Portable tool capable of triaging evidentiary samples at crime scenes to provide reliable investigative leads to fast forward investigations

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INTRODUCTION

Forensic laboratories are constantly looking at options to improve their efficiencies to produce meaningful results to investigators in a timely manner. Exhibits submitted to forensic laboratories often do not produce results that can assist investigators because: 1) they have no DNA or an insufficient amount to proceed forward in the DNA analysis process, 2) they have sufficient amounts but fail to produce STR profiles or generate profiles that are uninterpretable, and/or 3) they generate profiles that lead to inclusions with little forensic significance (e.g. victim's profile found on victim's clothing, suspect's profile identified on suspect's clothing). In addition, many exhibits brought over by investigators as resubmissions often produce redundant results with no added forensic significance. Narrowing down the best exhibits to submit is a difficult task for investigators as they often must rely on subjective criteria.

The ParaDNA® System (LGC, Abingdon, UK) [1-6] may provide an alternative and more scientific-based approach to prioritize samples to send to the forensic laboratory. The ParaDNA® System has three essential components: the disposable Sample Collector, the Reaction Plates and the ParaDNA® field portable instrument that comes in a Pelican case with two battery packs to be used at remote locations or in police vehicles. The ParaDNA® System can process up to 4 samples independently, sequentially or concurrently, from a wide range of crime or reference exhibits, directly, without purification in approximately 75 minutes.

Currently, two STR-based chemistry assays are offered with the ParaDNA® System: the Screening Test which targets two STR loci (D16S539 and THO1) and the gender marker Amelogenin [1-4] and the Intelligence Test which targets five STR loci (D16S539, D18S51, THO1, D8S1179 and D3S1358) plus Amelogenin [4-6]. The Screening Test provides a DNA detection score between 0-100% which is indicative of the amount of human DNA present in the sample and the gender of the contributor of that sample. The Intelligence Test provides a 5-STR DNA profile that includes the gender of the donor of the sample and a percentage DNA score that reflects the amount of human DNA present (can be seen as a quality indicator). This DNA profile can be compared to profiles generated from other evidence within the same or between crime scenes or even compared to reference samples. As such, the Intelligence Test can be used to decide on the best investigative leads to follow. Samples can be ranked according to their percentage score and, in case of replicates, those with the highest scores can be submitted to the laboratory.

METHODS

A five month field pilot project was run to assess the potential to use the ParaDNA® System to triage evidence samples at crime scenes. First, ParaDNA® training took place in the conference room of the RCMP National Forensic Laboratory in Edmonton, Alberta, Canada. Over the course of a week, two RCMP Reporting Scientists and one RCMP Technical Operations Leader received training along with four investigators (two from Edmonton Police Service and two from RCMP K Division in Edmonton). Thirty two (32) samples from three mocked scenarios (one homicide and two break and enter) were processed by each trainee as part of seven practical exercises where they used both the Screening and Intelligence Tests. In addition, a proficiency test was administered to ascertain their proficiency at sampling using two sampling methods (i.e. direct method vs indirect/or swabbing method). The direct method is preferred for clothing, cigarette butts and certain discarded items and involves using the Sample Collector directly on the item to collect cellular material. The indirect method or swabbing method is used for stains on hard surfaces, weapons and tools and some discarded items and involves swabbing the item first using a pre-wetted swab then sub-sampling the

swab using the Sample Collector. The Sample Collector is then inserted into the Reaction Plate then loaded into the ParaDNA® instrument. The exhibits or swabs are then readily available for the forensic laboratory as only 5-10% of the DNA present on any item sampled by the Sample Collector is removed (unpublished data from RCMP and Ref. 7).

Following training, a ParaDNA® field portable unit was loaned to each agency for the duration of the pilot project and each agency was provided with 280 ParaDNA® tests (a mix of Screening and Intelligence Tests). For this pilot project only, all ParaDNA®-tested evidentiary samples were submitted to the RCMP National Forensic Laboratory for autosomal STR analysis regardless of the ParaDNA® results. This was required in order to assess the number of false negatives and false positives and to establish if the investigative leads provided by the ParaDNA® testing were reliable.

RESULTS & DISCUSSION

Investigators used the ParaDNA® field portable instrument on a steady basis from Dec. 14, 2016 to May 17, 2017. Over this period, 55 exhibits were tested using the ParaDNA® Screening Test while 251 were analysed using the ParaDNA® Intelligence Test.

Exhibits from 116 cases representing 21 different offence types were subjected to ParaDNA® testing. The majority of the offences were Break and Enters (31.0%) followed by homicides (16.8%), robberies (13.8%) or thefts of motor vehicles (13.8%), assaults (9.5%), sexual assaults (4.3%) and 11.2% represented other offences such as “drug trafficking” and “discharge firearm with intent”. Exhibits subjected to ParaDNA® testing included 145 potential skin-cell based samples (trace/touch DNA samples), 92 blood samples, 59 saliva samples, 8 semen samples and 2 ligaments/tendons from collected human bones. The number of exhibits subjected to ParaDNA® testing ranged from 1 to 16 per case. Investigators decided on which samples they wanted subjected to ParaDNA® testing. Fifty seven (57) cases had only one ParaDNA®-tested exhibit but for many of these cases, more than one exhibit was submitted to the forensic laboratory for DNA analysis.

The outcome of the ParaDNA® testing is shown in Table 1. Prioritizing samples was the major application of the testing followed with 1) associating suspect and victim, 2) linking weapon and victim and, 3) tracking bleeders throughout the house where the homicide had occurred. Overall, 32 (27.6%) cases were impacted using the ParaDNA® testing and this number went up to 49 (42.2%) after reviewing melt curve data using the ParaDNA® Data Analysis software to gain additional DNA information. This review was carried out by the two RCMP Reporting Scientists who had received training on how to interpret ParaDNA® melt curves using this software. Unfortunately, investigators did not take advantage of this service offered to them during the field pilot project. They were left to believe many of the samples they processed did not produce ParaDNA® results because many had fewer than seven confident allele calls (7 or greater calls are required for a profile to be displayed on the instrument screen). Results with fewer than 7 confident calls can only be seen using Data Analysis. However, since the end of the field pilot project, LGC Forensics has modified the instrument software to allow all confident calls to be readily accessible to the users on the instrument screen even when there are fewer than 7 calls present.

Table 1. Outcome of the ParaDNA® testing for 116 criminal cases

ParaDNA® testing outcome	Number cases impacted	
	Instrument output	Using Data Analysis
Identified replicate samples from same contributor (within a crime scene); identified samples with different DNA signatures; prioritized samples	17	24
Associated suspect and victim (compared profiles from questioned stains on suspects clothing to known profiles from complainant or deceased)	3	6
Linked crime scenes	2	4
Tracked bleeders throughout house; identified bloodstains of interest on garments	3	4
Changed direction of investigation (determined gender/excluded)	2	4
Identified areas of interest on bedsheets using gender alone	2	4
Linked weapon to victim	3	3
Total	32 (27.6%)	49 (42.2%)

The possibility to identify replicate samples from the same contributor (within a crime scene) and identify samples with different DNA signatures in a large number of cases strongly supports the use of the ParaDNA® technology to prioritize samples to submit to the forensic laboratory for autosomal STR analysis. Only those samples deemed pertinent by the investigators could be submitted in a first instance. Samples can be triaged according to percentage DNA scores, gender calls and 2-STR (Screening) or 5-STR (Intelligence) profiles. Samples with the highest scores should be sent in but samples with a percentage DNA score <10% can still produce significant results. Nineteen (19) samples (6.2%) were found to be in this category. Nine of these 19 samples (2.9%) had a 0% DNA score yet produced AmpF*l*STR® Identifiler® Plus profiles in the forensic laboratory that were either uploaded to the National CODIS (N=6) or the National Mixture index (N=1) or had an inclusion with forensic significance (N=2). Inconsistencies between the ParaDNA® percentage DNA score and DNA amount obtained in the forensic laboratory for the same exhibit could be attributed to the limited amount of DNA present on the exhibit and/or to the different sampling methods used by the investigators versus the Evidence Recovery personnel in the forensic laboratory. For example, items sampled using the direct method in the field were taped or cut for DNA extraction in the forensic laboratory. Often different areas on the exhibit were examined separately by the Evidence Recovery personnel whereas a global sampling was carried out in the field. In addition, some samples did not have markings where sampling had occurred for ParaDNA® testing.

Contrary to what was anticipated, the ParaDNA® field portable unit was used mainly at the police detachment and plugged in. It was used twice in a police vehicle and three times at crime scenes. Following these trials, investigators felt there was no suitable area available in the field to use the instrument or felt its use increased processing time at the scene. They preferred processing samples in the detachment to determine which exhibit/swab would be useful to submit to the forensic laboratory for DNA analysis.

CONCLUSION

Results from the five month ParaDNA® field pilot project indicated that the ParaDNA® System is a reliable tool to triage evidentiary samples at police detachments to prioritize samples to submit to the forensic laboratory for autosomal STR analysis. Samples with the highest percentage DNA scores should be sent first. However, samples with <10% DNA scores should still be considered for submission if they represent the only samples available for a case as they could still produce significant results. Investigators must always keep in mind the ParaDNA® sampling approach they use in the field versus the one to be used by the Evidence Recovery personnel as divergent sampling methods may create inconsistencies between the percentage DNA score and amount of DNA extracted from any particular exhibit tested.

The review of the ParaDNA® melt curves using ParaDNA® Data Analysis was determined to be essential to maximize the data generated from the ParaDNA® tests and increase the number of ParaDNA® profile comparisons. Fortunately, since the end of the field pilot project, LGC has modified the instrument software to allow all confident calls to be readily accessible to the users on the instrument screen even when there are fewer than 7 calls present.

In addition, investigative leads provided by the ParaDNA® testing were determined to be reliable as confirmed by the subsequent analytical work performed on the ParaDNA®-tested samples submitted to the forensic laboratory. These leads could represent time and cost-savings for police agencies which may be able to 1) focus quickly on potential suspects, 2) quickly exclude suspects, 3) corroborate witness statements and 4) not allocate human resources on files with negative results. It is unknown if the ParaDNA® technology will be adopted by police agencies in a near future. The participants in the field pilot project all agreed that the ParaDNA® System was very simple to use and would give investigators added information with which to base their decisions on to prioritize samples (reduce number of resubmissions) and ultimately reduce the wait for critical laboratory results (sample batches composed of pertinent samples with potential for uploads to National CODIS, results of forensic significance and identification of suspect more quickly).

There are ongoing discussions to potentially triage evidentiary samples in RCMP Evidence Recovery Units for specific cases with a large number of exhibits, urgent cases, and sexual assault cases. This technology offers an option to enhance our current analytical processes in the forensic laboratory at very reasonable cost.

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REFERENCES

1. Dawnay N., Stafford-Allen B., Moore D., Blackman S., Rendell P., Hanson EK., Ballnatyne J., Kallifatidis B., Mendel J., Mills DK., Nagy R., Wells S. Developmental validation of the ParaDNA® Screening System – A presumptive test for the detection of DNA on forensic evidence items. Forensic Sci. Int. Genet. 11 (2014) 73-79.
2. Dawnay N., Ahmed R., Naif S. The ParaDNA® Screening System – A case study in bringing forensic R&D to market. Sci. Justice 54 (2014) 481-486.
3. Tribble N.D., Miller J.A.D., Dawnay N., Duxbury N.J. Applicability of the ParaDNA® Screening System to seminal samples. J. Forensic Sci. 60 (2015) 690-692.
4. Donachie G.E., Dawnay N., Ahmed R., Naif S., Duxbury N.J., Tribble N.D. Assessing the impact of common forensic presumptive tests on the ability to obtain results using a novel rapid DNA platform. Forensic Sci. Int. Genet. 17 (2015) 87-90.
5. Ball G., Dawnay N., Stafford-Allen B., Panasiuk M., Rendell P., Blackman S., Duxbury N., Wells S. Concordance study between the ParaDNA® Intelligence Test, a rapid DNA profiling assay, and a conventional STR typing kit (AmpF*l*STR® SGM® Plus). Forensic Sci. Int. Genet. 16 (2015) 48-51.
6. Blackman S., Dawnay N., Ball G., Stafford-Allen B., Tribble N., Rendell P., Neary K., Hanson E.K., Ballantyne J., Kallifatidis B., Mendel J., Mills D.K., Wells S. Developmental validation of the ParaDNA® Intelligence System-A novel approach to DNA profiling. Forensic Sci. Int. Genet. 17 (2015) 137-148.
7. Application Note. How much DNA is removed by the ParaDNA® Sample Collectors? © LGC Limited, 2013.