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Hair Strand Drug Testing
A Brief Introduction

With a little understanding of the science that underpins Hair Strand Drug Testing, the most appropriate testing options can be determined on a case-by-case basis, taking into account the history of drug use, claimed cessation, and issues of potential environment contamination. Before we examine the most appropriate Hair Strand Testing options in different cases, it's important to understand how hair grows, and thus, how it can be analysed it to assess historical consumption.

Introduction

Hair Growth

Hair consists primarily of a strong structural protein called keratin. It forms in the hair follicle, below the scalp, where it is fed by blood vessels and bathed with all the nutrients needed to grow. When drugs are consumed, they enter the bloodstream and are incorporated into the growing hair shaft. In this way, hair strand drug testing tends to be more straightforward than alcohol testing – as this route of entry via the blood vessels means that drugs, and their metabolites, are fixed within the hair shaft and thus provide a clear timeline of consumption with little migration up or down the hair. The further from the scalp we examine, the further back in time we go. As head hair grows at an average rate of 1cm per month (although this can vary between people), an analysis of 3cm allows us to assess consumption over the last 3 months.

It's important to consider the fact that there is a short distance (approximately 4mm) that the newly forming hair must travel to exit the hair follicle, grow above the scalp, and be sampled. This means that hair samples provides a detection window that begins approximately 2 weeks before the time of the sample collection, and goes back in time from there. The maximum recommended period of time assessed is a year (12cm), as increasing hair damage and environmental exposure beyond this point can reduce the level of substances.

Growth Phases

Another crucial feature of hair growth is the division of the lifecycle of each hair into active or resting phases. At any given point, approximately 15% of head hair is in 'telogen' (resting) phase, and has stopped growing. As telogen phase hair can remain on the head for about 5 months, drugs can still on average be detected in hair 5 months after cessation of use. Any analysis of a particular section (for example, the 1cm proximal to the scalp) will incorporate hair that has entered telogen phase in the past 5 months and stopped growing, and therefore may include detection of previous usage. Analysis of a month's worth section of hair will primarily identify drug consumption within that time period, but also a 'tail' of previous usage.

Taking this feature of hair growth into account is crucial, and was instrumental to our contribution in the High Court Case in 2017 *Re H: Hair Strand Testing* where we identified detected levels of cocaine in a mother as attributable to previous usage rather than continued consumption. Essentially, this feature of hair growth means that care must be applied when performing testing on individuals that have ceased, or cut down on consumption.

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Overview vs Segmented Analyses

One of the key factors in hair strand drug testing is whether drug consumption, or absence thereof, over a period of time must be tested as an overview, or through a segmented analysis. For example, we could take 3cm of hair and assess the whole section, or divide it into 1cm sections for a month-by-month analysis. When determining which approach should be taken, we have to take into account the concerns raised in the case, and the history of drug consumption.

If drug consumption is disputed entirely (at least recently), then we would recommend testing the section as an overview – just to assess whether drugs have at all been consumed. However, if a change in pattern is claimed (for example a decrease in usage) then we'll recommend a month-by-month analysis to track this pattern. Perhaps more importantly, a recent cessation in drug consumption should also be assessed with a segmentation. This is due to telogen phase hair, and the drugs trapped within, generating the potential for previous usage to be detected in hair more proximal to the scalp, and be attributed to more recent usage. Drug usage 5 months ago could show up in the most recent 2cm of hair, for example, despite more recent abstinence from usage. However, this telogen 'tail' can be identified through a segmented month-by-month analysis. As many cases involve previous usage and a claimed cessation, this can be crucial to a case.

The maximum period we recommend to test in a single overview is 3 months. Therefore, if we were performing a 12-month test, we'd recommended segmenting the hair into four 3 month sections. This is to ensure that a few instances of usage are not diluted beyond the point of detection.

Contamination vs Consumption

Introduction

Another crucial element of hair strand drug testing that must be considered is the issue of contamination. Passive exposure to drugs must be distinguished from active consumption to provide forensic analysis of the highest standard. This is especially true with drugs that are particularly prevalent such as cannabis or cocaine, and drugs that are smoked. While the hair is washed before testing to remove external contaminants that may attach onto the hair, the porosity of hair means that a proportion of external contaminants can enter the hair and therefore not be removed in the wash. Given the impact that drug testing can have on families in these cases, it is an issue that must be treated with the utmost importance.

Metabolite Detection

In order to properly assess the issue of contamination vs consumption, there are two practices that can be applied. The first is the assessment of drug metabolites (breakdown products) alongside the parent drugs, which indicate breakdown in the body and therefore consumption. For example, Cocaine is broken down into Benzoylecgonine and Norcocaine in the body. By measuring detected levels of these metabolites against the parent drug, we can, to a degree, distinguish active consumption from the possibility of exposure.

As an aside, I feel that it is important to mention here that not all metabolites are equal in their forensic capacity to indicate conclusions of consumption. To take Cocaine as an example, the presence of Benzoylecgonine (BZE) has traditionally taken as a clear sign of consumption, being indicative of the breakdown of cocaine within the body and the subsequent deposition of the metabolite in the hair. However, as a hydrolysis product, BZE can form spontaneously outside of the body in the presence of water (for example, in damp conditions within a household), and therefore enter the hair as an exogenous compound formed outside of the body, rather than within. Conversely Norcocaine (NCOC) can only form within the body. It’s therefore a true metabolite, but also a minor one that is produced

in relatively small proportions. Due to its importance in confirming or excluding cocaine consumption and the difficulty in detection due to its low proportional production and deposition in the hair, we've developed methods to detect and quantify NCOC at a forensic level 10x lower than of other toxicology providers. Other cocaine metabolites include Anhydroecgonine Methylester (AEME) – a pyrolysis product produced under high temperatures such as those found when crack cocaine is smoked, and Cocaethylene (CE) – produced in the presence of alcohol when Cocaine and Alcohol are consumed together. Essentially, each metabolite has unique qualities that can provide information about consumption, and the manner in which a drug is consumed.

Testing the Wash

The second practice that can be applied is assessing the possibility of contamination by testing the hair 'wash'. As previously discussed, hair is washed prior to testing to remove external contaminants – such as those from the passive Cannabis smoke of another person. However, given the porosity of hair, the possibility of movement of substances in and out means that external contaminants can enter the hair and be detected in an analysis, despite not being the results of active usage. This is an especially important consideration when a cessation of usage is claimed. During previous periods of drug consumption, the presence of drugs and the excretion of drugs and metabolites in sweat can cause contamination of surfaces at home, or elsewhere. These substances can then be transferred back into the hair, and enter the hair shaft.

Therefore, we assess the hair wash to provide extra information about the level of contamination present. This analysis allows us to properly assess contamination as a contributing factor to what is detected within the hair – and help prevent detected levels being incorrectly attributed to active continued consumption. Conversely, we can also reliably rule out contamination as a potential contributor to detected levels of consumption. To my knowledge, we're still the only forensic toxicology provider to do this as a matter of routine with every single drug test.

Alternative Samples

Introduction

The obtainment of head hair is always preferable in forensic assessment of drug consumption, as the relatively low proportion of hair in telogen phase provides a matrix with which a specific detection period can be specified, and one that can be segmented further to provide reliable assessments of patterns of usage.

However, it is not always possible to obtain a head hair sample; the head may be shaved or hair may be extensively bleached or dyed, depleting the substances within. Alternative samples are therefore occasionally required. In addition to testing head hair, we can also test body hair or nails. These differ in terms of growth patterns and detection windows, and examining these differences in growth helps to form an understanding of the relevant features of each matrix in drug testing.

Body Hair

Some of the physiological features of head hair that make it perfect for historical analyses of drug consumption are not present in body hair. For example, body hair generally grows more slowly than head hair, and contains a substantially higher proportion of hairs in telogen phase. While the percentage of *head* hair in telogen phase at a given point (~15%) is sufficiently low as to allow accurate month-by-month sectional analyses of indications of consumption, the higher percentage seen in *body* hair means that a sectional analysis is not feasible. With telogen proportions of up to 50%, accurately distinguishing indications of drug consumption temporally across the length of a sample of

hair becomes very difficult, as residual levels from previous usage are much higher. Therefore, only overview assessments of consumption can be performed on body hair.

In addition, the high variability in growth patterns of ungroomed body hair means that samples can be representative of somewhere between 4-8 months of deposition history when collected, and cannot be specified. This can be additionally subject to grooming patterns on a case-by-case basis, and the advised detection window may be altered upon examination by the toxicologist. Thus, body samples are suitable to confirm the presence or absence of indications of drug consumption – but cannot be used to investigate claimed patterns of change over this period.

Nails

Like hair, nails are formed primarily of keratin and trap drugs and their metabolites through deposition via the blood vessels in a similar manner. However, the detection windows and ability to segment samples differs with respect to head hair samples. While head hair collects drugs and metabolites in the follicle via deposition from the blood vessels and traps them within the hair shaft as it continues to grow – providing a linear timeline representative of consumption – nails trap these substances in a slightly different way.

The nail begins growth at the germinal matrix (base of the nail), but is also fed by blood vessels along the nail bed as it continues to grow towards the tip of the finger. By the time it reaches the end of the finger and may be clipped, sampled, and tested - it already represents an extended, and mixed, period of consumption. This means that the fingernail sample, when collected, represents an overview of up to 6 months of consumption history. Depending on length and growth rate, a fingernail assessment can provide anywhere between 3 to 6 months of history. Toenails grow in a similar way, but are larger and grow more slowly, providing a detection window of up to 12 months. This also means that nails cannot be segmented.