,822	1,892	1,799	1,902	1,888

TABLE 5—*The measured values of the Sarsılmaz Kılınç 2000 first 10 fired cartridge cases and (x ± σ) values.*

S.N.	1	2	3	4	5	6	7	8	9	10	x	σ
F.P.D.	1,153	1,346	1,374	1,410	1,306	1,412	1,290	1,313	1,417	1,412	1,343	0,083
E.M.W.	0,800	0,820	0,853	0,876	0,655	0,777	0,787	0,907	0,775	0,782	0,803	0,069
E.M.L.	1,984	2,052	1,961	1,753	1,826	2,062	2,057	2,060	2,096	2,075	1,993	0,116

TABLE 6—*The measured values of the Sarsılmaz Kılınç 2000 subsequent consecutive 250th fired cartridge cases.*

S.N.	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500
F.P.D.	1,361	1,382	1,331	1,344	1,417	1,410	1,336	1,402	1,313	1,417
E.M.W.	0,833	0,790	0,805	0,813	0,767	0,775	0,820	0,846	0,767	0,861
E.M.L.	1,969	2,073	1,884	2,045	1,892	2,007	2,029	2,022	1,946	1,885

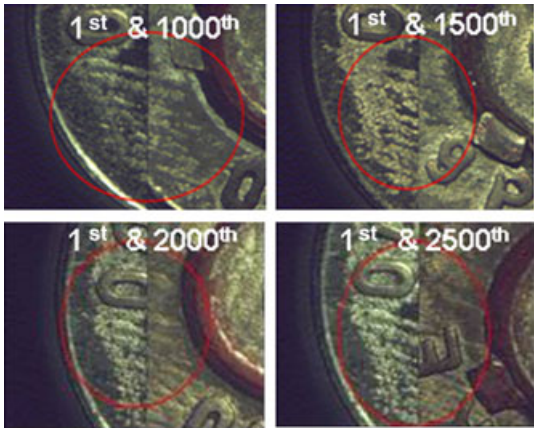

FIG. 3—*Breechface marks of the Sarsılmaz Kılınç 2000.*

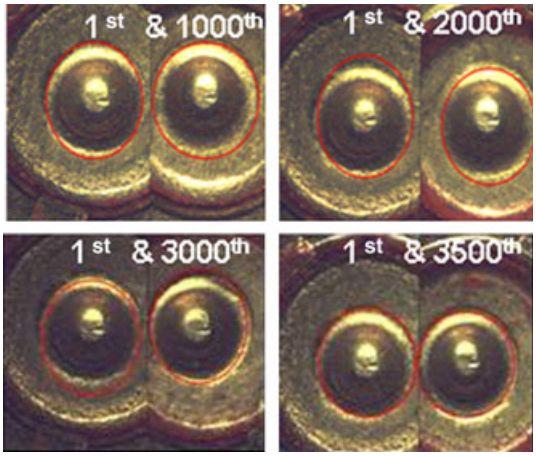

FIG. 4—*Firing pin impression of the Yavuz 16.*

For all of the five pistols examined, while there was no significant difference between the class characteristic values for the first 10 and the subsequent consecutive 250th fired cartridge cases it should be noted that the largest standard deviation was for the extractor mark length of the first 10 fired cartridge cases for the Sarsılmaz Kılınç 2000, Yavuz 16, and the Şahin 08 pistols. In addition, for the Şahin 08 self-loading pistol, the standard deviation for the extractor mark width was also large.

Overall, there were some slight changes observed within the individual characteristics of each pistol over time. However, these changes were not significant enough to alter the firearm examiner's conclusions. A conclusive match was determined between the first and last cartridge case fired in each of the five pistols.

Discussion

The class characteristics of all five pistols did not significantly change during the extensive test firing carried out in this study. However, the most obvious slight difference in class characteristics was found in the extractor mark length for the Canik 55, Yavuz, 16, and the Şahin 08 self-loading pistols and also in the extractor mark width for the Şahin 08. For the Şahin 08 the most significant

TABLE 7—*The measured values of the Yavuz 16 first 10 fired cartridge cases and (x ± σ) values.*

S.N.	1	2	3	4	5	6	7	8	9	10	x	σ
F.P.D.	1,539	1,539	1,577	1,539	1,628	1,554	1,562	1,554	1,572	1,491	1,556	0,035
E.M.W.	0,823	0,953	0,884	0,826	0,975	0,831	1,021	0,970	0,991	0,907	0,918	0,074
E.M.L.	2,212	2,299	1,895	2,324	2,550	2,352	2,583	2,314	2,309	2,629	2,347	0,212

TABLE 8—*The measured values of the Yavuz 16 subsequent consecutive 250th fired cartridge cases.*

S.N	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500	2,750	3,000	3,250	3,500
F.P.D.	1,521	1,537	1,532	1,521	1,560	1,544	1,590	1,521	1,537	1,567	1,532	1,577	1,529	1,552
E.M.W.	0,894	0,991	0,904	0,973	0,909	0,892	0,986	0,917	0,955	0,968	0,983	0,991	0,907	0,853
E.M.L.	2,421	2,466	2,344	2,492	2,545	2,344	2,329	2,281	2,197	2,527	2,405	2,428	2,398	2,395

TABLE 9—*The measured values of the Şahin 08 first 10 fired cartridge cases and (x ± σ) values.*

S.N.	1	2	3	4	5	6	7	8	9	10	x	σ
F.P.D.	1,560	1,514	1,334	1,445	1,207	1,730	1,430	1,323	1,176	1,237	1,395	0,175
E.M.W.	0,729	1,875	0,660	0,930	1,115	1,019	0,986	1,062	0,853	0,914	1,014	0,334
E.M.L.	1,626	2,027	1,537	1,260	1,374	1,044	1,229	0,998	1,715	1,382	1,419	0,315

TABLE 10—*The measured values of the Şahin 08 subsequent consecutive 250th fired cartridge cases.*

S.N.	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500	2,750	3,000	3,250	3,500	3,750	4,000	4,250	4,500	4,750	5,000
F.P.D.	1,245	1,346	1,222	1,349	1,422	1,285	1,524	1,453	1,339	1,483	1,417	1,473	1,240	1,369	1,224	1,285	1,450	1,463	1,407	1,349
E.M.W.	1,082	0,859	1,062	1,168	1,013	1,146	1,052	1,115	1,115	1,036	1,138	0,968	1,300	1,039	1,143	1,346	1,138	1,313	1,265	1,321
E.M.L.	1,346	1,107	1,407	1,331	1,295	1,275	1,389	1,422	1,176	1,422	1,179	1,316	1,549	1,499	1,334	1,308	1,313	1,328	1,400	1,242

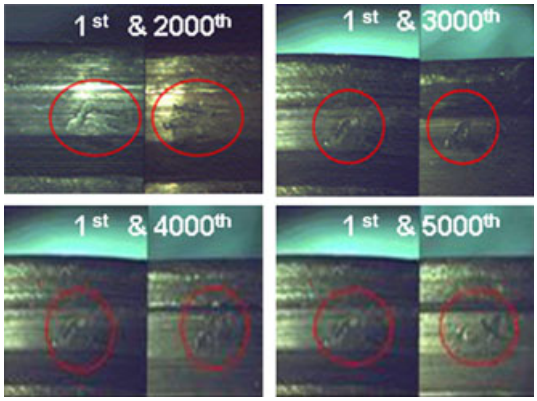

FIG. 5—*Extractor mark of the Sahin 08.*

change in the extractor mark measurements occurred on the first 10 fired cartridge cases, therefore creating the largest standard deviation for this class characteristic for all five pistols. The change in extractor mark length and width was less marked for all subsequent cartridges fired in this pistol. A similar outcome for changes in individual characteristics was observed by Schecter et al. (13) for ejector marks during a study in which they fired 7,100 cartridges in a 5.56 × 45 mm Galil rifle. They observed a similar change over the first few test fires, but then the ejector seemed to stabilize and mark the subsequent cartridge cases relatively consistently. In addition, Ogihara et al. (6) noticed that over time there were variations in the class characteristics of the firing pin and extractor marks and to a greater extent the ejector marks in a M1911A1 self-loading pistol that had been fired 5,000 times.

There were some slight changes in individual characteristics identified between the first and last cartridge case fired in each pistol; however, these were not significant and did not affect the ability of the firearms examiner to match the samples (Figs. 1–5). This has been observed in the previous studies of Vinci et al. (5) and Uchiyama (9).

In this study, MKE 9 mm Parabellum caliber cartridges were used. If a different make of cartridge were used then it is possible that the standard deviation values for the class characteristic may be altered. It also may be possible that differing amounts of the individual characteristics would be transferred between different makes of cartridge, as observed by Uchiyama in 2008 (9) between Speer, Remington, and Winchester cartridges and by Kirby in 1983 between cartridges with different primer types (7).

Overall, the results of this investigation broadly corroborated those findings of previous studies that while there were some slight differences in the class and individual characteristics observed over time, these changes were not significant and it was possible to conclusively match the last fired cartridge case to the first for all five pistols.

References

1. Moenssens A, Starrs J, Henderson C, Inbau F. Scientific evidence in civil and criminal cases, 4th edn. New York, NY: Westbury, 1995.
2. Bonfanti MS, Kinder JD. The influence of manufacturing processes on the identification of bullets and cartridge cases—a review of the literature. Sci Justice 1998;39(1):3–10.
3. Di Maio V. Gunshot wounds, practical aspects of firearms, ballistics and forensic techniques, 2nd edn. Florida, FL: Boca Raton, 2000.
4. Saferstein R, editor. Forensic science handbook, Vol. II. New Jersey: Prentice Hall, 1988.
5. Vinci F, Falamingo R, Campobass CP, Bailey JA. Morphological study of class and individual characteristics produced by firing 2500 cartridge in a .45 Caliber semi-automatic pistol. AFTE J 2005;37(4):368–73.
6. Ogihara Y, Kubota M, Sanada M, Fukuda K, Uchiyama T, Hamby J. Comparison of 5000 consecutively fired bullets and cartridge cases from a 45 Caliber M1911A1 pistol. AFTE J 1983;15(3):127–40.
7. Kirby S. Comparison of 900 consecutively fired bullets and cartridge cases from a 455 caliber S&W revolver. AFTE J 1983;15(3):113–26.
8. Shem R, Striupaitis P. Comparison of 501 consecutively fired bullets and cartridge cases from a 25 caliber raven pistol. AFTE J 1983; 15(3):109–12.
9. Uchiyama T. Toolmark reproducibility on fired bullets and expanded cartridge cases. AFTE J 2008;40(1):3–46.
10. Gouwe J, Hamby JE, Norris SA. Comparison of 10,000 consecutively fired cartridge cases from a model 22 Glock .40 S&W caliber semiautomatic pistol. AFTE J 2008;40(1):57–63.
11. GRC, General Rifling Characteristics [Computer Program]. MS-DOS version. Washington, DC: Firearms/Toolmarks Unit, FBI Laboratory, 2003.
12. Leloğlu UM, Sakarya U, Tek B, Cilingir O. A new automated firearms identification system using 3D information-Balistika. Forensic Sci Int 2003;136(1):160.
13. Schecter B, Silverwater H, Etzion M. Extended firing of a Galil Assault Rifle. AFTE J 1992;24(1):37–45.

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