Potential Impact and Application of 3D Scanning, 3D Modeling and 3D Printing in Toolmark Examination

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INTRODUCTION

3D printing is a manufacturing process that can transform a virtual digital model into a real-world three-dimensional solid object. This process is popular in producing prototypes of many designs. As 3D printing has increased in its affordability and availability in recent years, it has become a method of choice to manufacture functional products in many industries, including firearms.[1,2,3]

For firearms that are manufactured using the conventional methods, characteristic striations can be found on fired cartridges resulting from imperfections of the manufacturing tools, which were randomly left on the inner surface of the barrels. These toolmarks are the basis of forensic firearm examinations and identifications. However, 3D-printed firearms are manufactured without the need of physical contacts between any tools and the inner surface of the barrels to create rifling. It is uncertain whether distinguishable striations can be produced from 3D-printed barrels manufactured from the same printer using the same design.

To evaluate the potential impact and application of 3D scanning, modeling and printing technologies in toolmark examination, bullets discharged by using two 3D-printed 1911 barrels were examined.

MATERIALS AND METHODS

Instead of scanning the barrel from the reference firearm (Colt 1911 MK IV/ Series '70 Government Model 45 semi-automatic pistol) to obtain a printable digital design, the 3D model of the gun barrel was created through a computer software based on the original M1911 blueprint. The digital model was first tested by 3D-printing with plastic to observe any fallible design errors. Then, two gun barrels (Barrel A and B) were 3D-printed using the metal alloy, Inconel® alloy 718, at a local 3D printing facility (Figure 1).

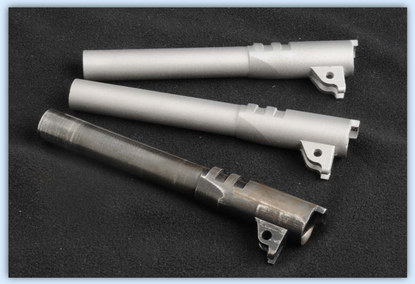

Figure 1: The two 3D-printed barrels are shown on the top and the bottom one is from a reference Colt 1911 45 Auto pistol.

RESULTS & DISCUSSION

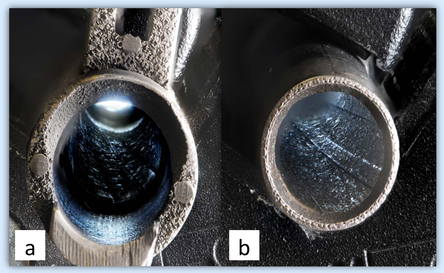

Figure 3: The close-up image of barrel A at the (a) chamber end and (b) the muzzle end., showing the extremely rough and granular surfaces.

Figure 4: The final assembly of the barrel in the reference pistol after hand-fitting.

Figure 5: The cartridges were seated somewhat differently in the 3D-printed chamber (left) and on the reference chamber (right).

- Hand-fitting was required to fit the barrels to the reference pistol and to ensure proper cycling and locking.
- The first 50 test-fires from both barrels were discharged without incident. Some improper extraction incidents were noticed during the 50th and 65th test-firing rounds.
- The chambers of the 3D-printed barrels were dremeled, smoothed, and oiled to properly seat the cartridges.
- Starting from around the 65th round to the end of the test-firing for both barrels, the slide was locked up and was unable to cycle back for extraction.

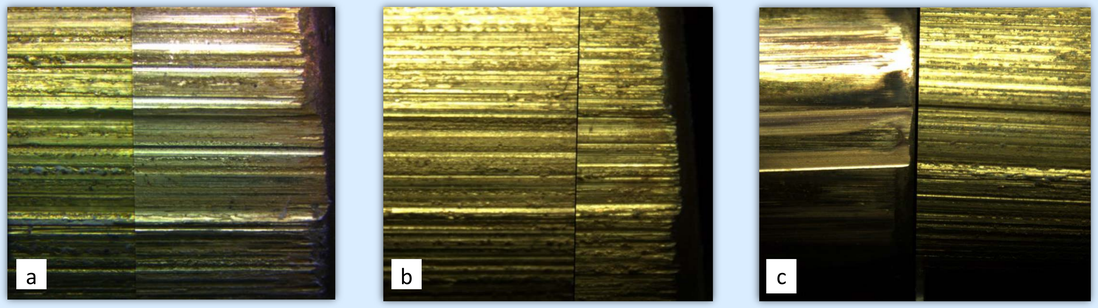

Figure 6: (a) Identifiable striations were observed from bullets fired from barrel A between 1st and 100th bullets; (b) Striations comparison between bullet fired from barrel A (left) and that from barrel B (Right) resulted in an elimination of firing from the same barrel; (c) Obvious differences between the striations obtained from bullets fired from the conventional reference barrel (left) and that from the 3D-printed barrel A (right).

CONCLUSIONS

- 3D-printed gun barrels manufactured from 3D modeling are functional to a certain extent.
- Bullets discharged from 3D-printed barrels manufactured from the same printer were differentiable from each other and from the conventional model.
- Designers of 3D-printed firearms require extensive knowledge and experience in the design and structure of the firearms. This might provide investigative leads if such firearms were involved in casework.
- Post-printing treatment for the outer surface of 3D printed barrels might be necessary to eliminate mechanical malfunction. The process of the treatment may result in characteristic toolmarks that would assist in examination.
- Well-controlled 3D scanning, modelling, and printing may offer a new way to design and produce standard tools for toolmark or pattern evidence examination.

MATERIALS AND METHODS

No post-printing surface treatment was performed on both of the barrels. The barrels were assembled to the reference pistol and test-fired by the firearm examiners at Harris County Institute of Forensic Sciences (HCIFS) in Houston, TX.

For safety reasons, the firearm was mounted on a ransom rest set-up to secure the pistol during test-firing (Figure 2a). A piece of tape was used to disengage the grip safety of the firearm for successful firing (Figure 2b). A total of 100 cartridges were test-fired from each barrel and the striations on the fired bullets were examined by the firearm examiners at HCIFS.

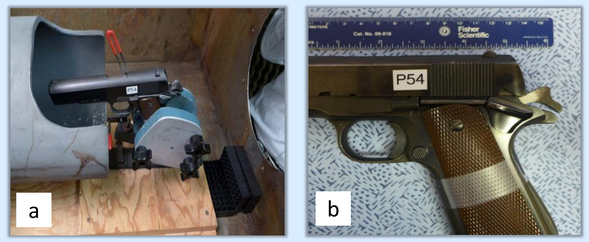

Figure 2: (a)The assembled pistol was secured in the ransom rest for test-firing; (b) The grip safety on the reference pistol was disengaged using a piece of tape before test-firing.

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