Forensic Onychology: An Essential Entity against Crime

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Abstract
Forensic Onychology (Greek word, Onuks = nail, Logia = study of) is the subject which deals with study of fingernails and toenails for better administration of justice in the court of law. Identification means determination of individuality of a person. Nails are important tissues for human identification. One of the major advantages of utilizing nail is that, in comparison with other tissues, sample size and sampling process can be considered relatively non invasive and non destructive and yet each nail retains a discrete record of detailed information on genetic inheritance, drug use, pathology, diet and location history as well as exposure to explosives residues or other pollutants. In contrast to soft tissues, nails survive relatively well in the decomposition environment. Furthermore, in contrast to other long lasting tissues (such as bone and teeth) nails are easy to decontaminate from external sources of DNA. Thus examination of nail is very useful in many ways against crime. In this paper, we discussed about structure and method of analysis of nail, utility of examination, drug use and nails and detection of DNA from nails.

Key Words: Forensic Onychology, Drug use and nails, DNA from nails, Justice

Introduction:
Forensic Onychology (Greek word, Onuks = nail, Logia = study of) is the subject which deals with study of fingernails and toenails for better administration of justice in the court of law. Nails are important tissues for human identification, employing morphological traits as well as bio-molecular information for individualization or direct comparison.

The nature of nail growth also provides unique chronological information along the length of the nail that is of utility in identification, bio-monitoring and in reconstructing recent life history. One of the major advantages of utilizing nail is that, in comparison with other tissues, sample size and sampling process can be considered relatively non invasive and non destructive and yet each nail retains a discrete record of detailed information on genetic inheritance, drug use, pathology, diet, and location history, as well as exposure to explosives residues or other pollutants. [1, 2]

Structure of Nail:
The main biological functions of nails are as protection for the underlying tissue of the nail bed.

Basically, the nail plate grows from the matrix, hidden by the proximal nail fold, eponychium, and true cuticle. The white proximal region of the nail, known as the lunula, is most prominent on the thumb and results from keratin that has not been completely flattened in the nail bed. Bulk of nail is comprised of hard alpha keratin. The water content will affect the flexibility of nails and can vary from 10% to 30%. [2]

Method:
Technological advances in electron microscopy (in particular, the advent of variable pressure scanning electron microscopy which allows for examination of nail in its native, uncoated state) and atomic force microscopy, the use of image analysis tools, and the development of cross-section techniques now provide a more comprehensive suite of techniques available to the nail examiner. [2]

Forensic evidence requires rigorous controls during sampling, packaging, and storage to ensure best preservation and to avoid problems of contamination. Although there is a certain degree of parity between different analytical techniques, it is important to take account of possible variation, particularly when dealing with small sample concentrations as with nail evidence, and also when this evidence may already be degraded. It is important to remember that use of one type of packaging material suited to one type of analysis may not benefit another, e.g. plastic packaging may affect chromatography because of the presence
of labile plasticizers, which can mask characteristic peaks on the spectra. [3]

In any scenario where low levels of DNA are present there is a risk that levels of external sources of DNA may be high enough to bias, mask or modify results of genetic analyses. As such it is important to ensure that potential sources of contamination, which may include foreign fluids such as blood, semen, or saliva, or even the cellular debris left on nail, post handling with bare hands, are removed prior to any genetic analysis. A number of studies have, therefore, been focused on the efficiency of potential cleaning methods in removing foreign DNA. These include more elaborate protocols such as cleaning the nail through ultrasonication and treatment with boiling water, acetone, bleach, ethanol and detergents. Another simple and apparently efficient method was direct soak for 1 hour in a detergent plus proteinase K solution. [4, 5, 6]

Utility:

Few physical traits have been discussed in relation to human nail for the purposes of identification, other than the condition of the margins (which may be used to determine wear) and the longitudinal striae of the lower concave surface of finger and toenails in post mortem remains. [7] During putrefaction, nails may be shed, particularly in aqueous environments. Identification may be aided by cultural practices and current fashion trends which influence the outward appearance of nail style, different types of nail polish, artwork and jewellery are also now used on nails. Nail abnormalities are also important in forensic identification. [2]

Common disorders in nail can involve alteration to the nail plate, nail bed, and periungual tissue. Fungal infections of nail (termed onychomycosis) are caused largely by dermatophytes, a specific group of fungi that can exploit keratin as a direct nutrient source. They result in clinical conditions such as tinea capitis caused predominantly by trichophyton or microsporum species. [8]

Nails may also be a useful source of residues trapped in the distal groove beneath the nail plate or around the cuticle. [2] Different formulations of nail polish and lacquer may be visually similar but have markedly different chemical compositions and formulations. [9] In cases of sexual assault, skin may be recovered from beneath the nail margin in instances where there has been contact with an assailant. [2]

The presence of explosives and gunshot residues beneath fingernails can be used to identify individuals, link them to a crime, and provide source information of particular importance with increasing terror attacks. Both inorganic and organic powder additives may provide characteristic signatures for sourcing explosives and gunshot residues. [2]

Because nail do not remodel, detailed chemical information (i.e., both isotopic information on food and water ingestion and molecular information on alcohol and other drugs) is locked into the nail as they form. This type of information can be used to build up a detailed picture of individual diet, recent location history, and exposure to pollutants or drugs of particular relevance to

1. Identification of unidentified remains,
2. Tracking the recent movement of people and
3. Exposure history or drug use. [2]

Drug Use and Nails:

Nails have been found to be a powerful alternative to hair for the detection of past drug use. Methamphetamine, amphetamine, cocaine, and opiates have been detected in forensic cases, although, so far, developing the potential of drug monitoring in nails has been held back by lack of harmonization and validation of analytical methodologies and better comprehension is needed of the possible correlation between drug concentrations in the matrix and period of exposure. [11]

The presence of therapeutic drugs in nail (such as antidepressant and antipsychotic drugs) may be useful in identifying post mortem remains. Sectional or “segmental” analysis provides a high resolution chronology for the last few months prior to death, which, together with post mortem examination, can distinguish deadly chronic abuse from single acute drug over dosage. Additionally, sectional analysis of nail may be used to indicate dosage history and the state of addiction or the compliance of patients under long term treatment. [2]

Nails also provide a substrate for sectional analysis; however, drugs are incorporated into nails by both deposition at the root end of the growing nail (via the blood flow in the nail matrix) and via the nail bed during growth from the lunula to the beginning of the free margin. [11] Interpretation of parent drug and/or metabolites in nail is not straightforward.
Certain drugs remain difficult to analyze in routine clinical and forensic toxicology because of their thermal instability and low therapeutic range (0.5–5 ng/ml). Similarly, cosmetic treatment and grooming practice are considered potential factors influencing drug uptake in the nail. [2] Two different techniques neutron activation analysis (NAA) and graphite furnace atomic absorption spectroscopy (AAS) have both been used for segmental analysis for the presence of arsenic, cadmium, cobalt, germanium, lead, lithium, manganese, mercury, nickel and thallium in the nails and the results were found to be comparable. Periodic ingestion of arsenic can manifest in tissues with correspondent formation of Aldrich Mees lines on the nails, characterized by white streaks. [1]

The nail has also been used to track heavy metal exposure as with uptake of high levels of tungsten traced in nails of a patient exposed during drinking. [12]

DNA from Nails:

DNA sequences can, in theory, be recovered from almost all biological tissues, including nail and as often survive relatively better than other tissues in the post mortem context, have obvious appeal for human identification. Both fresh and old or degraded nail has been used as a source of both nuclear DNA and mitochondrial DNA. [5, 6, 13, 14, 15] It seems that the DNA content of fresh nail does not appear to vary significantly between individuals or by individual finger. [15] Furthermore, DNA from nail is subject to the similar problems of degradation, contamination and probably allelic dropout.

Whether heteroplasmic is an issue as yet remains unstudied. Studies into the degradation of DNA in old nail suggest that age, environmental conditions and thermal energy are important in DNA survival, as is the structural integrity of the nail itself. [13, 16] Numbers of studies have reported the successful identification of assailants and rapists using DNA extracted from epithelial cells trapped below, and subsequently recovered, from fingernails of the victim. [4, 17]

Conclusion:

Nails are uniquely important trace evidence with a key use in human identification. Each nail may yield discrete information. Furthermore, the unique growth of these tissues (with rapid formation rates and no further biogenic change once formed) introduces the potential for gaining important time series data of high chronological resolution. This may be used to follow patterns of drug use or to track recent location history. In contrast to soft tissues, nails survive relatively well in the decomposition environment. Furthermore, in contrast to other long lasting tissues (such as bone and teeth) nails are easy to decontaminate from external sources of DNA. Therefore, nails represent a useful source of genetic information. It is important that any genetic analyses on such samples be performed in suitably controlled environments for example; those provided by specialist Forensic DNA laboratories. In short, Forensic Onychology is very useful in many ways to solve the crime.

References: