Rom J Leg Med [29] 65-68 [2021]
DOI: 10.4323/rjlm.2021.65

FORENSIC TEXTILE DAMAGE ANALYSIS: PRACTICAL ISSUES AND METHODOLOGICAL PERSPECTIVES

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Abstract: Clothing damage analysis is an important tool for forensic investigations and, even it is a niche field, it is gaining interest. Moreover, the attention is shifting from evaluating just the "biological" traces found on the clothes to the modifications that clothes themselves undergo in the context of a specific traumatic dynamic. The Authors analyze a case of the investigation on a hole in the jacket worn by the victim when he was attacked, performed through optical microscope and morphological and elemental SEM/EDX analysis, to determine the origin of this texture damage to verify a witness story.

Keywords: SEM/EDX, textile damage, microscopy.

INTRODUCTION

Clothing damage analysis is an important tool for forensic investigations [1, 2]. Among the many fields of application studied, the comparison between the clothing damage with the injuries on the body in case of trauma death and the analysis of evidence (such as blood, seminal, vaginal and other body secretions) found on clothes can provide useful informations. In case of a firearm related death, the gunshot residues on clothing are essential to evaluate the fire distance and to identify the ammunition [3]. More than that, the study of the features of the textile damage is important in order to understand better the dynamic of an event or verify a witness story. The authors report a case study of a homicide in which the analysis of textile damage was fundamental in the reconstruction of the criminal event.

CASE REPORT

Case History

During an investigation on a case of homicide, a key element in the crime scene reconstruction was represented by a hole in the jacket worn by the victim when he was attacked. No injury on the corpse corresponded to that hole. So, it was fundamental to determine the origin of this texture damage in order to verify the witness story. The item analyzed was a black jacket in good condition. The hole was located on a strip of knitted synthetic fiber on the lower, right side of the jacket (Fig. 1 A-D) and we performed a Gunshot Residues (GSR) analysis and an analysis of the characteristics of the hole through an analytical and a morphological one, using a Scanning Electron Microscope in conjunction with energy dispersive X-ray spectroscopy (SEM/EDX).

Analysis of the GSR

A GSR sample was taken using a ½ inch rigid, bi-adhesive carbon stub, lifting existing particles from around the hole [4]. The sample was observed and analyzed using a FEI, Quanta 400TM SEM microscope, able to operate on high or low vacuum modes (up to 1.3x10-3 atm) and an Environmental Scanning Electron Microscope (ESEM) (up to 2.6x10-2 atm),

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equipped with a Backscattered Electron Detector (BSED) and Silicon Lithium (SiLi) X-ray Detector, with a Super UltraThinWindow (SUTW). Technical and instrumental analysis on the stubs used for sampling showed some particles which, according to composition, size and morphology, may be considered typical of GSR. Some other particles were also detected which, due to morphology and elemental composition, may be compatible with, though not typical of, gunshot. However, their presence is further evidence of the nature of the above mentioned typical particles.

Morphological Analysis

The first step of the study was represented by an examination using a stereo zoom photo microscope. Then, the portion of fabric surrounding the hole has been cut and observed using a FEI, Quanta 400TM SEM microscope. As a case control, a sample of fabric from the same jacket from a not injured area was employed (Fig. 1 E). The procedure was carried out in 3 steps: 1) sampling of a portion of the fabric taken from a part of the jacket near the hole examined; 2) shooting test on the sample obtained using cartridges of the same brand, type and caliber as those used in the crime investigated, from a distance of about 50 cm (this distance was calculated by reconstructing trajectory and dynamics of the event); 3) the textile damage caused during the shooting test was studied and compared with the evidence taken from the crime. The textile sample used for the shooting test was studied through electronic microscopy. We reported the same characteristics in the hole documented in the jacket at the crime scene and in that we produced in the study sample. The morphological features of the textile fibers reported in both the samples could be described as: a) curled fibers and filaments; b) split-head fibers with a deformed, more or less pronounced bulb; c) fibers fused and/or joined together (Figs 2 and 3).

DISCUSSION

Clothing damage analysis is an important tool for forensic investigations and, even it is a niche field, it is gaining interest [1]. Moreover, the attention is shifting

Figure 1. Hole through the elastic fabric of the jacket, front view (A,C), internal view (B, D). Macroscopic aspect of the control sample from a different part of the jacket (E).

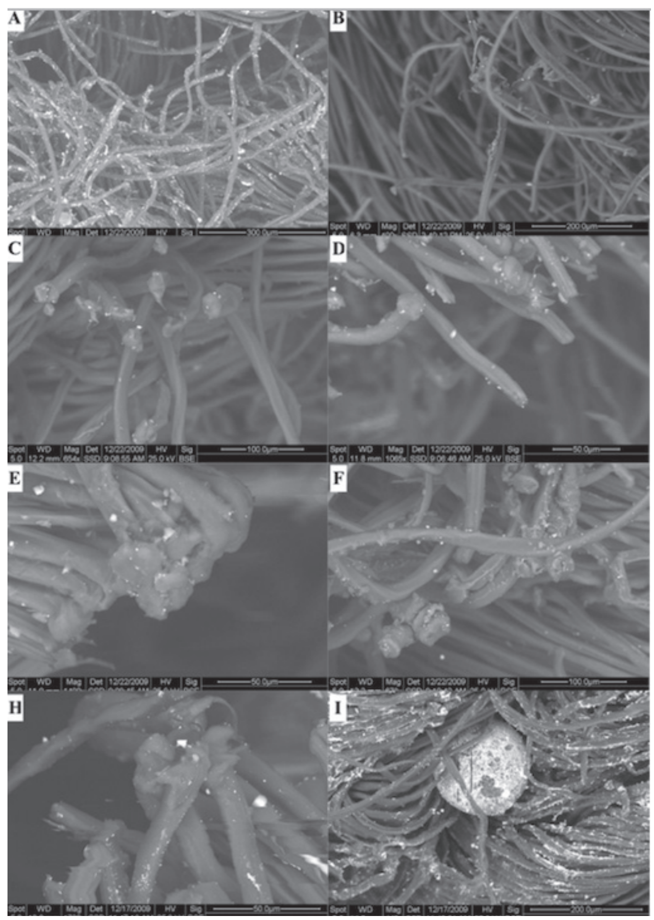

Figure 2. Case control, different features of the textile fibers around the hole A) curled fibers; BCD) dam-aged fibers; E) fibers joined together; F) Fibers fused; G) GSR in the textile fabric.

from evaluating just the "biological" traces found on the clothes to the modifications that clothes themselves undergo in the context of a specific traumatic dynamic. Most of the published studies about clothing damage mainly focused on damages produced by sharp force [5,6]. Kemp *et al.* studied the features of textile damage caused during stabbing in order to identify the blade type and size. They highlighted that blades could be differentiated and directionality estimated by observing differences in severance shape and size, the degree of fabric distortion, the position of severed yarn ends, loop snippets, curled yarns, planar array and the morphology of fractured fibres [6]. Daeid *et al.* analyzed both the clothing damage and the corresponding skin injury reporting a significant difference between the length of a wound on the skin and the above clothing damage when it was stretched over the skin, on the contrary, there was not a statistically significant difference when the fabric was loose over the skin [5]. Blunt trauma can determine three types of clothing damage: (1) fiber/yarn flattening, (2) fiber fracture and (3) holes [7]. Daroux *et al.* studied the effect of laundering on blunt force impact damage in fabrics reporting that laundering after the impact

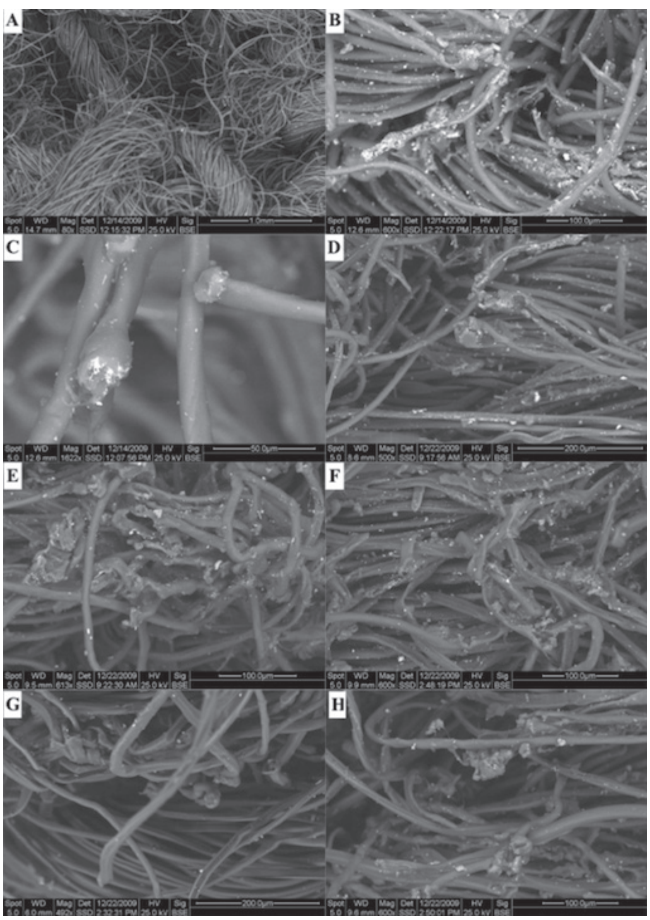

Figure 3. Evidence, different features of the textile fibers around the hole.

event altered the visible and microscopic damage and can produce holes in some specimens [7]. Regarding clothing damages related to gunshot bullet, Hinrichs *et al.* studied the modifications of cotton and polyester textiles due to shots fired at short range were analyzed with a variable pressure SEM reporting identifying different mechanisms of fiber rupture as a function of fiber type and shooting distance were detected, namely fusing, melting, scorching, and mechanical breakage [8]. In the case of our observation, the correct etiological diagnosis of some lesions on clothing is necessary and technologies help investigators to reconstruct the facts appropriately. Mainly, SEM observation of morphological elements showing specific features enables to determine whether the textile has been damaged by heat, tear or cut (possibly identifying the tool or weapon used), or by a combination of these. Through SEM observation, it was possible to analyze the heads of fabric filaments in the proximity of the hole caused by shooting test. In its trajectory, a projectile moves according to a combination of a uniform linear motion (axis x), a uniformly accelerated motion (axis y) and a rotation around its longitudinal axis, thus guaranteeing stability due to gyroscopic drift. The damage caused by the impact of a bullet is, therefore, closely related to the dynamics of its progression in space which, in turn, are complex [9]. The holes observed are therefore typical of a tear (fibers are curled, deformed by stress from stretching) and split. The heads of the split fibers present a bulb, more or less pronounced. Some of the fibers are joined and fused caused by the re-lease of heat due to friction, which occurred as the bullet penetrated the fabric. More heat was released (at least for the short distance between the muzzle and the target, about 50cm) by the still hot bullet itself. In addition, the ascertained presence of GSR corroborates and confirms our hypothesis of the effect of a ballistic impact. Based on the comparison, it is possible to ascertain that the hole on the jacket found as evidence presents the same, typical, morphological features of a hole caused by the penetration of a bullet, therefore excluding the possibility that the damage found on said item of clothing was the effect of other causes. In a case of a sharp force fabric damage, the typical features are represented by: a) scissor cuts create pinched ends, with or with-out lateral distortion; b) knife cuts produce flat tops with or without a lip, and c) impact tears pro-duce a mushroom (bulbous) cap [6]. In a case of accidental tear, it was unexplained the report of fibers fused and joined together. Also, the action of only high temperature would have explained just the presence of fibers fused and joined together, but not that of only torn fibers.

In conclusion, the used methodology allowed us to recreate the same effect on the fabric sample used for our test shooting as on the evidence collected. We believe that further studies on this topic will be helpful in forensic investigations.

Conflict of interest

The authors declare that they have no conflict of interest.

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