Effect of Screen Protector Type on Touch DNA Recovery from Smart Phone Surfaces

Gundala Pravalika[1], Kadam Lavanya[2], Nuta Tejaswi[3]*

[1,2,3]B. Sc (Hons). Digital Forensics Science, Malla Reddy university.Hyderabad,India

gundalapravalika8@gmail.com

Abstract

Touch DNA has become an important source of evidence in modern forensic investigations this is due to the common reason of people's contact with personal devices like smartphones. As smartphone usage increases, people use different screen protectors which would include different materials used in its manufacturing this would definitely impact the amount of DNA left on the screen's surface . The aim of the research is to describe about how touch DNA recovery is affected by the usage of different screen protectors which are of different surface textures and properties. Four commonly used protectors include tempered glass , matte film, glossy PET, and liquid nano coating were used for comparison regarding the recovery and quantity of DNA samples from them.

Mobiles with different protectors are being used to extract DNA samples from them using standard forensic swabbing methods. The results include analysing which protector can provide more or less DNA, like matte film could provide more DNA, while others like smooth surfaces or hydrophobic surfaces show lower DNA material. The findings would help forensic investigators and labs understand the effect of different screen protectors in dealing with touch DNA samples and what effective methods are to be used while collecting touch DNA.

Keywords: Touch DNA, screen protector, Swabbing methods.

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I. Introduction

We leave behind us, when we touch things, small imprints of the DNA, termed as touch DNA, and which is used by the forensic scientists to provide evidence. Even so, the source of this DNA is yet to be discovered. It can be found on the skin cells, broken cells, or even free floating DNA, in particular, the one in the sweat. In the majority of studies, all the contents of a surface are collected simultaneously, which facilitates the acquisition of greater amounts of DNA, but it does not clarify its real origin. As it is predicted by the recent researches, cell-free DNA can be one of the key factors, and its level can vary in each person and even throughout the day. Recent technological developments, such as the use of new DNA sequencing technology can offer valuable information using tiny or even degraded samples of DNA. Techniques that have been developed on cell-free DNA on blood are currently applied to touch DNA since they are effective in retrieval of minute DNA strains. In general, broken or degraded DNA is also becoming useful in the field of forensics, thus enhancing the methods of retrieving such DNA is becoming more significant in the investigation[1],[2]. With the PCR discovery, it was now possible to replicate minute quantities of DNA in the laboratory in millions of copies. Due to this fact, PCR soon became a valuable instrument of DNA and genetic studies enabling scientists to detect and scrutinize DNA faster and more accurately. Once DNA is produced in large quantities, a standard technique known as gel electrophoresis is involved in separating fragments of DNA in accordance to the size. When the DNA fragments are placed on a gel, the application of electricity causes the bands to visible bands. To view the DNA under ultraviolet light, and take photos of the size of the bands they are stained using special dyes. To carry out gel electrophoresis procedure, researchers require both, a PCR machine (thermal cycler), gels with size markers, a power supply, and an imaging system to view and capture the findings[3]. DNA profiling is a highly significant instrument of crime investigation and the present-day approach is delicate enough to examine DNA that is deposited on the objects touched by individuals. It has been demonstrated that various quantities of DNA can be left on the hands of the person, and in some instances, the unaffected good DNA profile is available in fingerprints on most surfaces. This DNA is referred to as touch or transfer DNA. The DNA through touch can be particularly handy in violent crime cases where individuals are brought into intimate physical contacts. But recent studies reveal that the existing practices are not always effective only a few objects that are handled can generate a complete DNA profile. In order to enhance these findings, the scientists should have a more comprehensive knowledge of the origin of touch DNA and its modes of communication. The knowledge of this can assist in determining the forces that influence the extent of left behind DNA. This is better knowledge and hence touch DNA empirical evidence will be more reliable and confidence in its application in the courts will be enhanced[4].

It is not straightforward how DNA is transferred out of our skin when we touch things. Data is not always present in the skin cells, however, since skin sheds naturally, these cells are able to collect DNA of other body parts before getting to the surface. This implies that the DNA that remains on the objects does not necessarily originate as the skin cells exclusively. Our hands and fingers may serve as vectors themselves, carrying the DNA with them and contaminating the mouth, nose or even eyes before we touch another person. The amount of the remaining DNA is not dependent on the duration of contact with an object, but on an individual and a surface. Porous or rugged surfaces have high affinities to DNA compared to smooth surfaces. The individuals also vary in the amount of DNA they leave behind and this may vary according to the recent activities. Eventually, the success of obtaining a clear DNA profile of a touched item is highly contingent upon a large number of factors, including the individual, the hand with which they do it, the things they had previously done, and the surface they touched[5].

2. Methodology

Types of screen protection films and their impact on the retention on DNA

Smartphones are covered with different kinds of screen protectors, such as glass or plastic films. These materials feel different to the touch and this can affect how much DNA from our fingers stays on the screen. Some surfaces are very smooth, so DNA may transfer easily but also come off easily. Other surfaces are slightly rough or flexible, which can hold onto more DNA. Because people touch their phone screens many times every day, knowing how different screen protector materials affect DNA transfer and recovery is important in forensic work. Understanding this can help investigators collect better DNA evidence from mobile devices.

Tempered glass screens are very smooth and hard, so DNA doesn’t stick well to them. Most of the DNA stays on the surface and gets wiped away during regular phone use. Because of this, only small amounts of touch DNA are usually found. Recovery is generally low. In addition, tempered glass does not have pores or rough areas where skin cells or sweat can get trapped.

Any DNA that is deposited remains exposed and is easily affected by friction, heat from the device and repeated touching. Overtime, this can lead to DNA becoming damaged or completely removed from the surface .This makes it harder to obtain strong or complete DNA profiles from such screens. Whereas the Plastic(PET) screen protectors are thin and flexible, with a slightly less smooth surface than glass. This allows them to hold a bit more DNA from touch. However, the DNA can still be lost easily if the screen is cleaned. Overall, DNA recovery is moderate. Because PET protectors are lightweight and commonly used, they frequently handled and exposed to repeated friction from fingers. This constant contact can cause the DNA present on the surface to break down or be spread thinly across the screen. Environmental factors such as heat, moisture, and oils from the skin can further affect DNA quality over time. And the other screen type which is TPU (thermoplastic polyurethane) protectors feel soft and slightly rubbery when touched. Their surface easily traps skin cells and DNA. Because of this, they tend to keep more touch DNA. These are better surfaces for DNA recovery. The flexible nature of TPU also plays important role. When pressure is applied while tapping or scrolling, the surface conforms to the finger, increasing contact allows more biological material to transfer and settle into the surface. As a result, both the amount and persistence of DNA on TPU screens are usually higher compared to harder, smoother protectors.

The Matte or anti-glare protectors have a rough texture that reduces glare. This roughness helps catch more skin material when touched. As a result, more DNA can be recovered. The increased surface of matte protectors helps DNA remain on the screen for longer periods, even with regular handling. However, frequent rubbing, swiping, or cleaning of matte screens can slowly damage the DNA. The constant friction can break DNA into smaller fragments, reducing its quality even if the quantity remains relatively high. Matte protectors are also more likely to collect DNA from multiple users, which can result in mixed DNA profiles. Other types like Liquid screen coatings create a very smooth, invisible layer on the screen. DNA does not stick well when a person touches the screen. These coatings also reduce friction between the finger and the screen, which limits the transfer of skin cells and sweat in the first place. Any DNA that is deposited is highly exposed and quickly affected by cleaning, heat from the device and repeated handling. As a result, both the amount and quality of touch DNA recovery from these protectors are very low.

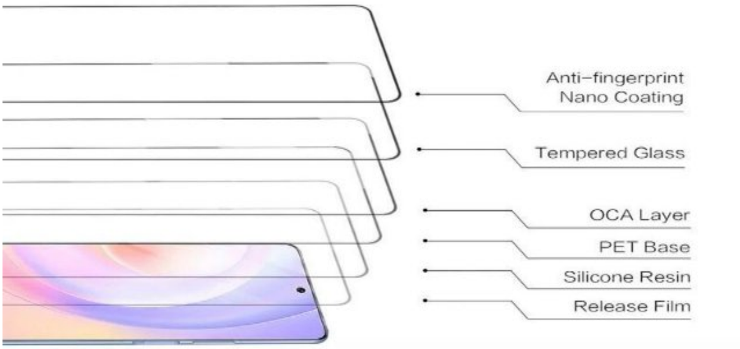

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Figure 1: Different screen protector types of mobile phone

3. Influence of Screen texture and Material properties

The amount of touch DNA that remains on a surface is strongly influenced by the texture and material properties of the surface. when a person touches an object, small amounts of skin cells, sweat, oils and DNA are transferred. How well this material stays on the surface depends on how rough, soft or smooth the surface is, and how it interacts with moisture and skin contact. Surface texture plays a major role in DNA retention. Rough or textured surfaces have tiny grooves, pores or uneven areas where skin cells and DNA can get trapped. Because of this, textured surfaces tend to hold more DNA and protect it from being easily wiped away. When it comes to very smooth surfaces such as polished glass, do not provide space for DNA to settle there. DNA remains exposed on the surface and is easily lost through improper handling.

Material properties such as hardness, flexibility and surface energy will also affect DNA retention. Hard materials like glass or ceramic do not absorb moisture or biological material, which limits how much DNA can stay attached. Softer materials, such as plastics and rubber-like polymers, are better at holding skin material because they slightly deform under pressure and increase contact with the skin. Some screen protectors are made with multiple layers or special coatings, such privacy screens. These layers can help trap DNA, but the amount retained can change depending on how often the phone is handled or cleaned. In simple terms we can say that how much DNA stays on a surface depends on how the surface feels and behaves when we touch it. When we handle an object , we naturally leave behind tiny bits of skin , sweat, oils, and DNA. Some surfaces are better at holding onto this material, while others let it slip aways very easily. Rough or slightly uneven surfaces act like tiny traps. The small grooves and pores give skin cells and DNA places to settle and hide, so they are less likely to be wiped away. Smooth surfaces, like polished glass, do not have these spaces. Any DNA left on them sits openly on the surface and can disappear quickly just from swiping, cleaning, or everyday handling.

The type of material also matters. Hard materials such as glass feel solid and do not absorb moisture, so they struggle to hold DNA . Softer materials, like plastics or rubbery protectors, gently press against the skin when touched, allowing more contact and helping DNA stick better. Sweat and natural skin oils can also help DNA stay behind, but many modern screens have special coatings that repel fingerprints and moisture, which makes it harder for DNA to remain. Flexibility also plays a role during repeated handling. S oft or slightly elastic materials can trap DNA initially, but constant rubbing, swiping, and pocket friction may gradually damage or redistribute the DNA, leading to mixed or degraded samples. Environmental exposure further affects DNA retention. Heat from the phone, humidity, and regular cleaning with cloths or chemicals can reduce both the amount and quality of DNA over time. As a result, even surfaces that initially retain more DNA may show reduced recover later. Over time, regular phone use, heat from the device, humidity, and frequent cleaning can reduce the amount and quality of DNA on any surface. Eeven surfaces that hold DNA well at first may lose it after repeated handling. Because of all these factors, touch DNA recover can vary a lot, and forensic scientists must carefully consider these properties.

4. Swabbing Methods

Different screens hold DNA differently, so different swabbing methods can be used for effective DNA recovery. The first one includes Dry swabbing method involves rubbing the screen with clean, dry swab. This is mostly used for very smooth screens like tempered glass. This method is a very quick and safe but limits the amount DNA collected. Second method which is the Wet swabbing method usually involves a swab dampened slightly with water. The moisture helps lift DNA that is stuck to the screen and this works better on plastic, TPU, matte screens. However, too much liquid(water) can reduce the DNA quality and also damage phone's surface. Other method which is a Double swabbing method is actually a two-step method and the most effective method that works almost all kind of phone screens. It involves using a damp swab to loosen the DNA, and a dry swab to pick it up. Certain swabs like Foam swabs which are softer than cotton swabs are used on smooth and coated screens. They collect DNA very gently by reducing the chance of damaging the screen which in turn helps preventing DNA from being lost due to swab fibres. Additionally ,Tape lifting involves pressing a sticky tape onto the screen's surface to lift skin cells and DNA. This process works well on textured or rough screens like matte. However, this technique must be used carefully as it can leave some marks or residue.

5. DNA Quantification method

It is a process of identifying the amount of DNA acquired from the collected touch DNA samples from different screen protectors. Because touch DNA is usually present in very small and fragile amounts, a highly sensitive method is need to measure it accurately. In this study, real-time PCR or qPCR was used for DNA measurement. This method works by making many copies of the DNA while at the same time measuring it using a fluorescent signal. As the DNA is copied, the signal increases, allowing the instrument to calculate the amount of DNA present in the sample.

qPCR is especially used for touch DNA because it can detect very small quantities of DNA and can also handle DNA that is broken or degraded. It provides reliable results even when only tiny amounts of DNA are present, which is common in samples collected from mobile phone screens. The another advantage of qPCR is that it will help in determining weather the DNA is suitable screen protectors, this method helps show how the type of screen protector affects touch DNA retention.

6. Extraction Method used

DNA extraction was performed to isolate the genetic material recovered from touch DNA samples collected from smartphone screen surface. A silica-based extraction method was used, as it's well suited for low quality and degraded DNA commonly found in touch DNA samples. This method allows efficient binding of DNA to a silica membrane, followed by washing steps to remove impurities and then finally getting out the purified DNA. The extraction process usually involves cell lysis using a lysis buffer and proteinase K to break down cellular material and release DNA. The lysate was then passed through silica column, here the DNA binds selectively. So, with unwanted material washed out , DNA collected in a clean solution that can be tested further. This method was chosen because it works well with touch DNA and helps recover both cell-based and free-floating DNA from smooth surfaces like smartphone screens.

7. STR profiling and Amplification

STR profiling and amplification of touch DNA can be understood as a way of making very tiny and invisible DNA used for identification. When a person touches an object like a mobile phone or it's screen protector, a few skin cells are left behind.

These skin cells contain DNA, but the amount is very small and can we very weak on its own, this DNA is too little to study. Inside our DNA are small repeating sections called short tandem repeats(STRs). Everyone has this repeat in same places, but the number of times they repeat is different for each person. This difference makes STRs very helpful telling people apart. Scientists study these repeating parts to create a DNA profile, which works like a personal identity code. Because touch DNA from screen protectors is present in such tiny amounts, it cannot be studied directly. To solve this problem, forensic scientists use a process called PCR amplification, which works like a powerful biological copying machine. PCR takes the small STR regions and makes millions of copies of them, turning a very faint DNA signal into something strong enough to be analysed. During this copying process, special fluorescent tags are added to so the DNA can be easily detected by laboratory instruments .

After amplification, the copied DNA fragments are passed through a machine that separates them based on size. Smaller fragments move faster, while larger ones move more slowly. As the fragments pass through the detector, the fluorescent tags light up and create a series of peaks on a graph. Each peak represents a specific STR pattern , and together these peaks represents a specific STR pattern, and together these peaks form a DNA profile that can be compared with known samples. Working with touch DNA from mobile screen protectors is not always perfect. Since the DNA amount is low, some parts of the profile may be missing, or DNA from more than one person may appear if multiple people interacted with the phone. Even with these challenges, the information obtained can still be very valuable. A partial DNA profile from a screen protector can help link a person to a mobile device, showing how STR profiling and amplification turn tiny traces of touch DNA into meaningful forensic evidence.

8. Effect of storage conditions

Touch DNA collected from smartphone screens is extremely delicate, so storage conditions can strongly affect whether it can later produce useful forensic results. By the time DNA is recovered from a mobile screen, it is often already stressed by heat from the phone, constant handling, sweat, skin oils, and cleaning products. This means that even small mistakes during storage can cause further damage. Proper storage is therefore just as important as proper collection. Dying the sample fully before storage is one of the most critical steps. Swabs used on phone screens often collected moisture from swear, cleaning residue, or screen oils. If these swabs are sealed while still damp, microorganisms can grow and begin breaking down the DNA almost immediately. Over time, this can lead to heavily degraded DNA or complete loss of genetic material. Allowing the swabs to air-dry in a clean, controlled environment greatly improves DNA preservation. Temperature control during storage also plays a major role. Touch DNA samples should not kept in warm or fluctuating temperatures, as heat speeds up DNA degradation. Because phones themselves generate heat, the DNA already experiences thermal stress before collection. Storing samples in cool, stable conditions- such as refrigeration-helps slow chemical reactions that damage DNA. Long-team storage at lower temperatures further increases the chances of successful profiling.

Another major concern is contamination during storage. Since touch DNA samples usually contain very small amounts of DNA, any foreign DNA introduced during storage can easily overwhelm the original sample. Improperly sealed containers, reused packaging, or frequent handling increases the risk of contamination. Each sample should be stored in a sterile, clearly labelled container, and contact should be kept to a minimum. Good storage practices help ensure that the DNA analysed truly reflects what was on the phone screen. Humidity and light exposure can also silently affect DNA quality. High humidity encourages microbial growth and chemical breakdown, while UV light from sunlight or strong laboratory lighting can damage DNA strands. Storing samples in dry, dark conditions using breathable but protective packaging helps prevent this damage. Overall, careful dying, cool temperatures, clean storage, low humidity, and protection from light all work together to preserve touch DNA from smartphone screens. When these conditions are maintained, even very small and fragile DNA samples can remain useful and reliable for forensic investigations[7].

9. Prevention of Quality and contamination

When touch DNA is collected from different types of screen protectors, both the quality of the DNA and the risk of contamination are important concerns. Touch DNA is usually present in very small amounts and is often degraded because mobile phones are handled frequently, cleaned regularly, and exposed to heat, moisture, and friction. Smooth surfaces like tempered glass or liquid-coated screens tend to lose DNA easily, which can result in low-quality DNA. In contrast, textured or softer protectors such as TPU, matte, or privacy screens can trap more DNA, but this DNA may still be damaged due to repeated handling. The type of screen protector therefore affects not only how much DNA is recovered but also how intact and usable that DNA is for analysis.

Preventing contamination is especially important when dealing with touch DNA, as even tiny amounts of unwanted DNA can affect results. Strict precautions must be followed during collection, including wearing gloves, masks, and preventive clothing, changing gloves between samples. Sterile, single-use swabs should always be used, and screens should be swabbed carefully to avoid transferring DNA from surrounding areas. Tools, work surfaces, and storage containers must be cleaned regularly to remove any background DNA. Samples should be properly labelled and stored in clean, dry conditions. By carefully controlling contamination and understanding how different screen protectors affect DNA quality, forensic scientists can improve the reliability and accuracy of touch DNA evidence collected from mobile phone screens. In addition, the way the DNA is collected and handled after sampling also plays a major role in maintaining its quality. Using the correct swabbing techniques, such as gentle but thorough swabbing with the right amount of moisture, helps recover DNA without causing further damage. Swabbing too aggressively can break down already fragile DNA, while swabbing too lightly may leave behind valuable material. Each screen protector surface may require slight adjustments in pressure and movement to achieve the best results. After collection, proper drying and storage of samples are crucial to prevent further degradation. Swabs collected from mobile screens aften contain sweat, oils, or cleaning residues, and if they are sealed while still damp, DNA can degrade rapidly. Allowing samples to dry completely and storing them in cool, dry, and dark conditions helps preserve DNA quality.

Minimizing handling during storage also reduces the chance of introducing contamination. So, knowing what type of screen protector is on a phone helps forensic investigators make better sense of the DNA results they get. If only a small or incomplete DNA profile is found on a very smooth screen protector, like tempered glass or a liquid coating, it does not automatically mean the phone was barely touched. These surfaces simply do not hold DNA well, and regular use or cleaning can remove most of it. So, low DNA recovery in such cases is often a result of the surface itself rather than limited contact. By looking at the screen protector material along with how the phone was used , handled and cleaned, investigators can avoid wrong conclusions. Considering all these factors together helps forensic scientists judge how reliable the DNA evidence is and how much weight it should carry in a case. This careful interpretation ensures that touch DNA from mobile screens supports investigations accurately rather than causing misunderstanding.

10. Face derived DNA compared to Touch DNA on mobile screens

When we talk about face-derived DNA affecting touch DNA on mobile phone screens , it helps to imagine how closely our phones interact with our face daily life. Most people regularly place their phones against their cheeks, lips, and ears during calls, video chats, or even while resting the phone against the face. Our face naturally sheds skin cells and produces sweat, oil(sebum), saliva droplets and respiratory moisture. All of these carry DNA . As a result, a phone screen often collects facial DNA even without direct hand contact, mobile phone screen quietly collects pieces of us every day. DNA reaches the screen mainly from two places: our face and our hands . when we make phone calls, hold the phone against our cheeks, speak into it, or keep it close to our face, DNA from the face easily transfer to the screen. Our face naturally releases skin cells, sweat, oily and moist, this DNA sticks very well to the screen . Even a short phone call can leave behind a good amount of facial DNA, and over time, this DNA slowly builds up on the screen and stays there longer. Touch DNA comes from our fingers when we tap, swipe or type on the phone. Fingers usually leave less DNA because they are often dry and shed fewer skin cells. Touch DNA lighter and does not stay for long. It can easily be removed by regular use, wiping the screen, or just by handling the phone again. If someone touches the phone only for a short time, their DNA may not remain for long. The type of screen also affects how DNA stays on it. Smooth glass screen allow both face and touch DNA to transfer easily, but facial DNA usually stays longer because of natural oils. Matte or rough screen protectors can trap some finger DNA in tiny grooves, while facial DNA spreads across the surface. Plastic screen protectors may not hold DNA strongly at first, but repeated contact with the face can still cause facial DNA to build up over time[7].

11. Overall limitations

When it is about touch DNA, screen protectors can make things much harder for forensic investigators. Most screen protectors are designed to stay clean, smooth, and free from fingerprints. While this is great for everyday phone users, it is not helpful for DNA recovery. When someone touches the screen, very little skin material actually sticks, and whatever does stick is easily lost as the person keeps using the phone. Simple actions like swiping, wiping the screen on clothes or putting the phone in a pocket can remove most of the DNA. Another big issue is cleaning their phone screens very often, especially when a protector is fitted. This regular wiping can remove DNA completely or damage it so badly that it cannot be analysed properly. Heat from the phone, constant finger movement, and moisture from sweat also weaken the DNA over time, making it break down faster. By the time the phone reaches a crime scene examiner, the DNA left on the screen may already be very small in amount or highly degraded.

The type of screen protector also changes how DNA behaves. soft or rough protectors may hold more DNA, but they can also trap oils, dirt and other substances that interfere with testing. Smooth protectors may give almost no DNA at all. Because of this, results can vary a lot from one phone to another, even if both were touched in similar ways. This makes it difficult for investigators to know how much importance to give to the DNA findings. Entirely screen protectors reduce both the amount and reliability of touch DNA on mobile screens. A lack of DNA does not always mean a person never touched the phone it may simply mean the surface did not hold the DNA well.

For this reason, investigators must be careful when collecting and interpreting touch DNA from phones with screen protectors and should always consider the type of protector used. Another problem with screen protectors is that they can give confusing DNA results. Phones are touched many times a day by the owner and sometimes by other people too. A screen protector can hold DNA from different moments in time. Older DNA may get stuck in tiny surface areas, while newer DNA may sit loosely on top. When this DNA collected, it can mix together, making it hard to tell who touched the phone last. Because of this, the DNA found on screen may not belong to the person who recently used the phone. It could be from someone who touched it earlier or even from normal daily handling. This can be misleading in investigations. So, touch DNA from phones with screen protectors should not be taken as clear proof on its own. It needs to be looked at carefully and supported with other evidence to understand what really happened.

12. Conclusion:

This study shows that our phones pick up tiny traces of our DNA every day, but how much stays on the screen depends a lot on the type of screen protector. Rough or soft protectors like matter or TPU holds onto more QNA because they give skin cells and sweat places to stick. Smooth protectors like tampered glass or liquid coatings do not hold DNA well, so it gets wiped away easily during normal use or cleaning. This means that finding little or no DNA on a phone does not always mean it was not touched. Phones are constantly handled, heated, cleaned, and pressed against the face, which weakens or removes DNA over time. Facial DNA can sometimes stay longer then finger DNA, and DNA from different people can mix together. Because of this, touch DNA from screens should be interpreted carefully, along with other evidence. Screen protectors protect phones, but they also change how DNA behaves, and understanding this helps investigators make better and fairer conclusions.

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