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Micro-segmental hair analysis for proving drug-facilitated crimes: Evidence that a victim ingested a sleeping aid, diphenhydramine, on a specific day

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ABSTRACT

Sleeping aids are often abused in the commission of drug-facilitated crimes. Generally, there is little evidence that a victim ingested a spiked drink unknowingly because the unconscious victim cannot report the situation to the police immediately after the crime occurred. Although conventional segmental hair analysis can estimate the number of months since a targeted drug was ingested, this analysis cannot determine the specific day of ingestion. We recently developed a method of micro-segmental hair analysis using internal temporal markers (ITMs) to estimate the day of drug ingestion. This method was based on volunteer ingestion of ITMs to determine a timescale within individual hair strands, by segmenting a single hair strand at 0.4-mm intervals, corresponding to daily hair growth. This study assessed the ability of this method to estimate the day of ingestion of an over-the-counter sleeping aid, diphenhydramine, which can be easily abused. To model ingestion of a diphenhydramine-spiked drink unknowingly, each subject ingested a dose of diphenhydramine, followed by ingestion of two doses of the ITM, chlorpheniramine, 14 days apart. Several hair strands were collected from each subject's scalp several weeks after the second ITM ingestion. Diphenhydramine and ITM were detected at specific regions within individual hair strands. The day of diphenhydramine ingestion was estimated from the distances between the regions and the days of ITM ingestion. The error between estimated and actual ingestion day ranged from −0.1 to 1.9 days regardless of subjects and hair collection times. The total time required for micro-segmental analysis of 96 hair segments (hair length: 3.84 cm) was approximately 2 days and the cost was almost the same as in general drug analysis. This procedure may be applicable to the investigation of crimes facilitated by various drugs.

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1. Introduction

Sleeping aids such as hypnotics and sedatives are often abused in the commission of drug-facilitated crimes. Suspects may spike drinks and foods with sleeping aids, provide them to targeted individuals, and commit robberies or sexual assaults while the victims are unwittingly asleep [1–4]. The victims may be unaware of the damage soon afterward due to memory loss or may hesitate to talk about the experience owing to the psychological shock resulting from sexual assaults. If the victims first report the damage to the police several weeks after the incident, the ingested drugs may not be detected in their urine and/or blood. Because it is difficult to prove that crimes occurred in such cases, there will potentially be more drug facilitated crimes.

Hair analysis may provide evidence of drug ingestion because the detection window ranges over months [3–8]. However, conventional segmental hair analysis cannot show that the detected drug was ingested on the day of the crime, because (1) many hair strands are cut above the scalp, leaving hair lengths of approximately 1 cm from the hair root end; (2) the hair strands are arranged along the cut end and normally segmented at 2-cm intervals, with many hair strands from the same segment

Abbreviations: ITM, internal temporal marker; CP, chlorpheniramine; DP, diphenhydramine; DDP, desmethyldiphenhydramine; MeCN, acetonitrile.

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combined to extract sufficient amounts of drugs for assessment using analytical instruments [5,9–12]; and (3) the growth rates of individual hair strands vary widely [13] (Fig. 1). Therefore, even if a drug is located at a specific region within each hair strand, pooling segments results in its distribution along several centimeters, equivalent months.

In contrast, recent development of mass spectrometer has enabled single hair analysis [14–23].

Additionally, micro-segmental hair analysis enables the assessment of drug history at daily intervals. In this procedure, a single hair strand is cut into 0.4-mm segments, corresponding to rate of daily growth, and each 0.4-mm segment is analyzed independently [24]. A preliminary study assessing the distributions of various cold medicines in individual hair strands found that the administration of a single dose of drug resulted in the distribution of analytes over ten 0.4-mm segments within each hair strand [25]. To accurately determine the day of administration of cold medicines, subjects ingested internal temporal markers (ITMs) to determine a timescale within individual hair strands [26]. In the first step of the recommended procedure (Fig. 2) is to choose easily available and safe over-the-counter medications, such as chlorpheniramine (CP) and methylephedrine, as ITMs. First, the inspectors ask the subjects about the recent use of over-the-counter medicines. If the subjects have ingested some over-the-counter medicines for self-medication within 2 weeks, the drugs are excluded from the ITM candidates. The subjects are asked to ingest the two doses of ITMs at an interval of approximately 2 weeks. Approximately 1 week after ingestion of the second dose of ITMs, three or more hair strands with their roots are plucked. Alternatively, if the subject is reluctant to pluck out hair, many hair strands are cut near the scalp with scissors approximately 3 week after ingestion of the second ITM dose. At least 2 individual hair strands are subjected to micro-segmental analysis to confirm the reproducibility of the assay. If analyses of the two strands yield different results, because the growth rate of an individual hair strand fluctuates during the growth or because one or both strands is in catagen or telogen phase [27], a third hair strand is analyzed.

In this study, this procedure was utilized to an estimation of the day of ingestion of a sleeping aid, diphenhydramine (DP).

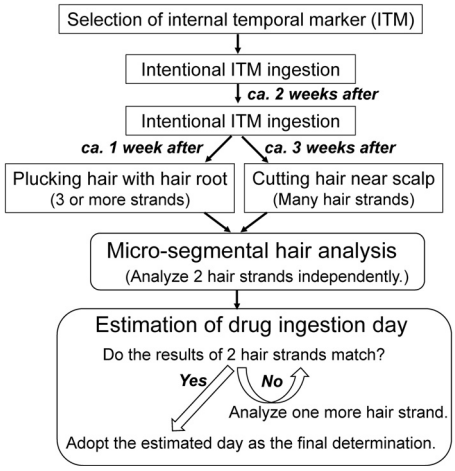

Fig. 2. Procedure using ITMs to estimate drug ingestion day.

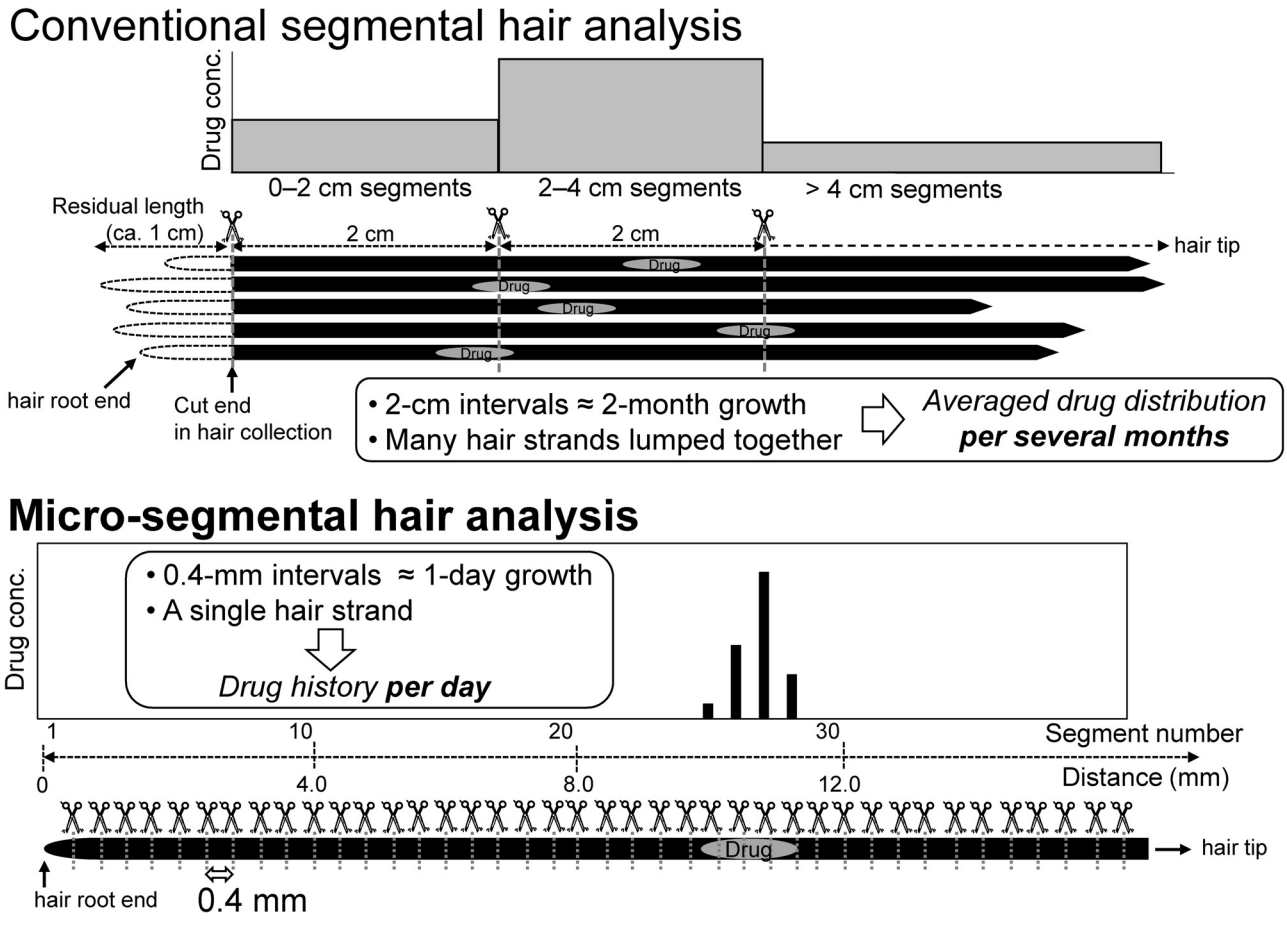

Fig. 1. Conventional segmental analysis of bundles of many hair strands and micro-segmental analysis of a single hair strand.

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