The Effects of Concealment Methods on the Visibility of Defining Shoe Print and Impression Characteristics

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Abstract: Forensic science is a continuously expanding field that incorporates the analysis of a multitude of variables in shoeprint and impression analysis. Footwear evidence is currently considered as evidence in crime scene investigations conducted by forensic experts. This research explores the differences in characteristic points on shoe impressions when additional material is added to the shoe. In this experiment, three groups of results involving the effects of a plastic bag, an elastic shoe cover comprised of nylon, or duct tape are considered. The impressions and footprints were documented in photographic results that are compared to impressions without added material. The data was analyzed through the observation of changes in the visibility in ten minutiae points of characteristics chosen before the beginning of the research. The results show that a nylon shoe cover has the smallest number of visible minutiae that correlates shoe impressions and prints that produces the most observable change in their visibility.

Key Words: *shoe impression, shoeprint, randomly acquired marks, concealment*

Forensic science applies a multitude of techniques from various branches of physical science to examine and document evidence. Among the new fields of study being further developed is shoe impression and print analysis. Within the specialty of forensic impression analysis, many categories of information can be concluded, such as determining the shoe length, size, brand, or style. The ability to determine these indicators of a specific make of shoe in a crime scene has been impeded due to a lack of complete shoe prints or impressions, but recent research has continued developing approaches to make conclusions from partial shoe prints and impressions. New technology to capture this evidence and methods to reduce the probability of producing inaccurate results when quantifying data are important to solidify these shoeprints as evidence. Regression analyses created from the two furthest visible points on partial shoeprints have reduced the average error related to the visibility of partial shoeprints (Zhang et al. 2020). This allows the concept of receiving accurate information from obscured shoeprints or impressions to be considered during criminal investigations when the probability of error could possibly declare the evidence as inadmissible. The Electrostatic Dust Print Lifter is an example of technology used to develop impressions

while reducing dust residue on surfaces. This technology can document higher quality prints for further review than the Electrostatic detection Apparatus that produced less accurate shoeprints (Craig et al. 2006). 3D scanners have become an available option for documenting both impressions and prints that do not result in the degradation of evidence from the production of an impression cast or documentation of a shoe print (Liao et al. 2020). Both instances of improvements in the technology available display the ability to more accurately document impressions and prints while reducing the chance of producing only partial evidence. Yet, these resources were tested on impressions and prints that were made unimpeded by other variables. The positive identifications made between two shoes are based off the ability to detect random individual characteristics that are visible on each shoe to result in a match of the physical shoe soles (Bodziak 2013). Randomly acquired marks or accidental marks are markings made that affect the shoeprint measure the rarity of a comparison between an impression found at a crime scene and an impression retrieved from a suspect. These characteristics can produce a probability on the rarity of finding the same combination of randomly acquired marks in the general population (Damary et al. 2018). The probability of matching characteristics decreases when only partial prints and impressions are considered. Soil substrates formed of sand can produce an adequate amount of randomly acquired marks in impressions made in a medium of sand to produce an identification with another impression (Snyder 2015). However, the materials that can affect the production of these impressions and prints could be a resource used to aid forensic examiners in identifying other areas of footwear evidence to link an individual to a crime scene. Wear or addition of other materials specific to the evidence can reduce the number of shoes in the general population capable of making the shoe print being investigated. The evaluation of these marks or characteristics in coordination allows forensic experts to match a suspect as a person at a scene when a positive match was not viable before. By analyzing the effect of characteristic, or minutiae, marks of impressions and prints, we can better analyze these types of evidence in the future.

Materials and Methods

The experiment procedure was split into three trials: documentation of the original shoe sole, the effect of concealment methods on shoe impressions in sand, and the effect of concealment methods in shoeprints created with acrylic paint. Concealment methods are for the purpose of this experiment defined as any material that can alter the visibility of a shoe impression or print. The three concealment methods for this experiment were a plastic grocery bag (Walmart, Bentonville, Arkansas), a nylon elastic shoe cover (Lowe's, Mooresville, North Carolina), and duct tape (Duck Tape, Avon, Ohio). The first trial photographically documented the sole of the shoe to be used in all further trials after this point in time. The second trial documents the changes in the visibility of a shoe impression in a medium of sand as each concealment method is applied. The sand was held in a metal tray that was deep enough to cast an impression in the sand without

reaching the bottom and disrupting the image. Water was then added to the metal tray in increments until the sand was able to hold its shape. The sand substrate was formed of grains that were fine rather than coarse. The sand was compressed into an undisturbed surface before the next steps of the experiment were performed. A new tray was used for the control group and each method of concealment that was tested. Each impression made by the same shoe was photographically documented after the completion. In the final trials, black acrylic paint (Plaid Enterprises, Peachtree Corners, Georgia) was poured into a metal tray to evenly coat the bottom of the shoe. This produced a series of black and white shoeprints that specific minutiae points of characteristics could later be determined following the curvature of the shoe (Wei et al. 2014). A control group was created first through three prints with no additional materials covering the sole of the shoe. The shoe prints were created by placing the sole of the shoe on white paper to create prints using acrylic paint. The same three groups of concealment methods used in the first trial were repeated in the trials of producing effected shoeprints. Each group created three copies of shoeprints that were labeled in the upper right corner and left to dry for 24 hours. The shoeprints were photographically documented in the same manner as the impressions and control groups. The photographic data was then reviewed and analyzed after the completion of the experiment.

Results

The experiment produced both qualitative and quantitative results. The first trial photographically documented ten minutiae points to match in further impressions and prints later in the experiment as seen in Fig. 1.

Fig. 1. The original shoe sole with ten chosen points of minutiae displaying areas of randomly acquired marks

The number of visible points of minutiae or randomly acquired marks that differentiate with the addition of concealment method materials made during trial two are described in Tab. 1. The group with the nylon shoe cover added onto the sole of the shoe displayed the highest number of non-visible areas. The comparison between the control group impression and the impression made with the nylon shoe cover is represented in Fig. 2 and Fig. 3

Tab. 1. Categorized minutiae points of differing concealment methods on shoe impressions

	Original	Plastic Bag	Nylon Shoe Cover	Duct Tape
Visible Minutiae Points	10	3	0	4
Non-Visible Minutiae Points	0	7	10	6

Fig. 2. Impression with no added materials used as a control group in trial two. Ten minutiae points are visible.

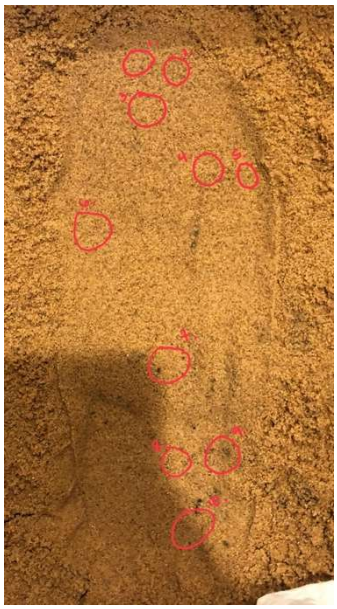

Fig. 3 Impression with nylon shoe covering added in trial two. No minutiae points are visible.

The concealment method using a nylon shoe cover had the lowest number of visible marks of minutiae that were modeled in the control group in Fig. 2. The number of randomly acquired marks present in shoeprints are cataloged in Table 2 that displays, similarly to the trials involving shoe impressions, the nylon shoe cover as producing the largest number of non-visible areas in shoeprints. The comparison between the control group shoeprint and the shoeprint made with the nylon shoe cover is contrasted in Fig. 4 and Fig. 5.

The concealment method using a nylon shoe cover produced similar results to the second trial by having the lowest number of visible marks of minutiae. There were no displayed visual similarities between the original shoeprint in Fig. 4 and the shoeprint impeded by a nylon shoe cover in Fig. 5.

Tab. 2. Categorized Minutiae Points of Shoeprints with Differing Concealment Methods in

	Original	Plastic Bag	Nylon Shoe Cover	Duct Tape
Visible Minutiae Points	10	6	0	7
Non-Visible Minutiae Points	0	4	10	3

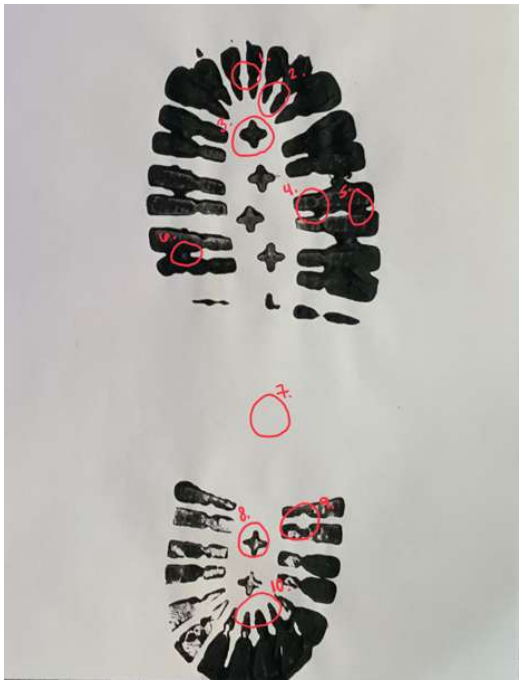

Fig. 4 Original shoeprint with no concealment method added in trial three. Ten minutiae points visible.

Fig. 5 Shoeprint with nylon shoe cover used as the concealment method added in trial three. No minutiae point visible.

Discussion

The results of the experiment show the shoe impressions and prints made with a nylon shoe have the lowest number of visible points that show characteristics specific to the tread of the shoe. The type of shoe concealment method that the largest difference in the number of visible accidental marks between the control group had the largest effect on casting shoeprints and impressions. The activities within the experiment observing differing shoeprints and impressions produced similar results in the number and pattern of visible points of characteristics. In both areas of the study the nylon shoe cover produced the least amount of visible randomly acquired marks that could be used to identify a match with the control group impression and shoeprint. Both trials then display that the addition of a plastic bag and then duct tape is the order in which the visible accidental marks increase to identify footwear evidence. The shoe impressions and prints created with the use of duct tape

produced the clearest footprints with the largest number of identifiable points in both trials, while the use of the nylon shoe cover created an obscured shoe impression and print. The comparison of randomly acquired marks allow the pattern of two shoe prints or impressions to be compared and reduces the prospects of having this category of forensic evidence be declared inadmissible (Petraco et al. 2010). With the use of a statistical algorithm, such as the Statistical Evaluation of Shoeprint Accidentals (SESA), randomly acquired marks can be compared to information of other accidental marks in a database to produce a score of rarity that can assist in the conclusion and credibility of a forensic (Wiesner et al. 2020). The ability to declare a match between multiple pieces of footwear evidence is based on the assessment of numerous variables, such as the quantity of randomly acquired marks and the intricacy of the pattern of these marks, that creates the probability of another piece of footwear matching in the general population (Stone 2015). When examining partial prints and impressions in footwear analysis, the scores and probabilities forensic experts consider to accurately declare findings decrease with the number of visible randomly acquired marks and the complexity of the configuration of these marks decreases as well. The identification of materials or resources used to conceal footwear can be used in combination with the statistical probability of declaring a match to produce results that are still considered admissible within the legal system. The ability to quantify the effect of elements that obscure shoeprints and impressions can be factored into regressions that can calculate information based on partial evidence to increase the reliability and statistical accuracy of results produced by forensic examiners.

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