

UNRAVELING CLUES: THE ROLE OF CLOTH DAMAGE ANALYSIS IN CRIME INVESTIGATION

V.kajjal¹ Dr Sudanva G Kulkarni² Dinsha K³ Nidhin S⁴

Department of Forensic Science & Criminology, Nehru Arts and Science College, Coimbatore, 641 105, India,
99949 01231, kajjalsonu5@gmail.com

Dr. Sudanva G Kulkarni, Dept of Criminology and Forensic Science, Nehru Arts and Science College Coimbatore
<https://orcid.org/0009-0001-2580-9805>

Dinsha K, Dept of Criminology and Forensic Science Nehru Arts and Science College Coimbatore
<https://orcid.org/0009-0007-2040-3260>

Nidhin S S, Assistant Professor, Dept of Criminology and Forensic Science Nehru Arts and Science College
Coimbatore <https://orcid.org/0009-0002-2380-0628>

Abstract

The forensic examination of clothing serves as a critical aspect of investigative processes. Analyzing attire can help establish an individual's identity and reveal physical, biological, or chemical traces present on the garment. This approach aids in reconstructing the events leading to a specific crime. Furthermore, clothing evidence can provide insights into the cause of death, the location of the incident, and, in numerous cases, the time elapsed since death. Considering these factors, it is essential to collect and preserve clothing evidence at the crime scene meticulously. Proper packaging and preparation for relevant tests are necessary to uncover specific types of evidence, thereby enhancing the investigation's efficacy. Damages to textiles involved in forensic science constitutes a fairly significant tool in criminal investigations and can be utilized to narrow down cases of stabbings, shootings, sexual assaults, and so on. Besides, it is a source of information that can also help in solving arson attacks and "acid attacks". The research is made in order to check out studies that deal with blunt force damage, stab and slash cuts, the so-called issue of falsification of proof in sexual assaults, projectiles damage, the chemical and decomposition effect on textiles damage, and the others. It is evident that there are not many contributions to the field of study, but where the research has been done, the studies have been of a very high standard to conduct. Nevertheless, there are aspects that still have to be handled, such as a better understanding of general wear and tear, and the possibility of chemical exposure as the cause of textiles damage.

Keywords: Clothing; Identification; Forensic Examination; Physical, Chemical, Biological Evidence.

INTRODUCTION

The process of assessing damage to fabric garments begins with identifying and classifying the garment type as well as consulting an expert on the various ways damage can occur, including cuts, punctures, shots, scratches, tears, towel pilling, high-force cleaning spots, clothing stains, or soiled fabrics that affect the intact portions of the garment. These evaluations can uncover evidence that may support or contradict the condition being analyzed, along with potential methods of inflicting the damage and the manner of infliction (such as single penetrations or cuts accompanied by tears). These textiles can be categorized as woven, knit, nonwoven, or a combination of these types. Understanding the construction of these fabrics and how different types of damage can be inflicted, particularly regarding cuts or tears along seams, is essential. Training may involve creating test cuts or damages to familiarize individuals with the types of injuries that can occur from both combat and ordinary movements. Cases of fabric damage from gunshots and stabbings should always be noted but not labeled as examined, which is often the case with cuts from hospitals and marks left by scissors. It's important to document the garment's condition prior to analysis by taking photographs. Any additional evidence requiring further investigation, such as hair, blood, or paint, should also be documented and collected. The documentation must account for any physical loss, recording dimensions such as size, length, and diameter of the damage, along with the distinct V-shaped notch indicating the use of a single-edged blade. Care must be taken to avoid altering the shape, position, layering, or arrangement of the questioned specimen until it has been thoroughly documented through photographs. It is crucial that the evidentiary weapon or other items, such as fabric, knife, or screwdriver, are not allowed to come into contact with other samples that are suspected of either originating from or causing damage to the questioned specimen until all necessary forensic examinations, including DNA, latent fingerprinting, and toolmark analysis, are completed. Duplicating observations, or making multiple assessments of a single item, can reduce the likelihood of overlooking biological contamination, which may include blood, semen, saliva, and other related pieces of evidence such as hair, paint, and fibers caught in rope

knots. Knots should only be untied for biological evidence collection like DNA or trace evidence in a controlled setting after capturing comprehensive photographs that detail all aspects of the knot structure. The insights gained from analyzing fabric cuts and tears can be vast. For instance, test cuts can be performed on suspected weapons to determine if they can cause damage similar to that found on the evidence. The garment has sustained significant damage. The fabric's base can be placed on various surfaces, ranging from cardboard boxes to gel molds and even high-end body replicas used for analyzing blood spatter patterns. While trying to understand the nature of evidence from test cuts or tears, one can determine the position of a knife at the cut mark if a single-edged knife was utilized and a V-shaped notch is found at one end of the tear. Weapons should be scrutinized for fibers similar to those found in the damaged clothing. If a connection between fibers is identified, it would corroborate the conclusion about the tear; however, forensic descriptions related to fabric damage must remain limited to those uniform in size and shape with experimental cuts and consistent with being created by that weapon or a tool with comparable characteristics (size, shape, sharpness, etc.). Testing should take place on uncontaminated sections of the garment being examined or on a similar type of fabric.

CLASSIFICATION OF FIBERS

Classification of Fibres	Types	Examples
Natural Fibres	Proteins (Animal - Keratin Polymer)	Wool, Silk, Leather, Skins, Alpaca, Mohair, Angora, Camel, Vicuna
	Cellulosics (Vegetable - Glucose Polymer)	Cotton, Linen, Ramie, Sisal, Jute, Coir, Pineapple, Grasses, Banana, Kapok, Bamboo, Hemp
	Mineral	Asbestos, Metals (e.g., copper, silver, and gold)
Man-Made Fibres	Natural Polymer	
	Regenerated Cellulosics	Viscose, Modal, Lyocell/Tencel, Bamboo, Alginate, Peat
	Cellulose Ester	Acetate, Triacetate
	Latex	Rubber
	Synthetic (Petrochemicals)	
	Polyamide	Nylon, Tactel, Cordura, Polyester, Acrylic, Elastane, Microfibres (derivatives of polyester, polyamide, and acrylic)
	Poly-vinyl	Acrylic, Modacrylic
	Chlorofibre	PVC (Polyvinyl chloride)
	Aramid	Kevlar, Nomex
	Polyolefin	Polyethylene, Polypropylene
	Fluorofibre	PTFE (Polytetrafluoroethylene)
Inorganic		Carbon, Glass, Metal, Ceramics, Rock wool

FABRICS

1. COTTON YARN

Cotton fibers are natural fibers with a hollow structure; they are soft, cool, breathable, and highly absorbent. These fibers can retain water at a capacity of 24–27 times their own weight. They are durable, capable of absorbing dyes, and resistant to both abrasion and high temperatures. Yarn refers to a long, continuous strand of interlocked fibers, which is utilized in activities such as sewing, crocheting, knitting, weaving, embroidery, rope making, and textile production. Thread is a specific type of yarn designed for hand or machine sewing. Contemporary manufactured sewing threads may be treated with wax or other lubricants to endure the stresses of sewing. Embroidery threads are specialized yarns created for needlework purposes. Yarn can be crafted from a variety of natural or synthetic materials and is available in an array of colors and thicknesses, known as "weights." While yarn can be dyed in various colors, most are solid shades with a consistent hue.

2. VISCOSE SEMI SYNTHETIC FABRIC

Rayon, also known as the viscose, is, says sabra silk or cactus silk in some places, a semi-synthetic fiber from natural sources based on the regenerated cellulose of such wood and various agricultural products. The molecular structure of it is the same as that of cellulose. Various types and qualities of viscose fibers and films are present. The fibers copy the feel and the texture of natural fibers as silk, wool, cotton and linen. Some of those are frequently referred to as artificial silk, this is the case with those that resemble silk. It can be knitted or woven to produce textiles for garments and other applications. Rayon, which is extensively referred to as viscose and in some situations, sabra silk, and cactus silk, are semi-synthetic fibers obtained from organic materials such as wood and other agricultural products. Its molecular structure is just the same as that of cellulose. In the market, there are various types and grades of viscose fibers and films. Some fibers mimic the feel and texture of natural

fibers such as silk, wool, cotton, and linen. Silk-like fibers are normally referred to as artificial. Rayon can be knitted or woven to produce fabrics for clothing and for other uses.

3. LINEN

Linen is derived from the flax plant. Its fibers are twisted into yarn and subsequently woven into fabric utilized for bedding, curtains, medical dressings, and home décor. Linen is light, an excellent conductor of heat, naturally absorbent, and has antibacterial properties. It is quite durable and absorbs moisture effectively while drying more quickly than cotton. Due to these qualities, linen is comfortable to wear during hot weather and is appreciated for use in clothing. Linen fabrics can be produced from the fibers of the flax plant, yarn, and can be either woven or knitted. Additionally, linen has unique traits, such as a propensity to wrinkle. Harvesting linen takes considerably longer than gathering cotton, despite both being natural fibers. Weaving linen is also more challenging compared to cotton. Linen textiles are among the oldest known materials in history, with origins stretching back thousands of years.

4. SILK

Silk is nothing but a natural protein fiber and different types can be made into the fabrics. Essentially, the silk protein fiber is mainly made up of fibroin and is generally produced by the specific insect larvae which form the cocoons. The most popular silk thread comes from the cocoons of the mulberry silkworm, *Bombyx mori* that are manufactured in the process called sericulture. The shiny aspect of silk arises as the glass-like structure that makes up the silk fiber can bend the light coming from different directions and make a wide range of colors.

5. IKKAT COTTON

Ikat, which means "to bind" in Malayo-Polynesian languages, is a dyeing method originating from Southeast Asia that creates patterns on textiles by applying resist dyeing to the yarns before the weaving process. In Southeast Asia, where it is most commonly practiced, ikat weaving traditions can be classified into two main categories. The first category is associated with Daic-speaking groups in Laos, northern Vietnam, and Hainan. The second, more extensive category is connected to the Austronesian peoples in Indonesia, the Philippines, Malaysia.

6. JUTE

Jute, often referred to as "Burlap" or Nature's "Golden Fiber," is a remarkable long bast fiber. It gets its name from the golden hue of the fiber and its significance as a sustainable crop. This strong fiber adds a rustic and classic charm to any environment.

7. SATIN

A satin weave is a style of fabric weaving those results in a smooth, glossy, or lustrous material, usually featuring a shiny top side and a matte reverse; it lacks durability as it is prone to snagging. Along with plain weave and twill weave, it is one of the three primary types of textile weaves.

8. POLYESTER

Polyester fibre provides cushioning and insulation in pillows, comforters, stuffed animals, and upholstery padding. Its hydrophobic nature gives polyester fabrics high stain resistance, preventing liquid absorption.

9. CASHMERE

Cashmere is one of the softest materials, made from fine wool fibres. Fleece is lightweight and soft but less warm than cashmere. Bamboo, when blended with cotton or silk, can be softer and more sustainable. Cashmere comes from the cashmere goat, native to mountainous regions of Asia like Mongolia and the Himalayas.

IMPORTANCE OF FIBER MATCHING IN FORENSIC SCIENCE

Fibre matching is an important part of forensic science. It involves comparing fibres found from various locations, which may help connect suspects, victims, and crime scenes. If an expert shows that a fibre from a suspect's clothing is consistent with a fibre found on a victim or a crime scene, strong circumstantial evidence of contact, or presence, is created. For forensic purposes, experts compare fibre composition (degree of damage), structure of pigment/dye (white and end-game colours), and surface characteristics using methods such as chromatography, infrared spectroscopy, and microscopic wince. Fibre evidence will bolster cases but will mostly supplement other discoveries of forensic evidence as it will almost certainly not be sufficient by itself to establish guilt. Fibres matching works well for investigative purposes, as a fibre will only yield correct results if it is properly collected, preserved, and analysed.

SCOPE OF FIBER MATCHING IN FORENSIC SCIENCE

Fibre matching may be utilized in a variety of criminal cases such as homicide, assault, and burglary that are all associated with fibre evidence implicating touch or movement. Fibre databases, transfer studies, and

degradation studies will be applied in future work to enhance the accuracy, reproducibility, and defensibility of fibre matching outcomes. Fibre matching abilities will continue to improve as forensic science evolves, its application in criminal investigations being even more. Fibre matching utilizes trace evidence to link crime scenes, victims, and suspects, it is a crucial forensic science method.

In assisting potential sources, fibre evidence analysis examines the fibre on a microscope and use methods such as spectroscopy and chromatography to examine the make-up, colour, and dye pattern of the fiber Improved.

LIMITATIONS OF FIBER MATCHING

Fibre matching is important in forensic investigations but suffers from fundamental limitations as evidence. Fibre evidence does not exclude all other sources, in contrast to DNA or fingerprint evidence. Many textiles are mass-produced and widely available. A matching fibre only means there might have been contact or transfer; it does not demonstrate how contact or transfer took place or when it happened. Additional factors related to the environment, such as air currents, washing, or the disturbance of a surface, can modify fibre transfer either by introducing new fibres or modifying which fibres adhere to a surface. A definitive connection between the suspect and crime scene becomes particularly problematic with the notion of secondary transfer—that is, fibres observed undergoing transfer to a surface cannot automatically imply the origin and therefore the status of a fibre as evidence is complicated. Since fibre analyses provide subject opinion evidence based on comparative methods rather than unique individualization, this technique must be coupled with another forensic evidence source to provide confidence in investigative conclusions.

OBJECTIVES

1. Analyse the various forms of clothing damage and their importance in forensic examination.
2. Explore the characteristic features of cloth damage in different situations through microscopic analysis.
3. Develop a database of clothing from diverse sources and assess its usefulness for identification purposes.

METHODOLOGY

Particulars	Methods
Signification of Study	Textile fiber matching helps link suspects, victims, and crime scenes through transfer analysis. Studying fiber behavior ensures reliable evidence interpretation. This research strengthens forensic investigations with scientific evidence.
Universe of the study	Thirumalayam Palayam (Coimbatore) Reason of this universe is Our Native Places and No Such Kind of Study has done in this Area
Sample Collection	Eight commonly occurring fabrics in home were collected for the analysis, this contained Plant, Animal and Synthetic Fibres classification. Fibres collected are the Following: <ul style="list-style-type: none"> • Cotton • Viscose • Linen • Silk • Ikkatt Cotton • Jute • Satine • Polyester
Research Design	Explorative and Descriptive
Tools of the Study	Fabrics, Microscope, Slides, Coverslip, Ethanol, Forceps, Gloves
Limitations	Only few fibres analysed due to the lack of time.

RESULT

These images shows the pattern of fiber disturbance in different conditions like Tool, Fabricated, Grazed and Force damages. These are carefully observed through microscope and photographed for further analysis.

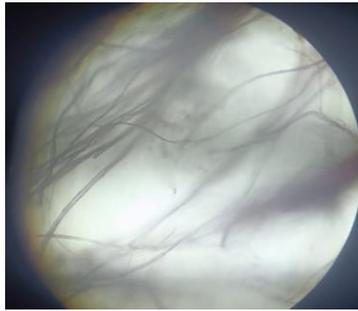
SAMPLE 1

Globally peer-reviewed and open access journal.

Forcefully



Self-Inflicted



Tool Mark



Grazed
SAMPLE 2
Forcefully

Self-Inflicted

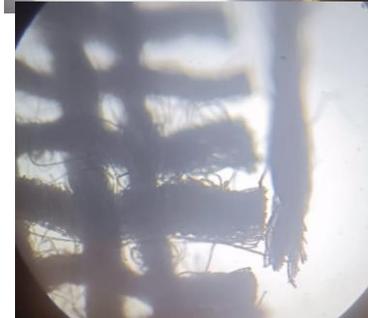
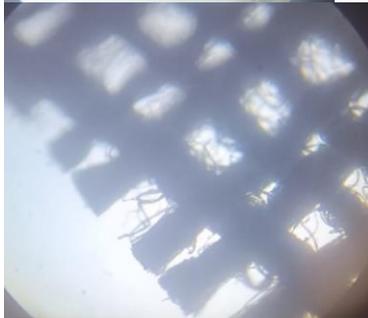


Tool

Grazed
SAMPLE 3
Tool

Grazed

Fabricated

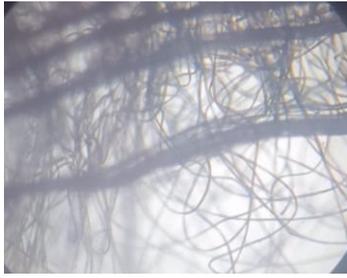


Force

SAMPLE 4

www.gapjibs.org/

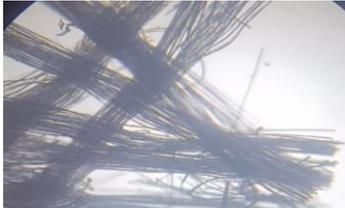
Fabricated



Tool



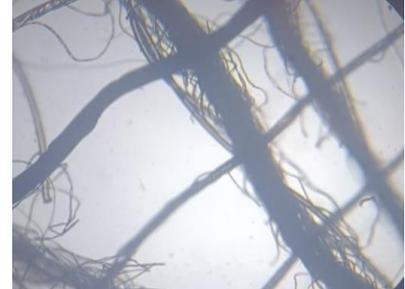
Force



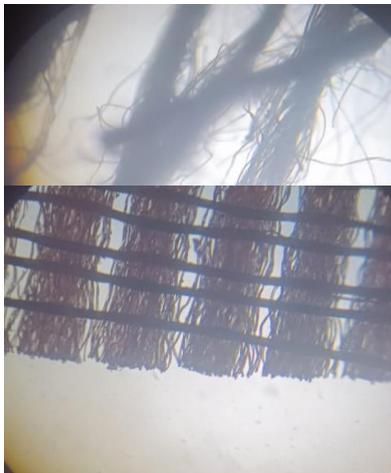
Grazed
SAMPLE 5
Tool

Grazed

Force



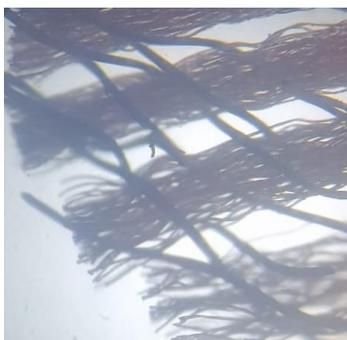
Fabricated



SAMPLE 6
Tool

Grazed

Fabricated

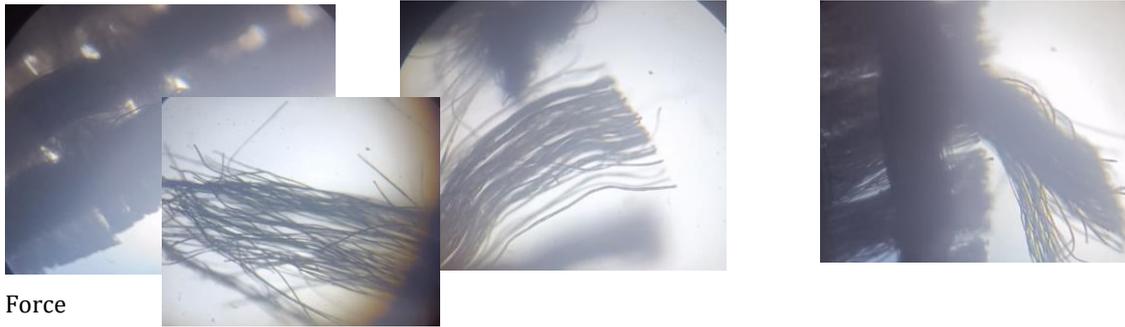


Force
SAMPLE 7

Tool

Fabricated

Grazed



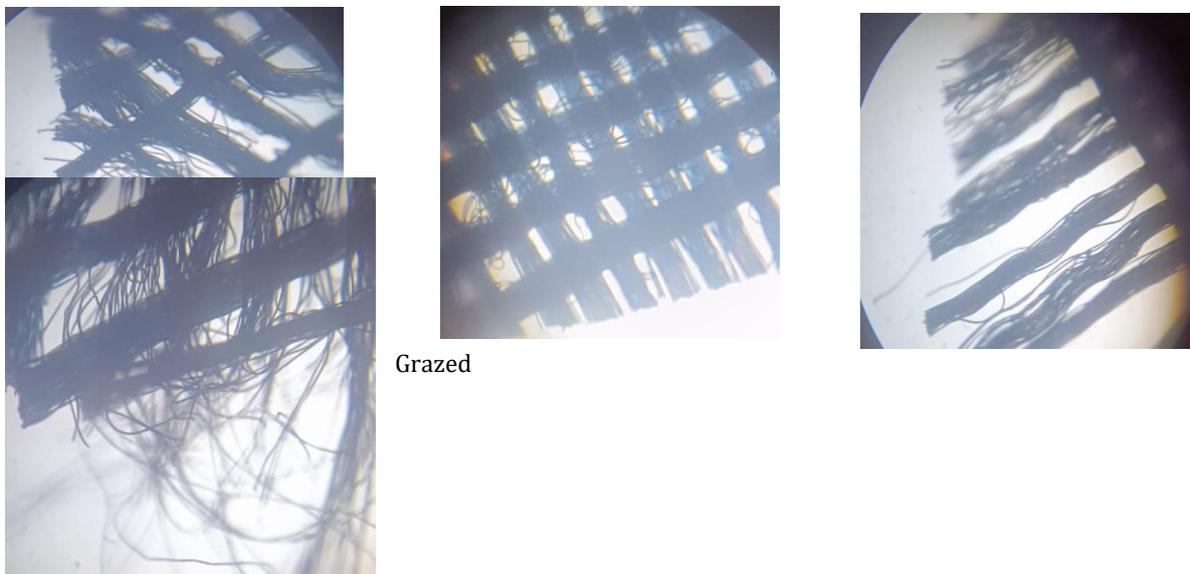
Force

SAMPLE 8

Force

Tool

Fabricated



Grazed

CONCLUSION

The analysis of clothing in forensic science plays a crucial role in criminal investigations, providing vital evidence that helps identify suspects and resolve cases. This study underscores the importance of textile examination in reconstructing crimes. When assessing fabric damage, if test cuts or tears correspond with documented damage, reports should state that the marks are comparable in size, shape, and overall appearance to those made by the examined weapon or a similar tool. The presence of fibre transfers on the weapon may strengthen the findings. However, reports should remain objective, avoiding overstatement or definitive exclusion of other potential weapons with similar characteristics.

Analysing fabric damage is a crucial aspect of forensic science, offering valuable insights into events preceding a crime. This research highlights the significance of meticulous inspection and detailed analysis of fabric damage, which aids in reconstructing complex crime scenes and identifying potential suspects. By examining texture, patterns, and the extent of damage, forensic specialists can extract critical information that contributes to the overall crime narrative, ultimately supporting the pursuit of justice.

Determining physical matches is essential when comparing two fabric pieces or cordage with cut or torn edges. A confirmed physical match should be supported by photographic evidence, detailed sketches, or comprehensive descriptions that document the condition of individual threads and their alignment in both the questioned and known items (referred to as "longs and shorts"). If a physical match cannot be established, a comparative study of color, pattern, construction, and material should be conducted to identify similarities and determine whether the items may have originated from the same source.

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