Sample-to-Result STR Genotyping Systems: Potential and Status

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ABSTRACT: Forensic DNA analysis using short tandem repeats (STRs) has become the cornerstone for human identification, kinship analysis, paternity testing, and other applications. However, it is a lengthy, laborious process that requires specialized training and numerous instruments, and it is one of the factors that has contributed to the formation and expansion of a casework backlog in the United States of samples awaiting DNA processing. Although robotic platforms and advances in instrumentation have improved the throughput of samples, there still exists a significant potential to enhance sample-processing capabilities. The application of microfluidic technology to STR analysis for human identification offers numerous advantages, such as a completely closed system, reduced sample and reagent consumption, and portability, as well as the potential to reduce the processing time required for biological samples to less than 2 h. Development of microfluidic platforms not only for forensic use, but clinical and diagnostic use as well, has exponentially increased since the early 1990s. For a microfluidic system to be generally accepted in forensic laboratories, there are several factors that must be taken into consideration and the data generated with these systems must meet or exceed the same guidelines and standards that are applicable for the conventional methods. This review covers the current state of forensic microfluidic platforms starting with microchips for the individual DNA-processing steps of extraction, amplification, and electrophoresis. For fully integrated devices, challenges that come with microfluidic platforms are covered, including circumventing issues with surface chemistry, monitoring flow control, and proper allele calling. Finally, implementation and future implications of a microfluidic rapid DNA system are discussed.

KEY WORDS: DNA extraction, microchip electrophoresis, micro total analysis system, PCR, rapid ID, STR typing.