TECHNICAL NOTE

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Casework Experience of GSR Detection in Israel, on Samples from Hands, Hair, and Clothing Using an Autosearch SEM/EDX System

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ABSTRACT: Casework experience in the detection of GSR particles on samples from hands, hair and clothing is reported for the period of 6 years (1989–1994). The overall "success" rate on the examined samples is about 10%. Aspects of the sampling procedures, the number of particles detected per sample and problems of possible contamination are discussed.

KEYWORDS: forensic science, criminalistics, gunshot residue, scanning electro microscopy-energy dispersive X-ray analysis

The detection and identification of gunshot residue (GSR) particles by scanning electron microscopy/energy dispersive X-ray (SEM/EDX) analysis is now a well-established technique and is applied in many forensic science laboratories [*1–5*]. For the past few years many automated systems have also been introduced and replaced the manual search for GSRs [*6–9*].

Nonetheless, there are hardly any reports in the literature on the success rate of GSR detection in casework. We actually are aware of only two reported studies regarding this aspect [*10,11*]. Wolten et al. [*10*] reported quite a high success rate (about 80%) of GSR detection in samples collected from hands (tapelifts) using a manual search (41 cases). King [*11*], on the other hand, reported much lower value about a 10% success rate in GSR detection (swabs and filtering). The second study used a manual search as well. King also reported a higher rate (33%) for the detection of propellant residues. It appears that the success rate for GSR detection in casework, in many forensic science laboratories is closer to 10% than to 80%.[2]

The purpose of this work is to present a comprehensive report on the success rate of GSR detection in Israel for the six years period of 1989 through 1994. In this report we also discuss sampling procedures, relative success rate of various sampling sites and possible problems of contamination.

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Case Examination—Experimental Procedure

Our kit for sampling GSRs from suspects consists of two 25-mm diameter aluminum stubs, coated with double-side adhesive tape ("Scotch Tape" no. 465, 3M company) [*12*]. Since 1979 until the end of 1990 the procedure was as follows: One stub was used to sample the right hand and the other—the left hand. The instructions were to dab the stub against the hand until the adhesive tape had lost its stickiness. The accumulated casework experience of about 12 years has shown that in only a very few cases a large number of particles was found in hand samples and in significantly lower number of these cases considerably more particles were found on one hand as compared to the other one so that some inference could be made concerning the firing hand. These results are consistent with the results of laboratory experiments which showed that 30 minutes after firing no significant difference was observed between samples collected from the right and the left hands with regards to the number of GSR particles [*5*]. The practical conclusion from these observations is that there is no significance in sampling the suspect's hands separately due to redistribution of particles within quite a short period of time.

We have already reported that GSRs can be efficiently collected from hair by the tape-lift method and that the persistence of GSRs on hair is much longer than on hands [*13*]. Persistences of 24 hours were observed in laboratory experiments when the hair had not been washed. Thus, in order not to increase the number of samples collected from a suspect it was decided in our laboratory (since the beginning of 1991 onwards) to use in casework one stub for sampling both hands and the other one for sampling the hair. Now the instructions for the field technicians are to dab the hands 50 times (25 times each hand) and the hair—200 times. If the outer garment worn by the suspect has long sleeves, its cuffs should be sampled additionally, 10 times each, using the hands sample. Usually, samples from the hands as well as from hair were examined even if there was a positive result in the sample collected from the other site of that suspect. This was done in order to assess the relative success rate of GSR detection of the two sites. Only in those cases where it was known that the hands or the hair had been washed would the samples not be examined.

The clothes of suspects are occasionally brought to the laboratory and sampled there using the tape-lift method. Usually one stub is

used to sample several items of clothing, such as shirt and trousers, if the suspect was apprehended while wearing them or if they were found in the same premises. The samples from clothes are usually examined only if the samples from the suspect himself (hands and hair) yield negative results. The same sampling method is also used to sample seat-covers of vehicles suspected of being involved in a shooting.

Until 1987 SEM/EDX analyses for GSRs were carried out by a manual search of about a quarter of the stub area, using a CamScan 3 scanning electron microscope (SEM) combined with a Tracor-Northern TN 5500 energy dispersive X-ray (EDX) system. Since the beginning of 1987 the analyses for GSR have been carried out using an automated search system attached to a CamScan 4 SEM equipped with a motorized stage drive and a four-samples holder, combined with a Tracor-Northern TN 5500 EDX system. Samples were carbon coated and the basic search area was 10 × 8mm 2 [*13*]. When only one GSR particle was found in the search area the search was usually extended to at least an additional search area on the stub.

Results and Discussion

The computerized storage of data and results relating to the examinations of GSR was started at our laboratory at the beginning of 1989. Therefore the statistics of our casework experience on GSR will be presented for the last six years (1989–1994).

The "success" rate in this study will be defined as the percentage of positive samples out of the number of samples examined or alternatively as the percentage of positive suspects out of the number of the suspects examined. Obviously, this is not the true success rate of the method, since this definition would need to involve the success rate of apprehending the right suspects (the ones that actually did the shooting). The true success rate of the method would be the percentage of positive suspects out of the known shooters. However, in casework there is no way of absolutely knowing that a suspect was a shooter even if he was legally found guilty.

Table 1 shows the "success" rate of GSR detection in casework during this period in our laboratory. It can be seen that the success rate is considerably less than reported by Wolten et al. [*10*] and is similar to the figure reported by King [*11*]. However, it should by pointed out that only 68% of the submitted cases were examined. The non-examined cases usually included the following:

1. Cases of suicide verification, since the victim might be contaminated with GSRs whether he shot himself or was shot from a close distance by somebody else.
2. Cases where the suspects were apprehended when holding the weapon or when the suspects physically delivered the weapon before sampling.
3. Cases in which an ammunition having a lead-only GSR composition (for example, 0.22″ caliber manufactured by Remington Corp.) was used. To our opinion, although spherical lead particles are consistent with GSR [*1,4*], they may also originate from an abundance of other sources such as vehicles exhausts so that their probative value is very low.
4. Cases where suspects were sampled for GSR by the field technicians but the suspects were cleared during the interrogation or the investigation of any connection to the shooting.

Should the non-examined cases been examined, the success rate would probably have been higher.

In a considerable number of cases it was observed that the field technicians did not follow the instructions concerning the number of the dabbings. They did much lower number of dabbings from hands and from hair than necessary, especially when there were several suspects. This conclusion could be reached by inspecting the relative area of the stub covered with various particles. In such cases a less-than-maximum collection efficiency should be expected [*13*], and this would be expected to effect the success rate of GSR detection. It should also be mentioned that the success rate increased by approximately 50% (based on the percentage of positive cases) after the introduction of the automated GSR search system.

Table 2 shows a higher success rate of finding GSRs in hands samples than in hair samples in casework. However the results show that it is important to sample both sites. Moreover, the non-examined hands samples in Table 2 were in those cases where it was known that the suspects washed their hands. This situation is much more probable than the opposite one, namely washing the hair but not the hands. The non-examined hair samples were in those cases where many GSR particles were found in the hands samples or when for some reason samples had not been collected from the hair.

Table 3 shows that, at least in our casework experience, there was no significant difference between the average time lapse between firing and sampling for the positive hands samples (2.7 hours) and the positive hair samples (3.3 hours). These results are somehow in contrast to laboratory observations and experiments which showed a much higher persistence of GSRs on hair than on hands [*5,13*]. However, additional factors that could effect the results should be considered. For instance, if the shooting took place outdoors, with some wind, less GSR particles would be deposited on the shooter's hair than in indoors shooting [*13*]. As

TABLE 1—*"Success" rate of GSR detection in casework during the period 1989–1994.*

Number of Cases	% of Cases Examined	% of Positive Cases Examined (a, b)	Number of Suspects	% of Suspects Examined	% of Positive Suspects Examined (a)	Number of Samples (b, c)	% of Samples Examined	% of Positive Samples Examined (a, d)
541	68%	22%	920	66%	15%	1517	58%	13%

NOTES:
(a)—Out of the examined ones.
(b)—75% of the cases with positive results involved handguns and the rest—assault rifles, sub-machine guns and shotguns.
(c)—Samples are from hands, hair, clothing and in few cases from other exhibits like vehicles seat-covers. Samples from hair have been taken since the beginning of 1991 (see text).
(d)—A sample is considered as being a positive one if at least one particle of unique composition or consistent with GSR composition (except lead-only particles) was found in it [*1,4*] (see text).

TABLE 2—*Comparison of GSR detection from hands and hair samples for a four year period (1991–1994).*

Number of Positive Hand Samples (Negative Hair Samples)	Number of Positive Hand Samples (Hair Samples Not Examined)	Number of Positive Hair Samples (Negative Hand Samples)	Number of Positive Hair Samples (Hand Samples Not Examined)	Both Hand and Hair Samples Positive
13	3	7	3	13

TABLE 3—*GSR detection in hand and hair samples for various time intervals between the firing incident and sampling (same casework period as Table 2).*

	Time Lapse between Firing and Sampling (hours)							Average Time Lapse, Positive Samples
	0–1	>1–2	>2–3	>3–4	>4–5	>5–6	>8–9	
Number of Positive Hands Samples	6	5	5	6	3	4		2.7 hours
Number of Positive Hair Samples	2	4	5	4	4	3	1	3.3 hours

has already been mentioned, in a considerable number of cases less dabbings of the hair were applied than should have been done by the field technicians. In the hand samples the situation was usually somehow better. The observed average time lapse for the positive hand samples in this study is similar to the casework results obtained by Wolten et al. [*10*] and is considerably higher than the time reported for laboratory experiments [*5*].

Table 4 shows that in most casework samples (83%) only a few (up to 5) GSR particles were found and that in a high percentage of these samples only one particle was found. As was already mentioned, in most of these samples more than one search area of 10 × 8mm 2 was searched.

Our policy is to report on the finding of even one GSR particle since this finding does not seem to be an exceptional finding based on the general casework statistics: inspecting the figures in Table 1 we see that the percentage of negative samples among those examined was quite high (87%) although apparently a considerable number of "negative" suspects had actually been suspects involved in shooting, based on other evidence. Then we have a high percentage of samples with only one GSR particle and a high percentage of samples with only few (2–5) particles (39% and 44%, respectively). Obviously, the danger of one GSR particle being a contamination is higher than if several particles are found. However, it cannot be excluded that even several GSR particles could be due to contamination. In a situation where a very low number of particles is found in a sample from a suspect, taking blank samples and not finding particles in them would not be a conclusive proof that the found particles in the suspect's samples had not been due to contamination.

Conclusions

The overall "success" rate of finding GSR particles in casework related samples, for the period of six years (1989–1994) in our laboratory, was about 10%. Although this rate is quite low, it has an inherent "benefit" for the probative value of this type of evidence since it diminishes the danger of finding GSRs due to accidental contamination. In a high percentage (39%) of the positive GSR samples only one particle was found. This result is consistent with a low detection rate of GSRs in the casework samples.

TABLE 4—*Percentage distribution based on the number of particles found in positive GSR samples for the six year period (1989–1994).*

% of Suspects with Only One GSR Particle	% of Positive Samples with:		
	One Particle	2–5 Particles	>5 Particles
31%	39%	44%	17%

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