Forensic Science International: Genetics Supplement Series 5 (2015) e69–e70

Contents lists available at ScienceDirect

Forensic Science International: Genetics Supplement Series

journal homepage: www.elsevier.com/locate/FSIGSS

Investigative leads from DNA: Casework experience from the IntegenX RapidHIT™ 200 System

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ARTICLE INFO

Article history:
Received 21 August 2015
Accepted 7 September 2015
Available online 12 September 2015

Keywords:
Rapid DNA
Urgent casework samples
Success rate

ABSTRACT

The IntegenX RapidHIT™ 200 System was first used for crime casework in the DNA Profiling Laboratory, Health Sciences Authority, Singapore, in March 2015. Since then, the use of rapid DNA processing has effectively assisted the investigation of various urgent crime cases. The DNA profiles obtained were concordant to the results obtained using the laboratory's standard genotyping protocol, albeit with lower sensitivity in the detection of alleles from minor contributors.

1. Introduction

The ability to identify possible perpetrators quickly not only prevents the perpetrator from committing more crimes, but also allows for their apprehension before they are able to cross borders and escape jurisdiction. Rapid DNA genotyping technology, often characterized as "sample-in, profile-out" within a few hours with minimal user intervention, was originally intended for use with reference samples. However, it has the potential to significantly reduce the time needed to generate DNA profiles from crime scene samples. The DNA Profiling Laboratory in Health Sciences Authority, Singapore, previously evaluated the RapidHIT™ 200 System (IntegenX Inc.) using casework samples [1]. This short paper will describe several applications of this rapid DNA technology since March 2015 on actual urgent crime cases in Singapore.

2. Materials and methods

Both the IntegenX RapidHIT™ 200 System genotyping protocol and standard genotyping protocol were performed according to previously described methods [1]. Essentially, the standard protocol consisted of DNA extraction using DNA IQ™ Casework Pro Kit (Promega) along with Maxwell® 16 System (Promega), followed by amplification with the AmpFℓSTR® Identifiler® Plus kit (Life Technologies) and detection on the ABI PRISM® 3500xL Genetic Analyzer (Life Technologies). Urgent casework samples were processed using the RapidHIT™ System. Automated data analysis followed by manual analysis and review were carried out prior to searching the DNA profile obtained against the Singapore's National DNA Database. All urgent casework samples were also processed using standard protocol to support the DNA profiles generated from RapidHIT™ System for subsequent formal reporting and Court admissibility.

3. Results and discussion

3.1. RapidHIT™ 200 System involved in crimes solving

Between March and August 2015, the RapidHIT™ System has been applied to various urgent police cases (Table 1). In an earlier study, it was shown that good success rates (>80%) could only be achieved from samples containing high amounts of DNA [1]. Hence, urgent casework exhibits involving touch/contact DNA were not processed using the RapidHIT™ System.

In nine urgent cases, 36 samples comprising of five different sample types (blood swabs, blood-stained FTA punches, bone marrows, cigarette butts and semen-stained tissue papers) were selected for processing using the RapidHIT™ System. These samples originated from two rape cases, one homicide case, one fire outbreak case, two assault cases, two house burglaries, and one case of unidentified body floating in the sea (Table 1). The resulting

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http://dx.doi.org/10.1016/j.fsigss.2015.09.028
1875-1768/

Table 1
Urgent casework samples processed by RapidHIT™ 200 System.

Case no	Nature of offence type	Sample type	Quantity	Results
1	Rape	Semen on tissue paper	3	Match reference
		Blood on FTA	3	Match to crime scene exhibits
2	Fire outbreak	Cigarette butt	6	Cold Hit
3	Rape	Semen on tissue paper	2	Match reference
4	Assault	Cigarette butt	6	No match in Database
5	Homicide	Blood swab	5	Cold Hit
		Cigarette butt	3	Cold Hit
6	House burglary	Blood swab	3	Cold Hit
7	House burglary	Cigarette butt	1	Cold Hit
8	Assault	Blood swab	2	No match in Database
9	Unidentified body floating in the sea	Bone marrow	2	Match reference

Table 2
Percentage success rate of different sample types processed by RapidHIT™ and standard protocol.

	RapidHIT™		Standard protocol	
Sample type	More than 50% alleles called	More than 80% alleles called	More than 50% alleles called	More than 80% alleles called
Blood swab	100% (10/10)	80% (8/10)	100% (10/10)	100% (10/10)
Blood on FTA	100% (3/3)	100% (3/3)	100% (3/3)	100% (3/3)
Bone marrow	100% (2/2)	100% (2/2)	100% (2/2)	100% (2/2)
Cigarette butt	81.3% (13/16)	75% (12/16)	100% (16/16)	100% (16/16)
Tissue paper with semen	100% (5/5)	100% (5/5)	100% (5/5)	100% (5/5)

DNA profiles were successfully matched to either reference DNA profiles, other crime scene sample profiles, or had Cold Hits in the Database.

3.2. Concordance and success rate of RapidHIT™ 200 System

Using the standard protocol, 1150 alleles were detected from the 36 profiles. There were two loci with possible allelic dropouts as the remaining sister alleles were below the laboratory's stochastic threshold. In comparison, the RapidHIT™ detected and correctly called 1032 alleles (89.7%) of the 1150 alleles. As shown in Table 2, the RapidHIT™ System was able to process blood swabs, blood-stained FTA punches, bone marrows, cigarette butts and semen-stained tissue papers with more than 80% success rate, where a successful profile is one with more than 50% alleles called. When the threshold for success was raised to more than 80% alleles called, the success rate declined moderately to 80% and 75% for blood swabs and cigarette butts, respectively. This performance is similar to the success rate reported in the earlier study [1]. As expected, the standard protocol yielded 100% success rate of profiles with more than 80% alleles called for all five sample types.

3.3. Standard protocol outperformed RapidHIT™ 200 System in detecting mixture

Among the 36 DNA profiles, nine of them (6 cigarette butts and 3 semen-stained tissue papers) were mixtures. To assess the capability of RapidHIT™ System in analysing DNA mixtures, we compared the unique minor alleles across the 9 pairs of electropherograms generated by RapidHIT™ System and standard protocol. RapidHIT™ System failed to detect any unique minor alleles from the cigarette butts. On the contrary, standard protocol detected between 1 and 15 unique minor alleles in 6 out of the 16 cigarette butts processed. For semen-stained tissue paper, RapidHIT™ System was able to detect between 7 and 10 unique minor alleles in each of the 3 samples. However, standard protocol performed better by consistently detecting 15 unique minor alleles for the same 3 samples.

3.4. Sensitivity of RapidHIT™ 200 System must be improved

Homicides and sexual assaults are generally rare in Singapore. The majority of cases handled by our Laboratory are touch/contact samples from volume crimes. Hence, there is a need to enhance the sensitivity of rapid DNA testing. Attempts were made to modify the RapidHIT™ System protocol by spiking extracted DNA generated from the standard protocol onto clean cotton swabs prior to processing using the rapid DNA platform. Preliminary data revealed no significant improvement over the existing RapidHIT™ workflow. There was, in fact, loss of allelic information in several occasions.

4. Concluding remarks

The present evaluation on urgent samples has demonstrated the use of RapidHIT™ System to generate DNA profiles in under 3 h. This rapid DNA technology can significantly shorten the time needed to identify criminals. However, the lower sensitivity of the system limits its ability to detect minor contributors in mixtures as well as to analyse touch/contact DNA samples. These are issues that still need to be addressed.

Conflict of interest

The authors have no financial interests to disclose regarding this work.

Acknowledgement

This work was funded by Health Sciences Authority, Singapore.

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