

Case Report

Identifying the Shoe Model Based on its Impression in Blood Led to Finding DNA on the Shoe Upper

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Abstract: In 2019, a double murder was committed in Jerusalem. The forensics department recorded evidence at the scene, including eight bloody footwear impressions. To help identify possible suspects, the footwear impressions were submitted to the authors' laboratory to see whether they could identify the shoe model. The laboratory identified the outsoles as having been made by Hi Tec. The case investigators used this information to search for a lead, but were unsuccessful. A year later, the footwear expert discovered a shoe made by Nabel Inc. that was consistent in outsole design to that of the Hi Tec brand previously identified. Three years later, a suspect in another murder case was arrested. Relying on information obtained regarding the Nabel shoe model, the investigators found a pair of Nabel boots stained with blood from one of the 2019 double murder victims in the suspect's mother's house. These boots became central evidence against the suspect.

Background

Footwear impressions are a key type of forensic evidence. In Israel, crime scene footwear impressions are documented by the crime scene investigators, who are members of the Forensics Division of the Israel Police. Bloody footwear impressions are

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particularly valuable because blood can connect a suspect's footwear to the crime. The laboratory guidelines require crime scene investigators to first take forensic photographs of such impressions, to chemically enhance the impressions, and then to photograph them again [1].

In crime scenes with suspects, the laboratory is asked to compare suspects' footwear with the impressions recorded at the scene. In other circumstances, when no suspect had been identified, the laboratory is asked to identify the footwear model as a means of advancing the investigation. In such cases, the laboratory experts may use the internet's publicly available search engines to assist in finding the model of footwear that made the impression. If the footwear model is identified, it is listed in the final report noting explicitly that the actual footwear might be of a similar model. This provision is included because many shoe manufacturers use similar outsole designs on different models, outsole manufacturers supply the same outsole to different shoe companies, and there are identical (or almost identical) counterfeits on the market of well-known brands [2].

There are several software programs available for identifying footwear outsoles. Some countries maintain and periodically update footwear outsole collections, and these can be used to identify footwear models from footwear impressions. There is also an automated software program that allows the investigators to locate similar models from other crime scenes [3, 4]. The authors currently use a semi-automated program that they developed in-house that allows a footwear expert to configure a template using elements that are present in the suspect impression to identify similar models from other crime scenes. With this program, it is simple to code the visible elements of a shoe outsole or a footwear impression to search for similar models from previously investigated crimes [5].

The Case

In January 2019, a couple was murdered in their home in Jerusalem. The suspect entered the house while the female victim was asleep and the male victim had gone to get some bags from his car. The suspect stabbed the sleeping female multiple times, then hid until an opportunity arose to stab the male, resulting in his subsequent death. One of their children arrived at the apartment the following day and found both parents dead.

There was adequate forensic evidence at the scene (e.g., many fingerprints, DNA samples from multiple locations, and eight footwear impressions). The fingerprints and DNA failed to lead to any suspect. The police questioned many suspects, including the couple's family, but made no headway. The couple's occupation led the investigators to suspect that the murder was related to a financial or legacy dispute. The investigation unit then asked the laboratory experts to identify the shoe model by the footwear impression photos. The experts identified a group of elements in the shoeprint that are typical of work or hiking boots, including elements resembling the letter V, a notched square, and a circle (Figure 1). This narrowed down the search to work and hiking boots. Boots made by Blundstone (Moonah, Tasmania), Redback (Alexandria, New South Wales), Salomon (Épagny-Metz-Tessy, France), Lowa (Jetzendorf, Germany), and Hi Tec (Amsterdam, Netherlands) were searched. The search



Figure 1

Elements in the shoeprint that are typical of work and hiking boots:
(a) elements resembling the letter "V"; (b) a notched square; and (c) a circle.

resulted in finding the Altitude IV WP boot by Hi Tec, which resembled the footwear impression from the crime scene. The investigators searched for leads using this additional information, but were unsuccessful. The laboratory experts continued searching for similar footwear impressions from other crime scenes. A year later, while searching for examples to present in a professional lecture, the footwear impression expert noticed an outsole with the same group of elements described above. It resembled a Hi Tec model, but was made by Nabel Inc. (Hebron, Israel)—an imitation manufactured in Nablus. Further analysis by the experts confirmed that the footwear impressions from the 2019 crime scene were more consistent with the Nabel outsole than with the previously mentioned Hi Tech model (Figure 2). This information was passed to the investigating unit. They discovered that the shoes came from a factory located in areas under Palestinian Authority jurisdiction. The investigation continued, but with little progress.

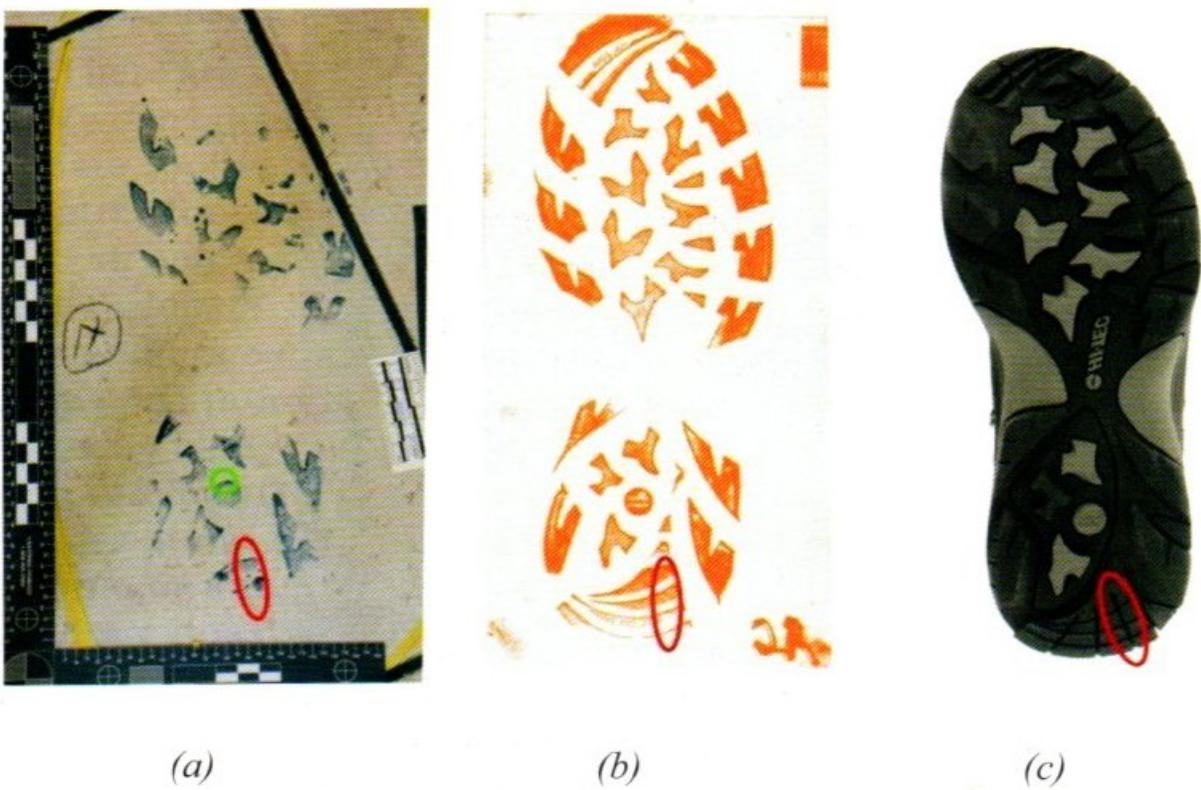


Figure 2

Footwear impressions: (a) from the crime scene; (b) test impression made from a Nabel boot; (c) actual Hi Tec sole.

The red circles mark the location of the groove in the Hi Tec boot. The green circle indicates manufacturing bubbles.

In 2022, three years into the original investigation, a murder and attempted murder of two men in Jerusalem, not far from the home of the male and female murder victims, occurred. Border police patrolmen on duty in the area at the time stopped a person, searched his bag, and found a bloodied knife. The investigators who questioned the suspect noted a similar mode of operation to the 2019 crime and suspected the two crimes could be connected. They challenged the suspect with this information, and he confessed to the 2019 murder of the couple in Jerusalem. The investigators went to the suspect's home hoping to find evidence that would tie him to the couple's murder scene. Because they now knew what model of shoes to look for, they searched and found a pair of Nabel boots in a closet in the suspect's mother's house. They sent the boots to the Institute of Forensic Medicine, and the analysis revealed a substance suspected to be blood. Preliminary tests of the stains on the boots were positive for blood, and the DNA extracted from the stains matched one of the persons murdered in 2019. Next, the boots were sent to the Toolmarks and Materials Laboratory to compare with the crime scene footwear impressions. Because the seized boots had barely been worn, there were few randomly acquired characteristics. The comparison between them and the footwear impression easily showed a match in model, size, and several manufacturing flaws, sufficient to establish a match in class characteristics. On questioning the suspect, the investigators found that he had been arrested for other offences a few days after the 2019 murder and had been under detention until one month before the 2022 murder. Consequently, he had not worn the Nabel boots during that time.

Methods

Identifying the footwear model from an outsole impression requires a different skill set than comparing two known outsoles. An outsole can be matched with an impression by superimposing one over the other. The expert creates test impressions of the shoe [6]. The impressions and the test impressions are scanned by TrasoScan (Laboratory Imaging, Praha, Czechia) and compared using an image processing software program (LUCIA Forensic, Laboratory Imaging). Next, the expert places the test impression over the corresponding area of the crime scene impression and determines whether the model, size, and degree of wear match. If they do, the next step is to check whether any randomly acquired characteristics (RACs) in the impression match similar markings on the outsole.

Model identification is performed using a side-by-side method: Here, the expert examines the crime scene impression alongside the known outsole. As part of the examination, the expert compares the impression with known outsoles submitted in the case and with common models available on the internet. The expert uses features of the impression to establish a possible style of footwear (e.g., hiking boots, sports shoes, flip-flops). When identifying potential footwear models, the geometric elements on the outsoles play an important part. The expert must maintain a collection of common elements featured on outsole models and also specify explicitly in the ensuing report that, although the geometric elements are consistent, there could be other outsole models that carry the same features.

Storing the knowledge about outsole features can help identify the make and model faster, which can benefit the investigation units.

In the present case, the shoe features (size and shape of outsole design) were consistent with a hiking boot. Together with a clear separation between the front and the heel, the search led to a Hi Tec boot.

Two years later, the footwear expert found another model with similar outsole and tread design and again performed a side-by-side comparison. The lab also checked for differences between Nabel and Hi Tec outsoles.

The investigation unit also purchased three pairs of Nabel boots in three sizes (8, 8.5, 9.5); the investigation unit believed that size information could give the investigation some direction about the perpetrator's identity.

When the suspect was arrested, the laboratory personnel compared the footwear impression that had been collected with the suspect's footwear found in his mother's home.

Results

The results of an internet search showed that the shoeprint from the crime scene resembled the outsole of a Hi Tec boot. Later, a similarity to a model of Nabel boots emerged, also. The lab found two differences between the Hi Tec sole and the Nabel sole: (1) The Nabel boots had manufacturing flaws whereas the Hi Tec boots had none, and (2) there was a groove in an element of the heel in the Hi Tec outsole, but this was absent in the Nabel outsole. The impression photographed at the crime scene lacked the groove that was visible in the Hi Tec boot (Figure 1).

An examination of the Nabel sizing showed that the crime scene impression was a better match for sizes 8.5 and 9.5.

The authors were asked to compare the suspect's Nabel boots found at his mother's house to the impressions on record from the crime scene. The comparison showed that the outsole of the boots matched the crime scene impressions in model and size, and the manufacturing flaws on the boots were consistent with those seen in the footwear impressions. There were no RACs or signs of wear on the suspect's boots, because they had not been worn for long.

Upon examination, the suspect's boots showed stains suspected to be blood. The stains were analyzed and the lab was able to extract DNA from them that matched the DNA of one of the 2019 victims.

Discussion and Conclusions

Footwear impressions are a key forensic tool, and recording these impressions at crime scenes is an important part of forensic evidence collection. This case highlights the importance of the additional actions that can be performed to advance a case investigation: finding the shoe outsole make and model may have advanced the case investigation and eventually linked the suspect with the murder scene. This is doubly important when there is a long gap in time between the crime and the apprehension of a suspect.

Forensic intelligence is a multidisciplinary specialty. This case demonstrates that primary information about footwear is meaningful to the extent that it can advance an investigation even when there is no suspect. Information about footwear make and model can provide investigators with alternative directions of investigation by informing them about place of manufacture, points of sale, unique footwear, and small-scale or specialized manufacturers. Shoe size can hint at the gender or height of the person who left the shoeprint.

At the same time, primary information given to the investigation unit about a footwear model has its limitations. In the present case, initially the suspected footwear was assumed to be a certain model, but this turned out to be incorrect. Such misidentifications are the result of one manufacturer using the same outsole on several of its models, but also of different manufacturers using similar outsoles.

Currently, when asked to identify a footwear model, the authors rely mainly on internet searches for types of footwear and outsole elements. In addition to this, the authors have developed a software tool, also based on outsole elements, that cross references crime scenes by impressions left at the scene. The same software is used to identify a footwear model based on a categorized collection of models that have been classified by an established set of elements [3]. The authors believe that enlarging this collection by analyzing and adding photos of more outsoles will contribute to being able to provide a better and faster response. It will also improve the ability to identify different footwear models bearing similar elements, thereby opening more directions of investigation to the investigation units.

In the present case, discarding the initially assumed shoe model and understanding that the focus should be a small-scale manufacturer allowed the investigation to change direction and focus its efforts on a specific region. When an impression is matched with a specific outsole model, it is important to check whether other models match the impression, as well, and to explicitly tell the investigators that there could be other outsoles with similar sole or tread design.

When a suspect is caught, it is important to establish which model of footwear left its impression at the scene. In the present case, identifying the footwear model drove the investigation unit to continue searching for the suspect's shoes in his mother's home (where they had been stored for three years while he was in detention for other offences).

This case exemplifies the role footwear expertise can play beyond suspect comparisons. The footwear expert can offer the investigation unit information about the size and model of footwear that had been present at the crime scene. The expert's experience and familiarity with many types and models of footwear outsoles can contribute to investigations even in the absence of a suspect. This case also emphasizes the value of having a well-maintained knowledge base of footwear outsoles as developed by the authors.

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