



Virtual Comparison Microscopy Revolutionizing Firearms Identification: A Review of Methods, Validity, and Admissibility

B. A. Best

Best Forensics
Maplesville, Alabama
United States of America

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* Contact information: Brandon Best, Best Forensics, LLC,
443 County Road 328, Maplesville, AL 36750; +1 706 570-
2319; brandon.best@best-forensics.com.

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ABSTRACT: Virtual comparison microscopy (VCM) affords firearms identification beneficial techniques and tools that the more traditional method of light comparison microscopy (LCM) does not offer. This new imaging method allows for the fast generation of 3-dimensional images that can be used for the examination of surface topography with a resolution unprecedented in firearms identification. Whether through coherence scanning interferometry or photometric stereomicroscopy, VCM is hitting its stride in a new age of firearms examination. While several validation studies indicate that VCM has a lower inconclusive rate and a lower error rate than LCM, a precedent has been set for the admissibility of VCM at trial. Having cleared all validity, admissibility, and standards hurdles, VCM is now poised to revolutionize the process of firearms identification.

KEYWORDS: 3D, acceptance, firearms identification, reliability, VCM, virtual comparison microscopy.

INTRODUCTION: FIREARMS IDENTIFICATION AS A SCIENCE

Firearms identification is an empirical science concerned with the examination and comparison of bullets and cartridge cases [27,38]. The main purpose of this discipline is to determine if a link is present between a suspect firearm and evidence items from the scene of a crime or from an autopsy. This is possible due to microscopic burrs and imperfections in the firearm created randomly during manufacturing. When a firearm is made, the various cutting and shaping processes leave behind imperfections in the metal that mark the bullet and cartridge case when they come into contact with the firearm surfaces [6,27]. Because the firearm is a fixed tool, subsequent firings involve contact with these imperfections, resulting in striations, or scratch marks, in the same relative location. The firearms examiner thus compares these striations using a comparison microscope in search of agreement of said striations, or the lack thereof. If there is such agreement between known samples and evidence samples, then a result of identification is founded. Likewise, if there is sufficient disagreement of these striations, then elimination is warranted. The third valid result possible is that of inconclusive. Similar to other disciplines, this simply means that the information available was insufficient to reach a determination.

The foundation of firearms identification is the principle of the built-up-edge (BUE) [6,27]. The BUE refers to the microscopic layer of metal that builds up on the cutting surface of a tool as it machines certain firearms components, whether the barrel or slide (**Figure 1**). This BUE of metal will build until it reaches its carrying capacity and breaks off at random intervals, leaving the burrs and imperfections discussed previously. The BUE

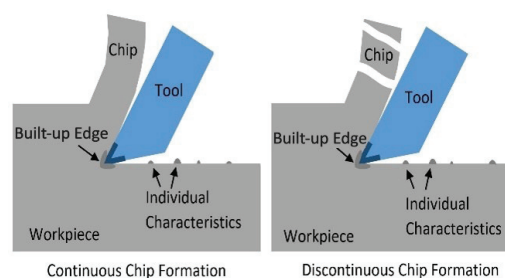


Figure 1. How BUE creates individual characteristics during machining, with continuous chip formation (left) and discontinuous chip formation (right). (Reproduced with permission from *AFTE J* 56:197; 2024 [6].)

is to firearms identification what the short tandem repeat (STR) is to DNA.

The cutting tool itself also contributes to the individuality of the marks left on a firearm. As the cutting tool wears from use, its surface will change, altering the marks that it leaves on the firearm surfaces. Damage to the cutting tool may become apparent. Any imperfections in the cutting surface will correspond to a mark on the firearm (**Figure 2**). For instance, the reaming blade used to form the barrel will leave marks on the surface of the lands, or raised portions, of the rifling in the barrel, which comes into direct contact with the bullets as they travel down the barrel. Any damage or wear to the reaming tool will leave concentric rings in the barrel that will in turn scratch the surface of a bullet (**Figure 3**).

History of Firearms Identification

The earliest known example of the use of firearms identification in a case dates back to 1835. Henry Goddard, an early detective in London, observed an imperfection in a bullet, which he was able to identify back to the bullet mold in which it was made. Much later, in 1912, Professor V. Balthazard of France was the first to photograph the sur-



Brandon A. Best received his B.S. degree in laboratory science from Auburn University (Auburn, AL), a M.S. degree in forensic science from the University of Alabama at Birmingham (UAB; Birmingham, AL), and an M.B.A. degree from Louisiana State University in Shreveport (Shreveport, LA). Mr. Best owns his own independent forensic firearms consulting firm, Best Forensics, where he is the chief forensic scientist.

Mr. Best previously served as a forensic scientist in the Firearm and Tool Mark Section of the Alabama Department of Forensic Sciences, Birmingham Regional Laboratory, for nine years. Before becoming a forensic scientist, Mr. Best served in the US Army Reserve for eight years as an engineer with the rank of sergeant. Following his military service, Mr. Best became a firearms examiner in Alabama's state crime laboratory system. He has examined firearms evidence in over 1,300 cases and testified as an expert witness over 98 times, and has several research publications.

Mr. Best is also a frequent guest lecturer, research mentor, and firearms technical leader at the University of Alabama at Birmingham's J. Frank Barefield, Jr. Department of Criminal Justice. His current research interests include a meta-analysis of firearms identification validation studies, as well as work on cognitive bias as it relates to the implementation of 3D methodologies in the field of firearms identification.

Mr. Best is a member of the American Academy of Forensic Sciences (AAFS) and the Association of Firearms and Tool Mark Examiners (AFTE). He holds certifications in Firearms, Tool Mark, and Gunshot Residue Testing from AFTE and is one of fewer than 30 individuals currently holding all three certifications internationally, and the first and currently the only such examiner in the state of Alabama (<https://afte.org/certification/certified-member-roster/>).