B2 Selective Separation of Sperm and Vaginal Epithelial Cells on Microfabricated Devices for Forensic Analysis

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The goal of this presentation is to demonstrate the potential of microchip technology for the separation of sperm and vaginal epithelial cells in rape kit analysis.

DNA analysis has proven to be a valuable technique used to identify the perpetrator of a crime. Such analyses have had the greatest impact on the investigation of crimes involving sexual abuse, specifically rape. Unfortunately, current methods for DNA analysis in crime labs require approximately two weeks to complete. These timeconsuming methods, along with a lack of appropriate funding, have led to a major backlog of cases to be analyzed. Because of this backlog, it is not uncommon for the evidence to be stored for six to nine months before being analyzed, if ever.

The ultimate goal of the current research presented focuses on reducing this backlog of rape kits needing DNA analysis by exploiting bioanalytical microdevice fabrication techniques. The successful development of a microfabricated device that could expedite this particular analysis would significantly reduce the analysis time, potentially from several weeks to approximately twenty minutes. Ultimately, this microchip will be fully integrated, that is, it will incorporate all of the necessary processing steps for complete analysis, from sample preparation to forensic DNA evaluation. These steps include: removal of the cells from the vaginal swab, separation of the sperm and epithelial cells, extraction of DNA from both sperm and epithelial cells, PCR amplification of the DNA, separation and detection of the PCR products. Introduction of this microchip technology to the forensic community will revolutionize forensic DNA analysis.

Not withstanding the ultimate goal of a micro-total analysis system (OTAS), microchip methods for the cell separation step alone will be advantageous to the forensic community. The proposed microscale method is much faster than the current differential lysis method. The time-consuming and labor-intensive preparatory steps translate directly into cost-ineffectiveness. Sample handling is significantly reduced in the microchip cell separation as compared to the current macroscale method, resulting in decreased chance of contamination and fewer opportunities for loss of biological material.

Development of a microchip for the selective separation of the sperm and epithelial cells is the focus of the research presented in this poster. Because the macroscale method is not easily transferable to a microscale process, new methods for sorting the male and female fractions were explored. Physical properties of the cells, such as density, size, and shape, are exploited as methods of sorting, rather than reverting to the more-complicated magnetic bead and/or antibody-based approaches. Gravity, pressure-driven, and electric field-driven flow have been explored to determine the best method of cell separation in the microchannel. These flow mechanisms are used to achieve a slow, stable flow of ~1 nL/sec. The sperm cells are concentrated in a designated sperm cell chamber, and the epithelial cells are retained in the sample reservoir. These cells can be subsequently lysed for DNA analysis or the microchip used as the storage vessel for analysis at another time. Methods for detection of sperm cells recovered, including electrical impedance detection and photodiode array detection, were investigated. By integrating a detection method into the cell separation microdevice, the purity and quantity of the sperm cell fraction can be assessed. Preliminary experiments used digital video microscopy to show the efficiency of separation. Optimum cell separation conditions have been determined and will be presented in this poster presentation.

Differential Extraction, Cell Separation, Microchip Technology

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