



## Case Report

## Foreign DNA in cosmetic gel nails

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## ABSTRACT

In this case study it was investigated whether foreign DNA may get encapsulated in a cosmetic gel nail. It was inspired by a murder case in which the main suspect claims that he was wrongly convicted. Most of the evidence in the case was circumstantial. The most direct piece of evidence was DNA of the suspect found beneath the victim's fingernails. According to the prosecution and the judges, the DNA meant that the suspect had murdered the victim. However, according to the suspect, the fact that his DNA was found could be explained by a physical altercation between him and the victim 17 days prior to the murder. In that alternative scenario, the suspect's DNA became encapsulated in the victim's gel nails and remained there up until her death 17 days later. In this article, we describe an experiment designed to assess the plausibility of the alternative scenario. In the experiment we tested whether foreign DNA could be recovered in gel nails of four female individuals two weeks after transfer. In six out of eight hands the profile of the donor could be detected. Hence, in situations resembling the circumstances of this case study, the encapsulation of DNA in a gel nail prior to the attack of interest must be considered.

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## 1. Introduction

In this case study, the possibility that foreign DNA gets encapsulated in a cosmetic gel nail was investigated. Whereas much work has been done on DNA transfer, persistence, prevalence and recovery (DNA-TPPR) in fingernail debris under normal circumstances (see [1] at p. 150 for an overview), in the current study a scenario was examined involving a broken cosmetic gel nail. In such a scenario, DNA may be encapsulated in the repaired gel nail and protected from external influences that would normally lead to degradation. The persistence and recovery of DNA in a cosmetic gel nail was tested in an experiment, inspired by the following case (the case is fully described in [2]).

## 1.1. The case

In 2002 firefighters discovered the bodies of the 23-year-old Ona and her 2-year-old daughter.<sup>2</sup> They were found in their home,

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<sup>2</sup> We changed the names of the individuals involved in this case.

which was on fire. Ona had moved from Eastern Europe to The Netherlands to work as a prostitute. She married her boss's son and together they had a daughter. At the time of the killings, Ona's husband was in jail for dealing drugs.

Ona and her daughter had both been strangled and Ona had also been stabbed four times with a knife. Post-mortem the nails of Ona were clipped, and the fingernail debris was analysed for DNA at the Netherlands Forensic Institute (NFI). At that time the NFI always pooled each hand's debris together because separate nails tended to hold too little material for a solid DNA analysis. On the nails of Ona's left hand an autosomal DNA mixture of Ona and a male were found. No foreign DNA was found on the nails of her right hand, nor on either hand of her daughter.

Ona's neighbour Jacob made himself a suspect when he told the police that he had been in Ona's house to pick up some stuff on the night she was killed. Jacob's DNA profile matched the one found in the DNA mixture on Ona's left hand. In the mixture, besides markers from Ona and Jacob, no additional markers were present. In a second analysis by another laboratory on request of the defence, the report said that there was not enough DNA for an autosomal profile.<sup>3</sup>

<sup>3</sup> We do not know whether this means that the second laboratory received less than 50% of the DNA extract, as would be standard procedure in the Netherlands. However, that is not an absolute requirement and the relevant law articles stipulate that a request by the defendant to have a second analysis will only be granted by a prosecutor or an investigating judge if there are enough materials for another analysis (article 151a and article 195b, Dutch Code of Criminal Procedure).

However, a Y-chromosomal DNA analysis could still be done, and confirmed the results. The DNA match was the most incriminating evidence against Jacob.

Jacob vehemently denied that he was in any way involved in the murder of Ona and her daughter. He said that he had not seen them that night and that his DNA must have gotten beneath Ona's nails during an incident that happened 17 days earlier. During that encounter, Ona had gone berserk in the street, probably under the influence of drugs. Jacob was called in for help and had carried the light-weighting Ona into her house. In the process she severely scratched Jacob's neck, leaving him bleeding a little.

Several witnesses confirmed the incident. However, the judges did not believe that Jacob's DNA could have been preserved on Ona's nails for over two weeks. That dismissal of Jacob's explanation was based on statements by several forensic experts, who, as will be described in more detail below, testified it would be 'highly unlikely' that Jacob's DNA would be preserved on Ona's nails for 17 days. Ultimately, Jacob was convicted a 16 years and 8 months prison term.<sup>4</sup>

## 1.2. Scenarios

Two scenarios are relevant in Jacob's case: the guilty scenario, in which Jacob committed the murder, and the innocent scenario, in which Jacob did not commit the murder. These scenarios offer differing explanations for the DNA found on Ona's fingernails.

The guilty scenario is obvious. If Jacob is guilty, his DNA must have gotten beneath Ona's nails when he attacked her. DNA analysis of fingernail scraping samples is a standard procedure for murder victims in the Netherlands [3]. Victims often try to defend themselves against their attacker, leaving DNA of the perpetrator beneath their fingernails [4]. Brief contact between a nail and someone else's skin often transfers enough foreign DNA to find a mixed DNA pattern beneath the nails, especially when the person scratches into deeper epidermal layers [5]. That is why co-habiting couples have DNA from their partners beneath their fingernails relatively often [6]. Although the incidence of non-self DNA beneath people's fingernails is low in the general population – it was found in 13 out of 100 samples [4] – the incidence may be much higher for victims who seem to have defended themselves against an attacker. Whereas DNA is transferred beneath the fingernails quite easily, it does not seem to be very persistent. Hence, DNA found beneath the nails of a murder victim is often assumed to be of the offender.

The defence's innocent scenario was that Jacob's DNA must have been transferred during the incident 17 days prior to Ona's death. Several experts were inquired to assess the likelihood of the innocent scenario. Whereas none of them could rule the scenario out, the experts agreed that it was rather unlikely for DNA to be preserved beneath a living person's fingernails for such a long period. For instance, activities such as dishwashing and showering are known to hinder detectability of non-self DNA beneath people's fingernails [7,8]. Ona was known to be a clean woman and her nails must have been in warm water on multiple occasions in the two weeks before her death. Besides, no DNA of other men was found, although Ona had worked as a prostitute the days before her death. So, the innocent scenario presented by the defence – that Jacob's DNA had persisted beneath the nails for some two weeks – did not hold.

However, Jacob's denial is not the only reason to raise questions about the guilty scenario. Ona's body was found on her bedroom floor after the room had been extinguished thoroughly by

firefighters. The room had been extinguished with a high-pressure extinguisher, and from above through a hole in the roof. In addition, the room was cooled off by spraying water. Several first responders described how Ona's body laid in a pool of water. A stream of water poured into the room, colouring red by Ona's blood. In these circumstances, persistence of DNA beneath Ona's fingernails seems exceptional.

There is, however, one other innocent scenario possible, not considered at the trial. That scenario was generated during a reanalysis in the Project Reasonable Doubt. Ona had so-called gel nails. During the scratching of Jacob's neck two weeks prior to Ona's death, one of the gel nails on her left hand broke. It also ruptured her natural nail, causing it to bleed. Tearing a gel nail requires a lot of force. It is also very painful. A female friend of Ona confirmed that Ona repaired the gel nail almost immediately after she broke it in Jacob's neck. That makes another innocent scenario possible: Jacob's body material came on Ona's nails when she scratched his neck, was encapsulated in the repaired gel nail and came loose when Ona's nails were clipped post-mortem. It was a scenario not considered by the experts who served at the criminal trial.

In the present case study, we empirically tested the possibility of encapsulating body material in a gel nail, inspired by the case of Jacob and Ona.

## 1.3. Gel nails and DNA

A first question when assessing the new innocent scenario is whether the chemicals used for gel nails may destroy DNA. Typically, when repairing gel nails, the first step is to stabilize the nail using glue. Please note that the police did not record what chemicals Ona's nail set contained. However, her regular nail stylist used glue with cyanoacrylaat (CA). CA may damage DNA to some extent. Especially when there is enough DNA (>50 µL), however, detection is still possible [9].

The gel of cosmetic gel nails contains oligomere acrylester, methacrylester and fotoinitiators. In addition, UV light is used to harden the gel, which may damage DNA [8]. Ona may have also disinfected her nails before repairing them. Based on the literature, we cannot assess how damaging gel nails may be for DNA. However, if these chemicals would be harmful, it would prevent finding any results in the present study.

## 2. Method

### 2.1. Transfer of the DNA onto the nails

Four female individuals who had never had gel nails before participated in the study. First, they washed their hands thoroughly with water and soap, to minimize contamination with foreign DNA from unrelated encounters. Then, each of them cut in their natural nails as far as possible without hurting themselves, to mimic a ruptured nail. They each used a different, newly bought pair of scissors, which had only been touched by themselves. One individual cut in two nails of both hands, two individuals three, and one individual four; so, in total 24 nails were cut in. Finally, a nurse dripped one drop of blood on each cut nail. The blood came from a registered male blood donor whose blood had been tested for, amongst others, HIV. A sample of his blood was sent to the DNA laboratory of The Maastricht Forensic Institute (TMFI) in The Netherlands, to be used as reference material.

### 2.2. Encapsulating the DNA in the gel nails

After the blood had dried, a nail stylist applied gel nails on all ten nails of each individual, not just on the nails with blood. She

<sup>4</sup> Decision Court of Appeals' s-Hertogenbosch, 15th December 2003, published as ECLI:NL:GHSHE:2004:AR0479 on [www.rechtspraak.nl](http://www.rechtspraak.nl) (in Dutch).



**Fig. 1.** Cosmetic nails applied to the natural nails (a) before and (b) after clipping and filing.

**Table 1**

Products used for the cosmetic gel nails, all from the brand Tilly's.

Products	Ingredients
Glue	Ethyl-2-cyanoacrylate (CA)
Primer	Methacrylic Acid Butyl Acetate, Butyl Methacrylate, Alcohol Denat
Gel	Polyurethane Acrylate Oligomer, Hydroxycyclohexyl phenyl ketone, Benzophenone
Gel polish	Di-Hema Trimethylhexyl Dicarbamate, PEG-4 Dimethacrylate, Ethyl Methacrylate, Hydroxycyclohexyl phenyl ketone, Violet 2/CI 60725

**Table 2**

Compositions of autosomal and Y-chromosomal DNA mixtures (char = characteristics).

Sample	# nails with donor blood	Autosomal DNA		Y-chromosomal DNA	
		Total DNA ng/ $\mu$ l	Male DNA ng/ $\mu$ l	Type of profile	DNA of the blood donor found?
1 (left)	3 nails	0.249	0.005	Mixture	Yes: Main profile
1 (right)	3 nails	1.440	0.036	Mixture	Yes: Main profile
2 (left)	3 nails	0.506	0.025	Mixture	Yes: Main profile
2 (right)	3 nails	0.690	0.009	Mixture	Yes: all char. present
3 (left)	2 nails	0.071	Not found	1 char.	–
3 (right)	2 nails	0.074	0.001	Some char.	–
4 (left)	4 nails	2.950	0.020	Mixture	Yes: All char. Present <sup>a</sup>
4 (right)	4 nails	2.830	0.139	Mixture	Yes: All but 2 char. Present <sup>a</sup>

<sup>a</sup> In addition, in these mixtures, all characteristics of another male were present. He contributed the main profile in the mixture found in the sample of the right hand.

was instructed to follow her normal procedure but to avoid cleaning and touching beneath the nails. The nail stylist worked as clean as possible, using different equipment for each individual. To prepare the nails for the gel nail, she cleaned their surface and filed it with an electric file. Then, she placed a cosmetic nail on the upper part of the natural nail, using glue (Fig. 1a). The cosmetic nails were clipped at the desired length and filed to blend with the natural nail (Fig. 1b). Then, a primer, two layers of gel, and one layer of gel polish were applied (see Table 1). After each of the upper three layers, the hands were placed under UV light for two minutes.

### 2.3. Recovery of the DNA

After 17 days, the four individuals went to TMFI's DNA laboratory. In the meantime, they had lived as usual and had no contact with the blood donor. At the laboratory, they washed their hands thoroughly and clipped their nails as short as possible. The clipped nails were sampled and analysed for DNA per hand. DNA has been extracted using the QIAamp DNA Investigator kit (Qiagen) and quantified using the Quantifiler Duo quantification kit (Thermo Fisher Scientific). Both autosomal and Y-chromosomal DNA profiles were generated using respectively NGM Select™ and Yfiler™ profiling kits (Thermo Fisher Scientific).

### 3. Results and discussion

In the samples of seven out of eight hands, an autosomal DNA mixture was found with the DNA of the individual as the main profile, and in addition a small quantity of male DNA (see Table 2). Only on the left hand of individual 3 just her own DNA was found. Because of the high amounts of DNA from the individuals themselves, the profile of the male blood donor could not be detected. That demonstrates that despite transferring DNA to two or more nails per hand, less male DNA may have been present in our experiment than in the case of Ona, whereas she only broke one nail. At the same time, Jacob's DNA could have gotten much deeper beneath Ona's nails than the male DNA in our experiment, making it more protected by the gel nail. In addition, Ona already had gel nails when she broke her nail, so instead of gluing a new clean nail onto the broken nail, she just put another layer of gel over her broken and bleeding nail. Hence, the low quantity of male DNA found in our experiment does not mean that the innocent scenario becomes implausible.

To analyse the male DNA, of the eight samples a Y-chromosomal DNA profile was made. That still gave mixture profiles. Since all individuals were female, they did not contribute to the mixture of the Y-chromosomal DNA profiles. Despite

washing their hands before sampling, some foreign DNA from males other than the donor must have been preserved beneath their nails (see also [10]).

The Y-chromosomal DNA of the male blood donor could be found in all samples from individual 1, 2, and 4 (see Table 2). That shows that DNA can be preserved in a cosmetic gel nail for 17 days. In the samples of individual 3, however, not enough DNA could be found to make a comparison to the blood donor. The samples of individual 3 may have been different from the other samples, because according to the others, she acted sloppy. She not only arrived too late at the laboratory, but also did not clip her nails very thoroughly. Hence, she may have failed to sample her natural nails, which contained the blood from the donor. Secondly, individual 3 received donor blood on only two of the nails of each hand, whereas the others had blood on three or four nails per hand. If the natural nails of individual 3 were sampled correctly, as she claimed herself, it means that the amount of DNA on just two nails may have been insufficient to be detected in the gel nails.

Our experiment by no means proves that Jacob's DNA has been encapsulated in Ona's nails 17 days prior to her death. The case study, however, demonstrates that finding DNA under these circumstances does not discriminate between an earlier transfer of DNA and a transfer of DNA during the crime. Encapsulating DNA in gel nails does happen, not only in theory but also in practice. In future cases where the victim has gel nails there is a genuine possibility that DNA unrelated to the victim's attack will be uncovered. In addition, this case study illustrates why experts must be careful when making activity-level statements. Without any empirical evidence taking into account all relevant elements of the case at hand, statements about the likeliness of a scenario are tricky.

#### Author agreement

We agree that all authors have seen and approved the final version of the manuscript being submitted. We warrant that the article is our original work, has not received prior publication and is not under consideration for publication elsewhere.

Although the DNA evidence and our experiment are discussed to some extent in a prior publication in Dutch [2], the current manuscript gives a more technical description and includes the full results of our experiment from the DNA laboratory.

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#### Declaration of Competing Interest

The authors report no declarations of interest.

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