EMPIRICAL EVALUATION AND EXAMINATION OF BREECHFACE MARKINGS

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The Empirical Evaluation and Examination of Breechface Markings on Ten Consecutively Manufactured Pistol Slides

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University of Central Oklahoma

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A THESIS
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Dr. Dwight E. Adams — Committee Chair

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Abstract

Previously published research and case studies exist pertaining to consecutively manufactured tool marks and the individuality of those markings on tools. This study seeked to assess the Association of Firearm and Tool Mark Examiners (AFTE) Theory of Identification and provide additional research into the investigation of characteristics potentially viewed on the breechfaces of pistol slides. The researcher obtained ten consecutively manufactured Ruger LCP .380 Auto slides for examination. The tool marks exhibited on the breechfaces were macroscopically examined, evaluated in terms of potential for the transfer of subclass characteristics, and examined for the presence of individual characteristics. This research indicated whether breechface markings were accorded to their respective slide or if misidentification by examiners was possible. The first phase of this study was in further validating the AFTE Theory of Identification through generation of a test for AFTE members. This test required examiners to distinguish between subclass and individual characteristics, identify cartridge cases to their respective slide, and determine whether there was potential for misidentification of breechface markings due to subclass carryover. The second phase observed the differences and similarities of examiner ability and IBIS®BRASSTRAX-3D™'s ability to identify cartridge cases. This study might also function as a test for firearm and tool mark examiners to utilize in their laboratories as a training exercise related to consecutively manufactured breechfaces. The research findings might also facilitate the development of error rates pertaining to this study.

Keywords: Consecutively Manufactured, Breechface, Ruger LCP .380 Auto, Error Rates, 3D Imaging Technology, IBIS®BRASSTRAX-3D™, AFTE Theory of Identification

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I would also like to thank Dr. Tracy Morris and Dr. Thomas Jourdan for their role in this process. Dr. Morris, you have worked so hard in preparing me and helping me understand the statistics in this project. You were there through the ups and downs willing to assist with the results every step of the way. Thank you for everything you have done. Dr. Jourdan, I would like to thank you for coming in in the final moments and agreeing to sit in on the thesis defense and for your suggestions on the writing of this thesis. Your technical ability and analytical approach provided an additional view on this project which I can only describe as beneficial.

Lastly I would like to thank my family. I could not have done any of this without your support. To my parents, you have always been there to pick me up when I fall and have always known when I needed to be pushed. You guys have been the ones to listen to me when I needed to talk and you have always been ready to give me advice and encouragement when I felt lost. I am so grateful for all you have done and for being there for me. To my sisters, you guys are the

greatest. I want to thank you guys for all your unwavering support and belief that I would be able to do this. You guys have always been there when I really needed you. I am so thankful to be blessed with such an amazing family. I love each and every one of you.

Table of Contents

Figures, Tables, and Equations

Chapter 1 : Introduction

The intent of applied research and development in the field of firearm and tool mark analysis is to project the findings of scientific research into broader scientific fields. Furthermore, conducting ongoing forensic science research that challenges a discipline's theories, has the potential to develop accurate, reliable, and effective methods for the analysis, and interpretation of physical evidence collected at crime scenes. This study assessed the Association of Firearm Toolmark Examiners' (AFTE) Theory of Identification through examination of characteristics viewed on the breechfaces of pistol slides. Ten consecutively manufactured Ruger LCP .380 Auto slides were acquired for examination into this topic.

Figure 1.1 Ruger LCP .380 Auto

The tool marks exhibited on each breechface were macroscopically inspected, evaluated in terms of potential for the transfer of subclass characteristics, and examined for the presence of individual characteristics. The first phase of this research generated a test for firearm and tool mark examiners related to the consecutively manufactured breechfaces procured from Sturm Ruger. The next phase reported the examiners' test results in order to facilitate further development of error rates for this field of expertise. This study indicated whether breechface markings were correctly identified to their respective pistol slide or if there was potential for

misidentification by a firearm and tool mark examiner. As with any research in this field, this study functions as a platform for future research.

Statement of the Problem

In any discipline of forensic science, it is necessary to consistently challenge and validate theories that support the foundations of that discipline. Furthermore, it is only by challenging theories repeatedly that scientists will be able to strengthen their respective credibilities and thus the foundation of the discipline. This study assessed the current application of the AFTE Theory of Identification in relation to consecutively manufactured breechfaces. During the manufacturing process of Ruger LCP .380 Auto breechfaces, there is potential that subclass characteristic carryover might affect the validity of the AFTE Theory of Identification and examiner interpretation of individual characteristics. Firearm manufacturers generate breechfaces for various models of firearms by following a series of particular protocols. In some cases, these procedures or protocols pose a dilemma for those with the belief that subclass carryover has no influence on the determination of an identification when applied to firearm comparisons. The previous studies on subclass carryover show that examiners have had no issue conducting examinations where carryover can exist. It is this researcher's opinion that repetition of this has led to examiners discounting the impact subclass carryover can potentially have. Research into subclass characteristic carryover on consecutively manufactured breechfaces, to date, has been firearm specific, meaning that the researcher procures a certain make and model of firearm for their study. Due to this specificity, the results of the research are only applicable to the particular firearm manufacturing method investigated or those manufactured by that manufacturer using the same technology. In addition, previous research has expressed the necessity for further research into this phenomenon (Miller & Beach, 2005; Smith, 2004; Uchiyama, 2010; LaCova et al., 2010; Garten & Neel, 2010; Ball, 2000; Uchiyama

& Nota, 1986; Bunch et al., 2009; Rivera, 2007; Matty, 1999, 1984; Bunch & Murphy, 2003; Lopez & Grew, 2000; Roberge & Beauchamp, 2006; Miller, 2001; Tulleners & Hamiel, 1999; Fadul, 2011; Coody, 2003; Lightstone, 2010).

Background and Need

The National Research Council (2009) reported on the discipline of firearm and tool mark identification, stating this discipline could no longer rely on the subjective nature of an examination and base conclusions solely on an examiners' experience. To provide conclusions and testimony supporting individualization, it is necessary for this discipline to implement a protocol that can objectively support examiners' observations. The National Research Council further stated, in order to improve and advance the validity and credibility of forensic science as a whole, it is essential for future research to serve three purposes: it must assist law enforcement in identifying offenders with higher reliability, improve forensic science practices and reduce the occurrence of wrongful convictions, and enhance National Security. This report has prompted examiners within the firearm and tool mark discipline to reassess the theories and criteria upon which they base their conclusions.

One theory, in particular, is the Association of Firearm and Tool Mark Examiners Theory of Identification. According to the AFTE Glossary (2012), the AFTE Theory of Identification pertains to comparison of toolmarks, and enables opinions of common origin to be formed when the unique surface contours of two toolmarks are in "sufficient agreement". The glossary further defines sufficient agreement as follows:

> "Sufficient agreement is related to the significant duplication of random toolmarks as evidenced by the correspondence of a pattern or combination of patterns of surface contours. Significance is determined by the comparative examination of two or more sets of surface contour patterns comprised of individual peaks, ridges and furrows.

> Specifically, the relative height or depth, width, curvature and spatial relationship of the individual peaks, ridges and furrows within one set of surface contours are defined and compared to the corresponding features in the second set of surface contours.
> Agreement is significant when it exceeds the best agreement demonstrated between toolmarks known to have been produced by different tools and is consistent with agreement demonstrated by toolmarks known to have been produced by the same tool.
> The statement that "sufficient agreement" exists between two toolmarks means that the agreement is of a quantity and quality that the likelihood another tool could have made the mark is so remote as to be considered a practical impossibility.
> Currently, the interpretation of individualization/identification is subjective in nature, founded on scientific principles and based on the examiner's training and experience" (AFTE Glossary, 2012, 5th Edition).

Three characteristics examiners might encounter during the course of their work are class characteristics, individual characteristics, and subclass characteristics. Heard (2009) defines class characteristics as a series of family resemblances, which will be present in all tools of the same make and model. AFTE (2001) further defines class characteristics as the measurable features determined prior to manufacturing which indicate a restricted group source. Individual characteristics are defined as markings produced by the random and unique markings of tool surfaces. AFTE (2001) stated that these imperfections are incidental to manufacture and can be caused by use, corrosion, or damage; individual characteristics are unique to a particular tool that distinguishes it from all other tools. The definition of these two terms is utilized in defining subclass characteristics. According to AFTE (2001), "subclass characteristics are the discernible surface features of an object which are more restrictive than class characteristics in

that they are: (1) produced incidental to manufacture, (2) are significant in that they relate to a smaller group source (a subset of the class they belong), and (3) can arise from a source which changes over time." Furthermore, AFTE (2001) advises that caution be exercised when trying to distinguish between subclass characteristics and individual characteristics. Based on these definitions, it was concluded that subclass characteristics are more restrictive than class characteristics but less so than individual characteristics.

Manufacturing Procedure: Ruger LCP .380 Auto Pistol Breechface

This study examined all characteristics (class, individual, and subclass) exhibited on the breechface during the manufacturing process. Haag (2006) has defined the breechface as a component of the breechblock or breech bolt that is seated against the headstamp region of the cartridge case or shotshell during firing (Figure 2).

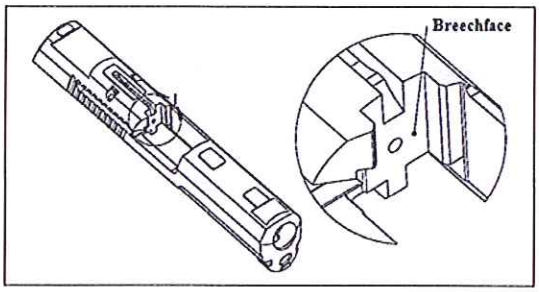

Figure 1.2 Ruger LCP .380 Auto pistol slide and breechface

Jim Elliot, plant manager, over the Prescott Division of Sturm, Ruger and Co., Inc., provided the manufacturing protocol for the breechface of this particular firearm. Manufacturing of the breechface began with placing the slide on a pneumatic cylinder clamp station (Figure 3 & 4). Throughout this entire manufacturing process, a water-soluble lubricant was dispensed over the cutting tool and workpiece (pistol slide) to prevent overheating.

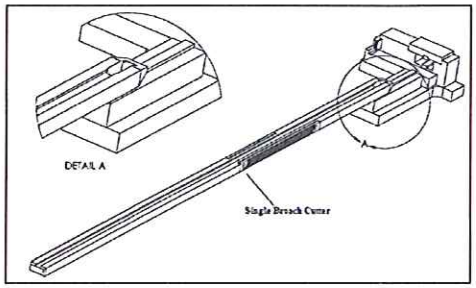

Figure 1.3 Pneumatic slide clamp and single broach cutter

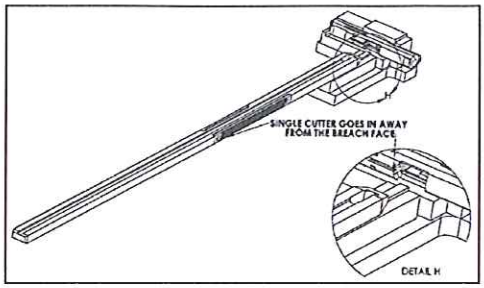

Figure 1.4 Pneumatic slide clamp with slide in place and single broach cutter

A single broach cutter was then positioned into the slide away from the breechface. The cutter was partially pushed through, by hand, until the broach puller retrieved it during which time the slide was clamped into place. The single broach cutter was pulled through the slide completely where it was stopped; the slide was unclamped and removed from the pneumatic cylinder clamp station. The operator reversed the broach puller to retrieve the single broach cutter and repeated the process (Figure 5).

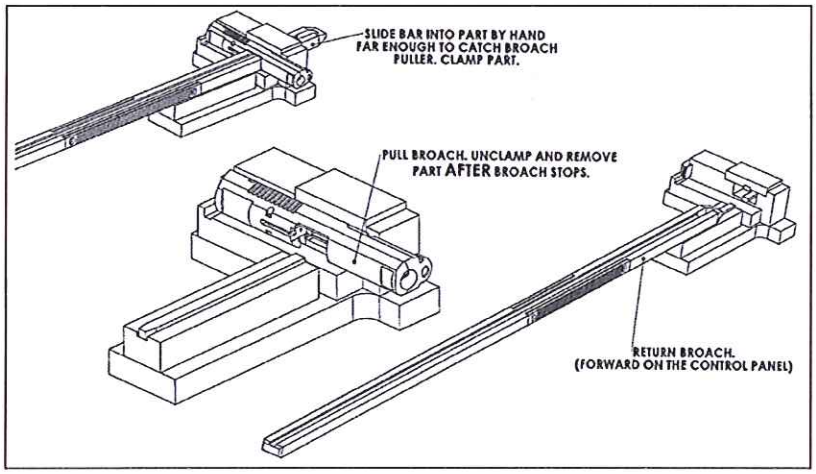

Figure 1.5 Sliding broach cutter through slide, removing slide, returning broach to original position

Purpose of the Study

The primary purpose of this study was to assess the AFTE Theory of Identification, accomplished through empirical evaluation and examination of breechface markings on ten consecutively manufactured Ruger LCP .380 Auto pistol slides by examiners and IBIS®

BRASSTRAX-3D™ and MatchPoint+™. This research reported both subjective and objective conclusions reached by examiners and known technology within the field of firearm and tool mark analysis to assist in the development of error rates as they relate to tool marks. The second purpose of this study was to provide additional research on the potential of subclass carryover on consecutively manufactured surfaces. This research provided findings relative to this phenomenon, and differs from the previously conducted research as it looked to utilize previously published methodologies and expand upon them. The researcher utilized two approaches for this project. The first approach entailed a test and survey for firearm and tool mark examiners regarding their analysis of the consecutively manufactured breechfaces, and the second approach involved using a three-dimensional imaging system to take the same test given to examiners. This approach allowed the researcher to look at the ability of three-dimensional imaging technology in examining similar characteristics examiners encountered, as well as compare capabilities of both examiners and the computer. The research determined how examiners identified subclass characteristics, if these characteristics were a factor taken into consideration when conducting analysis, and how much influence they had on the analysis process. Combination of these two approaches might serve in establishing and reducing error rates for the discipline with regard to class, individual, and subclass characteristics.

Research Questions

This study hypothesized many questions in particular areas to be researched.

Years of Experience (Years working excluding training)

1. **H_0:** There is no difference between the Sensitivity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

H_1: There is a difference between the Sensitivity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

2. **H_0:** There is no difference between the Specificity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the Specificity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

3. **H_0:** There is no difference between the False Positive Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the False Positive Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

4. **H_0:** There is no difference between the False Negative Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the False Negative Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

5. **H_0:** There is no difference between the Positive Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the Positive Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

6. **H_0:** There is no difference between the Negative Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the Negative Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

7. **H_0:** There is no difference between the Global Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience

   H_1: There is a difference between the Global Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

Years of Training

8. **H_0:** There is no difference between the Sensitivity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

   H_1: There is a difference between the Sensitivity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

9. **H_0:** There is no difference between the Specificity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

   H_1: There is a difference between the Specificity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

10. **H_0:** There is no difference between the False Positive Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

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11. **H_0:** There is no difference between the False Negative Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the False Negative Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

12. **H_0:** There is no difference between the Positive Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

H_1: There is a difference between the Positive Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

13. **H_0:** There is no difference between the Negative Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the Negative Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

14. **H_0:** There is no difference between the Global Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the Global Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

Scope Make

15. **H_0:** There is no difference between the Sensitivity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Sensitivity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

16. **H_0:** There is no difference between the Specificity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Specificity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

17. **H_0:** There is no difference between the False Positive Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the False Positive Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

18. **H_0:** There is no difference between the False Negative Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the False Negative Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

19. **H_0:** There is no difference between the Positive Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Positive Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

20. **H_0:** There is no difference between the Negative Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Negative Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

21. **H_0:** There is no difference between the Global Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Global Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

Observed Subclass Characteristics

22. **H_0:** There is no difference between the Sensitivity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the Sensitivity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

23. **H_0:** There is no difference between the Specificity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

H_1: There is a difference between the Specificity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

24. **H_0:** There is no difference between the False Positive Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the False Positive Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

25. **H_0:** There is no difference between the False Negative Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the False Negative Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

26. **H_0:** There is no difference between the Positive Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the Positive Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

27. **H_0:** There is no difference between the Negative Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

H_1: There is a difference between the Negative Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

28. **H_0:** There is no difference between the Global Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics

H_1: There is a difference between the Global Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

Distinguished Between Subclass and Individual Charactersitics

29. **H_0:** There is no difference between the Sensitivity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

H_1: There is a difference between the Sensitivity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

30. **H_0:** There is no difference between the Specificity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

H_1: There is a difference between the Specificity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

31. **H_0:** There is no difference between the False Positive Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and

examiners that were not able to distinguish subclass characteristics from individual characteristics.

H_1: There is a difference between the False Positive Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

32. **H_0:** There is no difference between the False Negative Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

H_1: There is a difference between the False Negative Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

33. **H_0:** There is no difference between the Positive Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

H_1: There is a difference between the Positive Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

34. **H_0:** There is no difference between the Negative Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the Negative Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

35. **H_0:** There is no difference between the Global Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the Global Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

Examined Knowns First

36. **H_0:** There is no difference between the Sensitivity of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the Sensitivity of examiners that examined knowns first and examiners that examined unknowns first.

37. **H_0:** There is no difference between the Specificity of examiners that examined knowns first and examiners that examined unknowns first.

H_1: There is a difference between the Specificity of examiners that examined knowns first and examiners that examined unknowns first.

38. **H_0:** There is no difference between the False Positive Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

H_1: There is a difference between the False Positive Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

39. **H_0:** There is no difference between the False Negative Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

H_1: There is a difference between the False Negative Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

40. **H_0:** There is no difference between the Positive Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

H_1: There is a difference between the Positive Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

41. **H_0:** There is no difference between the Negative Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

H_1: There is a difference between the Negative Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

42. **H_0:** There is no difference between the Global Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

H_1: There is a difference between the Global Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

Examiners' conclusions and IBIS® BRASSTRAX-3D™ conclusion

43. **H_0:** There is no difference between the Sensitivity for examiners and the Sensitivity for IBIS® BRASSTRAX-3D™.

H_1: There is a difference between the Sensitivity for examiners and the Sensitivity for IBIS® BRASSTRAX-3D™.

44. **H_0:** There is no difference between the Specificity for examiners and the Specificity for IBIS® BRASSTRAX-3D™.

H_1: There is no difference between the Specificity for examiners and the Specificity for IBIS® BRASSTRAX-3D™.

45. **H_0:** There is no difference between the False Positive Error Rate for examiners and the False Positive Error Rate for IBIS® BRASSTRAX-3D™.

H_1: There is a difference between the False Positive Error Rate for examiners and the False Positive Error Rate for IBIS® BRASSTRAX-3D™.

46. **H_0:** There is no difference between the False Negative Error Rate for examiners and the False Negative Error Rate for IBIS® BRASSTRAX-3D™.

H_1: There is a difference between the False Negative Error Rate for examiners and the False Negative Error Rate for IBIS® BRASSTRAX-3D™.

47. **H_0:** There is no difference between the Positive Predictive Value for examiners and the Positive Predictive Value for IBIS® BRASSTRAX-3D™.

H_1: There is a difference between the Positive Predictive Value for examiners and the Positive Predictive Value for IBIS® BRASSTRAX-3D™.

48. **H_0:** There is no difference between the Negative Predictive Value for examiners and the Negative Predictive Value for IBIS® BRASSTRAX-3D™.

H_1: There is a difference between the Negative Predictive Value for examiners and the Negative Predictive Value for IBIS® BRASSTRAX-3D™.

49. **H_0:** There is no difference between the Global Error Rate for examiners and the Global Error Rate for IBIS® BRASSTRAX-3D™.

H_1: There is a difference between the Global Error Rate for examiners and the Global Error Rate for IBIS® BRASSTRAX-3D™.

Significance to the Field

This research is significant to the field of Firearms and Tool Marks because it will provide further research into the subject of subclass characteristics. By providing further research, examiners can be better informed on this particular issue, which could potentially come up during casework at some point in their career. This information will be able to serve as a subclass characteristics reference when conducting examinations on evidence. A second aspect of significance provided in this study is error rates. Firearms and Tool Marks have well recognized error rates that were developed from research and studies conducted thus far through the history of the field. Conducting additional studies and research on error rates in the field will help hone the current error rates in place and allow examiners to provide not only an error rate but also a more accurate one. The third aspect of significance is in how this study demonstrates a new methodology for testing examiners. There is a traditional test in which examiners are asked to identify an unknown cartridge case to a known cartridge case. Examiners were then asked to submit a survey inquiring about their experience, training, and methodology utilized. This secondary feature allows us to look at error rates with regards to years of experience working in the field, amount of training, and how examiners conduct their examinations. Finally, this study is significant in that it demonstrates a recently developed technology that

could prove to be beneficial to the field when conducting examinations on evidence. By providing error rates and preliminary research on IBIS®BRASSTRAX-3D™, the field will be able to observe what this technology is capable of and see how it can be utilized as a tool for Firearms and Tool Marks examiners. The findings of this study can be used as a foundation upon which further research into these various aspects can be conducted.

Chapter 2 : Review of the Literature

Previous research and case studies have been published pertaining to consecutively manufactured tool marks and the individuality of markings on tools (Miller & Beach, 2005; Smith, 2004; Uchiyama, 2010; LaCova et al., 2010; Garten & Neel, 2010; Ball, 2000; Uchiyama & Nota, 1986; Bunch et al., 2009; Rivera, 2007; Matty, 1999, 1984; Bunch & Murphy, 2003; Lopez & Grew, 2000; Roberge & Beauchamp, 2006; Miller, 2001; Tulleners & Hamiel, 1999; Fadul, 2011; Coody, 2003; Lightstone, 2010). These studies have scrutinized the markings on consecutively manufactured surfaces for the possibility of subclass carryover. Investigation of potential subclass carryover is essential in alerting examiners of another factor they might encounter during the course of their work. Rivera (2007), Lightstone (2010), and Coody (2003), indicate that there is a need for inquiries into the possibility of subclass carryover on consecutively manufactured breechfaces and how they might affect an examiners analysis.

Consecutively Manufactured Surfaces

Throughout the history of firearm and tool mark examination, researchers have conducted studies utilizing consecutively manufactured tools investigating them for individuality (Mathews, 1962; Lutz, 1970; Nicholson, 1970; Skolrood, 1975; Haag, 1977; Freeman, 1978; Hall, 1983; Matty, 1984, 1999; Uchiyama & Nota, 1986; Maruoka, 1994; Thompson, 1994; Brundage, 1998; Bonfanti & DeKinder, 1999; Tulleners & Hamiel, 1999; Ball, 2000; Lopez & Grew, 2000; Miller, 2001; Bunch & Murphy, 2003; Coody, 2003; Hocherman et al., 2003; Fadul & Nunez, 2006; Roberge & Beauchamp, 2006; Nichols, 2007; Rivera, 2007; Bunch et al., 2009; Lightstone, 2010; Fadul, 2011). One of the potential issues with consecutively manufactured surfaces is the possibility that two barrels or breechfaces could produce enough similarity in microscopic markings the bullets and casings could be misidentified as being fired from the same

firearm (Smith, 2004). According to Miller and Beach (2005), the presence of subclass characteristics does not mean that individual characteristics will be absent as both will be present and potentially identifiable. Subclass characteristics can occur when the tool working surface exhibits the same tool marks as the one produced before and after it. Furthermore, Miller and Beach (2005) indicate the importance of examiners being able to distinguish between subclass characteristics and individual characteristics when comparing and evaluating tool marks. Distinguishing between these two types of characteristics can be attributed to the underlying principle of firearms identification in that no two firearms should exhibit identical features such that they could be falsely identified as having been fired from the same firearm. Miller and Beach (2005) recommended examiners search for possible subclass characteristics and deduce whether they might influence the tool mark produced by the tool working surface

There is importance in examiners' ability to recognize and differentiate subclass characteristics, but how does an examiner know when they might encounter subclass characteristics on a tool working surface or in a tool mark? An advantage for examiners, as stated by Miller and Beach, is in the manufacturing of tool working surfaces and the tools used to produce them because these tools wear down and are replaced, resulting in different tool marks being produced. Therefore, it is important to have the manufacturing protocol of the tool working surface available along with its potential for subclass characteristics and individuality. According to Miller (2001), the only way of ruling out subclass characteristic influence on that surface and subsequently a tool mark produced by that surface, is by familiarization of manufacturing processes, examination of the tool working surface, and examination of test tool marks produced using that tool. Another prospective method for identifying subclass characteristics is examining unfired ammunition or unused tool. This method dictates that an

examiner conduct a preliminary macroscopic examination for the presence of subclass characteristics prior to firing or use. Analysis of unfired ammunition or unused tools can inform the examiner of subclass characteristic influence and may be applicable to future comparisons.

Consecutively Manufactured Barrels

A multitude of studies have been conducted on consecutively manufactured barrels and their potential to deposit subclass characteristics on bullets (Mathews, 1962; Lutz, 1970; Skolrood, 1975; Haag, 1977; Freeman, 1978; Hall, 1983; Brundage, 1998; Tulleners & Hamiel, 1999; Miller, 2001; Hocherman et al., 2003; Fadul & Nunez, 2006; Roberge & Beauchamp, 2006; Fadul, 2011). This previously published research was conducted with the intention of investigating whether subclass characteristic carryover was identifiable on barrels and if so, would those characteristics be transferable from the barrel to the bullet. Utilizing these findings, examiners would be alerted to potential subclass characteristic influence on bullets which could possibly lead to misidentification. Miller (2001) puts forth previous studies that claim if subclass characteristics existed on barrels, they would most likely be produced on barrels that are consecutively manufactured attributable to the notion that less change can be expected to occur on tool working surfaces manufacturing barrels consecutively than the changes produced on barrels manufactured further apart from each other. The most prevalently used method for observing the presence of subclass characteristic influence on barrels and its potential to be misidentified is studying consecutively manufactured barrels and constructing tests for examiners in the field (Roberge & Beauchamp, 2006).

Among the earliest reported studies on consecutively manufactured barrels, it was determined that, although barrels may appear alike and exhibit similar characteristics, each barrel has its own distinct and separate individuality (Mathews, 1962; Lutz, 1970; Skolrood, 1975;

Freeman, 1978; Hall, 1983; Fadul, 2011). This notion was further proved in a study by Lutz (1970), who discovered that macroscopic comparison of bullets fired from consecutively manufactured barrels carried markings from each barrel and were different to such a degree that the lands and grooves contained a high amount of individual characteristics making them identifiable to their respective barrel. Later studies began to construct tests requiring examiners within the discipline to identify bullets back to its correct consecutively manufactured barrel. Thus, allowing researchers to initiate the development of error rates associated with subclass characteristics (Brundage, 1998). According to Nichols (2007), the exploration of error rates provides the discipline with a guide demonstrating the frequency with which misidentification related to subclass characteristics are reported. Research, by Brundage (1998), on subclass characteristics was one of the first studies to statistically assess that properly trained firearm and tool mark examiners could correctly identify bullets fired from consecutively manufactured barrels to the barrel from which they were fired. Further review of the literature on consecutively manufactured barrels shows that even if examination of the barrels shows subclass characteristic carryover, it is quite possible that these characteristics will not be transferable onto the bullet to the extent that it could lead to misidentification (Miller, 2001). Though the likelihood of subclass carryover on bullets from consecutively manufactured barrels is low, it is still essential for examiners to maintain an understanding of this influence should they ever encounter a similar situation during the course of their career (Tulleners & Hamiel, 1999; Fadul & Nunez, 2006). These previously published studies suggest that further research in this area will recurrently improve the scientific foundation of firearm and tool mark identification. It will allow for calculation of error rates from additional data, and it will provide empirical data that will strengthen the foundations of this discipline (Fadul, 2011).

Consecutively Manufactured Breechfaces

There have been an abundant number of studies published on consecutively manufactured breechfaces and the characteristics they leave on the headstamp region of the cartridge case as mentioned above. This research maintains that these characteristics are individual and identifiable (Nicholson, 1970; Rivera, 2007; Matty, 1984; Thompson, 1994). Though the majority of studies concur that breechface markings on the cartridge case headstamp region are identifiable to an individual firearm, not all studies achieved similar conclusions. Rivera (2007) stated that subclass characteristic carryover is an issue that has hovered over the field of firearm and tool mark examination for years. He also signifies that examiners should be aware of this potentially devastating issue, especially those who might rely on only one particular type of marking for identification (Rivera, 2007). His findings demonstrated that there was a strong possibility of manufacturing marks exhibiting subclass characteristics due to the closeness in serial numbers between two pistols (Rivera, 2007). Lardizabal (1995) also examined two consecutively manufactured pistols and concluded that the breechfaces exhibited great similarity. Upon further testing, the research found that these subclass characteristics persisted even after numerous firings. Matty (1999) discovered, after acquiring several fired cartridges from each firearm, that the breechface markings left by two consecutively manufactured firearms were similar but there were insufficient characteristics to make an identification.

Previous research has indicated to the field that subclass characteristic influence might present varying difficulty with the identification process, but it cannot prevent a properly trained and experienced examiner from correctly identifying evidence (Coody, 2003; Lightstone, 2010; Bunch & Murphy, 2003). For example, Coody (2003) conducted a study on consecutively

manufactured Ruger P89 pistol slides to confirm that breechface markings left on the cartridge were distinguishable and identifiable by individual characteristics present on the slide's breechface. Coody's findings demonstrated that although the slides exhibited similar class characteristics, comparisons of test-fired cartridges from each slide were identifiable to their respective slide. She further stated that due to the various tools and manufacturing procedures within the firearm industry, research on potential subclass carryover on multiple makes and models of firearms is necessary (Coody, 2003). Lightstone (2010) examined the breechfaces of ten consecutively manufactured Smith & Wesson Sigma SW40VE pistol slides, and ascertained that there was notable subclass carryover on the breechfaces between slides, but these characteristics did not transfer in the same degree to the fired cartridges. Lightstone (2010) concluded that the breechface markings were not sufficient enough to cause misidentification and that there were enough individual characteristics present on each breechface to allow identification of the cartridges. Bunch and Murphy (2003) constructed a test, for examiners in the field, investigating whether cartridges fired from ten consecutively manufactured Glock 9mm Luger pistol slides were identifiable to their respective slide. They found that examiners were capable of correctly identifying the fired cartridge cases, based solely on breechface markings, to the corresponding Glock slide fired from (Bunch & Murphy, 2003). These previously published studies demonstrate that subclass characteristic carryover might affect the difficultly of an examiner's examination, but it cannot prevent the examiner from making an identification.

Recognizing the potential for examiner misidentification of evidence due to subclass carryover on breechfaces, necessitates a need to provide information and precautions to prevent this from occurring. Several studies have put forth protocols and supplied pertinent material for examiners to utilize within the laboratory (Uchiyama & Nota, 1986; Ball, 2000; Maruoka, 1994;

Bunch et al., 2009). One such study, by Maruoka (1994), supplied a few conditions that might theoretically assist examiners. He stated, "Examiners should (1) look at all of their test fires (before firing and after) and evidence ammunition as well as the firearm, if available; (2) check for the continuation of tool marks from the breechface into the firing pin impression; (3) note if a firearm that typically exhibits a particular type of mark, class characteristic, is now leaving a different marking (e.g. cross hatching v. parallel); and (4) note when compound breechface marks are present but not reproducing or orienting to each other, and when breechface marks are not orienting to extractor/ ejector marks" (Maruoka, 1994). The most prevalently used techniques for preventing misidentification of breechface markings is examination of the firearm breechface itself as mentioned by Maruoka (1994) and examination of ammunition for manufacturing marks before it is test fired as prescribed by Ball (2000). Uchiyama and Nota (1986) mentioned that manufacturing marks might be exhibited on the cartridge case and potentially confused for breechface markings, but examination of the firing pin impression for continuation of these markings can indicate the origin of these markings. The importance of identifying and differentiating subclass characteristics is further demonstrated by Ball (2000), who indicated the necessity of alerting firearm and tool mark examiners to be cautious when examining fired cartridges with regard to breechface markings, especially if conclusions are based solely on these markings.

Further research into the phenomenon of subclass carryover on breechfaces is imperative in informing examiners within the discipline of markings which might lead to a misidentification. Bunch et al. (2009) and Lightstone (2010) express that, typically, this topic is not one to worry over, but in the event that it is, publishing results about subclass carryover on breechfaces will inform examiners to be more discriminating during their examination. The

aforementioned studies demonstrate that impressed markings (i.e. breechface markings and firing pin impressions) are more persistent by their nature meaning that given relatively clean parts breechface markings can persist for many thousands of firings. Bonfanti and De Kinder (1999) concluded that cartridge cases fired in a firearm in sequential order, cartridge number 1 will usually display significant macroscopic consistencies to cartridge number 10, 100, or even number 500 or 1000.

All of the previously conducted research has demonstrated that subclass characteristics have the highest potential to occur when examining consecutively manufactured surfaces. These studies have shown, overall, how examiners have been able to distinguish these characteristics from other characteristics. Furthermore, the presence of subclass characteristics has not prevented an examiner from forming a conclusion from their analysis. Bunch and Murphy (2003) provided error rates associated with examiners' analyses on subclass carryover. Their study included accuracy rates of the examiners' analysis such as false positive error rates, false negative error rates, sensitivity, and specificity.

Use of Imaging Technology in Firearm and Tool Mark Examination

Research into the application of imaging technology on firearm and tool mark examinations is a part of the field that has both historical significance as well as newly developing significance. Imaging technology is one element in this field that is genuinely static, in that it has been established in the past, but yet still proves to be new and ever changing. Previously conducted research shows that image analysis capability has added an entirely new dimension to comparisons (Warren, 1991; McLean, 1999; Bolton-King et al., 2010; Roberge and Beauchamp, 2006; Grom and Demuth, 2012). According to Warren (1991), imaging of tool marks provides examiners with an additional dimension of visualization thus providing more

information for analysis. Imaging technology provides firearm and tool mark examiners with multiple advantages. For instance, due to the electronic nature of an image, it can be converted to various formats, compared, examined, statistically analyzed, stored, enhanced, or transmitted to another location (Warren, 1991).

The use of imaging technology to assist firearms and tool marks examiners dates back to the early 1900's when Professor V. Balthazard was able to utilize photographs to identify firearms evidence (NIJ, 2013). This discovery allowed examiners to capture what they saw and provided them with the ability to show other examiners their conclusions or thoughts without accessing the evidence. It also gave examiners the ability to send evidence images essentially anywhere in the world without having to send the actual evidence. The next advancement in imaging technology took place in the late 1900's when the Federal Bureau of Investigation (FBI) introduced a system known as DRUGFIRE (NIJ, 2013). This system consisted of an electronic database and computer network designed to digitally image cartridge cases. The implementation of DRUGFIRE allowed examiners to compare their firearms evidence with other laboratories all over the United States as long as they were utilizing the DRUGFIRE system as well. A couple of years later, in the 1990's, Forensic Technology Incorporated (FTI), a company out of Montreal, Canada, developed a system known as BulletProof™ (NIJ, 2013). This imaging system design intended to assist examiners in the identification of bullets. The creation of BulletProof™ was one of the first digital imaging systems that allowed examiners to input bullet evidence instead of cartridge case evidence. Approximately four years after the creation of BulletProof™, FTI developed BrassCatcher™ (NIJ, 2013). The BrassCatcher™ and BulletProof™ system functioned on similar premises with the exception that BrassCatcher™ analyzed cartridge case evidence. Upon the creation of BrassCatcher™, FTI reached the

decision to combine both systems which they renamed the Integrated Ballistics Identification System (IBIS). These technologies are the forerunners to the digital imaging systems we see today.

Modern researchers have looked to build and improve upon the predeceasing technology available in the field of Firearms and Tool Marks. The early imaging systems functioned on two dimensions, but with the advancement in technology and imaging capability, it is now possible to surpass two-dimensional imaging systems for three-dimensional ones. The term three dimensional, as applied to firearms and toolmarks, implies that there is topographical measurement of the viewing surface (Bolton-King et al., 2010). One of the first three-dimensional systems to be developed was SCICLOPS. Intelligent Automation Incorporated (IAI) created SCICLOPS in the late 1990's. This system was the first fully automated system in that it was capable of automatically acquiring, processing, and comparing bullets (Bachrach, 2006). Another imaging system that came available within this period is the Automated Land Identification System (ALIS). This system functioned under the same principles as SCICLOPS in that it was also a three dimensional system for bullets (Hamby et al. 2009). A few years later, in the early 2000's, Pyramidal Technologies Limited created the Advanced Ballistics Analysis System (ALIAS) (Barrett and Warren, 2011). This system along with its fellow 3D systems was able to image topography, correlate evidence images, and provide visualization and confirmation for examiners. Two of the most recent systems available to firearms and tool marks examiners are the IBIS® BRASSTRAX-3D™ System and the IBIS® BULLETTRAX-3D™ System developed by FTI. The IBIS® BRASSTRAX-3D™ software and the IBIS® BULLETTRAX-3D™ software work in conjunction with Matchpoint+™. Matchpoint+™ is the software coupled with these systems. Once a cartridge case enters into the database, Matchpoint+™

calculates and reports the correlations. These two systems were designed to image the surface topography of the bullet or cartridge case, correlate it against the static database, provide three-dimensional visualization of the bullet or cartridge case, and score each correlation in a ranking system (FTI, 2013).

Imaging technology in the field of firearms and tool marks has come a long way since its start in the early 1900's. The evolution of this technology makes it a highly needed tool in the examinations of evidence. This technology allows the examiner to not only visualize their evidence, but also be able to connect the evidence to other cases. As incredible and advanced as technology has become in the last 100 years, it is important to point out that technology will never be the entire answer or entire solution to conducting examinations in casework. Examiners will always be a necessary part to the addition of imaging technology on examinations. They will either be fundamental in reviewing the computers work or in running the software and instrumentation. It is a well-known premise that computers will never be able to replace a highly trained and experienced examiner, however computers can function as a tool to examiners increasing their workflow and allowing them to keep up with increasing crime rates (McLean, 1999).

Chapter 3 : Methods

This study observed the ability of examiners and IBIS® BRASSTRAX-3D™ and Matchpoint+™ computerized imaging system in the evaluation of breechface markings on ten consecutively manufactured Ruger LCP .380 pistol slides. Once an examiner completed the test packet, they faxed or emailed their results to the researcher. After receiving the test for analysis, the researcher sent the examiners a survey asking them about their examination of consecutively manufactured breechface markings. The results of this test and survey have proved to be a useful step in further developing error rates in the firearm and tool mark discipline. The researcher analyzed the incoming data and prepared it for statistical computation. After computation of the raw data, performance of statistical analyses determined the error rates, sensitivity, specificity, and predictive values for examiners and the three-dimensional imaging technology. The numerical variables were defined as follows according to the NAS Report (NRC, 2009):

- Sensitivity: The fraction of identifications correctly identified by examiners in the test.
- Specificity: The fraction of eliminations correctly identified by examiners in the test.
- False Positive Error Rate: The fraction of identifications incorrectly identified by examiners in the test.
- False Negative Error Rate: The fraction of eliminations incorrectly identified by examiners in the test.
- Positive Predictive Value: The projected fraction of identifications correctly identified by examiners in general based on test results.
- Negative Predictive Value: The projected fraction of eliminations correctly identified by examiners in general based on test results.

- Global Error Rate: The projected fraction of incorrectly identified unknowns among all unknowns examined.

This study contained several hypotheses requiring answers.

Years of Experience

Examiner test results were grouped according to years of experience, excluding training, in the field. The researcher wanted to observe the effects of examiner experience on accuracy and error rates. Test results were placed into one of two groups based on examiner survey responses. The researcher placed test results into the zero to five years of experience group or the six or more years of experience group. Upon categorization of examiner test results, the groups were statistically analyzed for the following numerical variables: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Years of Training

The researcher grouped examiner test results based on years of training in order to observe the effects of examiner training period on accuracy and error rates. Test results were assigned to groups based on examiner survey responses. The researcher placed examiner results into one of the two groups, examiners with zero to one and half years of training and examiners with two or more years of training. After placing examiner results into their respective groups, performance of statistics analysis found the following numerical variables: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Scope Make

Examiner test results were sorted based on the make (brand) of comparison macroscope used for examination in order to observe the effects of comparison macroscope brand on

accuracy and error rates. The researcher sorted test results based on examiner responses in the survey. The examiner test results were placed into either the Leeds comparison macroscope group or the Leica comparison macroscope group. After the researcher placed the test results into groups, statistics were calculated for the following numerical variables: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Observed Subclass Characteristics

The researcher divided examiner test results, dependent on survey responses, into two categories based on whether examiners observed subclass characteristics or whether examiners did not observe subclass characteristics. Division of the test results into these two groups allowed the researcher to examine the effects of whether subclass characteristics observation on accuracy and error rates. Upon assignment into groups, the test results were statistically analyzed for the following numerical variables: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Distinguished Between Subclass and Individual Characteristics

Examiner test results were divided into groups based on their survey responses. The researcher asked examiners to state whether they were able to distinguish between subclass characteristics and individual characteristics during their examinations. Observation of test results for examiners able to distinguish between subclass and individual characteristics and for examiners unable to distinguish between both characteristics allowed the researcher to examine the effects of distinguishing subclass characteristics on accuracy and error rates. Based on responses, test results were sorted appropriately and then statistically analyzed for the following

numerical variables: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Examined Knowns First

Examiner test results were divided into one of two groups based on their survey responses. The researcher divided examiner test results based on whether the examiner examined knowns first or whether the examiner examined unknowns first. Division of test results into these two groups allowed the researcher to observe the effects of examination methodology on accuracy and error rates. After placing examiner tests into groups, the test results were statistically analyzed for the following numerical values: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Examiners' conclusions and IBIS® BRASSTRAX-3D™ conclusion

The researcher compared the total examiner test results and total computer test results to observe the effects of both on accuracy and error rates. Each set of examiner test results were totaled up for analysis while the computer had a single set of test results used for analysis. The test results for the examiners and computer were statistically analyzed for the following numerical values: Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate.

Setting

The construction of this test took place in Edmond, Oklahoma. Mr. Deion Christophe and the researcher fired and recovered cartridge cases from Oklahoma State Bureau of Investigations indoor firing range. After construction of the test packets, the researcher sent tests

to firearms examiners in various locations throughout the United States as well as a couple of locations outside the U.S.

Materials and Instruments

1. Ten consecutively manufactured Ruger LCP .380 Auto pistol slides:
    a. Provided by Jim Elliott, plant manager, at the Prescott Division of Sturm, Ruger and Co., Inc.
2. IBIS®BRASSTRAX-3D™ System at Forensic Technology Incorporated in Montreal, Canada
3. Provided by the Forensic Science Institute, University of Central Oklahoma, Edmond, Oklahoma:
    a. Ruger LCP .380 Auto frame
    b. One non-consecutively manufactured Ruger LCP .380 slide
    c. Forensic-sil Casting Material
    d. Leeds Comparison Microscope.
4. Procured with Research, Creative, and Scholarly Arts Grant Funding:
    a. Ammunition, Winchester FMJ .380 Automatic Ammunition purchased from Academy Sports and Outdoors.

Procedure for Collecting Data

This study utilized ten consecutively manufactured breechfaces. Based on the previous research, studies on consecutively manufactured tools have typically chosen ten samples to examine (Lightstone, 2010). According to Lightstone (2010), this number allows for a wide enough sample size to examine tool marks from the first manufactured to the last, and allows for conclusions on whether or not subclass characteristics carried over continually or whether the

tool producing the markings changed enough to create only individual markings. This sample size is also advantageous because it is not so large that a researcher would need unlimited time or resources to complete their study. Moreover, due to the cost necessary to procure these tools, anything more than ten consecutively manufactured tools would be impractical (Lightstone, 2010).

Forensic-sil castings were made of each breechface because this media has the ability to capture microscopic manufacturing marks that might not be transferable to the cartridge case. These ten Forensic-sil castings were examined on a Leeds Comparison Microscope for any potential subclass characteristics prior to firing any cartridges from the slides. Before firing the cartridge cases, the headstamp region of each cartridge was macroscopically examined to detect all markings present that might affect analysis of the breechface after firing the cartridge cases. Any manufacturing markings exhibited on the headstamp region of the cartridge case were photographed and documented. After examination, each cartridge case was etched with an identification code. The randomized code prevented examiners from discovering any numbering patterns, which could have potentially given away answers for the tests. There was a code for the known cartridges and a code for the unknown cartridges. The known code consisted of the letter "K" and a number ranging from 1A/B to 40A/B. K1A/B - K10A/B was used for knowns fired from slide one, K11A/B - K20A/B for slide two, etc. The unknowns code consisted of the letter "U" and a number ranging from 1 to 600. This code was put into a list and randomized so the researcher ensured no pattern or repetition existed

Each slide was alternatively attached to a Ruger LCP .380 frame and fired at the Oklahoma State Bureau of Investigation's indoor shooting range. One thousand four hundred cartridge cases were fired from the firearm, resulting in enough cartridge case samples for

developing forty test packets. One hundred thirty-six cartridge cases were fired from each of the consecutively manufactured slides and forty cartridge cases were fired from the non-consecutively manufactured slide. The researcher collected the fired cartridge cases and placed them in coin-sized paper envelopes labeled with the make and model of the firearm and the cartridge case code. The fired cartridge cases were stored inside envelopes to prevent the occurrence of any extraneous markings and to keep them organized.

Ruger LCP .380 Auto Test Design

The design for this test and survey was modeled after a similar test produced by Hamby et al. (2009). The researcher distributed test packets to Forensic Technology Inc. (FTI) and to AFTE members through a web blast requesting volunteers. Once an AFTE member volunteered to take the test, the researcher informed them that, if feasible, they were encouraged to complete the test packet and turn it in for analysis two weeks from the day they received it. There was a randomized distribution of test packets to participants. The randomization process entailed placing all the test packets into a box, which allowed the researcher to draw a randomly numbered packet to send to the examiner. With each test packet, the researcher documented the test packet identification number, an inventory of the test contents, and answers on a key prior to distribution. The test packet number identified the results of each test and survey making the study completely anonymous to prevent examiners from biasing their answers.

The test packets consisted of twenty-five cartridge cases and an examination sheet. Each packet contained instructions explaining that examiners were to base their conclusions on the breechface markings located on the cartridge case headstamp region. Ten knowns consisting of an A and a B, served as two test fire representations for each pistol slide, and the remaining fifteen cartridges were the unknowns for comparison. One of the unknowns was a cartridge case

fired from the non-consecutively manufactured Ruger slide while the remaining fourteen unknown cartridges were assigned by blind selection. The researcher placed the unknowns envelopes into a box then randomly selected envelopes to ensure that no pattern existed between test packets.

This study observed the ability of examiners and IBIS® BRASSTRAX-3D™ and Matchpoint+™ computerized imaging system in the evaluation of breechface markings on ten consecutively manufactured Ruger LCP .380 pistol slides. Examiners and the computer received a test packet that required them to conduct manual comparisons on fifteen unknown cartridge cases and ten known cartridge cases. Instructions advised analysts at Forensic Technology Inc. to conduct their examination utilizing IBIS®BRASSTRAX-3D™ imaging technology to analyze the known cartridge cases and compare them to the fifteen unknown cartridge cases recording their results on the included examination answer sheet, and instructions informed AFTE examiners to conduct manual comparisons utilizing a comparison microscope. The researcher asked participants to identify an unknown cartridge case to its corresponding known cartridge case by writing in the code of the known cartridge case they examined in the first column and the code of the unknown cartridge case they concluded as a match in the second column. The test also allowed examiners the option of listing the cartridge case as a match to none of the above.

The computer test packet was entered into the IBIS® BRASSTRAX-3D™ and Matchpoint+™ imaging systems at Forensic Technology Inc. in Montreal, Canada. Cartridge cases were entered into the IBIS database with the IBIS® BRASSTRAX-3D™ system, which is capable of capturing a 2D and 3D image of the cartridge case. These images were then manually compared to the other cartridge cases in the test packet using the Matchpoint+™ software. Matchpoint+™ functions as a virtual comparison macroscope allowing the examiner to analyze

and compare the cartridge cases. Figure 3.1 shows the IBIS® BRASSTRAX-3D™ methodology utilized.

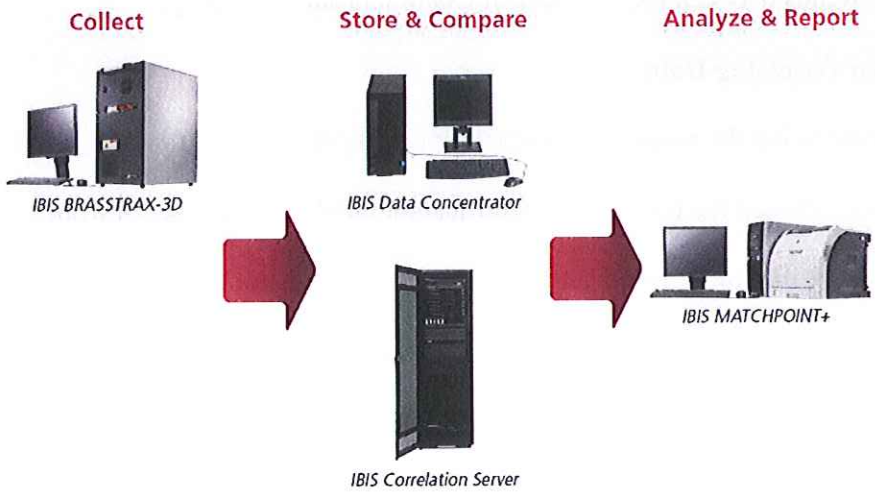


Figure 3.1 IBIS® BRASSTRAX-3D™ System (FTI, 2013)

Examiners received a test packet that required them to conduct manual comparisons on fifteen unknown cartridge cases and ten known cartridge cases. The participants were asked to identify an unknown cartridge case to its corresponding known cartridge case. Once the examiner completed the test packet, they sent their results to the researcher for grading. The researcher also distributed one test packet to Forensic Technology Incorporated where a certified operator entered it into the IBIS® BRASSTRAX-3D™ system. The computer test packet was entered into the IBIS® BRASSTRAX-3D™ and Matchpoint+™ imaging systems at Forensic Technology Inc. in Montreal, Canada. Cartridge cases were entered into the IBIS database with the IBIS® BRASSTRAX-3D™ system, which is capable of capturing a 2D or 3D image of the cartridge case. This image was then manually compared to the other cartridge cases in the test packet using the Matchpoint+™ software. Matchpoint+™ functions as a virtual comparison macroscope allowing the examiner to analyze and compare the cartridge cases. The researcher analyzed the incoming data and prepared it for statistical computation. After computation of the

raw data, performance of statistical analyses found the error rates, sensitivity, specificity, and predictive values for examiners and the three-dimensional imaging technology. The statistical data revealed trends between the accuracy of examiners and technology.

Procedure for Assessing Data

After receiving the results, the researcher reviewed each set of results and analyzed them. The researcher assigned the test packet identification number to each set of results in order to keep the results of the study completely anonymous. Analysis of the results included recording the conclusions of each test on the master key to verify which examiners achieved the correct conclusions. The second phase of assessment for this study was analysis of the survey sent out to examiners after they completed the test. Analysis of the test and survey responses looked at two different types of error: critical error and quality error. A quality error occurred when an examiner made an error due to an unsuitable sample and a critical error occurred when an examiner made an error due to misidentification.

The researcher added up the number of True Positives, number of False Positives, number of True Negatives, and number of False Negatives for each test packet. For the purposes of this study, a true positive was an identified unknown that was supposed to be identified, a false positive was an identified unknown that was not supposed to be identified or incorrectly identified, a true negative was an eliminated unknown that was supposed to be eliminated, and a false negative was an eliminated or inconclusive unknown that was not supposed to be eliminated or ruled inconclusive. The data consisted of seven numeric variables (Sensitivity, Specificity, False Positive Rate, False Negative Rate, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and Global Error Rate) and six categorical variables (Years of Experience, Years of Training, Scope Make, Observed Subclass Characteristics, Distinguished

Subclass From Individual Characteristics, and Examined Knowns First), with each of the categorical variables consisting of two potential outcomes. Definition of the numerical variables were as follows:

Equations 3.1 Seven numeric variable's formulas

$$\boldsymbol{Sensitivity} = \frac{\boldsymbol{\#\ of\ true\ positives}}{\boldsymbol{Total\ number\ of\ unknowns\ with\ an\ ID}\ (14)}$$

$$Specificity = \frac{\#\ of\ true\ negatives}{Total\ number\ of\ unknowns\ without\ an\ ID\ (1)}$$

$$False\ Positive\ Error\ Rate = \frac{\#\ of\ false\ positives}{Total\ number\ of\ unknowns\ that\ could\ have\ been\ false\ positives\ (15)}$$

$$False\ Negative\ Error\ Rate = \frac{\#\ of\ false\ negatives}{Total\ number\ of\ unknowns\ that\ could\ have\ been\ false\ negatives\ (14)}$$

$$Positive\ Predictive\ Value = \frac{\#\ of\ true\ positives}{Total\ number\ of\ identifications\ (varies\ for\ each\ examiner)}$$

$$Negative\ Predictive\ Value = \frac{\#\ of\ true\ negatives}{Total\ number\ of\ eliminations\ (varies\ for\ each\ examiner)}$$

$$Global\ Error\ Rate = \frac{\#\ of\ incorrect\ conclusions\ (false\ positive\ or\ false\ negative)}{Total\ number\ of\ unknowns\ (15)}$$

The researcher utilized Statistical Analysis System (SAS) and Statistical Package for Social Sciences (SPSS) in computing the summary statistics for each of the numeric variables, and performing *t*-tests (assuming unequal variances) to detect differences in the means of the two

groups for each combination of numeric and categorical variable. One of the assumptions of the *t*-test is that data be randomly sampled from normally distributed populations. Although the *t*-test is generally robust to violations of this assumption, it does not perform well when the data are from extremely skewed distributions or when the data contain outliers, especially when the sample sizes are small. This was the case for each of the numeric variables; consequently, exact Wilcoxon rank sum tests were also performed. For this test, the data are replaced by the corresponding ranks and the analysis is then performed on the ranks rather than the original data, thus reducing the effect of outliers. The Wilcoxon rank sum test is generally considered to be a test for the differences in the medians of two groups. P-values were found for each of the means and medians calculated. The p-value is the probability of obtaining a test statistic at least as extreme as the one that was observed in this test, assuming the null hypothesis is true. For all tests, p-values less than 0.05 are considered to be significant.

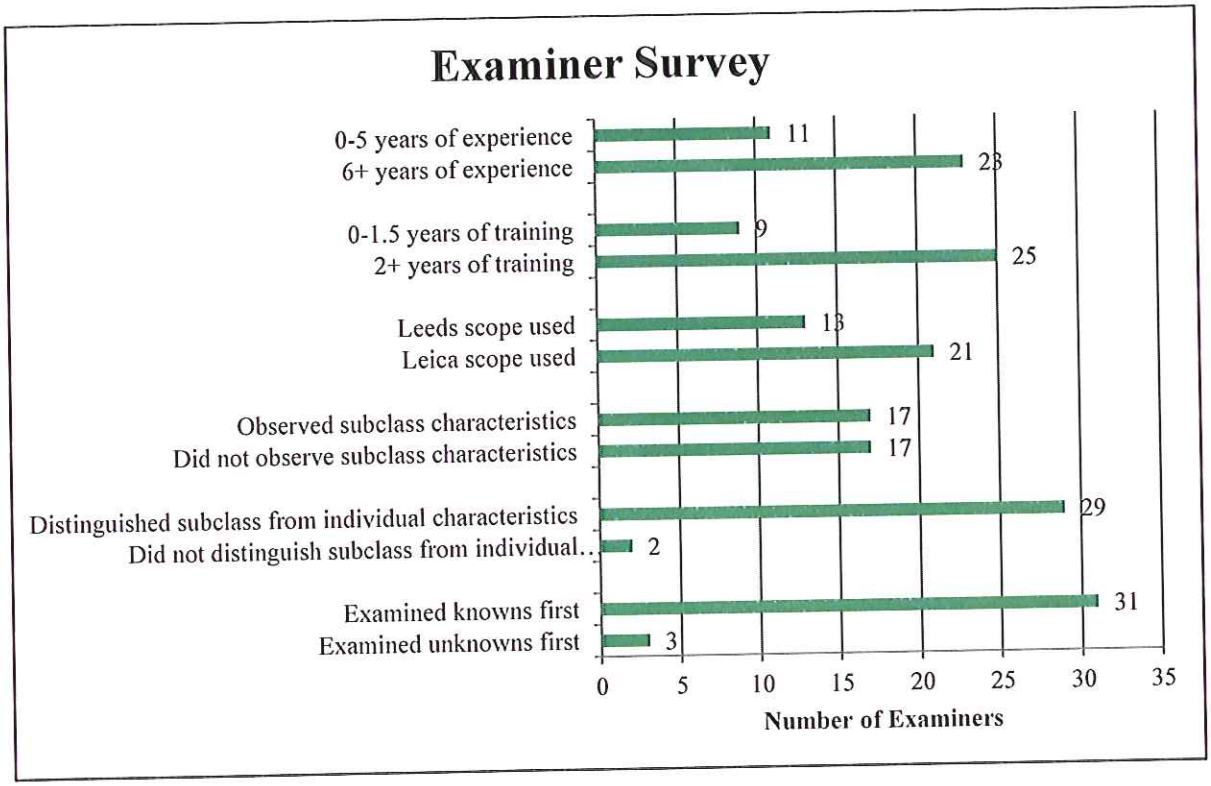
Chapter 4 : Results

The results were presented for each of the categorical variables separately.

Examiner Survey

After completion and submission of the test packet, examiners filled out a survey about their examination. The topics addressed in the examiner survey served as the categorical variables for statistical analysis of test packet results. Chart 4.1 lists the results of the survey.

Chart 4.1 Results of Examiner Survey



Years of Experience

The researcher posed the following hypotheses about examiners based on years of experience:

1. **H_0:** There is no difference between the Sensitivity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

H_1: There is a difference between the Sensitivity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

2. **H_0:** There is no difference between the Specificity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the Specificity of examiners with (0-5) years of experience and examiners with (6+) years of experience.

3. **H_0:** There is no difference between the False Positive Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the False Positive Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

4. **H_0:** There is no difference between the False Negative Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the False Negative Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

5. **H_0:** There is no difference between the Positive Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the Positive Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

6. **H_0:** There is no difference between the Negative Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

   H_1: There is a difference between the Negative Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.

7. **H_0:** There is no difference between the Global Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience

   H_1: There is a difference between the Global Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

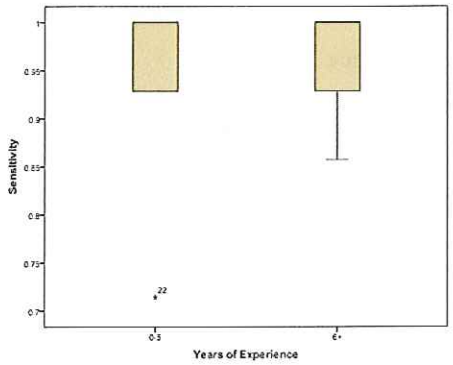
Table 4.1 displays summary statistics and p-values. There were no significant differences in the means of any of the seven numeric variables for those with 0-5 years of experience and those with 6 or more years of experience. Figure 4.1 displays boxplots of six of the seven numeric variables by years of experience. There are no boxplots for Specificity since the Specificity values are the same for each examiner. Due to the presence of outliers, exact Wilcoxon rank sum tests were also performed. Table 4.1 also displays p-values for these tests. There were no significant differences in the medians of any of the seven numeric variables for those with 0-5 years of experience and those with 6 or more years of experience.

Table 4.1 Summary Statistics and p-values by Years of Experience

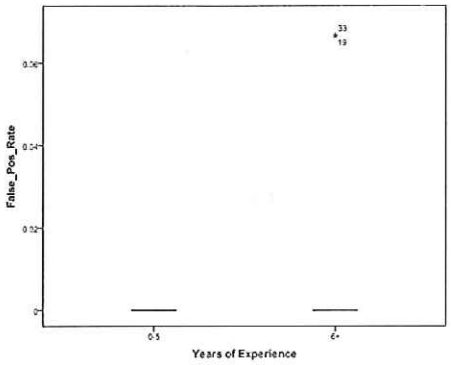
	Years of Experience	*N*	Mean	Median	St. Dev.	Range	*p*-values *t*-test	*p*-values Wilcoxon
Sensitivity (%)	0-5	11	95.45	100	8.61	71.43-100	0.7756	0.9122
	6+	23	96.27	100	5.22	85.71-100		
Specificity (%)	0-5	11	100	100	0	100-100	-	1.0000
	6+	23	100	100	0	100-100		
False Pos. Rate (%)	0-5	11	0	0	0	0-0	0.1619	0.5490
	6+	23	0.58	0	1.92	0-6.67		
False Neg. Rate (%)	0-5	11	4.55	0	8.61	0-28.57	0.6171	0.8012
	6+	23	3.11	0	5.20	0-14.29		
PPV (%)	0-5	11	100	100	0	100-100	0.1619	0.5490
	6+	23	99.38	100	2.06	92.86-100		
NPV (%)	0-5	11	79.09	100	30.15	20.00-100	0.7467	0.8012
	6+	23	82.61	100	27.28	33.33-100		
Global Error Rate (%)	0-5	11	4.24	0	8.04	0-26.67	0.7756	0.9122
	6+	23	3.48	0	4.87	0-13.33		

Figure 4.1 Boxplots by Years of Experience

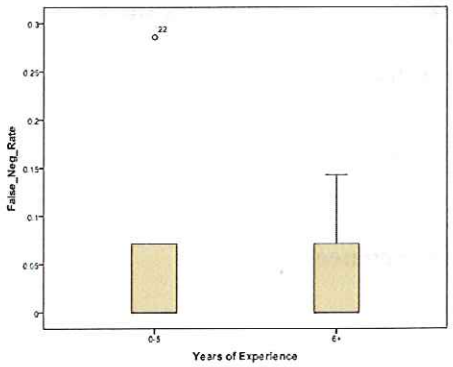
a. Sensitivity



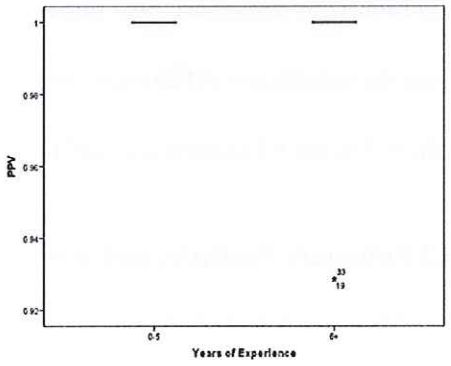
b. False Positive Rate



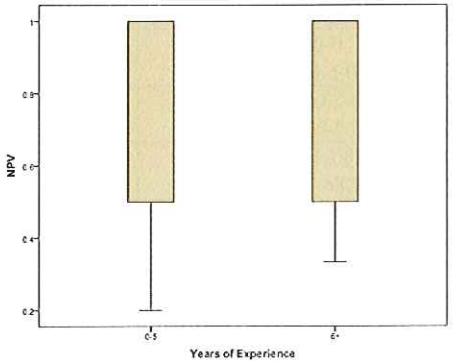
c. False Negative Rate



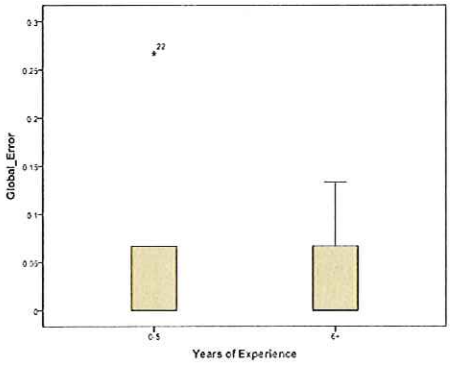
d. Positive Predictive Value



e. Negative Predictive Value



f. Global Error Rate



Years of Training

The researcher posed the following hypotheses about examiners based on years of training:

8. **H_0:** There is no difference between the Sensitivity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

   H_1: There is a difference between the Sensitivity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

9. **H_0:** There is no difference between the Specificity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

   H_1: There is a difference between the Specificity of examiners with (0-1.5) years of training and examiners with (2+) years of training.

10. **H_0:** There is no difference between the False Positive Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the False Positive Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

11. **H_0:** There is no difference between the False Negative Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the False Negative Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

12. **H_0:** There is no difference between the Positive Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the Positive Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

13. **H_0:** There is no difference between the Negative Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the Negative Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.

14. **H_0:** There is no difference between the Global Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

    H_1: There is a difference between the Global Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

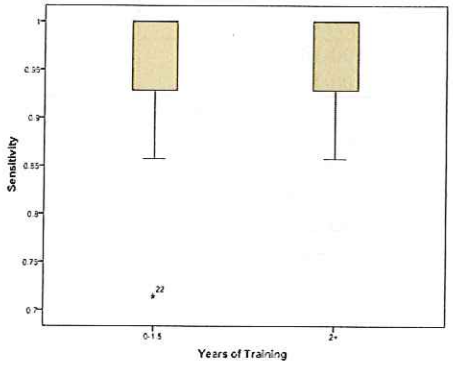
Table 4.2 displays summary statistics and p-values. There are no significant differences in the means of any of the seven numeric variables for those with 0-1.5 years of training and those with 2 or more years of training. Figure 4.2 displays boxplots of six of the seven numeric variables by years of training. There are no boxplots for Specificity since the Specificity values are the same for each examiner. Due to the presence of outliers, exact Wilcoxon rank sum tests were also performed. Table 4.2 also displays p-values for these tests. There are no significant differences in the medians of any of the seven numeric variables for those with 0-1.5 years of experience and those with 2 or more years of experience.

Table 4.2 Summary Statistics and p-values by Years of Training

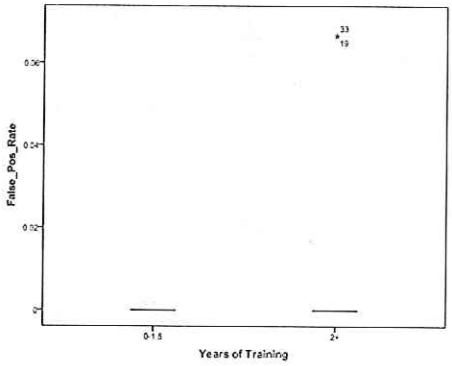
	Years of Training	*n*	Mean	Median	St. Dev.	Range	*p*-values *t*-test	*p*-values Wilcoxon
Sensitivity (%)	0-1.5	9	94.44	100	9.96	71.43-100	0.5522	1.0000
	2+	25	96.57	100	4.67	85.71-100		
Specificity (%)	0-1.5	9	100	100	0	100-100	-	1.0000
	2+	25	100	100	0	100-100		
False Pos. Rate (%)	0-1.5	9	0	0	0	0-0	0.1615	0.5989
	2+	25	0.53	0	1.85	0-6.67		
False Neg. Rate (%)	0-1.5	9	5.56	0	9.96	0-28.57	0.4531	0.7306
	2+	25	2.86	0	4.61	0-14.29		
PPV (%)	0-1.5	9	100	100	0	100-100	0.1615	0.5989
	2+	25	99.43	100	1.98	92.86-100		
NPV (%)	0-1.5	9	78.15	100	33.63	20.00-100	0.7214	0.7306
	2+	25	82.67	100	26.12	33.33-100		
Global Error Rate (%)	0-1.5	9	5.19	0	9.30	0-26.67	0.5522	1.0000
	2+	25	3.20	0	4.35	0-13.33		

Figure 4.2 Boxplots by Years of Training

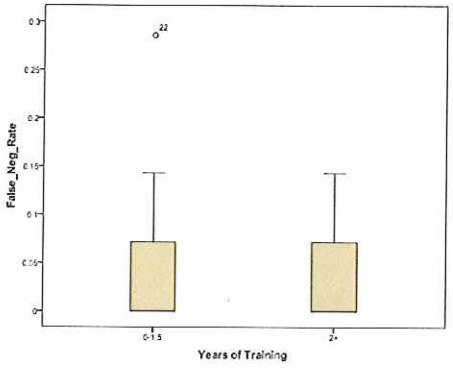
a. Sensitivity



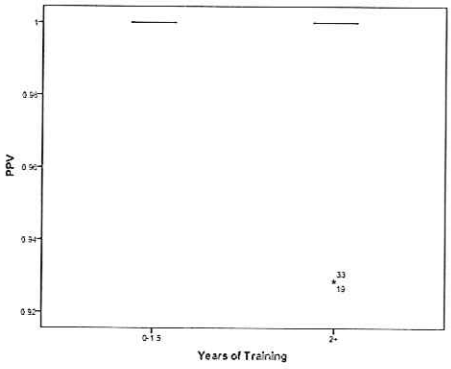
b. False Positive Rate



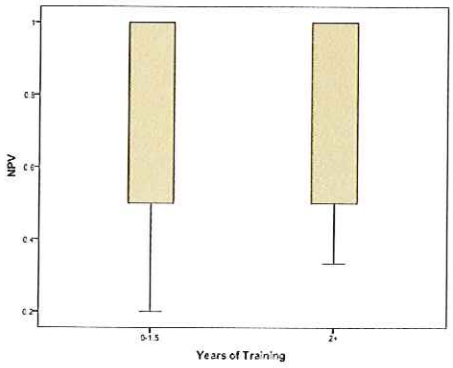
c. False Negative Rate



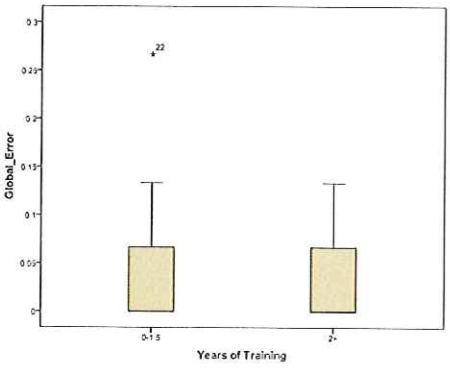
d. Positive Predictive Value



e. Negative Predictive Value



f. Global Error Rate



Scope Make

The researcher posed the following hypotheses about examiners based on comparison macroscope make used for examination:

15. **H_0:** There is no difference between the Sensitivity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Sensitivity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

16. **H_0:** There is no difference between the Specificity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Specificity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

17. **H_0:** There is no difference between the False Positive Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the False Positive Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

18. **H_0:** There is no difference between the False Negative Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the False Negative Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

19. **H_0:** There is no difference between the Positive Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Positive Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

20. **H_0:** There is no difference between the Negative Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Negative Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

21. **H_0:** There is no difference between the Global Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

    H_1: There is a difference between the Global Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

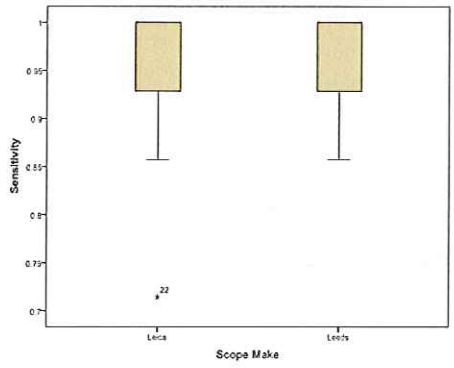
Table 4.3 displays summary statistics and p-values. There are no significant differences in the means of any of the seven numeric variables for those who used a Leica scope and those who used a Leeds scope. Figure 4.3 displays boxplots of six of the seven numeric variables by scope make. There are no boxplots for Specificity since the Specificity values are the same for each examiner. Due to the presence of outliers, exact Wilcoxon rank sum tests were also performed. Table 4.3 also displays the p-values for these tests. There are no significant differences in the medians of any of the seven numeric variables for those who used a Leica scope and those who used a Leeds scope.

Table 4.3 Summary Statistics and p-values by Scope Make

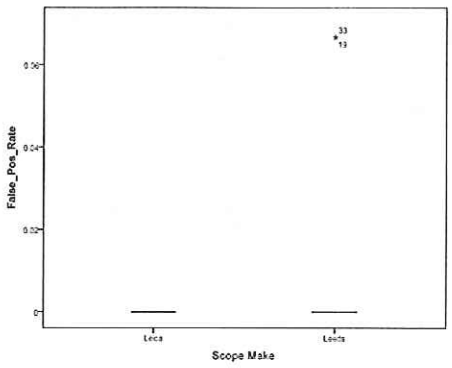
	Scope Make	*n*	Mean	Median	St. Dev.	Range	*p*-values *t*-test	Wilcoxon
Sensitivity (%)	Leica	21	95.92	100	6.99	71.43-100	0.9141	0.9721
	Leeds	13	96.15	100	5.54	85.71-100		
Specificity (%)	Leica	21	100	100	0	100-100	-	1.0000
	Leeds	13	100	100	0	100-100		
False Pos. Rate (%)	Leica	21	0	0	0	0-0	0.1654	0.1390
	Leeds	13	1.03	0	2.50	0-6.67		
False Neg. Rate (%)	Leica	21	4.08	0	6.99	0-28.57	0.5403	0.4826
	Leeds	13	2.75	0	5.49	0-14.29		
PPV (%)	Leica	21	100	100	0	100-100	0.1654	0.1390
	Leeds	13	98.90	100	2.68	92.86-100		
NPV (%)	Leica	21	78.73	100	28.59	20.00-100	0.4694	0.4826
	Leeds	13	85.90	100	27.09	33.33-100		
Global Error Rate (%)	Leica	21	3.81	0	6.52	0-26.67	0.9141	0.9721
	Leeds	13	3.59	0	5.18	0-13.33		

Figure 4.3 Boxplots by Scope Make

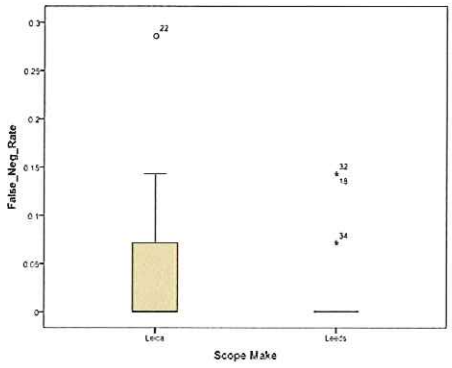
a. Sensitivity



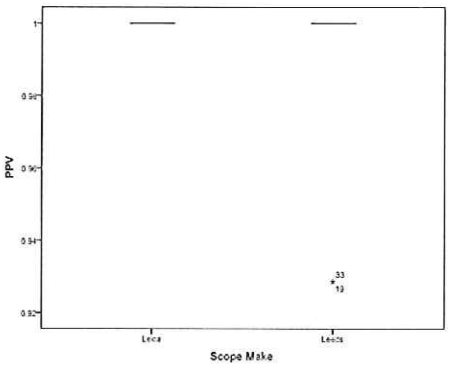
b. False Positive Rate



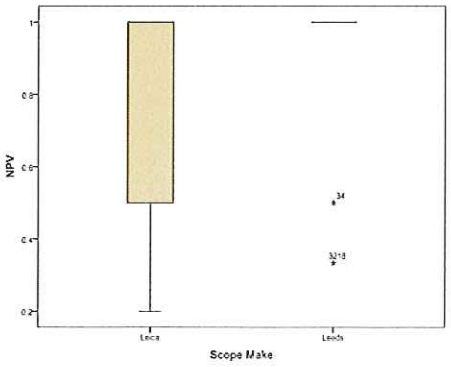
c. False Negative Rate



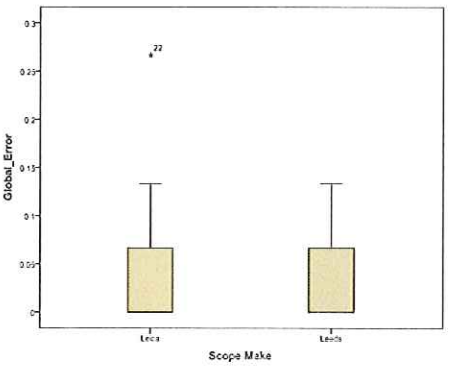
d. Positive Predictive Value



e. Negative Predictive Value



f. Global Error Rate



Observed Subclass Characteristics

The researcher posed the following hypotheses about examiners based on whether examiners observed subclass characteristics or not:

22. **H_0:** There is no difference between the Sensitivity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the Sensitivity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

23. **H_0:** There is no difference between the Specificity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the Specificity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

24. **H_0:** There is no difference between the False Positive Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the False Positive Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

25. **H_0:** There is no difference between the False Negative Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the False Negative Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

26. **H_0:** There is no difference between the Positive Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the Positive Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

27. **H_0:** There is no difference between the Negative Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

    H_1: There is a difference between the Negative Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

28. **H_0:** There is no difference between the Global Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics

    H_1: There is a difference between the Global Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

Table 4.4 displays summary statistics and p-values. There are no significant differences in the means of any of the seven numeric variables for those who did observe subclass characteristics and those who did not. Figure 4.4 displays boxplots of six of the seven numeric variables by whether subclass characteristics were observed. There are no boxplots for Specificity since the Specificity values are the same for each examiner. Due to the presence of outliers, exact Wilcoxon rank sum tests were also performed. Table 4.4 also displays the p-

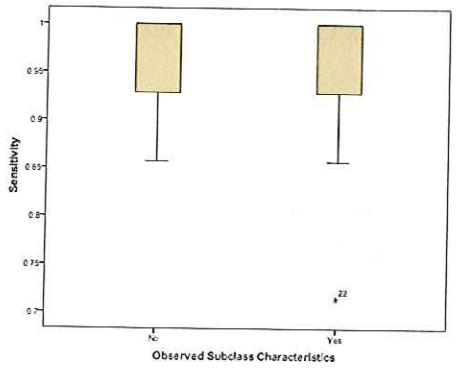
values for these tests. There are no significant differences in the medians of any of the seven numeric variables for those who did observe subclass characteristics and those who did not.

Table 4.4 Summary Statistics and p-values by Whether Subclass Characteristics Were Observed

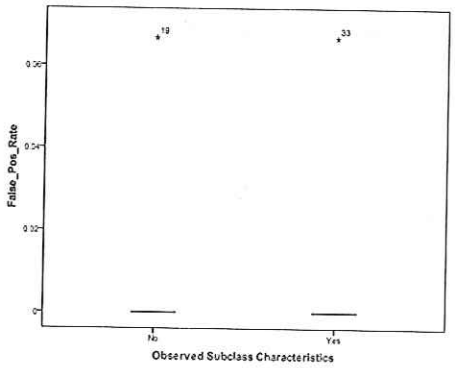
	Observed Subclass	*n*	Mean	Median	St. Dev.	Range	*p*-values *t*-test	*p*-values Wilcoxon
Sensitivity (%)	No	17	97.06	100	4.42	85.71-100	0.3473	0.6187
	Yes	17	94.96	100	7.89	71.43-100		
Specificity (%)	No	17	100	100	0	100-100	-	1.0000
	Yes	17	100	100	0	100-100		
False Pos. Rate (%)	No	17	0.39	0	1.62	0-6.67	1.0000	1.0000
	Yes	17	0.39	0	1.62	0-6.67		
False Neg. Rate (%)	No	17	2.52	0	4.33	0-14.29	0.3485	0.6097
	Yes	17	4.62	0	7.96	0-28.57		
PPV (%)	No	17	99.58	100	1.73	92.86-100	1.0000	1.0000
	Yes	17	99.58	100	1.73	92.86-100		
NPV (%)	No	17	84.31	100	25.32	33.33-100	0.5596	0.6097
	Yes	17	78.63	100	30.64	20.00-100		
Global Error Rate (%)	No	17	2.75	0	4.12	0-13.33	0.3473	0.6187
	Yes	17	4.71	0	7.37	0-26.67		

Figure 4.4 Boxplots by Whether Subclass Characteristics Were Observed

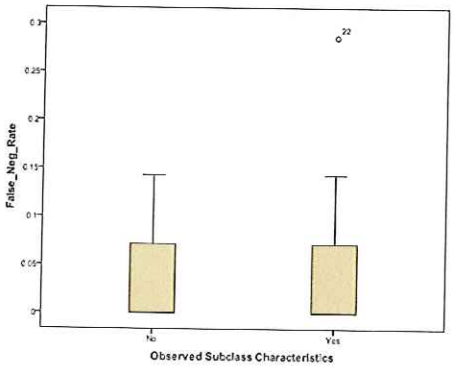
a. Sensitivity



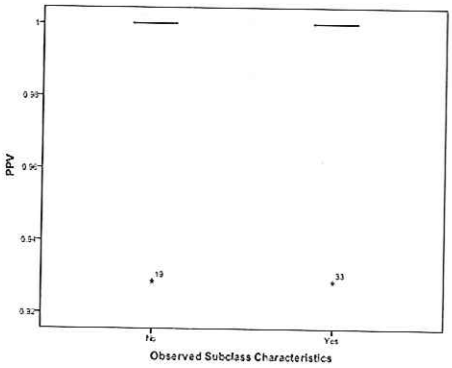
b. False Positive Rate



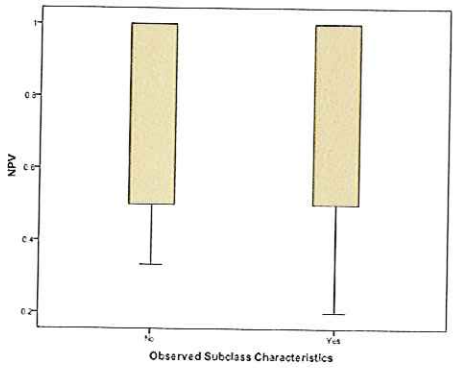
c. False Negative Rate



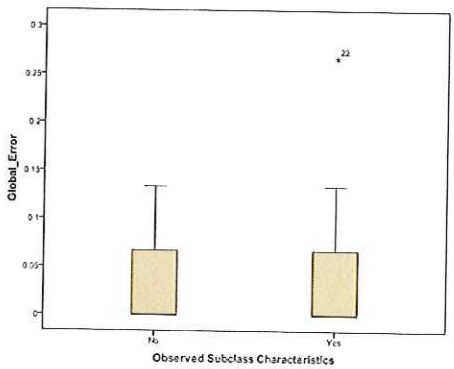
d. Positive Predictive Value



e. Negative Predictive Value



f. Global Error Rate



Distinguished Subclass from Individual Characteristics

The researcher posed the following hypotheses about examiners based on whether examiners were able to distinguish between subclass and individual characteristics:

29. **H_0:** There is no difference between the Sensitivity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the Sensitivity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

30. **H_0:** There is no difference between the Specificity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the Specificity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

31. **H_0:** There is no difference between the False Positive Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the False Positive Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

32. **H_0:** There is no difference between the False Negative Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the False Negative Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

33. **H_0:** There is no difference between the Positive Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the Positive Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

34. **H_0:** There is no difference between the Negative Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

    H_1: There is a difference between the Negative Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and

examiners that were not able to distinguish subclass characteristics from individual characteristics.

35. **H_0:** There is no difference between the Global Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

H_1: There is a difference between the Global Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

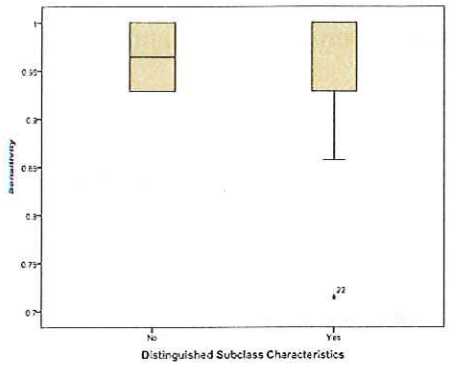
Table 4.5 displays summary statistics and p-values. There are no significant differences in the means of any of the seven numeric variables for those who did distinguish subclass from individual characteristics and those who did not. Figure 4.5 displays boxplots of six of the seven numeric variables by whether subclass characteristics were distinguished from individual characteristics. There are no boxplots for Specificity since the Specificity values are the same for each examiner. Due to the presence of outliers, exact Wilcoxon rank sum tests were also performed. Table 4.5 also displays the p-values for these tests. There are no significant differences in the medians of any of the seven numeric variables for those who did distinguish subclass from individual characteristics and those who did not.

Table 4.5 Summary Statistics and p-values by Whether Subclass Characteristics Were Distinguished from Individual Characteristics

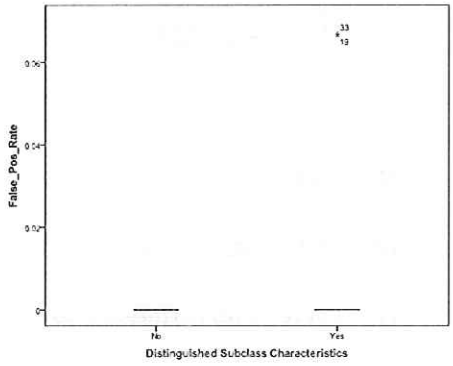
	Distinguished Subclass	*n*	Mean	Median	St. Dev.	Range	*p*-values *t*-test	*p*-values Wilcoxon
Sensitivity (%)	No	2	96.43	96.43	5.05	92.86-100	0.8511	1.0000
	Yes	29	95.57	100	6.73	71.43-100		
Specificity (%)	No	2	100	100	0	100-100	-	1.0000
	Yes	29	100	100	0	100-100		
False Pos. Rate (%)	No	2	0	0	0	0-0	0.1609	1.0000
	Yes	29	0.46	0	1.72	0-6.67		
False Neg. Rate (%)	No	2	3.57	3.57	5.05	0-7.14	0.9354	1.0000
	Yes	29	3.94	0	6.77	0-28.57		
PPV (%)	No	2	100	100	0	100-100	0.1609	1.0000
	Yes	29	99.51	100	1.84	92.86-100		
NPV (%)	No	2	75.00	75.00	35.36	50.00-100	0.8749	1.0000
	Yes	29	80.00	100	28.74	20.00-100		
Global Error Rate (%)	No	2	3.33	3.33	4.71	0-6.67	0.8511	1.0000
	Yes	29	4.14	0	6.28	0-26.67		

Figure 4.5 Boxplots by Whether Subclass Characteristics Were Distinguished from Individual Characteristics

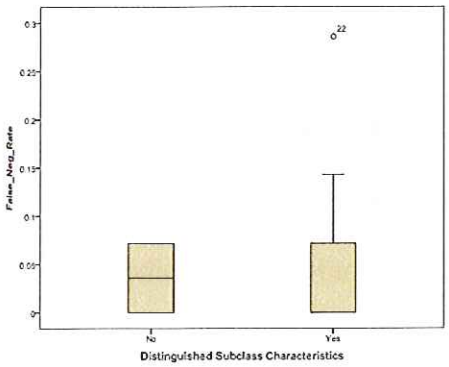
a. Sensitivity



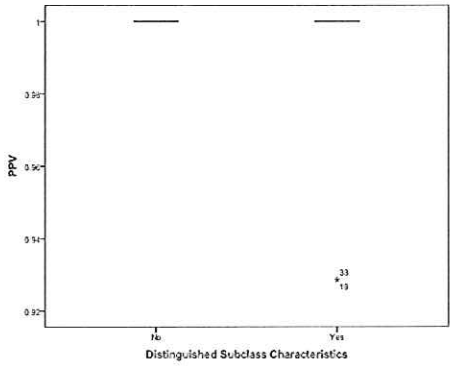
b. False Positive Rate



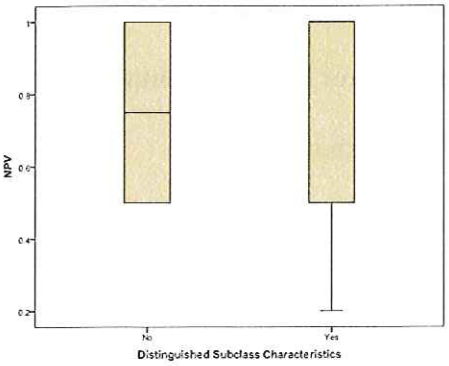
c. False Negative Rate



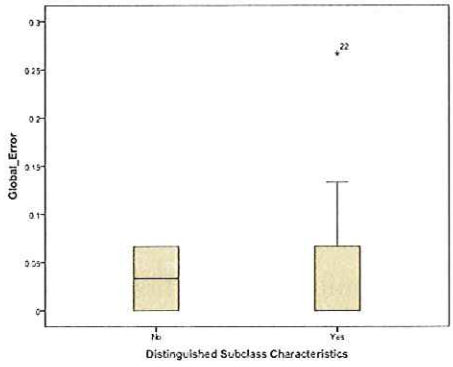
d. Positive Predictive Value



e. Negative Predictive Value



f. Global Error Rate



Knowns Examined First

The researcher posed the following hypotheses about examiners based whether examiners examined knowns first or not:

36. **H_0:** There is no difference between the Sensitivity of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the Sensitivity of examiners that examined knowns first and examiners that examined unknowns first.

37. **H_0:** There is no difference between the Specificity of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the Specificity of examiners that examined knowns first and examiners that examined unknowns first.

38. **H_0:** There is no difference between the False Positive Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the False Positive Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

39. **H_0:** There is no difference between the False Negative Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the False Negative Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

40. **H_0:** There is no difference between the Positive Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the Positive Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

41. **H_0:** There is no difference between the Negative Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the Negative Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.

42. **H_0:** There is no difference between the Global Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

    H_1: There is a difference between the Global Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

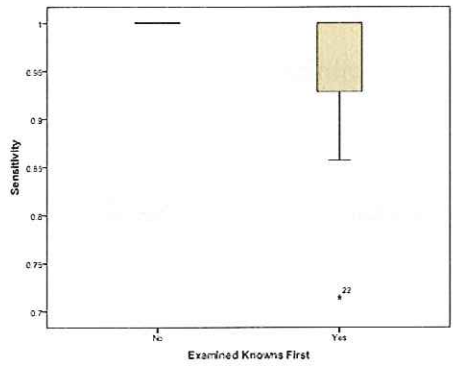
Table 4.6 displays summary statistics and p-values. There are significant differences in the mean sensitivity (p=0.0008), mean false negative rates (p=0.0025), mean NPVs (p=0.0004), and mean global error rates (p=0.0008) among those who examined knowns first and those who examined unknowns first. Figure 4.6 displays boxplots of six of the seven numeric variables by whether knowns were examined first. There are no boxplots for Specificity since the Specificity values are the same for each examiner. Due to the presence of outliers, exact Wilcoxon rank sum tests were also performed. Table 4.6 also displays the p-values for these tests. There are no significant differences in the medians of any of the seven numeric variables for those who examined knowns first and those who examined unknowns first.

Table 4.6 Summary Statistics and p-values by Whether Knowns Were Examined First

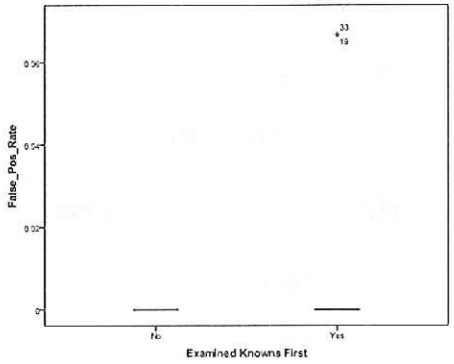
	Knowns First	*n*	Mean	Median	St. Dev.	Range	*p*-values *t*-test	*p*-values Wilcoxon
Sensitivity (%)	No	3	100	100	0	100-100	0.0008	0.2911
	Yes	31	95.62	100	6.57	71.43-100		
Specificity (%)	No	3	100	100	0	100-100	-	1.0000
	Yes	31	100	100	0	100-100		
False Pos. Rate (%)	No	3	0	0	0	0-0	0.1607	1.0000
	Yes	31	0.43	0	1.67	0-6.67		
False Neg. Rate (%)	No	3	0	0	0	0-0	0.0025	0.4542
	Yes	31	3.92	0	6.61	0-28.57		
PPV (%)	No	3	100	100	0	100-100	0.1607	1.0000
	Yes	31	99.54	100	1.78	92.86-100		
NPV (%)	No	3	100	100	0	100-100	0.0004	0.4542
	Yes	31	79.68	100	28.54	20.00-100		
Global Error Rate (%)	No	3	0	0	0	0-0	0.0008	0.2911
	Yes	31	4.09	0	6.13	0-26.67		

Figure 4.6 Boxplots by Whether Knowns Were Examined First

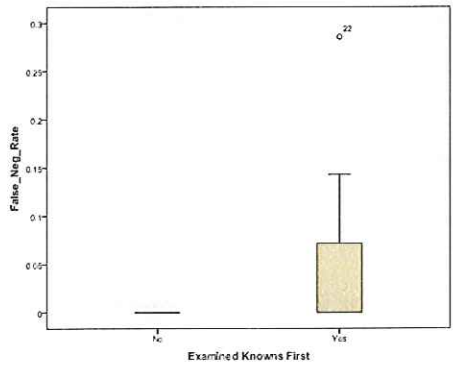
a. Sensitivity



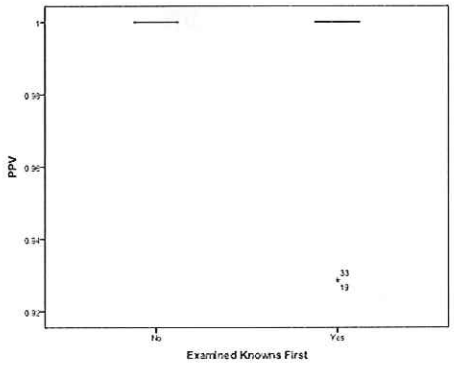
b. False Positive Rate



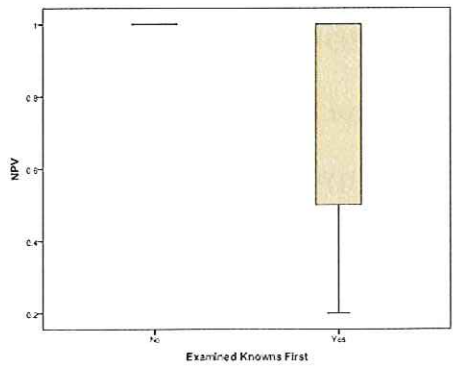
c. False Negative Rate



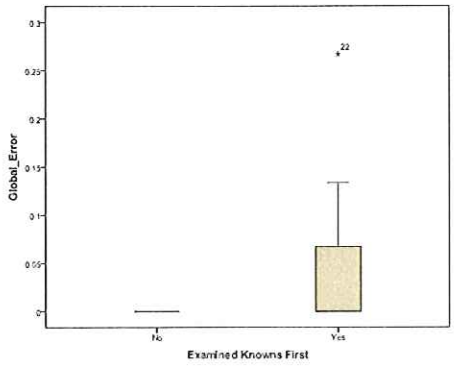
d. Positive Predictive Value



e. Negative Predictive Value



f. Global Error Rate



Comparison of Examiners to the Computer

The researcher posed the following hypotheses about examiners' results and IBIS® BRASSTRAX-3D™:

43. **H_0:** There is no difference between the Sensitivity for examiners and the Sensitivity for IBIS® BRASSTRAX-3D™.

    H_1: There is a difference between the Sensitivity for examiners and the Sensitivity for IBIS® BRASSTRAX-3D™.

44. **H_0:** There is no difference between the Specificity for examiners and the Specificity for IBIS® BRASSTRAX-3D™.

    H_1: There is no difference between the Specificity for examiners and the Specificity for IBIS® BRASSTRAX-3D™.

45. **H_0:** There is no difference between the False Positive Error Rate for examiners and the False Positive Error Rate for IBIS® BRASSTRAX-3D™.

    H_1: There is a difference between the False Positive Error Rate for examiners and the False Positive Error Rate for IBIS® BRASSTRAX-3D™.

46. **H_0:** There is no difference between the False Negative Error Rate for examiners and the False Negative Error Rate for IBIS® BRASSTRAX-3D™.

    H_1: There is a difference between the False Negative Error Rate for examiners and the False Negative Error Rate for IBIS® BRASSTRAX-3D™.

47. **H_0:** There is no difference between the Positive Predictive Value for examiners and the Positive Predictive Value for IBIS® BRASSTRAX-3D™.

    H_1: There is a difference between the Positive Predictive Value for examiners and the Positive Predictive Value for IBIS® BRASSTRAX-3D™.

48. **H_0:** There is no difference between the Negative Predictive Value for examiners and the Negative Predictive Value for IBIS® BRASSTRAX-3D™.

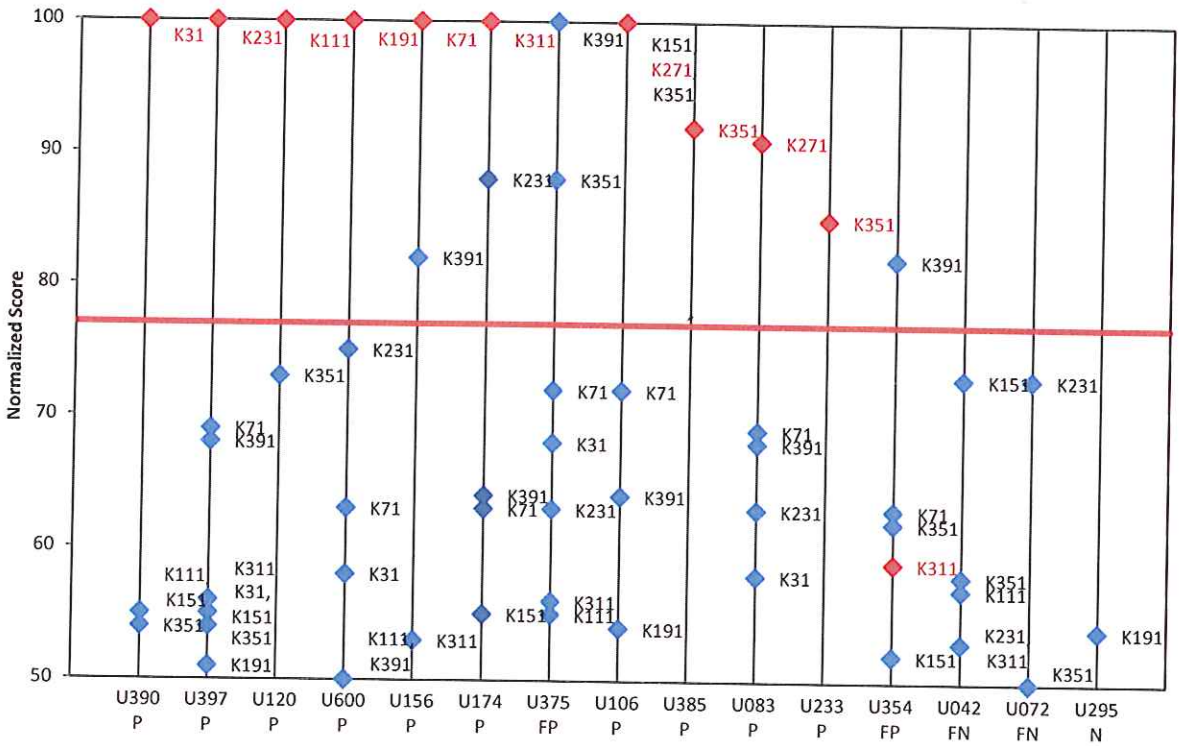
    H_1: There is a difference between the Negative Predictive Value for examiners and the Negative Predictive Value for IBIS® BRASSTRAX-3D™.

49. **H_0:** There is no difference between the Global Error Rate for examiners and the Global Error Rate for IBIS® BRASSTRAX-3D™.

    H_1: There is a difference between the Global Error Rate for examiners and the Global Error Rate for IBIS® BRASSTRAX-3D™.

Each known was compared to all unknowns using the IBIS® Matchpoint+™ software. To identify the unknown(s) that was the best match for each known, all of the unknowns were ranked according to normalized scores for breech face markings. Figure 7 displays the corresponding normalized scores for each unknown. In two instance (K31 & K391), the best match was not one of the unknowns; therefore, the normalized scores were adjusted so that the best matching unknown had a score of 100.

Figure 4.7 Normalized Scores for Each Unknown



For each unknown, the known with the highest normalized score was considered the computer's chosen match. In one case (U106), three knowns had normalized scores of 100, one of which was the correct identification. Consequently, the computer received the benefit of the doubt and the correct identification was considered the computer's chosen match. In Figure 7, correct identifications are indicated in red. The highest normalized score for the true positives was 100 and the highest normalized score for the true negative was 54. The average of these two values was 77; consequently, any unknowns without normalized scores above 77 were considered eliminations. If the computer assigned at least one normalized score above 77, the match was classified as either a positive identification (P) or a false positive identification (FP). Otherwise, the match was classified as an elimination (N) or a false elimination (FN). In all, the computer had 10 positive identifications, 2 false positive identifications, 1 elimination, and 2

false eliminations resulting in a Sensitivity of 71.43%, Specificity of 100%, False Positive Rate of 13.33%, False Negative Rate of 14.29%, PPV of 83.33%, NPV of 33.33%, and Global Error Rate of 26.67%. Performance of one-sample *t*-tests looked to see if the mean rates of the examiners were significantly different from the corresponding rate for the computer. Table 4.7 displays the results of these *t*-tests. The mean False ID Error Rate, mean False Elimination Error Rate, and mean Sensitivity of the examiners are all significantly different from the corresponding values for the computer. Since all of the examiners had the same Specificity (resulting in a standard deviation of zero), there was no *t*-test for Specificity.

Table 4.7 *t*-test Results

	Computer	Examiners mean (s.d.)	*T*	*p*-value
Sensitivity (%)	71.43	96.01 (6.39)	22.44	<0.0001
Specificity (%)	100	100 (0)	-	-
False Pos Rate (%)	13.33	0.39 (1.59)	-47.38	<0.0001
False Neg Rate (%)	14.29	3.57 (6.40)	-9.76	<0.0001
PPV (%)	83.33	99.58 (1.71)	55.54	<0.0001
NPV (%)	33.33	81.47 (27.83)	10.09	<0.0001
Global Error Rate (%)	26.67	3.73 (5.96)	-22.44	<0.0001

One of the assumptions of the *t*-test was that data be sampled from a normally distributed population. As noted earlier, the *t*-test was generally robust to departures from normality except in cases of extreme skewedness or in the presence of outliers. These data are certainly not normal and several outliers have been identified (see the boxplots above). Consequently, binomial tests were performed in addition to the *t*-tests. The binomial test was a test for the median of a distribution. Since the median was robust to outliers, the binomial test was also unaffected by outliers. Table 4.8 displays the results of these binomial tests. In each case, the

median value for the examiners was significantly different from the corresponding value for the computer.

Table 4.8 Binomial Test Results

	Computer	Examiners Median	*Z*	*p*-value
Sensitivity (%)	71.43	100	-5.32	<0.0001
Specificity (%)	100	100	5.66	<0.0001
False Pos Rate (%)	13.33	0	5.66	<0.0001
False Neg Rate (%)	14.29	0	5.32	<0.0001
PPV (%)	83.33	100	5.66	<0.0001
NPV (%)	33.33	100	-5.32	<0.0001
Global Error Rate (%)	26.67	0	5.66	<0.0001

Including Inconclusive Conclusions and Excluding Inconclusive Conclusions

Means for the seven numeric variables, Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate, were calculated for the study under two different scenarios. This study analyzed the similarities and differences in mean values when examiners included inconclusive conclusions versus when the examiner did not make any inconclusive conclusions. In the first scenario, the researcher calculated the mean values on all tests including those with inconclusive conclusions, which were categorized as false negative since the researcher could not assume the examiners mindset when making that conclusion. The second scenario involved the exclusion of any examiner tests that had an inconclusive conclusion. Table 4.9 lists the mean values. It was crucial to point out that correlation or statistical analysis of these two scenarios did not occur. These scenarios could not be correlated because they are overlapping groups and not separated. The researcher listed these mean values strictly for the purposes of drawing attention to the similarity and dissimilarities between test packet data when inconclusive conclusions are included in analysis and when inconclusive conclusions are excluded from analysis.

Table 4.9 Inconclusive Conclusions vs. Excluding Inconclusive Conclusions

	Including Inconclusive Conclusions	Excluding Inconclusive Conclusions
Sensitivity (%)	96.01%	97.78%
Specificity (%)	100%	100%
False Pos. Rate (%)	0.39%	0.46%
False Neg. Rate (%)	3.57%	1.72%
PPV (%)	99.58%	99.51%
NPV (%)	81.47%	89.08%
Global Error Rate (%)	3.73%	2.07%

Chapter 5 : Discussion

Years of Experience

1. **H_0:** There is no difference between the Sensitivity of examiners with (0-5) years of experience and examiners with (6+) years of experience.
2. **H_0:** There is no difference between the Specificity of examiners with (0-5) years of experience and examiners with (6+) years of experience.
3. **H_0:** There is no difference between the False Positive Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.
4. **H_0:** There is no difference between the False Negative Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.
5. **H_0:** There is no difference between the Positive Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.
6. **H_0:** There is no difference between the Negative Predictive Value of examiners with (0-5) years of experience and examiners with (6+) years of experience.
7. **H_0:** There is no difference between the Global Error Rate of examiners with (0-5) years of experience and examiners with (6+) years of experience.

According to the results, hypotheses 1-7 were accepted. There were no significant differences in Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate between examiners with zero to five years of experience and examiners with six or more years of experience. Comparison of the mean categorical values revealed there was a slight difference in numerical values for examiners with zero to five years of experience and six or more years of experience,

but due to outliers and skewedness of the data, the median categorical values provide the most accurate representation of trends observed in this study (See Figure 4.1).

The results in Table 4.1 show that there were no significant differences in accuracy and error rates of examiners with zero to five years of experience and examiners with six or more years of experience. These findings can be attributed to education and training prior to entering the workforce. According to the National Research Council, the increased media attention on forensic science has resulted in a higher demand for forensic courses and degree programs preparing students to work in forensic science (2009). Since the implementation of these programs and courses, enrollment levels have skyrocketed at primary and secondary schools. In the 1970's, only a handful of colleges offering forensic degree programs (22) existed in the United States, but, today, that number has increased to over two hundred programs ranging from undergraduate degrees to doctoral degrees (NRC, 2009). This influx in education, as well as student enrollment, has led examiners with little to no experience to obtain a wealth of knowledge related to their field before they even begin their career. This field has begun increasing its education requirements, asking for examiners with Bachelors Degrees or better. This higher education requirement is causing examiners to go to college and to take courses or training programs related to the field they wish to work in. This learning and training is giving incoming examiners with no experience a strong foundation of principles and knowledge applicable to their field. Furthermore, this education allows examiners with less experience to come into this field with a working knowledge of the science. This strong foundation is allowing incoming examiners with little to no experience to function and make examination conclusions as accurately as examiners with six or more years of experience.

Years of Training

8. **H_0:** There is no difference between the Sensitivity of examiners with (0-1.5) years of training and examiners with (2+) years of training.
9. **H_0:** There is no difference between the Specificity of examiners with (0-1.5) years of training and examiners with (2+) years of training.
10. **H_0:** There is no difference between the False Positive Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.
11. **H_0:** There is no difference between the False Negative Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.
12. **H_0:** There is no difference between the Positive Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.
13. **H_0:** There is no difference between the Negative Predictive Value of examiners with (0-1.5) years of training and examiners with (2+) years of training.
14. **H_0:** There is no difference between the Global Error Rate of examiners with (0-1.5) years of training and examiners with (2+) years of training.

Hypotheses 8-14 were accepted. The results show there were no significant differences in Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate between examiners with zero to one and a half years of training and examiners with two or more years of training. The mean categorical values revealed a minimal difference in values for examiners with zero to one and a half years of training and two or more years of experience. Due to outliers and skewedness of the data, the median categorical values provide a more accurate representation of trends observed in this study than the mean values calculated (See Figure 4.2).

The results of Table 4.2 demonstrates that there were no significant differences in accuracy or error rates for examiners with zero to one and a half years of training and examiners with two or more years of training. These results illustrate the quality of on-the-job training programs provided once an examiner is hired. With the implementation of accreditation and certification organizations such as ASCLD/LAB (American Society of Crime Laboratory Directors/ Laboratory Accreditation Board) and AFTE, on-the-job training programs are becoming more technical and standardized in order to meet accrediting board standards. These accrediting standards require crime laboratories to improve and expand training programs to be of a higher quality, and have required laboratories to demonstrate more consistency in training with other accredited laboratories. Obviously, all laboratories are not identical so the training programs must be tailored to suit each laboratory's needs, but by applying accrediting board standards throughout all training programs, be they zero to one and half years or two or more years, examiners from either of the training groups are equally as accurate in their examinations.

Scope Make

15. **H_0:** There is no difference between the Sensitivity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.
16. **H_0:** There is no difference between the Specificity of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.
17. **H_0:** There is no difference between the False Positive Error Rate of examiners whouse Leeds/Olympus scopes and examiners that use Leica scopes.
18. **H_0:** There is no difference between the False Negative Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

19. **H_0:** There is no difference between the Positive Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.
20. **H_0:** There is no difference between the Negative Predictive Value of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.
21. **H_0:** There is no difference between the Global Error Rate of examiners who use Leeds/Olympus scopes and examiners that use Leica scopes.

According to the results, hypotheses 15-21 were accepted. There were no significant differences in Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate between examiners that used a Leica comparison macroscope and examiners that used a Leeds comparison macroscope. The mean categorical values revealed there was a slight difference in numerical values for examiners with zero to five years of experience and six or more years of experience, but due to outliers and skewedness of the data, the median categorical values provided a more accurate representation of trends observed in this study than mean values (See Figure 4.3).

Table 4.3 shows there were no significant differences in examiner accuracy and error rate based on the make (brand) of comparison macroscope used for examination. These results emphasize the quality of manufacturing on comparison macroscopes and further demonstrate the quality of examiner training. The comparison macroscope is a well-known tool utilized by examiners in the field, however it is just as well known that if a tool is not used correctly or calibrated correctly, it is pretty much useless. This brings up the point of manufacturing and calibration. A high quality of manufacturing and calibration provides the examiner with the best tool available to conduct their examinations. Leeds and Leica are the two most popular brands of comparison macroscopes seen in the laboratory. These brands are known for their quality,

workmanship, and cutting-edge technology. The quality of these comparison macroscopes has provided examiners with the ability to conduct examinations with the highest potential for accuracy. Another point to mention that affects these results is examiner training and ability. If the examiner is not properly trained or using the comparison macroscope appropriately, then the likelihood of an examiner achieving a quality examination is small. The comparison macroscope is intended to function as a tool to assist the examiner with their work. Without the proper knowledge or training of how to use the tool, the comparison macroscope is unable to serve its purpose. Proper training has allowed examiners to utilize comparison macroscope to the fullest potential and high quality manufacturing has ensured that examiners are provided with the best possible tool for their examinations. Results of this study show that examiner accuracy and error rate is not affected by the type of comparison macroscope utilized for comparison.

Observed Subclass Characteristics and Distinguished Subclass from Individual Characteristics

22. **H_0:** There is no difference between the Sensitivity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.
23. **H_0:** There is no difference between the Specificity of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.
24. **H_0:** There is no difference between the False Positive Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.
25. **H_0:** There is no difference between the False Negative Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.

26. **H_0:** There is no difference between the Positive Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.
27. **H_0:** There is no difference between the Negative Predictive Value of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics.
28. **H_0:** There is no difference between the Global Error Rate of examiners that observed subclass characteristics and examiners that did not observe subclass characteristics
29. **H_0:** There is no difference between the Sensitivity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.
30. **H_0:** There is no difference between the Specificity of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.
31. **H_0:** There is no difference between the False Positive Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.
32. **H_0:** There is no difference between the False Negative Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

33. **H_0:** There is no difference between the Positive Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

34. **H_0:** There is no difference between the Negative Predictive Value of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

35. **H_0:** There is no difference between the Global Error Rate of examiners that were able to distinguish subclass characteristics from individual characteristics and examiners that were not able to distinguish subclass characteristics from individual characteristics.

Hypotheses 22-35 were accepted. There were no significant differences in Sensitivity, Specificity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate between examiners that stated they observed subclass characteristic carryover and examiners that stated they did not observe subclass characteristic carryover. There were also no significant differences between examiners that stated they were able to distinguish between subclass and individual characteristics. The mean categorical values show a slight variance in value between groups, but due to the occurrence of outliers and skewedness of the data, the median categorical values best demonstrate the trend observed in this study (See Figure 4.4 and Figure 4.5).

The conclusions reached by examination of the results of Tables 4.4 and 4.5 can be combined to look at the effects of subclass characteristics on examiner accuracy and error rates

with regard to examiner ability to observe subclass characteristics and examiner ability to distinguish subclass characteristics from individual characteristics. Subclass characteristics are viewed as more restrictive than class characteristics but not as specific as individual characteristics. For this reason, subclass characteristics are difficult to visualize. This study conducted research on ten consecutively manufactured breechfaces. By having the consecutively manufactured surface available, it was possible to view the subclass carryover on the headstamp region of the cartridge cases. The knowledge of consecutive manufacture can potentially cause biases in examiners' examination. If the examiners knew the potential for subclass existed, they would be aware to search for it. Since this study did not inform examiners that the breechface markings were created by consecutively manufactured breechfaces, the examiners had to examine the cartridge cases identifying subclass features carried over between cartridge cases as well as identifying them from the individual characteristics they used for their conclusions. This method provided the best way to blindly test the examiners and observe whether they were able to visualize subclass characteristics when they were not predisposed to the knowledge of their potential existence. During the course of this study, inquiries were repeatedly made asking if the test was a consecutively manufactured one. These inquiries led the researcher to believe that most of the previous studies conducted on consecutively manufactured surfaces informed examiners of their consecutive nature thus biasing the examiners by letting them know that they may encounter subclass characteristics. This study is among the few that did not provide this information to examiners and truly tested their ability to identify subclass characteristics. The previously mentioned research stated that subclass characteristic carryover is a potential issue that examiners should be aware of but that it will not inherently affect an examiner's ability to make an identification correctly. The findings of this study further support the previous

research's conclusions and expands upon it by demonstrating that examiners are able to identify subclass characteristics as well as distinguish them from individual characteristics when blindly tested.

Knowns Examined First

36. **H_0:** There is no difference between the Sensitivity of examiners that examined knowns first and examiners that examined unknowns first.
37. **H_0:** There is no difference between the Specificity of examiners that examined knowns first and examiners that examined unknowns first.
38. **H_0:** There is no difference between the False Positive Error Rate of examiners that examined knowns first and examiners that examined unknowns first.
39. **H_0:** There is no difference between the False Negative Error Rate of examiners that examined knowns first and examiners that examined unknowns first.
40. **H_0:** There is no difference between the Positive Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.
41. **H_0:** There is no difference between the Negative Predictive Value of examiners that examined knowns first and examiners that examined unknowns first.
42. **H_0:** There is no difference between the Global Error Rate of examiners that examined knowns first and examiners that examined unknowns first.

According to the results, hypotheses 36-42 were accepted. There were no significant differences in Specificity, False Positive Error Rate, and Positive Predictive Value in the mean values for examiners that examined knowns first and examiners that examined unknowns first. The t-test revealed significant differences in mean values for Sensitivity, False Negative Error Rate, Negative Predictive Rate, and Global Error Rate, but comparison of the mean categorical

values showed there was a slight difference in numerical values for examiners that examined knowns first and examiners that examined unknowns first. Due to the occurrence of outliers and skewedness of the data, the median categorical values provided a more accurate representation of trends observed in this study than the mean values (See Figure 4.6).

Table 4.6 shows that there were no significant differences in the accuracy and error rates of examiners that examined knowns first and examiners that examined unknowns first. These results illustrates that the methodology of examiners has no effect on examiner ability to form correct conclusions. There is no increased chance of misidentification or false elimination if the examiner examines knowns or unknowns first. Examination of unknowns first is thought to bias an examiner by predisposing them to the individual characteristics of the evidence. The fear is that an examiner will see these characteristics and will then project the individual characteristics viewed on the evidence onto the knowns due to the characteristics being freshly in their mind. This study shows that no matter the method utilized, the accuracy and error rate is the same for examiners whether they examined knowns or unknowns first. It is this researcher's opinion that as long as examiners choose a method and remain consistent with that method, their accuracy and error rate will not be affected.

Comparison of Examiners to the Computer

43. **H_0:** There is no difference between the Sensitivity for examiners and the Sensitivity for IBIS® BRASSTRAX-3D™.

44. **H_0:** There is no difference between the Specificity for examiners and the Specificity for IBIS® BRASSTRAX-3D™.

45. **H_0:** There is no difference between the False Positive Error Rate for examiners and the False Positive Error Rate for IBIS® BRASSTRAX-3D™.

46. **H_0:** There is no difference between the False Negative Error Rate for examiners and the False Negative Error Rate for IBIS® BRASSTRAX-3D™.

47. **H_0:** There is no difference between the Positive Predictive Value for examiners and the Positive Predictive Value for IBIS® BRASSTRAX-3D™.

48. **H_0:** There is no difference between the Negative Predictive Value for examiners and the Negative Predictive Value for IBIS® BRASSTRAX-3D™.

49. **H_0:** There is no difference between the Global Error Rate for examiners and the Global Error Rate for IBIS® BRASSTRAX-3D™.

Based on the results of this study, hypotheses 43-49 were accepted. There was no significant difference in the mean values for Specificity, significant differences were observed in Sensitivity, False Positive Error Rate, False Negative Error Rate, Positive Predictive Value, Negative Predictive Value, and Global Error Rate between examiners test results and computer test results. Comparison of mean categorical values showed noticeable difference in numerical values for examiner test results and computer results, but due to the occurrence of outliers and skewedness of the data, the median categorical values provided a more accurate representation of trends observed in this study than the mean values (See Table 4.7 and Table 4.8).

The results of Table 4.8 show that there were significant differences observed in accuracy and error rates between examiner test results and computer test results. These results show that examiner test results were consistently higher than computer test results. The computer's results were impressive considering the difficulty of the study test packets, but were not nearly as accurate as examiner test results. One possible explanation for this difference in test results is the variability of characteristics. Examiners are able to examine the characteristics present on the cartridge case headstamp region and take into account the variability of individual

characteristics between cartridge cases. The computer system uses an algorithm which creates a normalized score allowing the computer to search the database for the most likely candidate match. Another possible explanation for the difference in test results between the computer and examiners is the subjective nature with which the computer test was graded. As seen in Figure 4.7, the computer generated three different knowns for U106. The computer was given the benefit of the doubt and counted as correct because, in a scenario where the computer provided multiple candidates, examination of each known by an examiner, acting as verifier, would have identified the correct known. Though the computer provided impressive results, it is not yet capable of taking all of the information and variability into consideration that examiners can. The results of this research show that technology cannot fully replace examiner ability. The computer is better intended to serve as a tool to assist the examiner, similar to the comparison macroscope. By utilizing the 3D imaging system as a tool working in conjunction with the examiner, examiners will be able to provide a higher quality of work, expand and advance their capability, increase their work flow by gaining the ability to conduct more comparison is a shorter amount of time than normal.

Including Inconclusive Conclusions or Excluding Inconclusive Conclusions

Since no statistical analysis could be run on the data in Table 4.9 due to the overlapping of data groups, there was no way to definitively determine the significance of including inconclusive conclusions versus excluding them. The researcher drew comparisons from calculation of the mean values from the raw data. The mean values show that there was minimal effect to the values when calculated in both scenarios. The only differences the researcher noted are the differences in False Negative Error Rate and Negative Predictive Value. These differences were to be expected because exclusion of inconclusive conclusions affects the

number of false negatives in the study. As stated previously, the researcher classified inconclusive conclusions as false negatives since the researcher could not assume the examiner's no conclusion would be correct. Table 4.9 demonstrates that the inclusion of inconclusive conclusions and the exclusion of inconclusive conclusions did not largely affect the mean values for accuracy and error rate of examiner test results in this study.

Limitations

There were several limitations to this study that must be pointed out and should be addressed in future studies. One of the first limitations was the sample size. This study only allowed the researcher to put together forty test packets to send out. Results were not received for all test packets sent out, therefore the sample size was not very large. When using small sample sizes such as this, the data was more easily skewed and the chances for outliers increase. The second limitation in this study was with testing on the 3D imaging system. Only one test could be run through the 3D imaging system so all of the results for the computer's ability was based on one test packet. The reasoning for this being the location of the IBIS® BRASSTRAX-3D™ system which brings up the third limitation for this study. The 3D imaging system was located in Montreal, Canada. Travel and lodging to use the IBIS® BRASSTRAX-3D™ system was a large expense. Due to this expense, it was not cost effective to stay for a long period of time or to make multiple trips. This severely limited the amount of system usage for the study. There was physically no time to run all of the test packets through the 3D imaging system prior to sending them out to examiners. The final limitation of this study was the method utilized to score the conclusions. Originally, the researcher asked examiners to use only identification or elimination as their conclusions on the test, but many examiners used inconclusive as well. An inconclusive answer was unable to be scored because it was essentially a non-answer so all

inconclusive conclusions had to be considered false eliminations. This categorization of inconclusive conclusions increased the number of false eliminations made in the test results.

Significance of Findings

This study conducted a test on breechface markings of ten consecutively manufactured slides for examiners and coupled IBIS® BRASSTRAX-3D™ and Matchpoint+™ system. The results of examiners tested in this study validate the AFTE Theory of Identification in that examiners were able to form correct conclusions based on "sufficient agreement" of the breechface markings between two cartridge cases. Findings in this study will serve as additional research into subclass characteristic carryover, particularly on breechface markings impressed by a Ruger LCP .380 pistol slide. The testing methodology approached in this study corroborates that examiners are able to distinguish between class, individual, and subclass characteristics. This study also indicates examiners are able to take subclass characteristics into consideration and that carryover is not an obstacle that hinders examiners from drawing a correct conclusion.

The second aspect of this study analyzed the ability of examiners and a three-dimensional imaging system to draw forensic conclusions. The results demonstrate that imaging technology system cannot adequately replace an examiner's ability, but by utilizing certain aspects, such as normalized scores, the potential exists for it to be best utilized as a tool working in conjunction with the examiner. Furthermore, examiners can use this type of technology as a filtering tool. IBIS® BRASSTRAX-3D™ and Matchpoint+™ software allows the examiner to review many cartridge cases in a shorter amount of time and provides the examiner with the highest-ranking candidates. This imaging technology has the potential to assist the examiner with increasing workflow.

Suggestions for Future Research

In the future, it is recommended that the researcher run a larger quantity of tests on examiners so that there will be a larger sample size to conduct statistical analysis on. This larger sample size will minimize the chances of have skewed data and outliers. Future research should also run more tests on the 3D imaging system. Ideally, the test packets intended to be sent out to examiners should be run through the 3D imaging system first. This way the researcher can have direct correlations between the examiners and the 3D imaging system. It will also allow the researcher to have a close to equal amount of results for the examiners and the computer to compare. Further research should be conducted on use of the 3D imaging technology in comparisons. Examiners currently use comparison macroscopes to conduct manual comparisons on evidence. Research should observe the effects and implications of examiners utilizing 3D imaging technology to conduct technological comparisons. Future research into this area could potentially show that examiners and technology can work together with the computer and examiner checking each other's findings during the course of casework. Additional research should be conducted utilizing this same test format on other makes and models of firearms to see if subclass characteristic carryover has an effect on examiners' or the 3D imaging system's ability to identify unknowns correctly. If the test format in this study is used, the test should include a larger number of true negatives. Inclusion of true negatives, or true eliminations, better represents scenarios examiners are likely to encounter in casework and allows the examiners to be blindly tested by having unknowns that match the knowns provided as well having unknowns that will need to be eliminated. Another suggestion for future research is to conduct more extensive verification of the test packets. During the course of this research, there was one incident where a labeling issue was encountered with one of the test packets subsequently

leading to the removal of that test packet from the sample size. If possible, a better method for systematic labeling and verification should be imposed to ensure that labeling issues and test packet formation is consistent. Lastly, future research should look into finding a way for all three examiner conclusions (identification, elimination, and inconclusive) to be achieved by the 3D imaging system and how to statistically analyze test packet results accounting for all three conclusions.

Conclusions

This study found that subclass characteristics carryover was observed on the breechfaces of consecutively manufactured Ruger LCP .380 Auto pistol slides and that carryover was transferable to the headstamp region of fired cartridge cases. Results of the study showed that subclass characteristic carryover from the breechfaces of Ruger LCP .380 Auto pistols slides did not hinder an examiner's ability to identify fired cartridge cases. The researcher compared examiners based on their years of experience, years of training, the comparison macroscope make (brand) used during examination, whether examiners observed subclass characteristics or not, whether they were able to distinguish subclass from individual characteristics, and whether they examined the known samples first. Subclass characteristic carryover also had no effect on IBIS® BRASSTRAX-3D™'s ability to identify fired cartridge cases either. The researcher then compared the results of examiners to the IBIS® BRASSTRAX-3D™ and MatchPoint+™ imaging systems' normalized scores. The values calculated for the examiners and computer were then reported as False Positive Error Rate, False Negative Error Rate, Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value, and Global Error Rate. Based on these rates, there was no significant difference with examiners when categorized by years of experience, years of training, the scope make used during examination, whether they observed

subclass characteristics or not, whether they were able to distinguish subclass from individual characteristics, and whether they examined the known samples first. There was a significant difference in the means and medians between the examiners and the 3D imaging system. Comparison of the means and medians of examiners versus the computer revealed that examiners had a lower error rate and higher accuracy. Examiners proved to be consistently better than the computer in all when compared according to the seven numerical variables. The results of this study demonstrate that technology has advanced and progressed far in its time, however technology is not intended to take the place of an examiner, but to function in an assisting capacity. 3D imaging technology would make an excellent tool for examiners to use when conducting their examinations. The IBIS® BRASSTRAX-3D™ system can function as a filtering tool for the examiner reducing the list of potential candidates, which an examiner could then examine manually. This tool would also be helpful in the scenario where there was nothing to compare the unknown to. The IBIS® BRASSTRAX-3D™ system can be used to image the unknown and run it through the database to see if any potential matches exist in the system, if not, IBIS® BRASSTRAX-3D™ can store the unknown in the database so that it might be compared at a later date.

References

AFTE- Association of Firearms and Tool Mark Examiners (2001). *AFTE Glossary* (5th ed). Retrieved December 27, 2012 from http://afte.org/MembersArea/AFTEGL/glossary/s2/s2_class_characteristics.htm.

Ball, P. D. (2000). Toolmarks which may lead to false conclusions. *AFTE JOURNAL*, 32 (3), 292-293.

Barrett, M., Warren, G. (2011). Portable forensic ballistics examination instrument: Advanced ballistics analysis system (ALIAS). *AFTE JOURNAL*, 43 (1), 74-78.

Bolton-King, R. S., Evans, J. P., Smith, C. L., Painter, J. D., Allsop, D. F., Cranton, W. M. (2010). What are the prospects of 3D profiling systems applied to firearms and toolmark identificiation? *AFTE JOURNAL*, 42 (1), 23-33.

Bonfanti, M. S., DeKinder, J. (1999). The influence of the use of firearms on their characteristic marks. *AFTE JOURNAL*, 31 (3), 318-323.

Brundage, D. (1998). The identification of consecutively rifled gun barrels. *AFTE JOURNAL*, 30 (3), 438.

Bunch, S. G., Murphy, D. P. (2003). A comprehensive validity study for the forensic examination of cartridge cases. *AFTE JOURNAL*, 35 (2), 201-203.

Bunch, S. G., Smith, E. D., Giroux, B. N., Murphy, D. P. (2009). Is a match really a match? A primer on the procedures and validity of firearm and toolmark identification. *FORENSIC SCIENCE COMMUNICATIONS*, 11 (3), 1-9.

Clow, C. M. (2005). Cartilage stabbing with consecutively manufactured knives: A response to Ramirez v. State of Florida. *AFTE JOURNAL*, 37 (2), 86-116.

Coody, A. C. (2003). Consecutively manufactured Ruger P-89 slides. *AFTE JOURNAL*, 35 (2), 157-160.

Fadul, T. G. (2011). An empirical study to evaluate the repeatability and uniqueness of striations/ impressions imparted on consecutively manufactured Glock EBIS gun barrels. *AFTE JOURNAL*, 43 (1), 37-44.

Fadul, T. G., Nunez, A. (2006). Glock's new EBIS barrel: The finale to the Miami barrel saga. *AFTE JOURNAL*, 38 (2), 96-100.

FTI- Forensic Technology Inc. (2013). *IBIS TRAX-3D*. Retrieved March 30, 2013 from http://www.forensictechnology.com/IBISTRAX/.

Freeman, R. (1978). Consecutively rifled polygon barrels. *AFTE JOURNAL,* 10 (2), 40.

Garten, S. R., Neel, M. T. (2010). The effect of subclass characteristics involving shotgun ammunition on IBIS entries and correlation results. *AFTE JOURNAL*, 42 (4), 364-369.

Grom, T. L., Demuth, W. E. (2012). IBIS correlation results of cartridge cases collected over the course of 500 firings from a Glock pistol. *AFTE JOURNAL*, 44 (4), 361-363.

Haag, L. (1977). Heckler & Koch polygonal rifling. *AFTE JOURNAL*, 9 (2), 45-47.

Haag, L. C. (2006). Shooting incident reconstruction. (p 303). Academic Press.

Hall, E. E. (1983). Bullet markings from consecutively rifled Shilen DGA barrels. *AFTE JOURNAL,* 15 (1), 33.

Hamby, J. E., Brundage, D. J., Thorpe, J. W. (2009). The identification of bullets fired from 10 consecutively rifled 9mm Ruger pistol barrels: A research project involving 507 participants from 20 countries. *AFTE JOURNAL,* 41 (2), 99-110.

Heard, B. J. (2009). Handbook of firearms and ballistics: Examining and interpreting forensic evidence. (2nd ed). (p 132). Singapore: Wiley-Blackwell.

Hocherman, G., Givers, P., Shosani, E. (2003). Identification of polygonal barrel sub-family characteristics. *AFTE JOURNAL*, 35 (2), 197-200.

LaCova, S., Fox, J., Mattia, N. (2010). Subclass characteristics on CCI Speer cartridge case heads. *AFTE JOURNAL*, 42 (3), 281-284.

Lardizabal, P. (1995). Cartridge case study of the Heckler & Koch USP. *AFTE JOURNAL*, 27 (1), 49-51.

Lightstone, L. (2010). The potential for and persistence of subclass characteristics on the breech faces of SW40VE Smith & Wesson Sigma pistols. *AFTE JOURNAL*, 42 (4), 308-322.

Lopez, L. L., Grew, S. (2000). Consecutively machined Ruger bolt faces. *AFTE JOURNAL*, 32 (1), 19-24.

Lutz, M. C. (1970). Consecutive revolver barrels. *AFTE NEWSLETTER*, (9), 25.

Mathews, J. H. (1962). Firearms Identification, Vol. I. Charles C. Thomas, Springfield, IL.

Matty, B. (1999). Lorcin L9mm and L388 pistol breechface toolmark patterns. *AFTE JOURNAL*, 31 (2), 134-137.

Matty, W. (1984). Raven 25 Automatic pistol breech face tool marks. *AFTE JOURNAL,* 16 (3), 57-60.

Maruoka, R. K. (1994). Guilty before the crime? The potential for a possible misidentification or elimination. *AFTE JOURNAL*, 26 (3), 206-213

McLean, D. (1999). Examiners make explosive gains in the ballistic labs: Productivity rockets to levels unheard of before. *AFTE JOURNAL*, 31 (3), 386-392.

Miller, J. (2001). An examination of two consecutively rifled barrels and a review of the literature. *AFTE JOURNAL*, 32 (3), 259-270.

Miller, J., Beach, G. (2005). Toolmarks: Examining the possibility of subclass characteristics. *AFTE JOURNAL*, 37 (4), 296-345.

NRC - National Research Council. Strengthening Forensic Science in the United States: A Path Forward. Washington, DC: The National Academies Press, 2009.

Nicholson, T. (1970). Breech face characteristics of Browning .25 Auto pistols. *AFTE JOURNAL*, 2 (NL09-3), 39.

Nichols, R. (2007). Defending the scientific foundations of the firearms and tool mark identification discipline: Responding to recent challenges. *JOURNAL OF FORENSIC SCIENCES*, 52 (3), 586-594.

NIJ- National Institute of Justice (2013). *Firearms Examiner* Training. Retrieved March 30, 2013, from http://www.nij.gov/training/firearms-training/module01/fir_m01.htm.

Rivera, G. C. (2007). Subclass characteristics in Smith & Wesson SW40VE Sigma pistols. *AFTE JOURNAL*, 39 (3), 253-258.

Roberge, D., Beauchamp, A. (2006). The use of BulletTrax-3D in a study of consecutively manufactured barrels. *AFTE JOURNAL*, 38 (2), 166-172.

Skolrood, R. W. (1975). Comparison of bullets fired from consecutively rifled Cooey .22 caliber barrels. *CANADIAN SOCIETY FORENSIC SCIENCE JOURNAL*, 8 (2), 49.

Smith, E. D. (2004). Cartridge case and bullet comparison validation study with firearms submitted in casework. *AFTE JOURNAL*, 36 (4), 130-135.

Thompson, E. (1994). Phoenix Arms (Raven) breech face tool marks. *AFTE JOURNAL,* 26 (2), 134-135.

Tulleners, F. A., Hamiel, J. S. (1999). Sub class characteristics of sequentially rifled 38 Special S&W revolver barrels. *AFTE JOURNAL*, 31 (2), 117-122.

Uchiyama, T. (2010). Variation of markings on primers of expended cartridge cases: Analysis of cartridge cases fired from caliber .25 Semi-Automatic pistols. *AFTE JOURNAL*, 42 (2), 120-131.

Uchiyama, T., Nota, O. (1986). Non-firing markings on primer of Remington cartridges. *AFTE JOURNAL*, 18 (4), 78-90.

Warren, G. (1991). New system for toolmark identification: Electronic imaging, recording, and comparison. *AFTE JOURNAL*, 23 (4), 990-996.

Definition of the Terms

As defined in the AFTE GLOSSARY 5th Edition (AFTE, 2012) and the National Research Council's Strengthening Forensic Science in the United States: A Path Forward (NRC, 2009).

Breech	The part of the firearm at the rear of the bore into which the cartridge or propellant is inserted.
Breechblock	The locking and cartridge head supporting mechanism of a firearm that does not operate in line with the axis of the bore.
Breechbolt	The locking and cartridge head supporting mechanism of a firearm that operates in line with the axis of the bore, such as common bolt action rifles.
Breechface	That part of the breechblock or breech bolt that is against the head of the cartridge case or shotshell during firing.
Breechface marks	Negative impressions of the breechface of the firearm found on the head of the cartridge case, and/ or in the primer around the firing pin impression after discharge.
Class characteristics	Measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture.
Critical Error	Error rendered because of examiner
False Negative Error Rate	The fraction of eliminations incorrectly identified by examiners in the test The number of false negatives in a test divided by the total number of unknowns that could have been false negatives

False Positive Error Rate	The fraction of identifications incorrectly identified by examiners in the test The number of false positives in test divided by the total number of unknowns that could have been false positives
Global Error Rate	The projected fraction of incorrectly identified unknowns among all unknowns examined The number of incorrect conclusions (false positive and false negatives) divided by the total number of unknowns
Individual characteristics	Marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/ or caused by use, corrosion, or damage. They are unique to that tool and distinguish it from all other tools.
Macroscopic	Viewing magnification is 120x or lower
Negative Predictive Value	The projected fraction of eliminations correctly identified by examiners in general based on test results The number of true negatives divided by the total number of eliminations made (varies for each examiner)
Positive Predictive Value	The projected fraction of identifications correctly identified by examiners in general based on test results The number of true positives divided by the total number of positives made (varies for each examiner)
Quality Error	Error rendered because of poor sample quality
Sensitivity	The fraction of identifications correctly identified by examiners in the test The number of true positives divided by the total number of unknowns with an ID
Specificity	The fraction of eliminations correctly identified by examiners in the test The number of true negatives divided by the total number of unknowns without an ID

Subclass characteristics	Discernible surface features of an object which are more restrictive than class characteristics in that they are: (1) produced incidental to manufacture, (2) are significant in that they relate to a smaller group source (a subset of the class to which they belong), and (3) can arise from a source which changes over time.

APPENDIX

IBIS® BrassTrax-3D™ Imaging Technology Data

IBIS MATCHPOINT+

Correlation Results Filtering

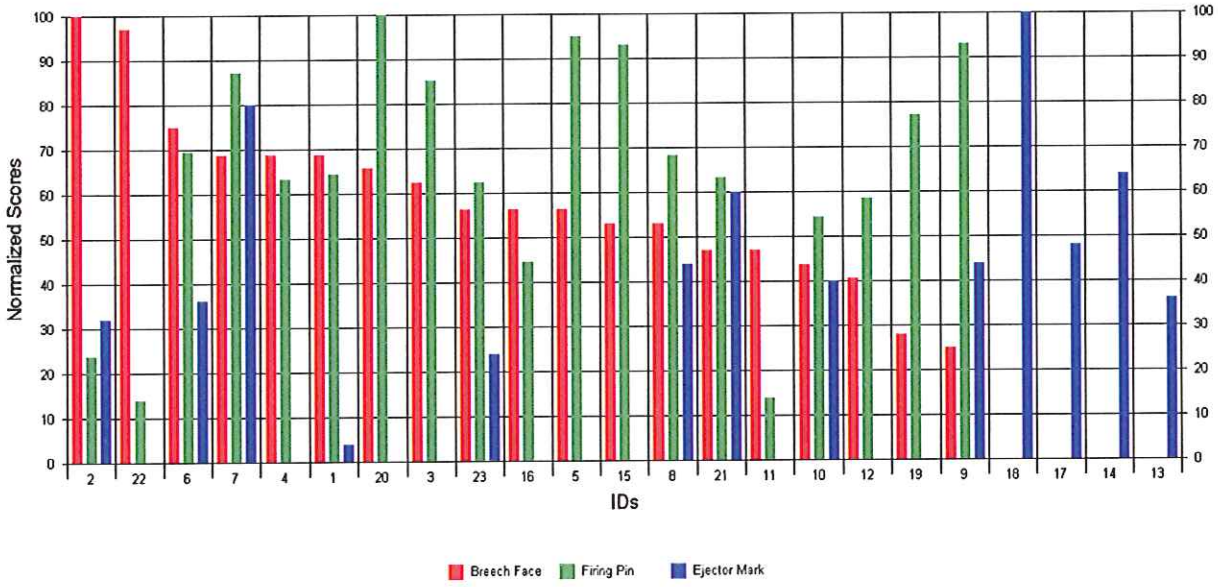
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K31B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C31B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:40 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
2	OK-K111A	C111A	BRX2-TNG	100	1	24	15	32	9
22	OK-U390	CU390	BRX2-TNG	97	2	14	16	N/A	12
6	OK-K151A	C151A	BRX2-TNG	75	3	69	7	36	8
7	OK-K71A	C71A	BRX2-TNG	69	4	87	4	80	2
4	OK-K311A	C311A	BRX2-TNG	69	4	63	10	N/A	12
1	OK-K351A	C351A	BRX2-TNG	69	4	64	9	4	11
20	OK-U375	CU375	BRX2-TNG	66	5	100	1	N/A	12
3	OK-K271A	C271A	BRX2-TNG	63	6	85	5	N/A	12
23	OK-U600	CU600	BRX2-TNG	56	7	62	11	24	10
16	OK-U083	CU083	BRX2-TNG	56	7	45	14	N/A	12
5	OK-K231B	C231B	BRX2-TNG	56	7	95	2	N/A	12
15	OK-U397	CU397	BRX2-TNG	53	8	93	3	N/A	12
8	OK-K391B	C391B	BRX2-TNG	53	8	68	8	44	6
21	OK-U106	CU106	BRX2-TNG	47	9	63	10	60	4
11	OK-U295	CU295	BRX2-TNG	47	9	14	16	N/A	12

Reference Case

Case Number: OK-K31B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C31B

Sorted by: Breech Face (Normalized Scores)

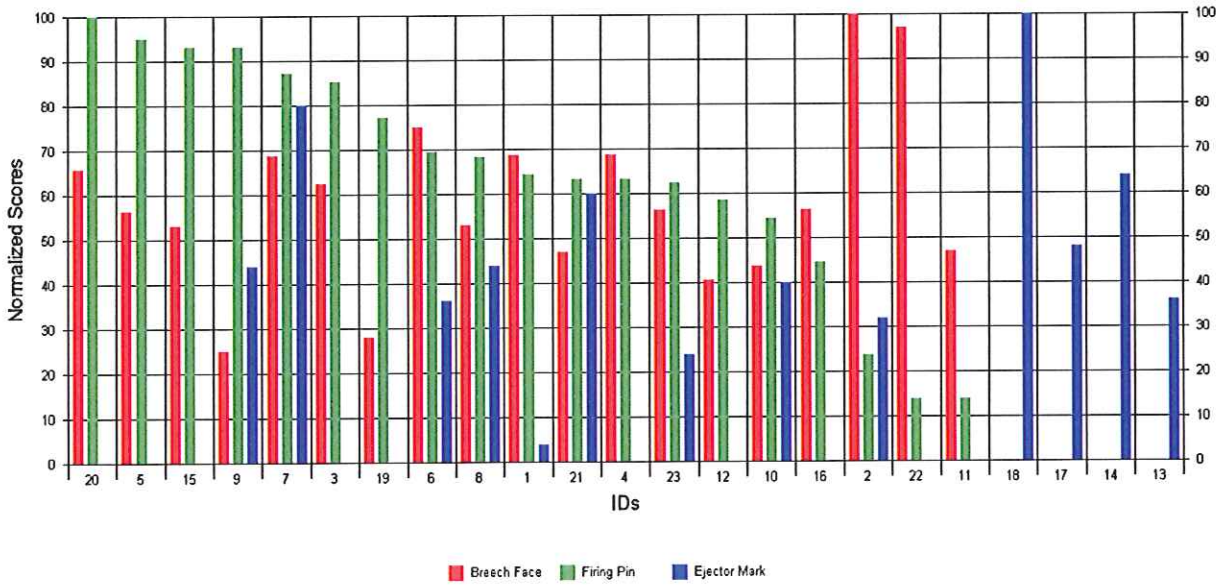
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
10	OK-U354	CU354	BRX2-TNG	44	10	54	13	40	7
12	OK-U174	CU174	BRX2-TNG	41	11	58	12	N/A	12
19	OK-U385	CU385	BRX2-TNG	28	12	77	6	N/A	12
9	OK-K191A	C191A	BRX2-TNG	25	13	93	3	44	6
18	OK-U072	CU072	BRX2-TNG	N/A	14	N/A	17	100	1
17	OK-U233	CU233	BRX2-TNG	N/A	14	N/A	17	48	5
14	OK-U156	CU156	BRX2-TNG	N/A	14	N/A	17	64	3
13	OK-U120	CU120	BRX2-TNG	N/A	14	N/A	17	36	8

Reference Case

Case Number: OK-K31B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C31B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:40 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
20	OK-U375	CU375	BRX2-TNG	66	5	100	1	N/A	12
5	OK-K231B	C231B	BRX2-TNG	56	7	95	2	N/A	12
15	OK-U397	CU397	BRX2-TNG	53	8	93	3	N/A	12
9	OK-K191A	C191A	BRX2-TNG	25	13	93	3	44	6
7	OK-K71A	C71A	BRX2-TNG	69	4	87	4	80	2
3	OK-K271A	C271A	BRX2-TNG	63	6	85	5	N/A	12
19	OK-U385	CU385	BRX2-TNG	28	12	77	6	N/A	12
6	OK-K151A	C151A	BRX2-TNG	75	3	69	7	36	8
8	OK-K391B	C391B	BRX2-TNG	53	8	68	8	44	6
1	OK-K351A	C351A	BRX2-TNG	69	4	64	9	4	11
21	OK-U106	CU106	BRX2-TNG	47	9	63	10	60	4
4	OK-K311A	C311A	BRX2-TNG	69	4	63	10	N/A	12
23	OK-U600	CU600	BRX2-TNG	56	7	62	11	24	10
12	OK-U174	CU174	BRX2-TNG	41	11	58	12	N/A	12
10	OK-U354	CU354	BRX2-TNG	44	10	54	13	40	7

Reference Case

Case Number: OK-K31B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C31B

Sorted by: Firing Pin (Normalized Scores)

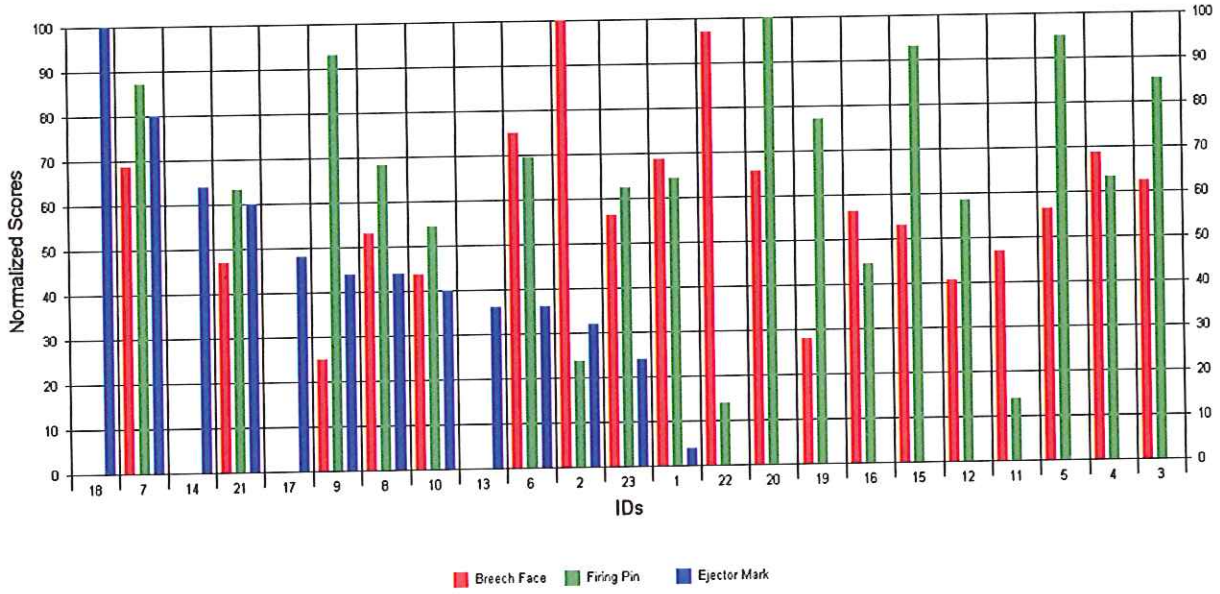
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
16	OK-U083	CU083	BRX2-TNG	56	7	45	14	N/A	12
2	OK-K111A	C111A	BRX2-TNG	100	1	24	15	32	9
22	OK-U390	CU390	BRX2-TNG	97	2	14	16	N/A	12
11	OK-U295	CU295	BRX2-TNG	47	9	14	16	N/A	12
18	OK-U072	CU072	BRX2-TNG	N/A	14	N/A	17	100	1
17	OK-U233	CU233	BRX2-TNG	N/A	14	N/A	17	48	5
14	OK-U156	CU156	BRX2-TNG	N/A	14	N/A	17	64	3
13	OK-U120	CU120	BRX2-TNG	N/A	14	N/A	17	36	8

Reference Case

Case Number: OK-K31B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C31B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:40 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
18	OK-U072	CU072	BRX2-TNG	N/A	14	N/A	17	100	1
7	OK-K71A	C71A	BRX2-TNG	69	4	87	4	80	2
14	OK-U156	CU156	BRX2-TNG	N/A	14	N/A	17	64	3
21	OK-U106	CU106	BRX2-TNG	47	9	63	10	60	4
17	OK-U233	CU233	BRX2-TNG	N/A	14	N/A	17	48	5
9	OK-K191A	C191A	BRX2-TNG	25	13	93	3	44	6
8	OK-K391B	C391B	BRX2-TNG	53	8	68	8	44	6
10	OK-U354	CU354	BRX2-TNG	44	10	54	13	40	7
13	OK-U120	CU120	BRX2-TNG	N/A	14	N/A	17	36	8
6	OK-K151A	C151A	BRX2-TNG	75	3	69	7	36	8
2	OK-K111A	C111A	BRX2-TNG	100	1	24	15	32	9
23	OK-U600	CU600	BRX2-TNG	56	7	62	11	24	10
1	OK-K351A	C351A	BRX2-TNG	69	4	64	9	4	11
22	OK-U390	CU390	BRX2-TNG	97	2	14	16	N/A	12
20	OK-U375	CU375	BRX2-TNG	66	5	100	1	N/A	12

Correlation Results Filtering

Reference Case

Case Number: OK-K31B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C31B

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
19	OK-U385	CU385	BRX2-TNG	28	12	77	6	N/A	12
16	OK-U083	CU083	BRX2-TNG	56	7	45	14	N/A	12
15	OK-U397	CU397	BRX2-TNG	53	8	93	3	N/A	12
12	OK-U174	CU174	BRX2-TNG	41	11	58	12	N/A	12
11	OK-U295	CU295	BRX2-TNG	47	9	14	16	N/A	12
5	OK-K231B	C231B	BRX2-TNG	56	7	95	2	N/A	12
4	OK-K311A	C311A	BRX2-TNG	69	4	63	10	N/A	12
3	OK-K271A	C271A	BRX2-TNG	63	6	85	5	N/A	12

IBIS MATCHPOINT+

Correlation Results Filtering

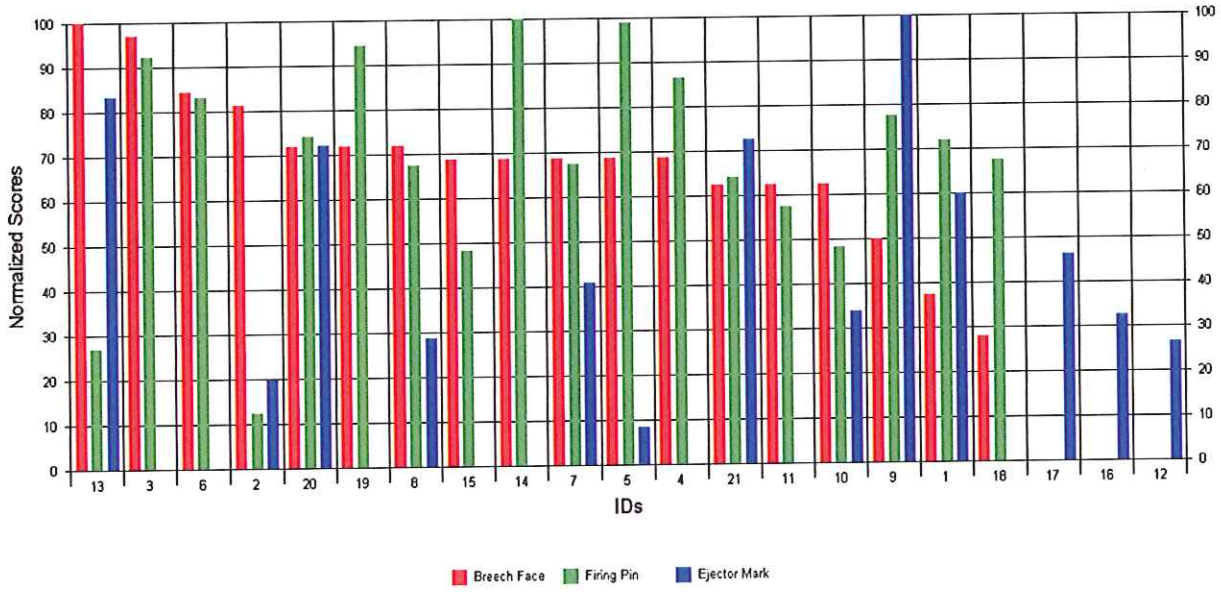
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K71A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C71A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



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Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
13	OK-U156	CU156	BRX2-TNG	100	1	27	14	83	2
3	OK-K271A	C271A	BRX2-TNG	97	2	92	4	N/A	14
6	OK-K231B	C231B	BRX2-TNG	84	3	83	6	N/A	14
2	OK-K111A	C111A	BRX2-TNG	81	4	12	15	20	12
20	OK-U106	CU106	BRX2-TNG	72	5	74	8	72	4
19	OK-U375	CU375	BRX2-TNG	72	5	94	3	N/A	14
8	OK-K391B	C391B	BRX2-TNG	72	5	67	10	29	10
15	OK-U083	CU083	BRX2-TNG	69	6	48	13	N/A	14
14	OK-U397	CU397	BRX2-TNG	69	6	100	1	N/A	14
7	OK-K151A	C151A	BRX2-TNG	69	6	67	10	41	7
5	OK-K31B	C31B	BRX2-TNG	69	6	99	2	9	13
4	OK-K311A	C311A	BRX2-TNG	69	6	87	5	N/A	14
21	OK-U600	CU600	BRX2-TNG	63	7	64	11	73	3
11	OK-U174	CU174	BRX2-TNG	63	7	57	12	N/A	14
10	OK-U354	CU354	BRX2-TNG	63	7	48	13	34	8

Reference Case

Case Number: OK-K71A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C71A

Sorted by: Breech Face (Normalized Scores)

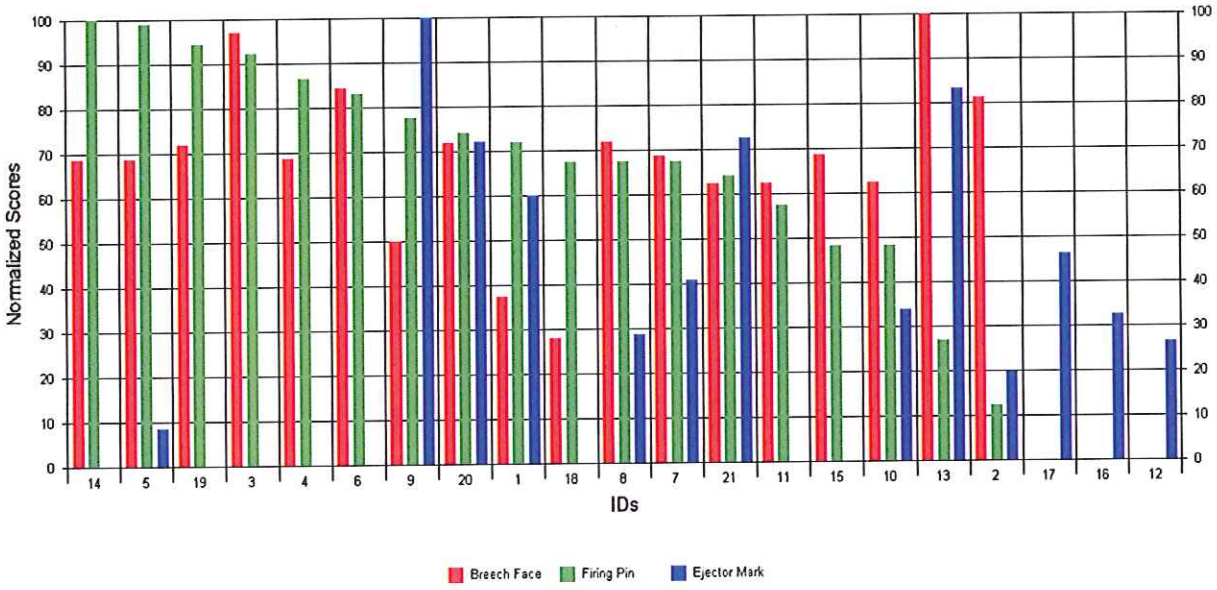
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
9	OK-K191A	C191A	BRX2-TNG	50	8	78	7	100	1
1	OK-K351A	C351A	BRX2-TNG	38	9	72	9	60	5
18	OK-U385	CU385	BRX2-TNG	28	10	67	10	N/A	14
17	OK-U072	CU072	BRX2-TNG	N/A	11	N/A	16	46	6
16	OK-U233	CU233	BRX2-TNG	N/A	11	N/A	16	33	9
12	OK-U120	CU120	BRX2-TNG	N/A	11	N/A	16	27	11

Reference Case

Case Number: OK-K71A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C71A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:47:05 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
14	OK-U397	CU397	BRX2-TNG	69	6	100	1	N/A	14
5	OK-K31B	C31B	BRX2-TNG	69	6	99	2	9	13
19	OK-U375	CU375	BRX2-TNG	72	5	94	3	N/A	14
3	OK-K271A	C271A	BRX2-TNG	97	2	92	4	N/A	14
4	OK-K311A	C311A	BRX2-TNG	69	6	87	5	N/A	14
6	OK-K231B	C231B	BRX2-TNG	84	3	83	6	N/A	14
9	OK-K191A	C191A	BRX2-TNG	50	8	78	7	100	1
20	OK-U106	CU106	BRX2-TNG	72	5	74	8	72	4
1	OK-K351A	C351A	BRX2-TNG	38	9	72	9	60	5
18	OK-U385	CU385	BRX2-TNG	28	10	67	10	N/A	14
8	OK-K391B	C391B	BRX2-TNG	72	5	67	10	29	10
7	OK-K151A	C151A	BRX2-TNG	69	6	67	10	41	7
21	OK-U600	CU600	BRX2-TNG	63	7	64	11	73	3
11	OK-U174	CU174	BRX2-TNG	63	7	57	12	N/A	14
15	OK-U083	CU083	BRX2-TNG	69	6	48	13	N/A	14

Correlation Results Filtering

Reference Case

Case Number: OK-K71A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C71A

Sorted by: Firing Pin (Normalized Scores)

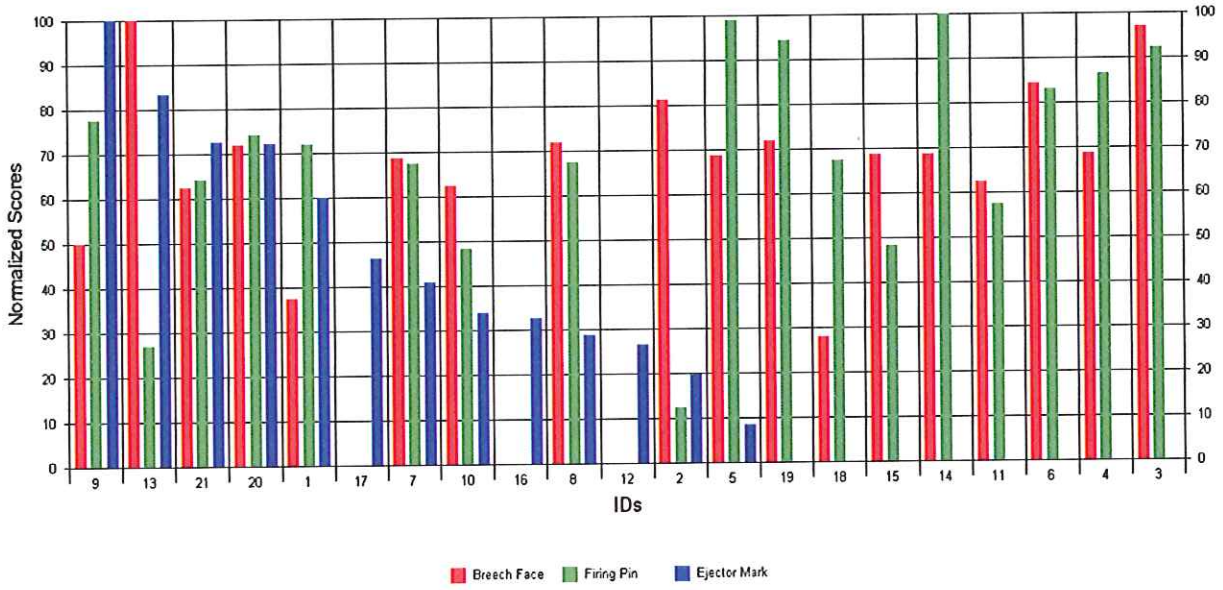
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
10	OK-U354	CU354	BRX2-TNG	63	7	48	13	34	8
13	OK-U156	CU156	BRX2-TNG	100	1	27	14	83	2
2	OK-K111A	C111A	BRX2-TNG	81	4	12	15	20	12
17	OK-U072	CU072	BRX2-TNG	N/A	11	N/A	16	46	6
16	OK-U233	CU233	BRX2-TNG	N/A	11	N/A	16	33	9
12	OK-U120	CU120	BRX2-TNG	N/A	11	N/A	16	27	11

Reference Case

Case Number: OK-K71A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C71A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:47:05 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
9	OK-K191A	C191A	BRX2-TNG	50	8	78	7	100	1
13	OK-U156	CU156	BRX2-TNG	100	1	27	14	83	2
21	OK-U600	CU600	BRX2-TNG	63	7	64	11	73	3
20	OK-U106	CU106	BRX2-TNG	72	5	74	8	72	4
1	OK-K351A	C351A	BRX2-TNG	38	9	72	9	60	5
17	OK-U072	CU072	BRX2-TNG	N/A	11	N/A	16	46	6
7	OK-K151A	C151A	BRX2-TNG	69	6	67	10	41	7
10	OK-U354	CU354	BRX2-TNG	63	7	48	13	34	8
16	OK-U233	CU233	BRX2-TNG	N/A	11	N/A	16	33	9
8	OK-K391B	C391B	BRX2-TNG	72	5	67	10	29	10
12	OK-U120	CU120	BRX2-TNG	N/A	11	N/A	16	27	11
2	OK-K111A	C111A	BRX2-TNG	81	4	12	15	20	12
5	OK-K31B	C31B	BRX2-TNG	69	6	99	2	9	13
19	OK-U375	CU375	BRX2-TNG	72	5	94	3	N/A	14
18	OK-U385	CU385	BRX2-TNG	28	10	67	10	N/A	14

Reference Case

Case Number: OK-K71A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C71A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
15	OK-U083	CU083	BRX2-TNG	69	6	48	13	N/A	14
14	OK-U397	CU397	BRX2-TNG	69	6	100	1	N/A	14
11	OK-U174	CU174	BRX2-TNG	63	7	57	12	N/A	14
6	OK-K231B	C231B	BRX2-TNG	84	3	83	6	N/A	14
4	OK-K311A	C311A	BRX2-TNG	69	6	87	5	N/A	14
3	OK-K271A	C271A	BRX2-TNG	97	2	92	4	N/A	14

IBIS MATCHPOINT+

Correlation Results Filtering

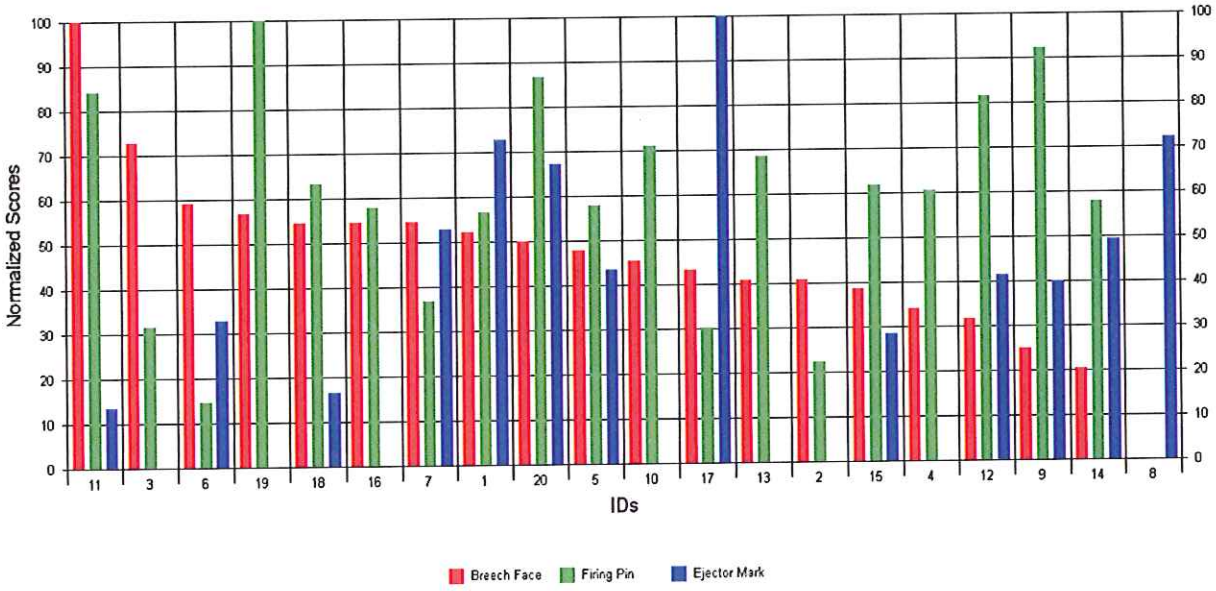
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K111A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP study

Reference Exhibit

Exhibit Number: C111A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/24/2013 10:40:59 AM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
11	OK-U120	CU120	BRX2-TNG	100	1	84	4	14	13
3	OK-K31B	C31B	BRX2-TNG	73	2	32	14	N/A	14
6	OK-K71A	C71A	BRX2-TNG	59	3	14	17	33	10
19	OK-U042	CU042	BRX2-TNG	57	4	100	1	N/A	14
18	OK-U390	CU390	BRX2-TNG	55	5	63	8	16	12
16	OK-U375	CU375	BRX2-TNG	55	5	58	11	N/A	14
7	OK-K391B	C391B	BRX2-TNG	55	5	37	13	53	5
1	OK-K351A	C351A	BRX2-TNG	52	6	57	12	73	2
20	OK-U600	CU600	BRX2-TNG	50	7	87	3	67	4
5	OK-K151A	C151A	BRX2-TNG	48	8	58	11	44	7
10	OK-U174	CU174	BRX2-TNG	45	9	71	6	N/A	14
17	OK-U106	CU106	BRX2-TNG	43	10	30	15	100	1
13	OK-U397	CU397	BRX2-TNG	41	11	68	7	N/A	14
2	OK-K271A	C271A	BRX2-TNG	41	11	22	16	N/A	14
15	OK-U072	CU072	BRX2-TNG	39	12	62	9	29	11

Reference Case

Case Number: OK-K111A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C111A

Sorted by: Breech Face (Normalized Scores)

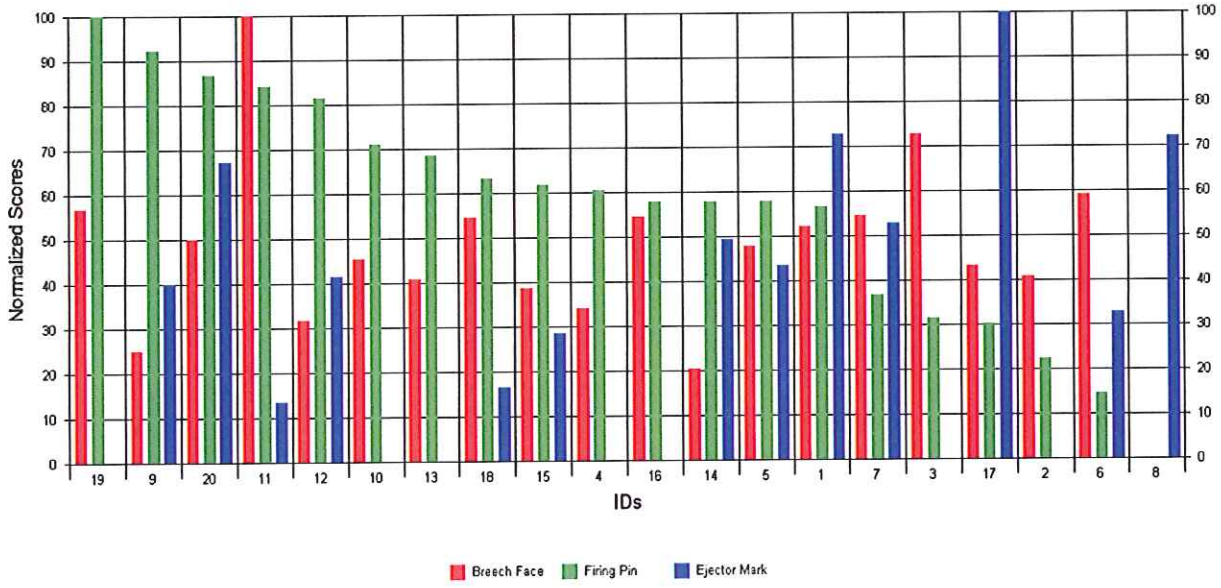
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
4	OK-K231B	C231B	BRX2-TNG	34	13	61	10	N/A	14
12	OK-U156	CU156	BRX2-TNG	32	14	82	5	41	8
9	OK-U354	CU354	BRX2-TNG	25	15	92	2	40	9
14	OK-U233	CU233	BRX2-TNG	20	16	58	11	49	6
8	OK-K191A	C191A	BRX2-TNG	N/A	17	N/A	18	72	3

Reference Case

Case Number: OK-K111A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP study

Reference Exhibit

Exhibit Number: C111A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/24/2013 10:40:59 AM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
19	OK-U042	CU042	BRX2-TNG	57	4	100	1	N/A	14
9	OK-U354	CU354	BRX2-TNG	25	15	92	2	40	9
20	OK-U600	CU600	BRX2-TNG	50	7	87	3	67	4
11	OK-U120	CU120	BRX2-TNG	100	1	84	4	14	13
12	OK-U156	CU156	BRX2-TNG	32	14	82	5	41	8
10	OK-U174	CU174	BRX2-TNG	45	9	71	6	N/A	14
13	OK-U397	CU397	BRX2-TNG	41	11	68	7	N/A	14
18	OK-U390	CU390	BRX2-TNG	55	5	63	8	16	12
15	OK-U072	CU072	BRX2-TNG	39	12	62	9	29	11
4	OK-K231B	C231B	BRX2-TNG	34	13	61	10	N/A	14
16	OK-U375	CU375	BRX2-TNG	55	5	58	11	N/A	14
14	OK-U233	CU233	BRX2-TNG	20	16	58	11	49	6
5	OK-K151A	C151A	BRX2-TNG	48	8	58	11	44	7
1	OK-K351A	C351A	BRX2-TNG	52	6	57	12	73	2
7	OK-K391B	C391B	BRX2-TNG	55	5	37	13	53	5

Correlation Results Filtering

Reference Case

Case Number: OK-K111A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C111A

Sorted by: Firing Pin (Normalized Scores)

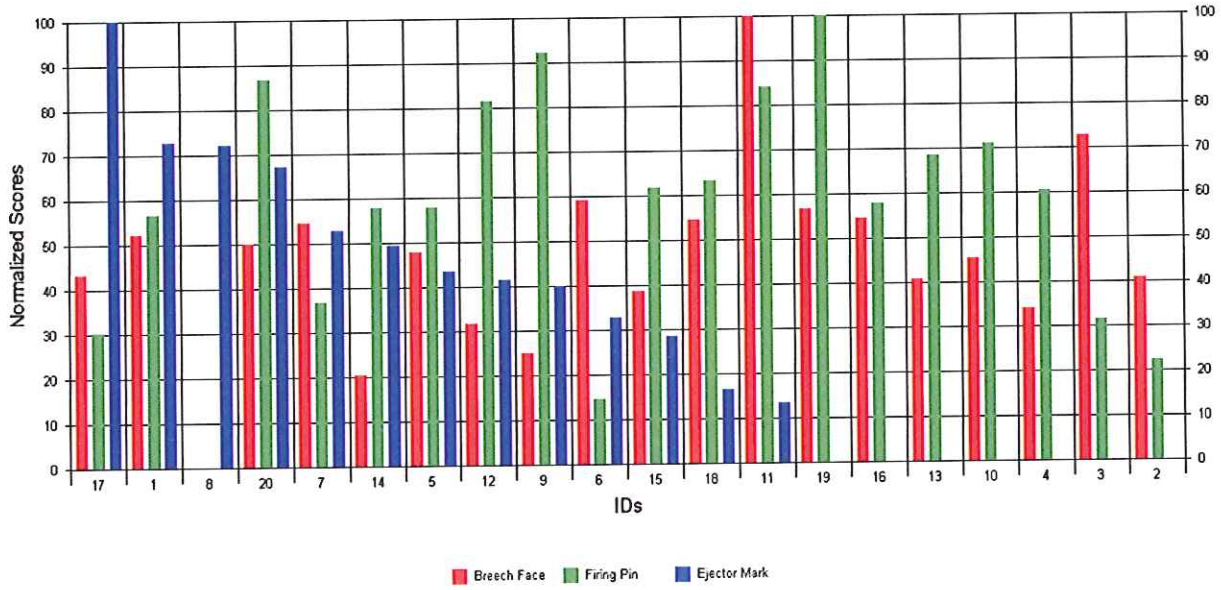
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
3	OK-K31B	C31B	BRX2-TNG	73	2	32	14	N/A	14
17	OK-U106	CU106	BRX2-TNG	43	10	30	15	100	1
2	OK-K271A	C271A	BRX2-TNG	41	11	22	16	N/A	14
6	OK-K71A	C71A	BRX2-TNG	59	3	14	17	33	10
8	OK-K191A	C191A	BRX2-TNG	N/A	17	N/A	18	72	3

Reference Case

Case Number: OK-K111A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP study

Reference Exhibit

Exhibit Number: C111A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/24/2013 10:40:59 AM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
17	OK-U106	CU106	BRX2-TNG	43	10	30	15	100	1
1	OK-K351A	C351A	BRX2-TNG	52	6	57	12	73	2
8	OK-K191A	C191A	BRX2-TNG	N/A	17	N/A	18	72	3
20	OK-U600	CU600	BRX2-TNG	50	7	87	3	67	4
7	OK-K391B	C391B	BRX2-TNG	55	5	37	13	53	5
14	OK-U233	CU233	BRX2-TNG	20	16	58	11	49	6
5	OK-K151A	C151A	BRX2-TNG	48	8	58	11	44	7
12	OK-U156	CU156	BRX2-TNG	32	14	82	5	41	8
9	OK-U354	CU354	BRX2-TNG	25	15	92	2	40	9
6	OK-K71A	C71A	BRX2-TNG	59	3	14	17	33	10
15	OK-U072	CU072	BRX2-TNG	39	12	62	9	29	11
18	OK-U390	CU390	BRX2-TNG	55	5	63	8	16	12
11	OK-U120	CU120	BRX2-TNG	100	1	84	4	14	13
19	OK-U042	CU042	BRX2-TNG	57	4	100	1	N/A	14
16	OK-U375	CU375	BRX2-TNG	55	5	58	11	N/A	14

Correlation Results Filtering

Reference Case

Case Number: OK-K111A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C111A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
13	OK-U397	CU397	BRX2-TNG	41	11	68	7	N/A	14
10	OK-U174	CU174	BRX2-TNG	45	9	71	6	N/A	14
4	OK-K231B	C231B	BRX2-TNG	34	13	61	10	N/A	14
3	OK-K31B	C31B	BRX2-TNG	73	2	32	14	N/A	14
2	OK-K271A	C271A	BRX2-TNG	41	11	22	16	N/A	14

IBIS MATCHPOINT+

Correlation Results Filtering

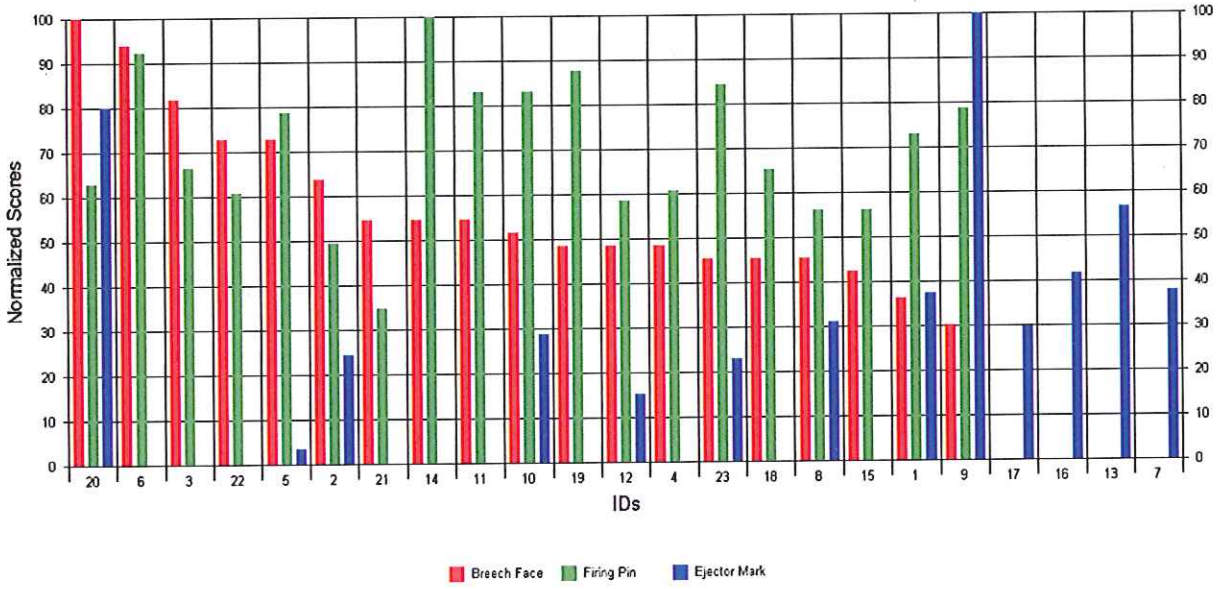
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K151A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C151A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:45:08 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
20	OK-U106	CU106	BRX2-TNG	100	1	63	10	80	2
6	OK-K231B	C231B	BRX2-TNG	94	2	92	2	N/A	14
3	OK-K271A	C271A	BRX2-TNG	82	3	66	8	N/A	14
22	OK-U042	CU042	BRX2-TNG	73	4	61	11	N/A	14
5	OK-K31B	C31B	BRX2-TNG	73	4	79	6	4	13
2	OK-K111A	C111A	BRX2-TNG	64	5	49	14	24	10
21	OK-U390	CU390	BRX2-TNG	55	6	35	15	N/A	14
14	OK-U397	CU397	BRX2-TNG	55	6	100	1	N/A	14
11	OK-U174	CU174	BRX2-TNG	55	6	83	5	N/A	14
10	OK-U354	CU354	BRX2-TNG	52	7	83	5	29	9
19	OK-U375	CU375	BRX2-TNG	48	8	88	3	N/A	14
12	OK-U120	CU120	BRX2-TNG	48	8	58	12	15	12
4	OK-K311A	C311A	BRX2-TNG	48	8	61	11	N/A	14
23	OK-U600	CU600	BRX2-TNG	45	9	84	4	23	11
18	OK-U385	CU385	BRX2-TNG	45	9	65	9	N/A	14

Reference Case

Case Number: OK-K151A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C151A

Sorted by: Breech Face (Normalized Scores)

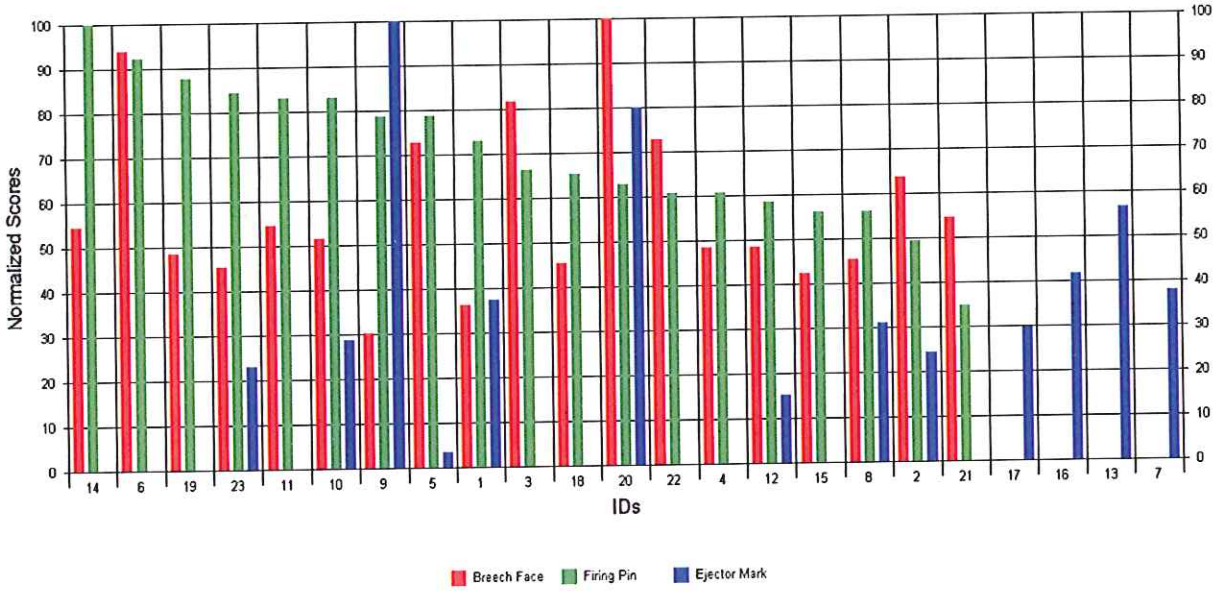
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
8	OK-K391B	C391B	BRX2-TNG	45	9	56	13	31	7
15	OK-U083	CU083	BRX2-TNG	42	10	56	13	N/A	14
1	OK-K351A	C351A	BRX2-TNG	36	11	73	7	37	6
9	OK-K191A	C191A	BRX2-TNG	30	12	79	6	100	1
17	OK-U072	CU072	BRX2-TNG	N/A	13	N/A	16	30	8
16	OK-U233	CU233	BRX2-TNG	N/A	13	N/A	16	42	4
13	OK-U156	CU156	BRX2-TNG	N/A	13	N/A	16	57	3
7	OK-K71A	C71A	BRX2-TNG	N/A	13	N/A	16	38	5

Reference Case

Case Number: OK-K151A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C151A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:45:08 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
14	OK-U397	CU397	BRX2-TNG	55	6	100	1	N/A	14
6	OK-K231B	C231B	BRX2-TNG	94	2	92	2	N/A	14
19	OK-U375	CU375	BRX2-TNG	48	8	88	3	N/A	14
23	OK-U600	CU600	BRX2-TNG	45	9	84	4	23	11
11	OK-U174	CU174	BRX2-TNG	55	6	83	5	N/A	14
10	OK-U354	CU354	BRX2-TNG	52	7	83	5	29	9
9	OK-K191A	C191A	BRX2-TNG	30	12	79	6	100	1
5	OK-K31B	C31B	BRX2-TNG	73	4	79	6	4	13
1	OK-K351A	C351A	BRX2-TNG	36	11	73	7	37	6
3	OK-K271A	C271A	BRX2-TNG	82	3	66	8	N/A	14
18	OK-U385	CU385	BRX2-TNG	45	9	65	9	N/A	14
20	OK-U106	CU106	BRX2-TNG	100	1	63	10	80	2
22	OK-U042	CU042	BRX2-TNG	73	4	61	11	N/A	14
4	OK-K311A	C311A	BRX2-TNG	48	8	61	11	N/A	14
12	OK-U120	CU120	BRX2-TNG	48	8	58	12	15	12

Reference Case

Case Number: OK-K151A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C151A

Sorted by: Firing Pin (Normalized Scores)

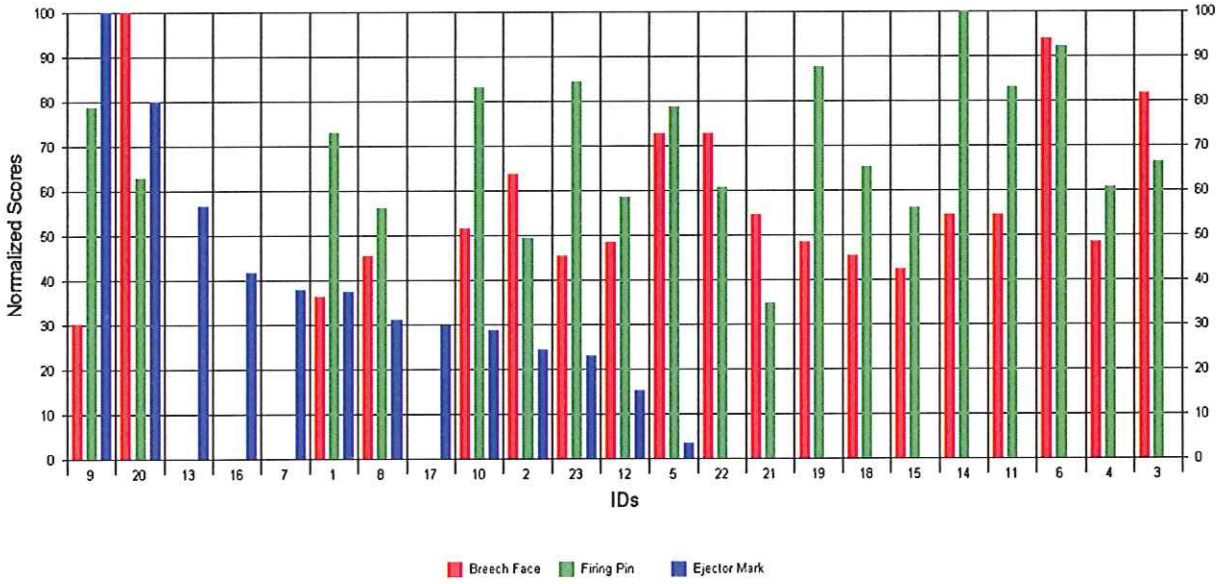
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
15	OK-U083	CU083	BRX2-TNG	42	10	56	13	N/A	14
8	OK-K391B	C391B	BRX2-TNG	45	9	56	13	31	7
2	OK-K111A	C111A	BRX2-TNG	64	5	49	14	24	10
21	OK-U390	CU390	BRX2-TNG	55	6	35	15	N/A	14
17	OK-U072	CU072	BRX2-TNG	N/A	13	N/A	16	30	8
16	OK-U233	CU233	BRX2-TNG	N/A	13	N/A	16	42	4
13	OK-U156	CU156	BRX2-TNG	N/A	13	N/A	16	57	3
7	OK-K71A	C71A	BRX2-TNG	N/A	13	N/A	16	38	5

Reference Case

Case Number: OK-K151A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C151A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:45:08 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
9	OK-K191A	C191A	BRX2-TNG	30	12	79	6	100	1
20	OK-U106	CU106	BRX2-TNG	100	1	63	10	80	2
13	OK-U156	CU156	BRX2-TNG	N/A	13	N/A	16	57	3
16	OK-U233	CU233	BRX2-TNG	N/A	13	N/A	16	42	4
7	OK-K71A	C71A	BRX2-TNG	N/A	13	N/A	16	38	5
1	OK-K351A	C351A	BRX2-TNG	36	11	73	7	37	6
8	OK-K391B	C391B	BRX2-TNG	45	9	56	13	31	7
17	OK-U072	CU072	BRX2-TNG	N/A	13	N/A	16	30	8
10	OK-U354	CU354	BRX2-TNG	52	7	83	5	29	9
2	OK-K111A	C111A	BRX2-TNG	64	5	49	14	24	10
23	OK-U600	CU600	BRX2-TNG	45	9	84	4	23	11
12	OK-U120	CU120	BRX2-TNG	48	8	58	12	15	12
5	OK-K31B	C31B	BRX2-TNG	73	4	79	6	4	13
22	OK-U042	CU042	BRX2-TNG	73	4	61	11	N/A	14
21	OK-U390	CU390	BRX2-TNG	55	6	35	15	N/A	14

Correlation Results Filtering

Reference Case

Case Number: OK-K151A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C151A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
19	OK-U375	CU375	BRX2-TNG	48	8	88	3	N/A	14
18	OK-U385	CU385	BRX2-TNG	45	9	65	9	N/A	14
15	OK-U083	CU083	BRX2-TNG	42	10	56	13	N/A	14
14	OK-U397	CU397	BRX2-TNG	55	6	100	1	N/A	14
11	OK-U174	CU174	BRX2-TNG	55	6	83	5	N/A	14
6	OK-K231B	C231B	BRX2-TNG	94	2	92	2	N/A	14
4	OK-K311A	C311A	BRX2-TNG	48	8	61	11	N/A	14
3	OK-K271A	C271A	BRX2-TNG	82	3	66	8	N/A	14

IBIS MATCHPOINT+

Correlation Results Filtering

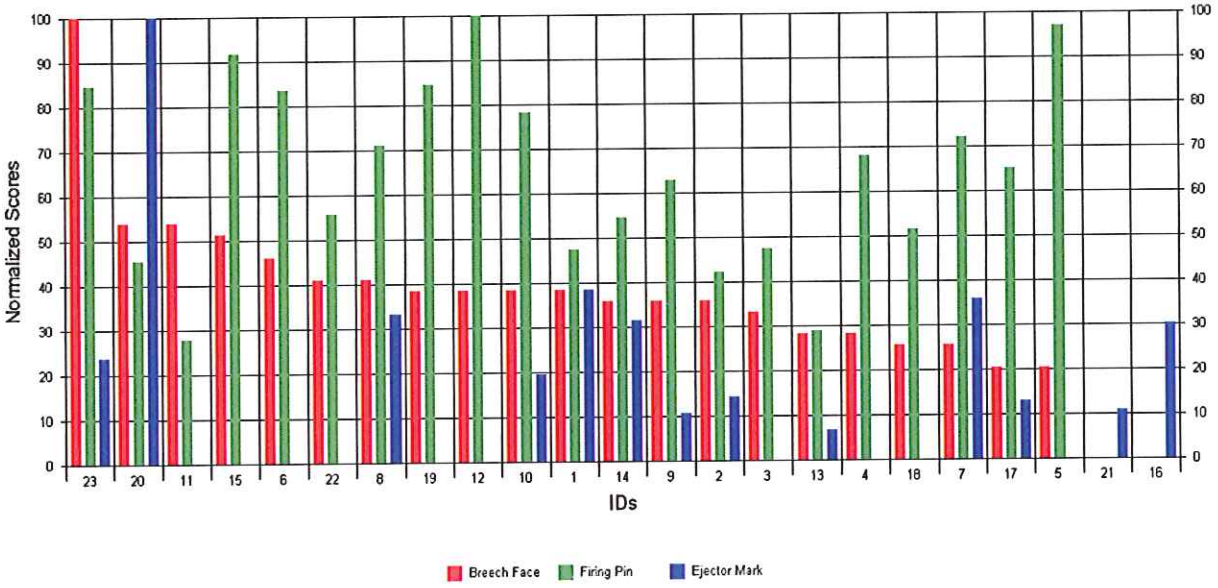
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K191A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C191A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:06 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
23	OK-U600	CU600	BRX2-TNG	100	1	85	4	24	7
20	OK-U106	CU106	BRX2-TNG	54	2	45	16	100	1
11	OK-U295	CU295	BRX2-TNG	54	2	28	19	N/A	14
15	OK-U397	CU397	BRX2-TNG	51	3	92	3	N/A	14
6	OK-K231B	C231B	BRX2-TNG	46	4	84	5	N/A	14
22	OK-U042	CU042	BRX2-TNG	41	5	56	12	N/A	14
8	OK-K71A	C71A	BRX2-TNG	41	5	71	8	33	4
19	OK-U375	CU375	BRX2-TNG	38	6	85	4	N/A	14
12	OK-U174	CU174	BRX2-TNG	38	6	100	1	N/A	14
10	OK-U354	CU354	BRX2-TNG	38	6	78	6	20	8
1	OK-K351A	C351A	BRX2-TNG	38	6	47	15	39	2
14	OK-U156	CU156	BRX2-TNG	36	7	55	13	32	5
9	OK-K391B	C391B	BRX2-TNG	36	7	63	11	11	12
2	OK-K111A	C111A	BRX2-TNG	36	7	42	17	14	9
3	OK-K271A	C271A	BRX2-TNG	33	8	47	15	N/A	14

Correlation Results Filtering

Reference Case

Case Number: OK-K191A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C191A

Sorted by: Breech Face (Normalized Scores)

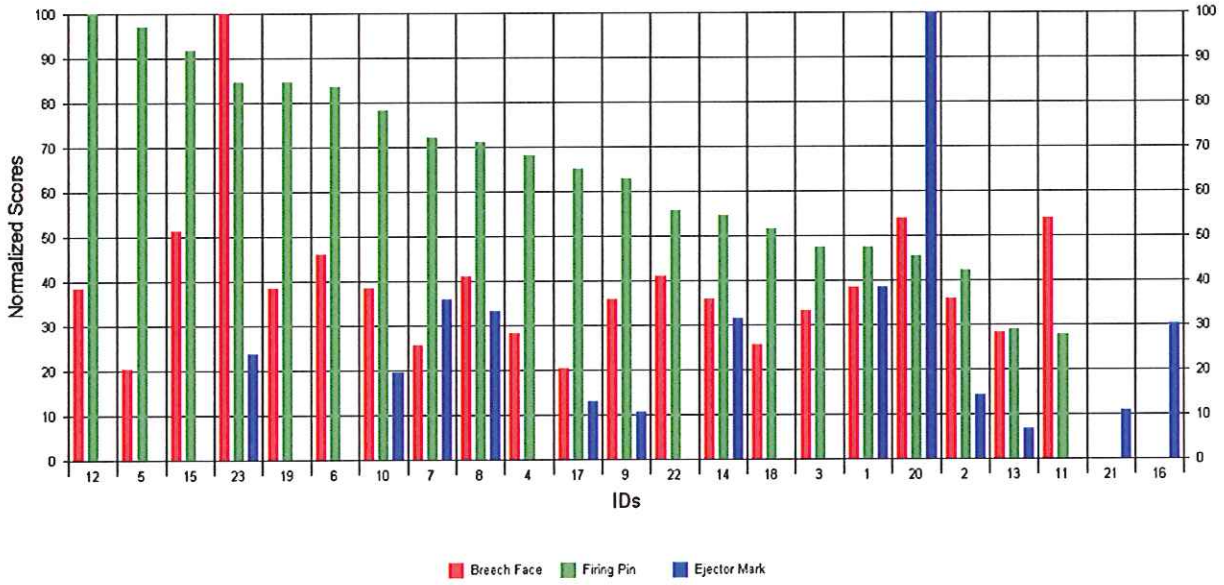
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
13	OK-U120	CU120	BRX2-TNG	28	9	29	18	7	13
4	OK-K311A	C311A	BRX2-TNG	28	9	68	9	N/A	14
18	OK-U385	CU385	BRX2-TNG	26	10	52	14	N/A	14
7	OK-K151A	C151A	BRX2-TNG	26	10	72	7	36	3
17	OK-U072	CU072	BRX2-TNG	21	11	65	10	13	10
5	OK-K31B	C31B	BRX2-TNG	21	11	97	2	N/A	14
21	OK-U390	CU390	BRX2-TNG	N/A	12	N/A	20	11	11
16	OK-U233	CU233	BRX2-TNG	N/A	12	N/A	20	30	6

Reference Case

Case Number: OK-K191A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C191A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:06 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
12	OK-U174	CU174	BRX2-TNG	38	6	100	1	N/A	14
5	OK-K31B	C31B	BRX2-TNG	21	11	97	2	N/A	14
15	OK-U397	CU397	BRX2-TNG	51	3	92	3	N/A	14
23	OK-U600	CU600	BRX2-TNG	100	1	85	4	24	7
19	OK-U375	CU375	BRX2-TNG	38	6	85	4	N/A	14
6	OK-K231B	C231B	BRX2-TNG	46	4	84	5	N/A	14
10	OK-U354	CU354	BRX2-TNG	38	6	78	6	20	8
7	OK-K151A	C151A	BRX2-TNG	26	10	72	7	36	3
8	OK-K71A	C71A	BRX2-TNG	41	5	71	8	33	4
4	OK-K311A	C311A	BRX2-TNG	28	9	68	9	N/A	14
17	OK-U072	CU072	BRX2-TNG	21	11	65	10	13	10
9	OK-K391B	C391B	BRX2-TNG	36	7	63	11	11	12
22	OK-U042	CU042	BRX2-TNG	41	5	56	12	N/A	14
14	OK-U156	CU156	BRX2-TNG	36	7	55	13	32	5
18	OK-U385	CU385	BRX2-TNG	26	10	52	14	N/A	14

Reference Case

Case Number: OK-K191A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C191A

Sorted by: Firing Pin (Normalized Scores)

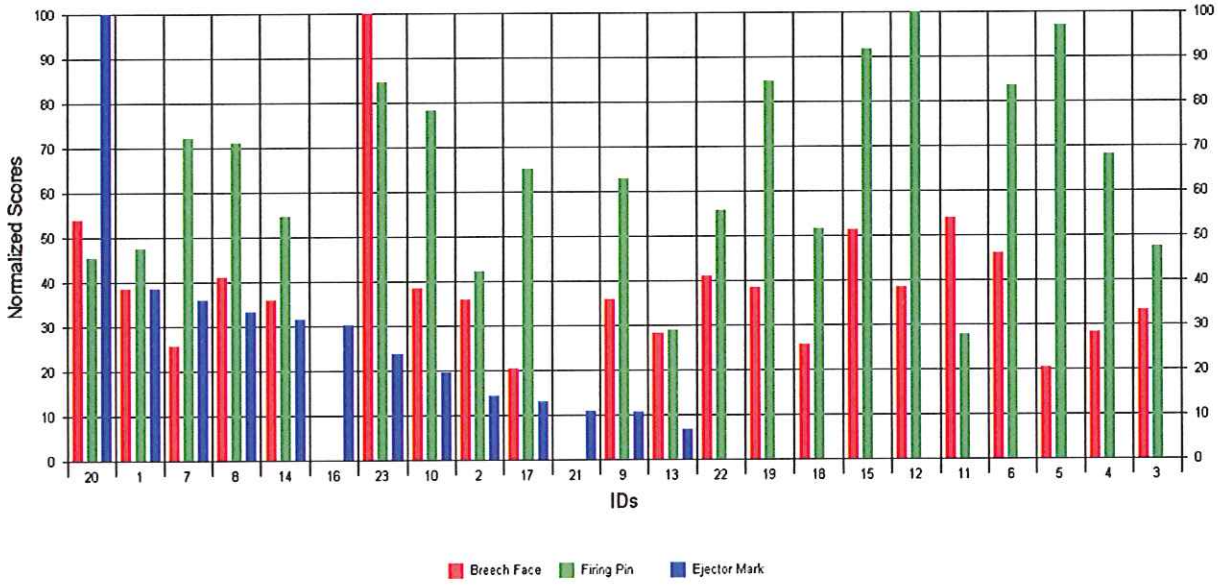
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
3	OK-K271A	C271A	BRX2-TNG	33	8	47	15	N/A	14
1	OK-K351A	C351A	BRX2-TNG	38	6	47	15	39	2
20	OK-U106	CU106	BRX2-TNG	54	2	45	16	100	1
2	OK-K111A	C111A	BRX2-TNG	36	7	42	17	14	9
13	OK-U120	CU120	BRX2-TNG	28	9	29	18	7	13
11	OK-U295	CU295	BRX2-TNG	54	2	28	19	N/A	14
21	OK-U390	CU390	BRX2-TNG	N/A	12	N/A	20	11	11
16	OK-U233	CU233	BRX2-TNG	N/A	12	N/A	20	30	6

Reference Case

Case Number: OK-K191A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C191A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:06 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
20	OK-U106	CU106	BRX2-TNG	54	2	45	16	100	1
1	OK-K351A	C351A	BRX2-TNG	38	6	47	15	39	2
7	OK-K151A	C151A	BRX2-TNG	26	10	72	7	36	3
8	OK-K71A	C71A	BRX2-TNG	41	5	71	8	33	4
14	OK-U156	CU156	BRX2-TNG	36	7	55	13	32	5
16	OK-U233	CU233	BRX2-TNG	N/A	12	N/A	20	30	6
23	OK-U600	CU600	BRX2-TNG	100	1	85	4	24	7
10	OK-U354	CU354	BRX2-TNG	38	6	78	6	20	8
2	OK-K111A	C111A	BRX2-TNG	36	7	42	17	14	9
17	OK-U072	CU072	BRX2-TNG	21	11	65	10	13	10
21	OK-U390	CU390	BRX2-TNG	N/A	12	N/A	20	11	11
9	OK-K391B	C391B	BRX2-TNG	36	7	63	11	11	12
13	OK-U120	CU120	BRX2-TNG	28	9	29	18	7	13
22	OK-U042	CU042	BRX2-TNG	41	5	56	12	N/A	14
19	OK-U375	CU375	BRX2-TNG	38	6	85	4	N/A	14

Correlation Results Filtering

Reference Case

Case Number: OK-K191A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C191A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
18	OK-U385	CU385	BRX2-TNG	26	10	52	14	N/A	14
15	OK-U397	CU397	BRX2-TNG	51	3	92	3	N/A	14
12	OK-U174	CU174	BRX2-TNG	38	6	100	1	N/A	14
11	OK-U295	CU295	BRX2-TNG	54	2	28	19	N/A	14
6	OK-K231B	C231B	BRX2-TNG	46	4	84	5	N/A	14
5	OK-K31B	C31B	BRX2-TNG	21	11	97	2	N/A	14
4	OK-K311A	C311A	BRX2-TNG	28	9	68	9	N/A	14
3	OK-K271A	C271A	BRX2-TNG	33	8	47	15	N/A	14

IBIS MATCHPOINT+

Correlation Results Filtering

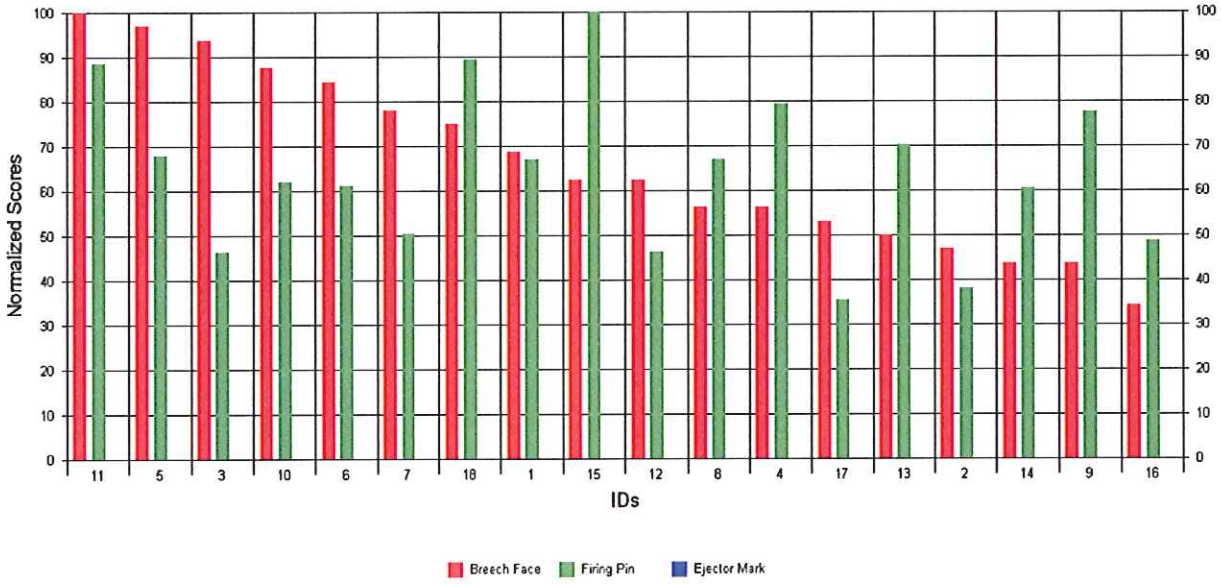
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K231B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C231B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:14 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
11	OK-U397	CU397	BRX2-TNG	100	1	88	3	N/A	0
5	OK-K151A	C151A	BRX2-TNG	97	2	68	7	N/A	0
3	OK-K271A	C271A	BRX2-TNG	94	3	46	14	N/A	0
10	OK-U174	CU174	BRX2-TNG	88	4	62	9	N/A	0
6	OK-K71A	C71A	BRX2-TNG	84	5	61	10	N/A	0
7	OK-K391B	C391B	BRX2-TNG	78	6	50	12	N/A	0
18	OK-U600	CU600	BRX2-TNG	75	7	89	2	N/A	0
1	OK-K351A	C351A	BRX2-TNG	69	8	67	8	N/A	0
15	OK-U375	CU375	BRX2-TNG	63	9	100	1	N/A	0
12	OK-U083	CU083	BRX2-TNG	63	9	46	14	N/A	0
8	OK-K191A	C191A	BRX2-TNG	56	10	67	8	N/A	0
4	OK-K31B	C31B	BRX2-TNG	56	10	79	4	N/A	0
17	OK-U042	CU042	BRX2-TNG	53	11	36	16	N/A	0
13	OK-U072	CU072	BRX2-TNG	50	12	70	6	N/A	0
2	OK-K111A	C111A	BRX2-TNG	47	13	38	15	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K231B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C231B

Sorted by: Breech Face (Normalized Scores)

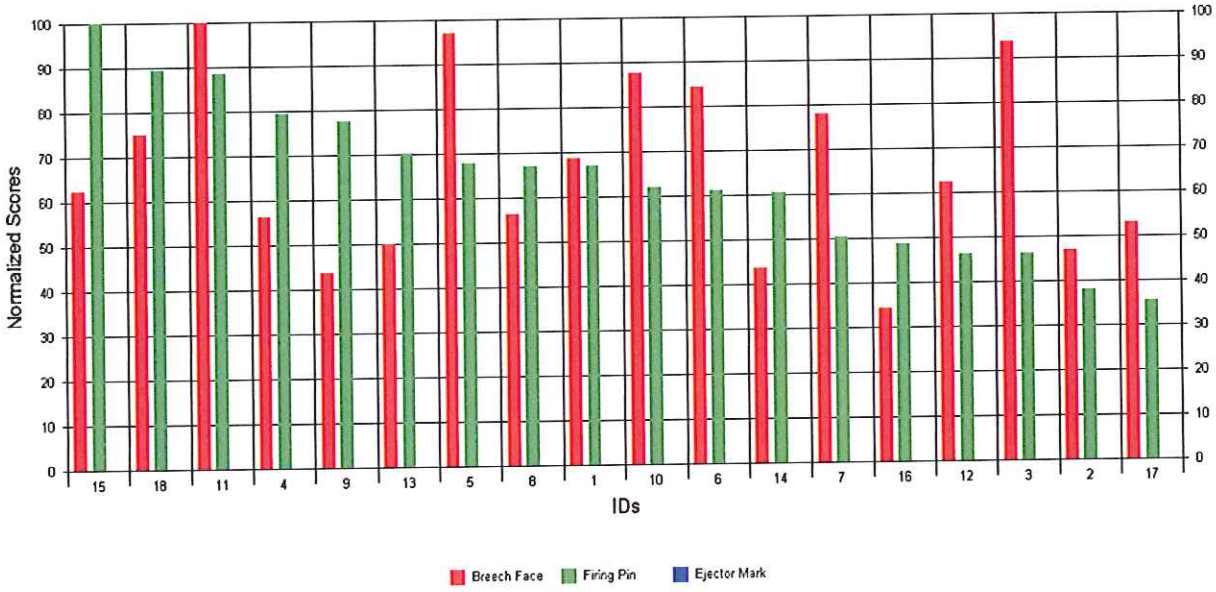
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
14	OK-U385	CU385	BRX2-TNG	44	14	60	11	N/A	0
9	OK-U354	CU354	BRX2-TNG	44	14	78	5	N/A	0
16	OK-U106	CU106	BRX2-TNG	34	15	49	13	N/A	0

Reference Case

Case Number: OK-K231B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C231B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



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Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
15	OK-U375	CU375	BRX2-TNG	63	9	100	1	N/A	0
18	OK-U600	CU600	BRX2-TNG	75	7	89	2	N/A	0
11	OK-U397	CU397	BRX2-TNG	100	1	88	3	N/A	0
4	OK-K31B	C31B	BRX2-TNG	56	10	79	4	N/A	0
9	OK-U354	CU354	BRX2-TNG	44	14	78	5	N/A	0
13	OK-U072	CU072	BRX2-TNG	50	12	70	6	N/A	0
5	OK-K151A	C151A	BRX2-TNG	97	2	68	7	N/A	0
8	OK-K191A	C191A	BRX2-TNG	56	10	67	8	N/A	0
1	OK-K351A	C351A	BRX2-TNG	69	8	67	8	N/A	0
10	OK-U174	CU174	BRX2-TNG	88	4	62	9	N/A	0
6	OK-K71A	C71A	BRX2-TNG	84	5	61	10	N/A	0
14	OK-U385	CU385	BRX2-TNG	44	14	60	11	N/A	0
7	OK-K391B	C391B	BRX2-TNG	78	6	50	12	N/A	0
16	OK-U106	CU106	BRX2-TNG	34	15	49	13	N/A	0
12	OK-U083	CU083	BRX2-TNG	63	9	46	14	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K231B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C231B

Sorted by: Firing Pin (Normalized Scores)

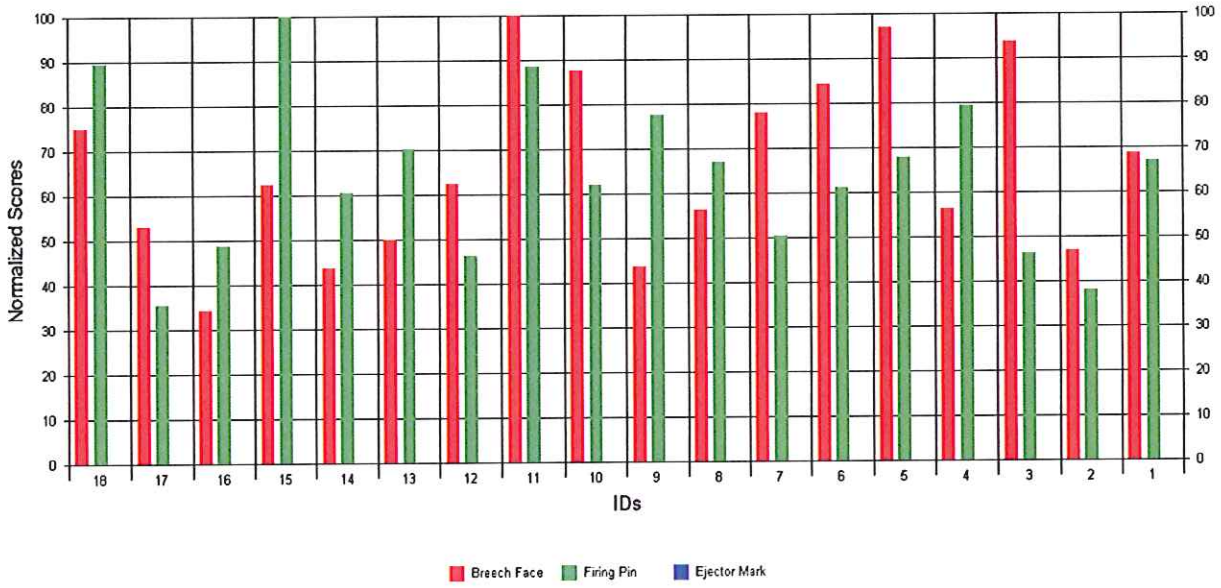
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
3	OK-K271A	C271A	BRX2-TNG	94	3	46	14	N/A	0
2	OK-K111A	C111A	BRX2-TNG	47	13	38	15	N/A	0
17	OK-U042	CU042	BRX2-TNG	53	11	36	16	N/A	0

Reference Case

Case Number: OK-K231B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C231B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



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Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
18	OK-U600	CU600	BRX2-TNG	75	7	89	2	N/A	0
17	OK-U042	CU042	BRX2-TNG	53	11	36	16	N/A	0
16	OK-U106	CU106	BRX2-TNG	34	15	49	13	N/A	0
15	OK-U375	CU375	BRX2-TNG	63	9	100	1	N/A	0
14	OK-U385	CU385	BRX2-TNG	44	14	60	11	N/A	0
13	OK-U072	CU072	BRX2-TNG	50	12	70	6	N/A	0
12	OK-U083	CU083	BRX2-TNG	63	9	46	14	N/A	0
11	OK-U397	CU397	BRX2-TNG	100	1	88	3	N/A	0
10	OK-U174	CU174	BRX2-TNG	88	4	62	9	N/A	0
9	OK-U354	CU354	BRX2-TNG	44	14	78	5	N/A	0
8	OK-K191A	C191A	BRX2-TNG	56	10	67	8	N/A	0
7	OK-K391B	C391B	BRX2-TNG	78	6	50	12	N/A	0
6	OK-K71A	C71A	BRX2-TNG	84	5	61	10	N/A	0
5	OK-K151A	C151A	BRX2-TNG	97	2	68	7	N/A	0
4	OK-K31B	C31B	BRX2-TNG	56	10	79	4	N/A	0

Reference Case

Case Number: OK-K231B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C231B

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
3	OK-K271A	C271A	BRX2-TNG	94	3	46	14	N/A	0
2	OK-K111A	C111A	BRX2-TNG	47	13	38	15	N/A	0
1	OK-K351A	C351A	BRX2-TNG	69	8	67	8	N/A	0

IBIS MATCHPOINT+

Correlation Results Filtering

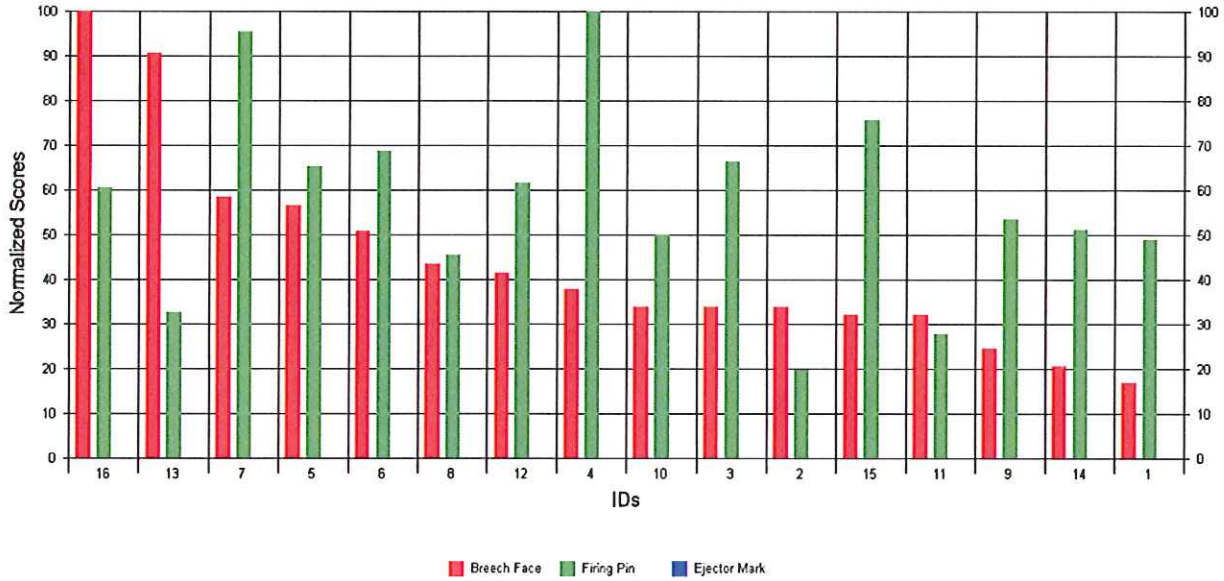
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K271A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C271A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



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Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
16	OK-U106	CU106	BRX2-TNG	100	1	60	8	N/A	0
13	OK-U083	CU083	BRX2-TNG	91	2	33	14	N/A	0
7	OK-K71A	C71A	BRX2-TNG	58	3	95	2	N/A	0
5	OK-K231B	C231B	BRX2-TNG	57	4	65	6	N/A	0
6	OK-K151A	C151A	BRX2-TNG	51	5	69	4	N/A	0
8	OK-K391B	C391B	BRX2-TNG	43	6	45	13	N/A	0
12	OK-U397	CU397	BRX2-TNG	42	7	62	7	N/A	0
4	OK-K31B	C31B	BRX2-TNG	38	8	100	1	N/A	0
10	OK-U174	CU174	BRX2-TNG	34	9	50	11	N/A	0
3	OK-K311A	C311A	BRX2-TNG	34	9	66	5	N/A	0
2	OK-K111A	C111A	BRX2-TNG	34	9	20	16	N/A	0
15	OK-U375	CU375	BRX2-TNG	32	10	76	3	N/A	0
11	OK-U156	CU156	BRX2-TNG	32	10	28	15	N/A	0
9	OK-K191A	C191A	BRX2-TNG	25	11	53	9	N/A	0
14	OK-U385	CU385	BRX2-TNG	21	12	51	10	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K271A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C271A

Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
1	OK-K351A	C351A	BRX2-TNG	17	13	49	12	N/A	0

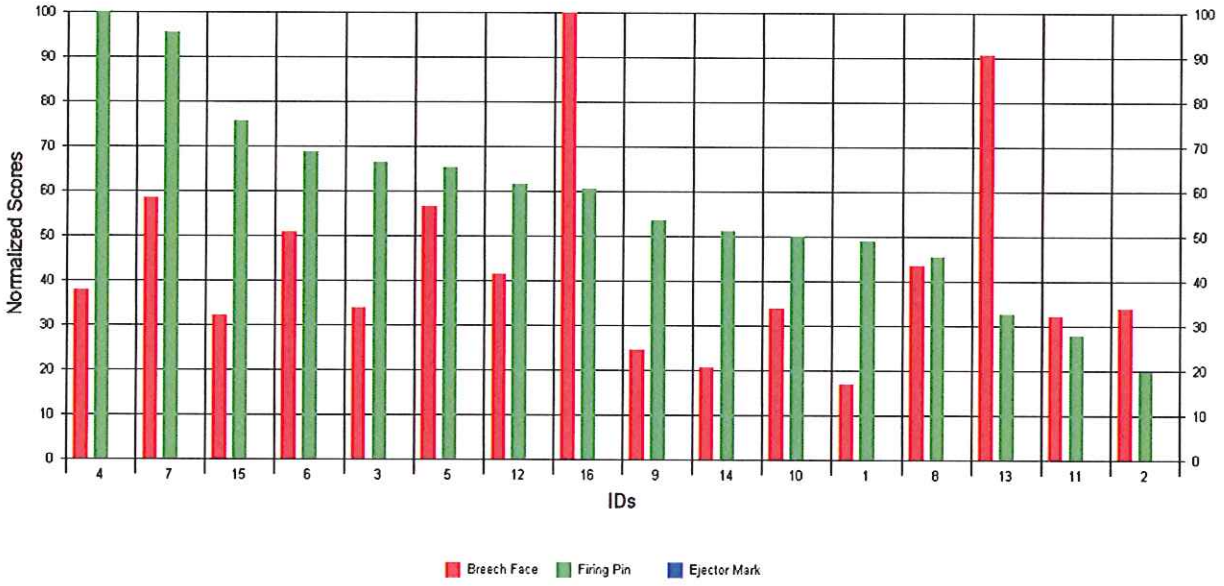
Correlation Results Filtering

Reference Case

Case Number: OK-K271A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C271A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:22 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
4	OK-K31B	C31B	BRX2-TNG	38	8	100	1	N/A	0
7	OK-K71A	C71A	BRX2-TNG	58	3	95	2	N/A	0
15	OK-U375	CU375	BRX2-TNG	32	10	76	3	N/A	0
6	OK-K151A	C151A	BRX2-TNG	51	5	69	4	N/A	0
3	OK-K311A	C311A	BRX2-TNG	34	9	66	5	N/A	0
5	OK-K231B	C231B	BRX2-TNG	57	4	65	6	N/A	0
12	OK-U397	CU397	BRX2-TNG	42	7	62	7	N/A	0
16	OK-U106	CU106	BRX2-TNG	100	1	60	8	N/A	0
9	OK-K191A	C191A	BRX2-TNG	25	11	53	9	N/A	0
14	OK-U385	CU385	BRX2-TNG	21	12	51	10	N/A	0
10	OK-U174	CU174	BRX2-TNG	34	9	50	11	N/A	0
1	OK-K351A	C351A	BRX2-TNG	17	13	49	12	N/A	0
8	OK-K391B	C391B	BRX2-TNG	43	6	45	13	N/A	0
13	OK-U083	CU083	BRX2-TNG	91	2	33	14	N/A	0
11	OK-U156	CU156	BRX2-TNG	32	10	28	15	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K271A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C271A

Sorted by: Firing Pin (Normalized Scores)

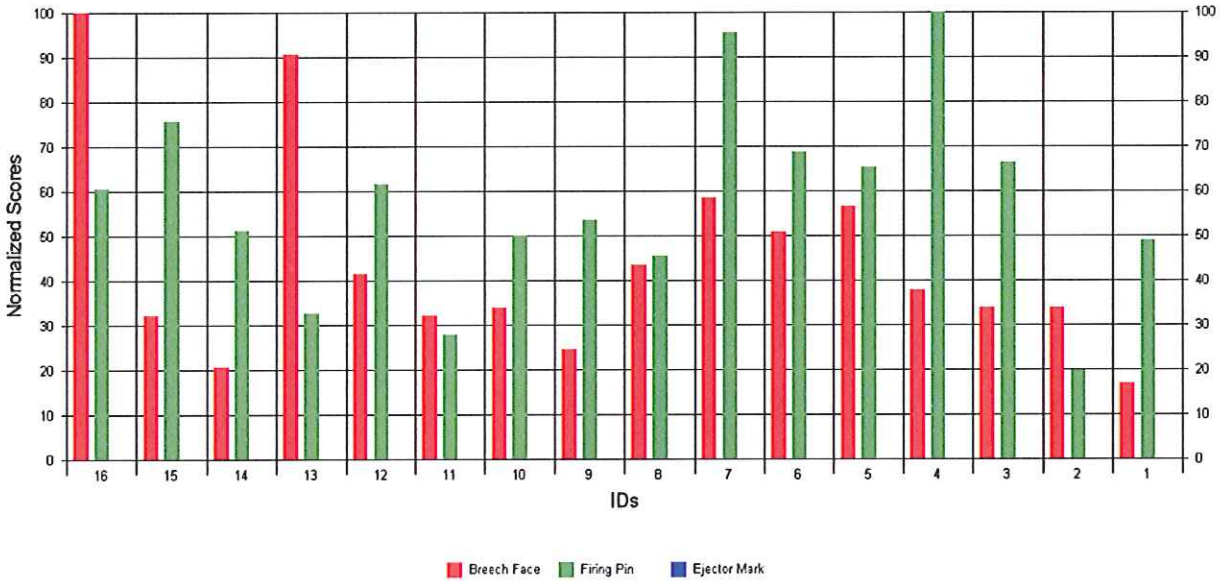
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
2	OK-K111A	C111A	BRX2-TNG	34	9	20	16	N/A	0

Reference Case

Case Number: OK-K271A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C271A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:22 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
16	OK-U106	CU106	BRX2-TNG	100	1	60	8	N/A	0
15	OK-U375	CU375	BRX2-TNG	32	10	76	3	N/A	0
14	OK-U385	CU385	BRX2-TNG	21	12	51	10	N/A	0
13	OK-U083	CU083	BRX2-TNG	91	2	33	14	N/A	0
12	OK-U397	CU397	BRX2-TNG	42	7	62	7	N/A	0
11	OK-U156	CU156	BRX2-TNG	32	10	28	15	N/A	0
10	OK-U174	CU174	BRX2-TNG	34	9	50	11	N/A	0
9	OK-K191A	C191A	BRX2-TNG	25	11	53	9	N/A	0
8	OK-K391B	C391B	BRX2-TNG	43	6	45	13	N/A	0
7	OK-K71A	C71A	BRX2-TNG	58	3	95	2	N/A	0
6	OK-K151A	C151A	BRX2-TNG	51	5	69	4	N/A	0
5	OK-K231B	C231B	BRX2-TNG	57	4	65	6	N/A	0
4	OK-K31B	C31B	BRX2-TNG	38	8	100	1	N/A	0
3	OK-K311A	C311A	BRX2-TNG	34	9	66	5	N/A	0
2	OK-K111A	C111A	BRX2-TNG	34	9	20	16	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K271A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C271A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
1	OK-K351A	C351A	BRX2-TNG	17	13	49	12	N/A	0

IBIS MATCHPOINT+

Correlation Results Filtering

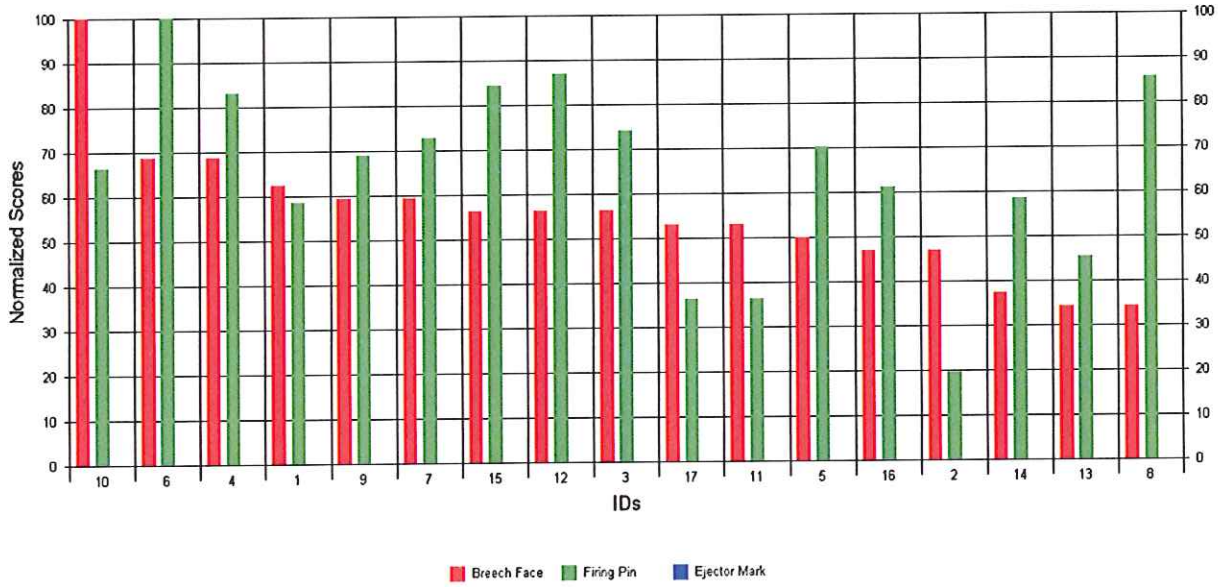
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K311A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C311A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:31 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
10	OK-U174	CU174	BRX2-TNG	100	1	66	10	N/A	0
6	OK-K71A	C71A	BRX2-TNG	69	2	100	1	N/A	0
4	OK-K31B	C31B	BRX2-TNG	69	2	83	5	N/A	0
1	OK-K351A	C351A	BRX2-TNG	63	3	58	12	N/A	0
9	OK-U354	CU354	BRX2-TNG	59	4	69	9	N/A	0
7	OK-K391B	C391B	BRX2-TNG	59	4	73	7	N/A	0
15	OK-U375	CU375	BRX2-TNG	56	5	84	4	N/A	0
12	OK-U397	CU397	BRX2-TNG	56	5	87	2	N/A	0
3	OK-K271A	C271A	BRX2-TNG	56	5	74	6	N/A	0
17	OK-U042	CU042	BRX2-TNG	53	6	36	14	N/A	0
11	OK-U156	CU156	BRX2-TNG	53	6	36	14	N/A	0
5	OK-K151A	C151A	BRX2-TNG	50	7	70	8	N/A	0
16	OK-U106	CU106	BRX2-TNG	47	8	61	11	N/A	0
2	OK-K111A	C111A	BRX2-TNG	47	8	19	15	N/A	0
14	OK-U385	CU385	BRX2-TNG	38	9	58	12	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K311A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C311A

Sorted by: Breech Face (Normalized Scores)

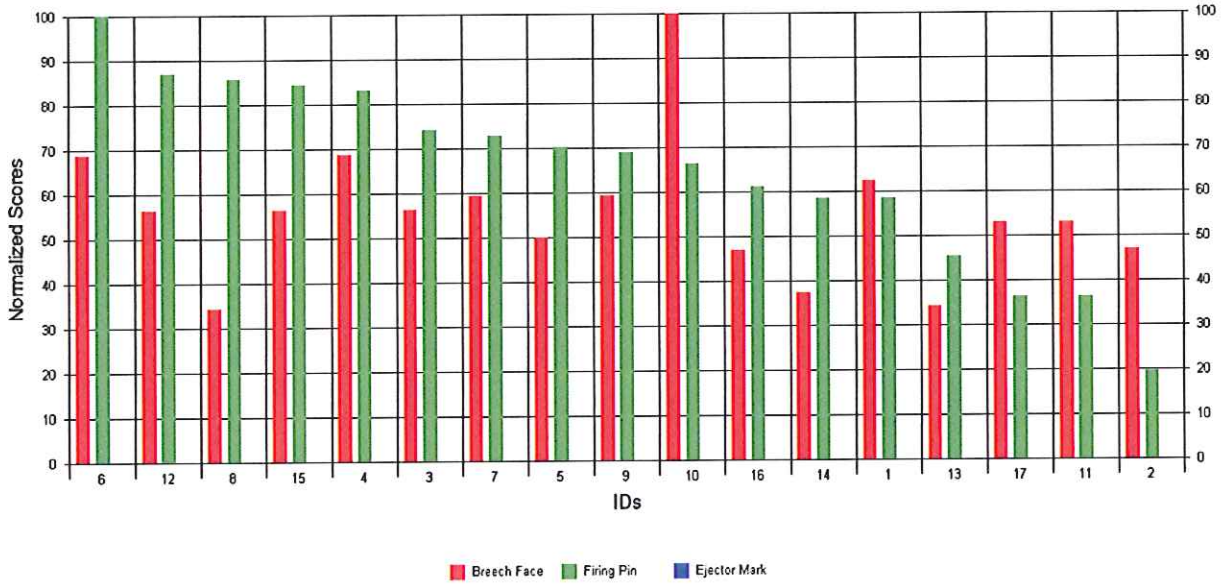
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
13	OK-U072	CU072	BRX2-TNG	34	10	45	13	N/A	0
8	OK-K191A	C191A	BRX2-TNG	34	10	86	3	N/A	0

Reference Case

Case Number: OK-K311A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C311A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



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Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
6	OK-K71A	C71A	BRX2-TNG	69	2	100	1	N/A	0
12	OK-U397	CU397	BRX2-TNG	56	5	87	2	N/A	0
8	OK-K191A	C191A	BRX2-TNG	34	10	86	3	N/A	0
15	OK-U375	CU375	BRX2-TNG	56	5	84	4	N/A	0
4	OK-K31B	C31B	BRX2-TNG	69	2	83	5	N/A	0
3	OK-K271A	C271A	BRX2-TNG	56	5	74	6	N/A	0
7	OK-K391B	C391B	BRX2-TNG	59	4	73	7	N/A	0
5	OK-K151A	C151A	BRX2-TNG	50	7	70	8	N/A	0
9	OK-U354	CU354	BRX2-TNG	59	4	69	9	N/A	0
10	OK-U174	CU174	BRX2-TNG	100	1	66	10	N/A	0
16	OK-U106	CU106	BRX2-TNG	47	8	61	11	N/A	0
14	OK-U385	CU385	BRX2-TNG	38	9	58	12	N/A	0
1	OK-K351A	C351A	BRX2-TNG	63	3	58	12	N/A	0
13	OK-U072	CU072	BRX2-TNG	34	10	45	13	N/A	0
17	OK-U042	CU042	BRX2-TNG	53	6	36	14	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K311A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C311A

Sorted by: Firing Pin (Normalized Scores)

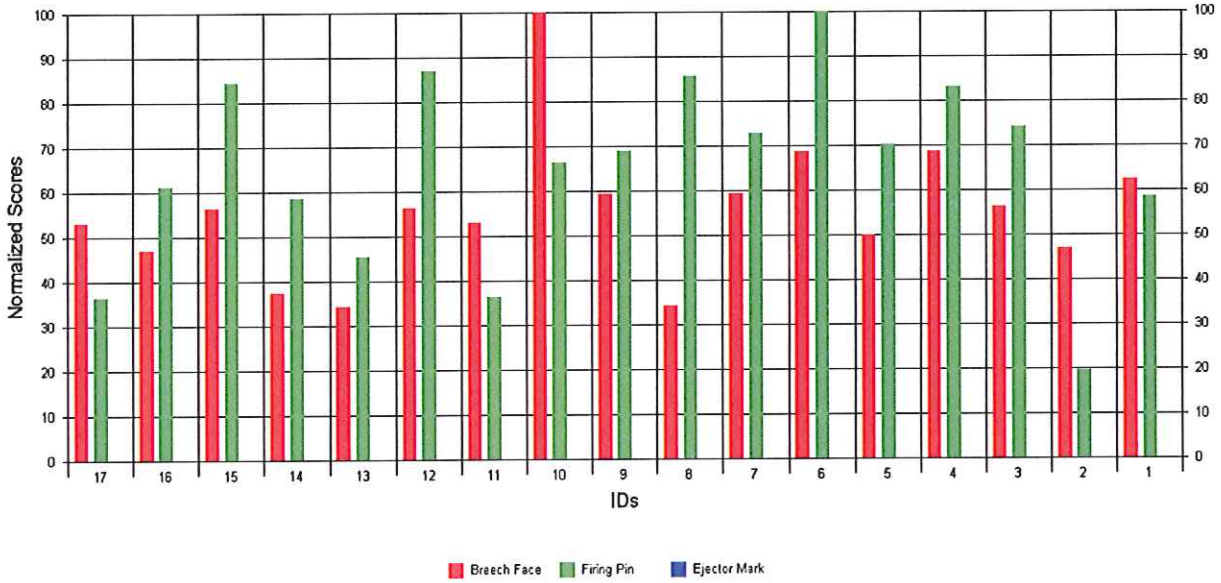
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
11	OK-U156	CU156	BRX2-TNG	53	6	36	14	N/A	0
2	OK-K111A	C111A	BRX2-TNG	47	8	19	15	N/A	0

Reference Case

Case Number: OK-K311A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C311A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:31 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
17	OK-U042	CU042	BRX2-TNG	53	6	36	14	N/A	0
16	OK-U106	CU106	BRX2-TNG	47	8	61	11	N/A	0
15	OK-U375	CU375	BRX2-TNG	56	5	84	4	N/A	0
14	OK-U385	CU385	BRX2-TNG	38	9	58	12	N/A	0
13	OK-U072	CU072	BRX2-TNG	34	10	45	13	N/A	0
12	OK-U397	CU397	BRX2-TNG	56	5	87	2	N/A	0
11	OK-U156	CU156	BRX2-TNG	53	6	36	14	N/A	0
10	OK-U174	CU174	BRX2-TNG	100	1	66	10	N/A	0
9	OK-U354	CU354	BRX2-TNG	59	4	69	9	N/A	0
8	OK-K191A	C191A	BRX2-TNG	34	10	86	3	N/A	0
7	OK-K391B	C391B	BRX2-TNG	59	4	73	7	N/A	0
6	OK-K71A	C71A	BRX2-TNG	69	2	100	1	N/A	0
5	OK-K151A	C151A	BRX2-TNG	50	7	70	8	N/A	0
4	OK-K31B	C31B	BRX2-TNG	69	2	83	5	N/A	0
3	OK-K271A	C271A	BRX2-TNG	56	5	74	6	N/A	0

Correlation Results Filtering

Reference Case

Case Number: OK-K311A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C311A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
2	OK-K111A	C111A	BRX2-TNG	47	8	19	15	N/A	0
1	OK-K351A	C351A	BRX2-TNG	63	3	58	12	N/A	0

IBIS MATCHPOINT+

Correlation Results Filtering

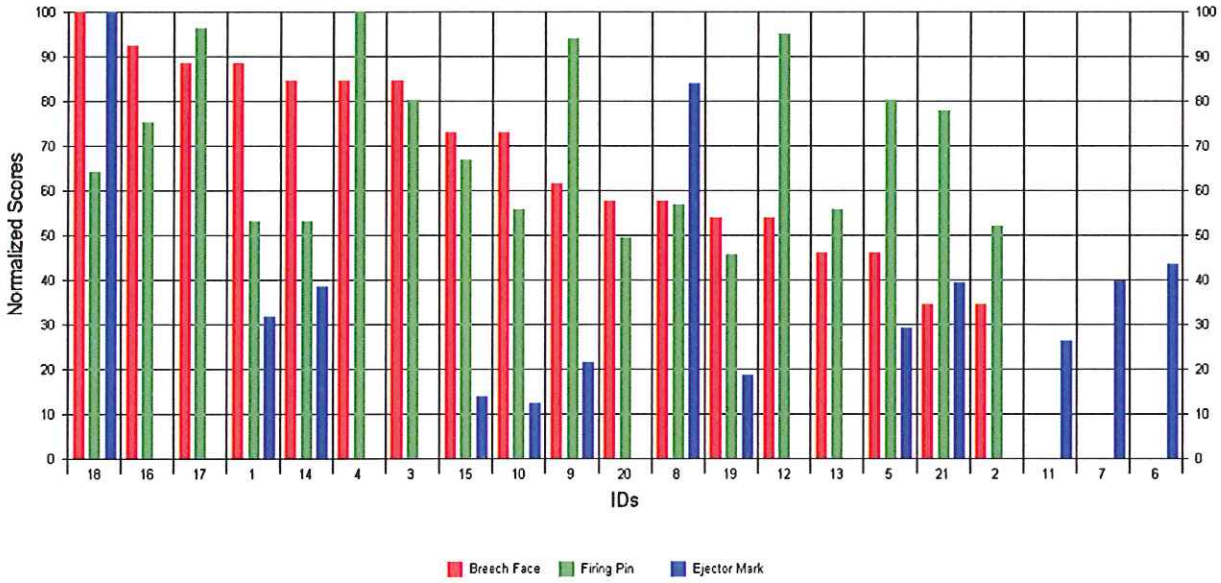
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K351A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C351A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:48 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
18	OK-U106	CU106	BRX2-TNG	100	1	64	9	100	1
16	OK-U385	CU385	BRX2-TNG	92	2	75	7	N/A	14
17	OK-U375	CU375	BRX2-TNG	88	3	96	2	N/A	14
1	OK-K111A	C111A	BRX2-TNG	88	3	53	12	32	7
14	OK-U233	CU233	BRX2-TNG	85	4	53	12	39	6
4	OK-K231B	C231B	BRX2-TNG	85	4	100	1	N/A	14
3	OK-K31B	C31B	BRX2-TNG	85	4	80	5	N/A	14
15	OK-U072	CU072	BRX2-TNG	73	5	67	8	14	12
10	OK-U120	CU120	BRX2-TNG	73	5	56	11	12	13
9	OK-U354	CU354	BRX2-TNG	62	6	94	4	21	10
20	OK-U042	CU042	BRX2-TNG	58	7	49	14	N/A	14
8	OK-K191A	C191A	BRX2-TNG	58	7	57	10	84	2
19	OK-U390	CU390	BRX2-TNG	54	8	46	15	19	11
12	OK-U397	CU397	BRX2-TNG	54	8	95	3	N/A	14
13	OK-U083	CU083	BRX2-TNG	46	9	56	11	N/A	14

Reference Case

Case Number: OK-K351A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C351A

Sorted by: Breech Face (Normalized Scores)

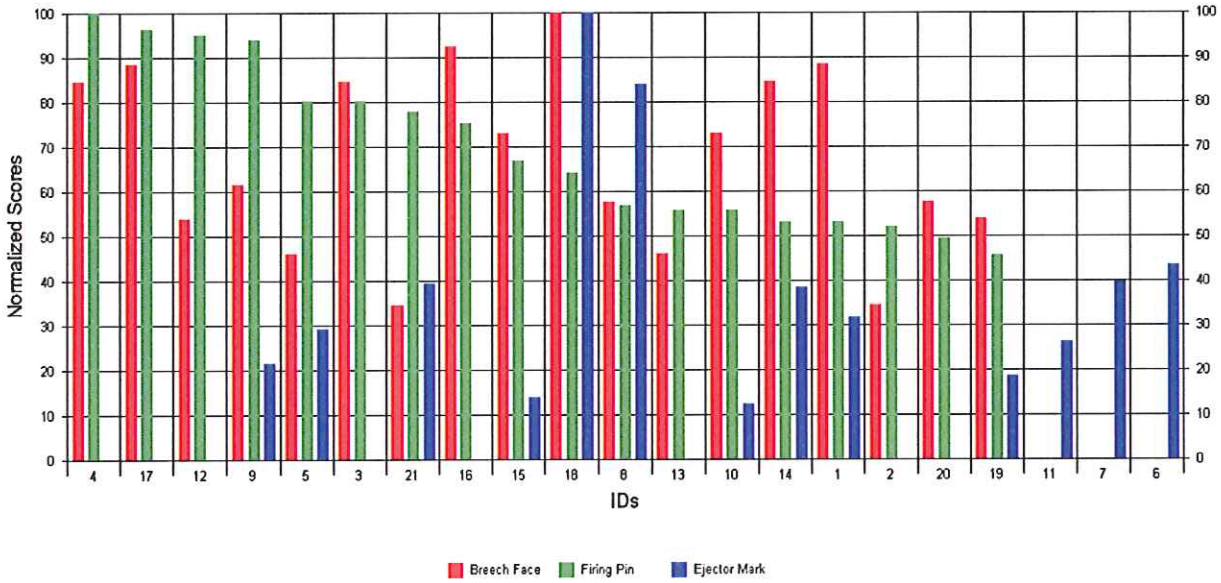
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
5	OK-K151A	C151A	BRX2-TNG	46	9	80	5	29	8
21	OK-U600	CU600	BRX2-TNG	35	10	78	6	39	5
2	OK-K271A	C271A	BRX2-TNG	35	10	52	13	N/A	14
11	OK-U156	CU156	BRX2-TNG	N/A	11	N/A	16	26	9
7	OK-K391B	C391B	BRX2-TNG	N/A	11	N/A	16	40	4
6	OK-K71A	C71A	BRX2-TNG	N/A	11	N/A	16	43	3

Reference Case

Case Number: OK-K351A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C351A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:48 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
4	OK-K231B	C231B	BRX2-TNG	85	4	100	1	N/A	14
17	OK-U375	CU375	BRX2-TNG	88	3	96	2	N/A	14
12	OK-U397	CU397	BRX2-TNG	54	8	95	3	N/A	14
9	OK-U354	CU354	BRX2-TNG	62	6	94	4	21	10
5	OK-K151A	C151A	BRX2-TNG	46	9	80	5	29	8
3	OK-K31B	C31B	BRX2-TNG	85	4	80	5	N/A	14
21	OK-U600	CU600	BRX2-TNG	35	10	78	6	39	5
16	OK-U385	CU385	BRX2-TNG	92	2	75	7	N/A	14
15	OK-U072	CU072	BRX2-TNG	73	5	67	8	14	12
18	OK-U106	CU106	BRX2-TNG	100	1	64	9	100	1
8	OK-K191A	C191A	BRX2-TNG	58	7	57	10	84	2
13	OK-U083	CU083	BRX2-TNG	46	9	56	11	N/A	14
10	OK-U120	CU120	BRX2-TNG	73	5	56	11	12	13
14	OK-U233	CU233	BRX2-TNG	85	4	53	12	39	6
1	OK-K111A	C111A	BRX2-TNG	88	3	53	12	32	7

Reference Case

Case Number: OK-K351A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C351A

Sorted by: Firing Pin (Normalized Scores)

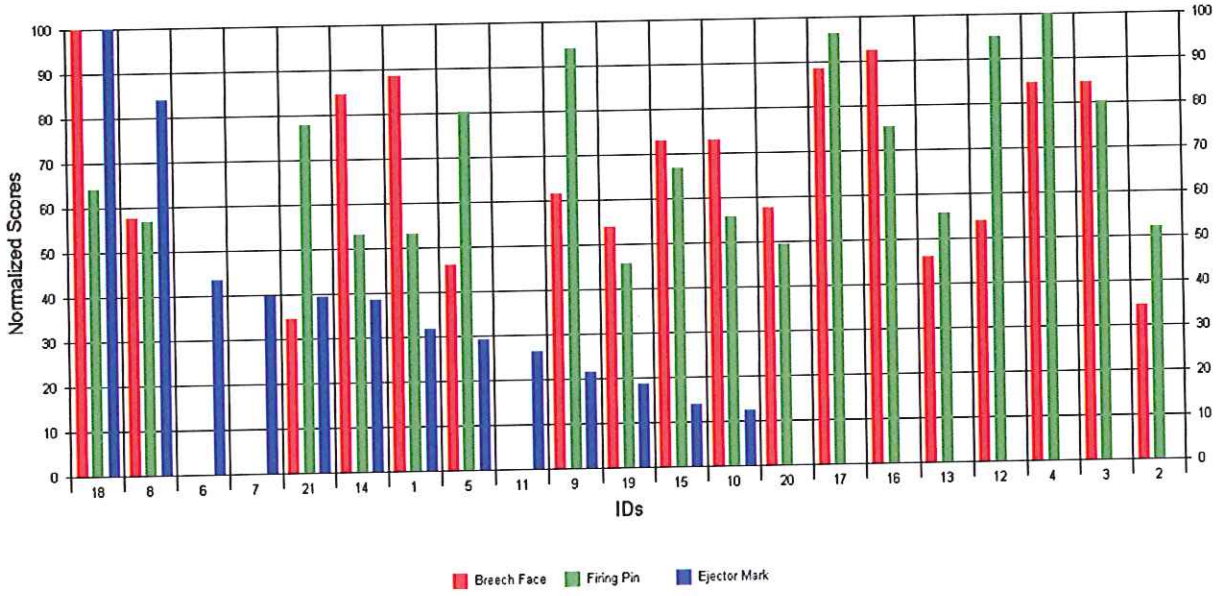
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
2	OK-K271A	C271A	BRX2-TNG	35	10	52	13	N/A	14
20	OK-U042	CU042	BRX2-TNG	58	7	49	14	N/A	14
19	OK-U390	CU390	BRX2-TNG	54	8	46	15	19	11
11	OK-U156	CU156	BRX2-TNG	N/A	11	N/A	16	26	9
7	OK-K391B	C391B	BRX2-TNG	N/A	11	N/A	16	40	4
6	OK-K71A	C71A	BRX2-TNG	N/A	11	N/A	16	43	3

Reference Case

Case Number: OK-K351A
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C351A
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:48 PM
Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
18	OK-U106	CU106	BRX2-TNG	100	1	64	9	100	1
8	OK-K191A	C191A	BRX2-TNG	58	7	57	10	84	2
6	OK-K71A	C71A	BRX2-TNG	N/A	11	N/A	16	43	3
7	OK-K391B	C391B	BRX2-TNG	N/A	11	N/A	16	40	4
21	OK-U600	CU600	BRX2-TNG	35	10	78	6	39	5
14	OK-U233	CU233	BRX2-TNG	85	4	53	12	39	6
1	OK-K111A	C111A	BRX2-TNG	88	3	53	12	32	7
5	OK-K151A	C151A	BRX2-TNG	46	9	80	5	29	8
11	OK-U156	CU156	BRX2-TNG	N/A	11	N/A	16	26	9
9	OK-U354	CU354	BRX2-TNG	62	6	94	4	21	10
19	OK-U390	CU390	BRX2-TNG	54	8	46	15	19	11
15	OK-U072	CU072	BRX2-TNG	73	5	67	8	14	12
10	OK-U120	CU120	BRX2-TNG	73	5	56	11	12	13
20	OK-U042	CU042	BRX2-TNG	58	7	49	14	N/A	14
17	OK-U375	CU375	BRX2-TNG	88	3	96	2	N/A	14

Correlation Results Filtering

Reference Case

Case Number: OK-K351A
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C351A

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
16	OK-U385	CU385	BRX2-TNG	92	2	75	7	N/A	14
13	OK-U083	CU083	BRX2-TNG	46	9	56	11	N/A	14
12	OK-U397	CU397	BRX2-TNG	54	8	95	3	N/A	14
4	OK-K231B	C231B	BRX2-TNG	85	4	100	1	N/A	14
3	OK-K31B	C31B	BRX2-TNG	85	4	80	5	N/A	14
2	OK-K271A	C271A	BRX2-TNG	35	10	52	13	N/A	14

IBIS MATCHPOINT+

Correlation Results Filtering

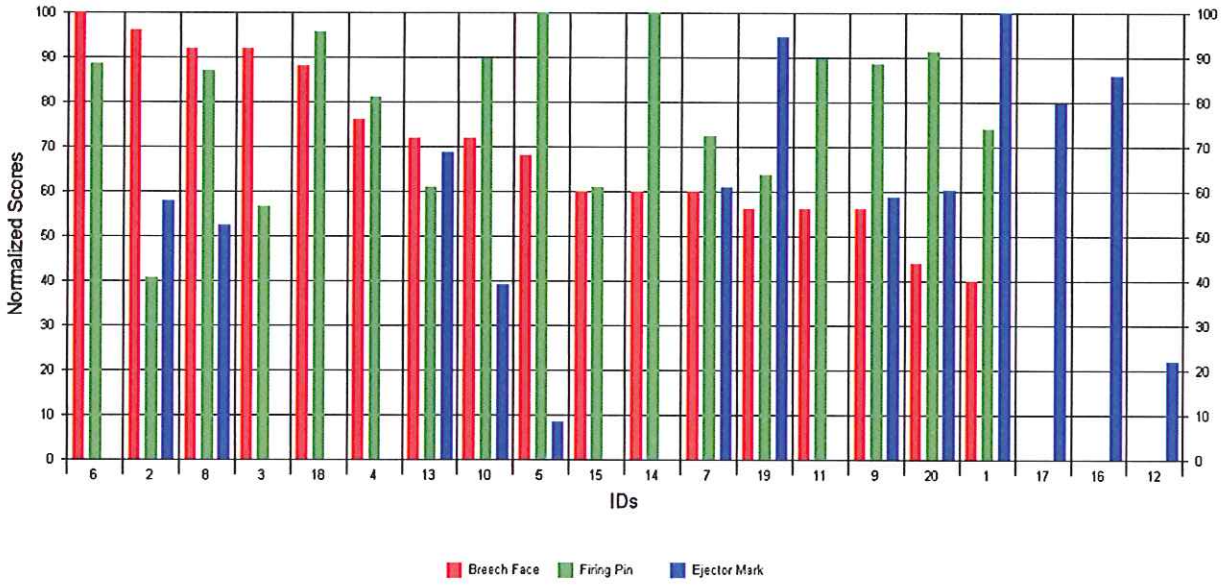
FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K391B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C391B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:56 PM
Sorted by: Breech Face (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
6	OK-K231B	C231B	BRX2-TNG	100	1	88	5	N/A	14
2	OK-K111A	C111A	BRX2-TNG	96	2	41	13	58	9
8	OK-K71A	C71A	BRX2-TNG	92	3	87	6	52	10
3	OK-K271A	C271A	BRX2-TNG	92	3	57	12	N/A	14
18	OK-U375	CU375	BRX2-TNG	88	4	96	2	N/A	14
4	OK-K311A	C311A	BRX2-TNG	76	5	81	7	N/A	14
13	OK-U156	CU156	BRX2-TNG	72	6	61	11	69	5
10	OK-U354	CU354	BRX2-TNG	72	6	90	4	39	11
5	OK-K31B	C31B	BRX2-TNG	68	7	100	1	9	13
15	OK-U083	CU083	BRX2-TNG	60	8	61	11	N/A	14
14	OK-U397	CU397	BRX2-TNG	60	8	100	1	N/A	14
7	OK-K151A	C151A	BRX2-TNG	60	8	72	9	61	6
19	OK-U106	CU106	BRX2-TNG	56	9	64	10	95	2
11	OK-U174	CU174	BRX2-TNG	56	9	90	4	N/A	14
9	OK-K191A	C191A	BRX2-TNG	56	9	88	5	59	8

Reference Case

Case Number: OK-K391B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C391B

Sorted by: Breech Face (Normalized Scores)

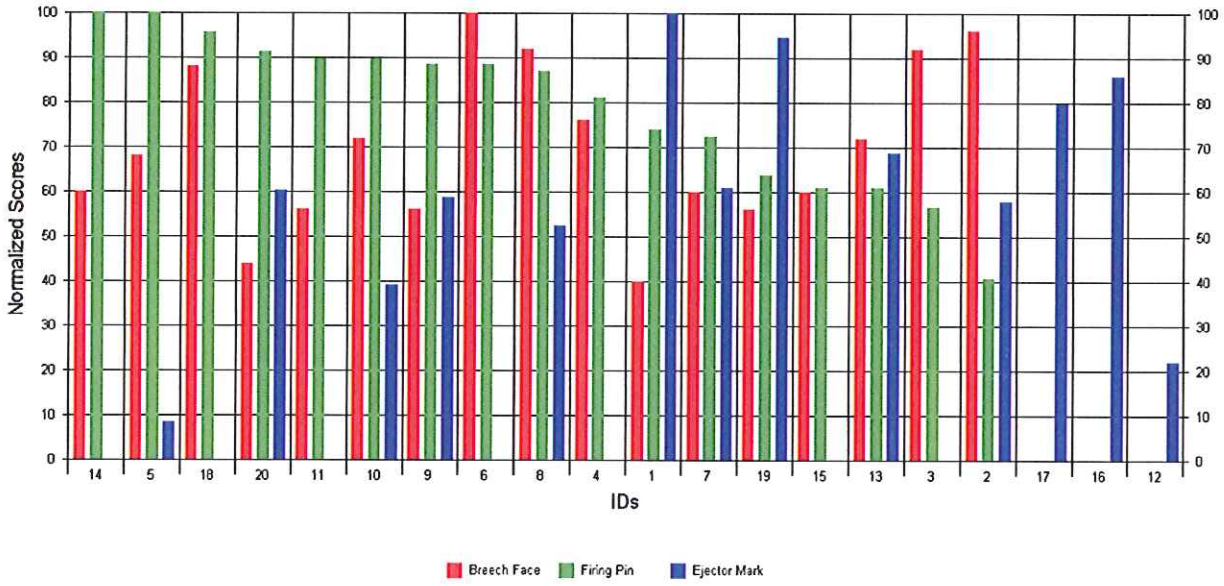
ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
20	OK-U600	CU600	BRX2-TNG	44	10	91	3	60	7
1	OK-K351A	C351A	BRX2-TNG	40	11	74	8	100	1
17	OK-U072	CU072	BRX2-TNG	N/A	12	N/A	14	80	4
16	OK-U233	CU233	BRX2-TNG	N/A	12	N/A	14	86	3
12	OK-U120	CU120	BRX2-TNG	N/A	12	N/A	14	22	12

Reference Case

Case Number: OK-K391B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C391B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



Request Creation Date: 1/25/2013 2:46:56 PM
Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
14	OK-U397	CU397	BRX2-TNG	60	8	100	1	N/A	14
5	OK-K31B	C31B	BRX2-TNG	68	7	100	1	9	13
18	OK-U375	CU375	BRX2-TNG	88	4	96	2	N/A	14
20	OK-U600	CU600	BRX2-TNG	44	10	91	3	60	7
11	OK-U174	CU174	BRX2-TNG	56	9	90	4	N/A	14
10	OK-U354	CU354	BRX2-TNG	72	6	90	4	39	11
9	OK-K191A	C191A	BRX2-TNG	56	9	88	5	59	8
6	OK-K231B	C231B	BRX2-TNG	100	1	88	5	N/A	14
8	OK-K71A	C71A	BRX2-TNG	92	3	87	6	52	10
4	OK-K311A	C311A	BRX2-TNG	76	5	81	7	N/A	14
1	OK-K351A	C351A	BRX2-TNG	40	11	74	8	100	1
7	OK-K151A	C151A	BRX2-TNG	60	8	72	9	61	6
19	OK-U106	CU106	BRX2-TNG	56	9	64	10	95	2
15	OK-U083	CU083	BRX2-TNG	60	8	61	11	N/A	14
13	OK-U156	CU156	BRX2-TNG	72	6	61	11	69	5

Reference Case

Case Number: OK-K391B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C391B

Sorted by: Firing Pin (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
3	OK-K271A	C271A	BRX2-TNG	92	3	57	12	N/A	14
2	OK-K111A	C111A	BRX2-TNG	96	2	41	13	58	9
17	OK-U072	CU072	BRX2-TNG	N/A	12	N/A	14	80	4
16	OK-U233	CU233	BRX2-TNG	N/A	12	N/A	14	86	3
12	OK-U120	CU120	BRX2-TNG	N/A	12	N/A	14	22	12

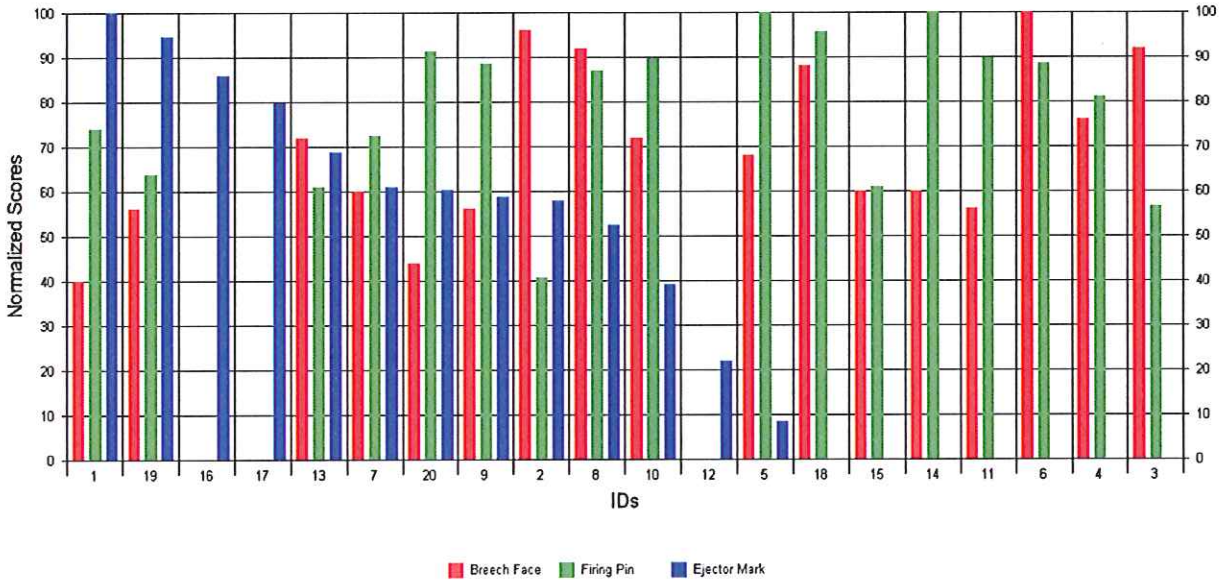
Correlation Results Filtering

Reference Case

Case Number: OK-K391B
Site Name: BRX2-TNG
Law Agency: (Unknown LAW Agency)
Event Type: Other
Comments: Ruger LCP Study

Reference Exhibit

Exhibit Number: C391B
Caliber: 380 Auto
Last Acq. By: demo
Event Type: Other
Comments:



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Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
1	OK-K351A	C351A	BRX2-TNG	40	11	74	8	100	1
19	OK-U106	CU106	BRX2-TNG	56	9	64	10	95	2
16	OK-U233	CU233	BRX2-TNG	N/A	12	N/A	14	86	3
17	OK-U072	CU072	BRX2-TNG	N/A	12	N/A	14	80	4
13	OK-U156	CU156	BRX2-TNG	72	6	61	11	69	5
7	OK-K151A	C151A	BRX2-TNG	60	8	72	9	61	6
20	OK-U600	CU600	BRX2-TNG	44	10	91	3	60	7
9	OK-K191A	C191A	BRX2-TNG	56	9	88	5	59	8
2	OK-K111A	C111A	BRX2-TNG	96	2	41	13	58	9
8	OK-K71A	C71A	BRX2-TNG	92	3	87	6	52	10
10	OK-U354	CU354	BRX2-TNG	72	6	90	4	39	11
12	OK-U120	CU120	BRX2-TNG	N/A	12	N/A	14	22	12
5	OK-K31B	C31B	BRX2-TNG	68	7	100	1	9	13
18	OK-U375	CU375	BRX2-TNG	88	4	96	2	N/A	14
15	OK-U083	CU083	BRX2-TNG	60	8	61	11	N/A	14

IBIS MATCHPOINT+

Correlation Results Filtering

FORENSIC TECHNOLOGY

Reference Case

Case Number: OK-K391B
Site Name: BRX2-TNG

Reference Exhibit

Exhibit Number: C391B

Sorted by: Ejector Mark (Normalized Scores)

ID	Test Exhibit			Breech Face		Firing Pin		Ejector	
	Case	Exhibit	Site	Score	Rank	Score	Rank	Score	Rank
14	OK-U397	CU397	BRX2-TNG	60	8	100	1	N/A	14
11	OK-U174	CU174	BRX2-TNG	56	9	90	4	N/A	14
6	OK-K231B	C231B	BRX2-TNG	100	1	88	5	N/A	14
4	OK-K311A	C311A	BRX2-TNG	76	5	81	7	N/A	14
3	OK-K271A	C271A	BRX2-TNG	92	3	57	12	N/A	14