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Persistency of Gunshot Residue in the Head Area Practical Approach - Part II

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ABSTRACT: In this article are continued the experiments carried out in order to achieve more information regarding the persistency and abundance of GSR particles found in the head area of the human body. The results obtained in the first study were really surprising and had a major impact in our expertise area, confirming the theories about the fact that GSR particles are still detectable after a longer period of time in areas very exposed, but mistakenly unexplored during crime scene investigation, due to lack of attention or knowledge, most of the times. These unexploited areas offer valuable information in most cases where relevant results are missing. Same conditions of analysis were applied in order to have a better reproducibility of the data obtained, detection and characterization of the GSR particles were performed with SEM/EDS analysis, where elemental composition, surface morphology, particle size and particle population were taken into consideration. This new set of experiments was carried out on more types of ammunition and the results surprised us once more.

KEYWORDS: gunshot residue, firearms, crime scene investigation, GSR particles

Introduction

Continuing the experiments started in the previous article, it was impossible not to make some small observations regarding the collection of samples and the areas from where GSR particles were sampled in the past period of time, also some specific procedures to exclude analysis of samples collected from victims of gunshots (Lindsay and McVicar 2004). Most of the forensic laboratories analyze samples collected from the hands of the shooter or suspect, and almost no samples collected from other areas/parts of the human body, for example in this case, from the head area. For decades most of the experts in GSR analysis took into consideration the idea of analyzing samples collected from the head area, only if the samples collected from the hands of the suspect were negative or if the samples were missing at all and they didn't experienced that type of lack of evidence many times, unfortunately. For this reason, in most of the cases investigated were lost considerable amount of evidence, for so long, because of some aspect that should've become a mandatory standard procedure (Trimpe, 1997; DeGaetano and Harrison 2004). Few authors had carried out a series of experiments with GSR particles collected from the face area and the results reported were not satisfying at all, and this is why they concluded that samples collected from the face area are not valuable for further GSR analysis. The result was that the GSR community took for granted that conclusion and the face area remained unexplored until recently. No criticism for their work, but on the contrary. Times are different now, also the technological possibilities. It's a fact that certain aspects were not taken into consideration when those experiments were carried out. Also, from the face area were collected sample from the forehead, chicks and chin (Niewoehner, Andrasko, Biegstraaten, Gunaratnam, Steffen and Uhlig 2005). These areas are the most exposed and most touched during a whole day. This is the reason why the results of the experiments were not satisfactory. Even if the suspect used a gun and fired with it, during the period of time elapsed from the shooting until the police caught him and eventually sampled him, the suspect had various activities that also imply the natural reflex of rolling his hands all over the face for thousands of times during that day. Also those reflexes accelerate when a person is found in such a situation. Encouraged by the results of the experiments carried out, in some ideal conditions, made us realize the importance of the discovery, how much value can be added by sampling ears and nostrils in the crime scene. It was already established in the previous study that the main interest is to establish a connection between the time since discharge and period of time for the particle deposition. GSR analysis was performed exclusively through scanning electron microscopy equipped with energy dispersive X-ray spectrometer (SEM-EDS). The present article continues the experiments carried out on both detection and loss of GSR, when samples were taken at different time intervals after the shooting and analyzed by scanning electron microscopy through SEM-EDS technique.

Experimental

Preliminary analysis

As already discovered in the previous set of experiments, it was established that GSR particles were detected in the orifices found on the face/head area (nose and ears) of a person/suspect who used a firearm in an incident. The presence was confirmed, and the main issue is also to be able to identify the particles distribution by the area/zone where they were found, also the persistence of this particles deposition in a specific period of time, calculated from the shooting moment. Three types of ammunition were used for this second series of experiments: Luger 9 mm, .22 Long Rifle and .223 Remington hunting rifle. Just like in the first series of experiments, were performed 5 series of shootings with each type of ammunition. Same condition for the collection of the sample wew applied. After the first series of shootings, samples were collected from each subject, from the nose area (both nostrils) and from the outer ear area of both ears. The samples were collected using cotton swabs and then transferred on carbon tape, covered with a thin layer of carbon and analyzed with SEM coupled with an Oxford Inca energy dispersive X-Ray spectrometer, in secondary electron mode, 20 kV accelerating voltage.

Main study

The series of shootings were carried out in the indoor shooting training chamber from the Police, especially designed for such activities (Schwoeble and Exline 2000). The weapons used were a Luger 9 mm, a .22 Long Rifle and a .223 Remington hunting rifle. The ammunition used is listed in Table 1. Same protocol was applied in order to have a better reproducibility of the results and is described below. The whole experiment was repeated to produce five sets of data. The test person loaded and fired 5 cartridges holding the gun with both hands. Loading and firing were carried out by the same person, so that skin retention of particles remained the same. The barrel was cleaned with a specific cleaning solution before each shot. The external surface of the weapons was cleaned also. After firing each type of ammunition, the firearms were completely dissembled and cleaned. Sampling was carried out immediately after the first test firing, 8 hours after the second test firing, 16 hours after the third test firing, 24 and 48 hours after the fourth test firing and after 72 hours after the fifth test firing. The subject of testing was instructed to continue his normal activity in office or outside, in areas that were not exposed to GSR contamination. The main condition was to not wash his face or ears. Samples were collected from the both nostrils and both outer ears using cotton swabs and then transferred to 12 mm carbon double adhesive SEM stubs specially designed for GSR collection and packed in kits of five pieces. Each stub was dabbed repeatedly with the swab until stickiness of the surface became ineffective. A blank sample test stub was activated and exposed to the ambient air during the sampling (Brozek-Mucha 2009; Brozek-Mucha 2014). The analysis was performed with a fully automated scanning electron microscope (SEM), in backscattered electron (BSE) mode, with an automated stage and an energy dispersive X-ray spectrometer (EDX), controlled by software specially created for GSR analysis.

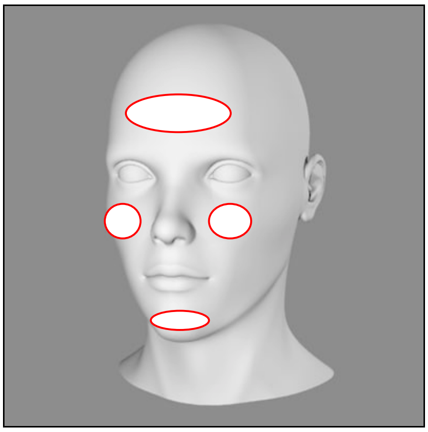

Figure 1. Areas of interest for GSR sampling used before by other examiners in their past studies.

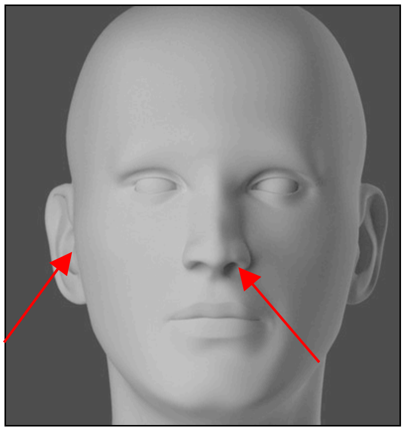

Figure 2. Ear and nose areas of interest for GSR sampling study

Main study SEM-EDS analysis

SEM-EDS analysis was focused on particles that had the elemental combinations shown in Table 2, 3 and 4. Only unique and characteristic particles were counted in the identification of the GSR, environmental particles have no value as a proof (Zeichner and Levin 1995; Jalanti, Henchoz, Gallusser and Bonfanti; Schwoeble and Exline 2000). The particle population distribution on the right and left nostrils and right and left outer ears of the test persons is shown in Table 1. In addition to these results, no GSR was detected when sample tests of non-exposed subjects were analyzed.

Table 1. The persistency of GSR particles

Type of ammunition	Type of analysis	Number of series/shots	Type of surface	Period of persistency
Luger 9 mm	SEM/EDS	5/1	nostrils	up to 48 h
			outer ear	up to 72 h
.22 Long Rifle	SEM/EDS	5/1	nostrils	up to 24 h
			outer ear	up to 48 h
.223 Remington	SEM/EDS	5/1	nostrils	up to 30 h
			outer ear	up to 48 h

Table 2. Distribution of particles on samples for Luger 9 mm

INCA_GSR (elemental combinations)	Samples - Luger 9 mm			
	right ear	**left ear**	**right nostril**	**left nostril**
SbBaPb	15	9	20	4
SbPbSn	-	-	-	-
SbBaSn	-	-	-	-
SbBa	112	104	150	115
BaPb	77	89	104	95
SbPb	53	48	73	76
CuZn	101	117	184	134
Pb	92	256	49	202
Fe	160	122	111	232

Table 3. Distribution of particles on samples for .22 Long Rifle

INCA_GSR (elemental combinations)	Samples - .22 Long Rifle			
	right ear	**left ear**	**right nostril**	**left nostril**
SbBaPb	10	4	8	5
SbPbSn	-	-	-	-
SbBaSn	-	-	-	-
SbBa	72	45	31	18
BaPb	65	56	41	48
SbPb	36	29	39	77
CuZn	117	179	197	114
Pb	530	595	670	223
Fe	498	444	300	507

Table 4. Distribution of particles on samples for .223 Remington

INCA_GSR (elemental combinations)	Samples - .223 Remington			
	right ear	**left ear**	**right nostril**	**left nostril**
SbBaPb	12	9	6	2
SbPbSn	-	-	-	-
SbBaSn	-	-	-	-
SbBa	25	31	28	20
BaPb	17	23	24	23
SbPb	30	13	15	17
CuZn	88	69	43	99
Pb	173	127	118	180
Fe	56	45	75	81

Discussion and results

Just like in the past study different results were noticed in the number of the GSR particles detected. This showed big variations from one shot to the other. The quantity of particles found during analysis varied pretty much in controlled laboratory tests, but this time in a major manner and that affected the interpretation of the results obtained. One of the main reasons involved the type of firearms used and the distribution of the particle cloud after the shooting took place. Same pattern was confirmed: after the first series of shots was found the biggest amount of GSR collected from outer ears and nostrils. Results obtained varied in some predictable limits because of the loss and transfer of the particles during time and during the activities performed through the day. These observations were constant for all the subjects involved in the study, with few exceptions.

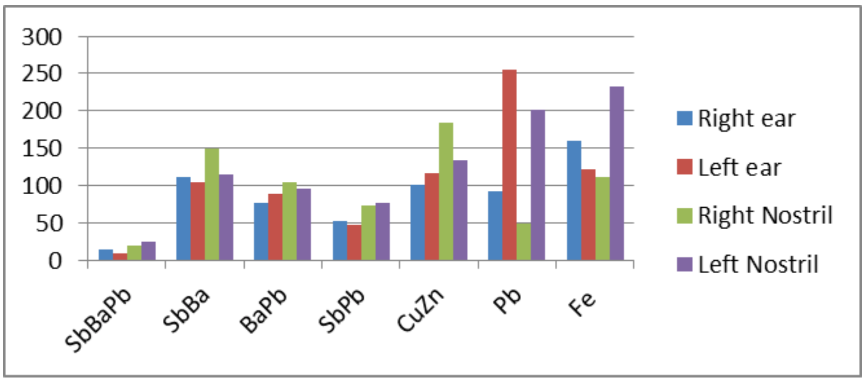

Figure 3. Occurrence of elemental combinations of particles in Luger 9 mm samples

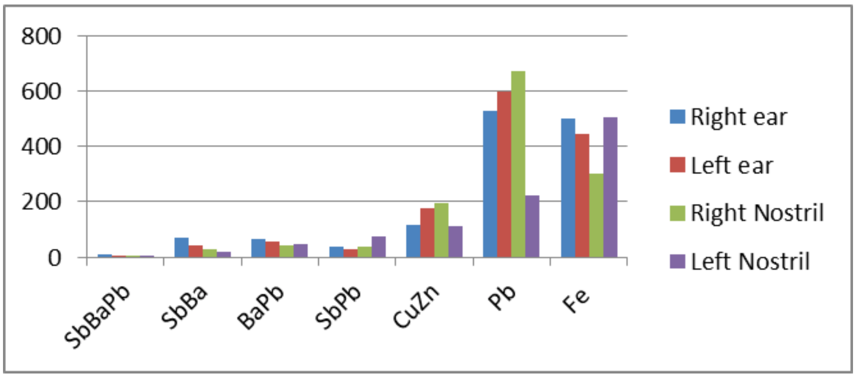

Figure 4. Occurrence of elemental combinations of particles in .22 Long Rifle samples

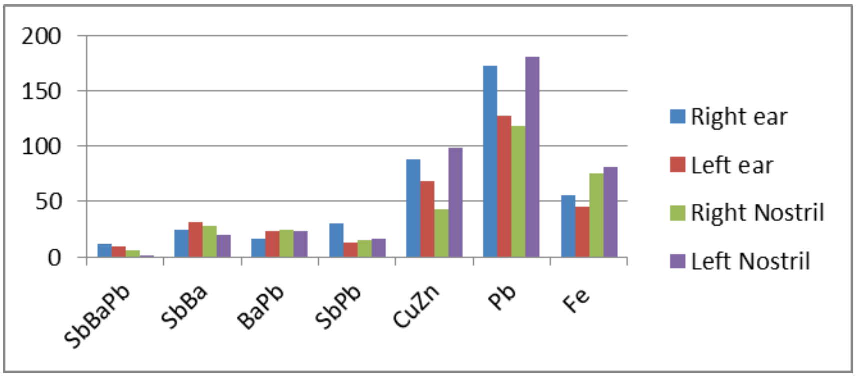

Figure 5. Occurrence of elemental combinations of particles in .223 Remington samples

The density of GSR particles left after discharge depends on the type of ammunition used and the dispersion of the particles into the environment after discharge varies depending of the type of firearm used. In figures 3, 4 and 5 it is shown that the amount of GSR particles formed is different for the 3 types of the ammunition and also the type of guns in this case, though these are samples collected from outer ears and nostrils (Brozek-Mucha 2011). We can observe the fact that the distribution and density are similar for the 2 rifles, but differs from the Luger. This happened because the residue population/deposition is directly dependent with the type of ammunition and firearm used, in this case is characterized by the particle cloud from the 2 rifles which after the discharge took place, went far away from the subject, this way explaining the smaller amount of particles deposited and then detected through SEM analysis. Interpretation of the results for the residue population in this case it was quite challenging. The longer period of time suitable for detection of GSR particles remained after discharge is still the main criteria, in choosing these areas first for collection of evidence, due to low contamination rate. Once more, sampling with swabs from the outer ears and nostrils of the shooter proved to be beneficial, but not the best, because of the loss of the particles retained in the cotton fibers from the swab. The new device designed for this purpose that is still in tests, revealed also some good results, but still needs more tests before being presented publicly. Hopefully, in a couple of months the tests results will be revealed.

Conclusions

This new sets of experiments confirmed, once more, that the remaining period for GSR particles increases dramatically when collected from outer ears and nostrils, but also that is in direct dependence with the type of firearms used. This time also, we had the confirmation of a minimum rate contamination. Finally, we consider that these results will be very useful for the forensic community and the justice providers. These new analytical data obtained, were also added to the laboratory database, which extends its size with every new experiment performed and contributes to the expertise quality and increases the ammount of cases solved.

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