MICROSCOPIC EXAMINATION OF DAMAGE TO TEXTILES CAUSED BY VARIOUS TOOLS

Kanchalee Sirimongkol[1], Suda Riengrojpitak[1], Taweechai Amornsakchai[1] and Somchai Chalermsooksant[2]

1. M.Sc. Programme in Forensic Science, Faculty of Science, Mahidol University, Bangkok, Thailand
2. Central Institute of Forensic Science Thailand, Ministry of Justice, Bangkok, Thailand

Damage to clothing is commonly encountered in serious crimes of violence such as homicide and rape. The purpose of this study was to establish the morphological characteristics of damage to fabrics caused by different types of sharp objects commonly used in Thailand.

Three types of fabric-- woven fabric, knitted fabric, and blue jean fabric were tested. Thirteen different sharp objects were used to inflict the damage on the fabrics. The morphological characteristics of the damaged textiles were investigated through both macroscopic and stereomicroscopic examinations.

For all types of fabric tested, the damage produced by single sharp edged knives produced a regular cut pattern and appeared as a straight line with a neat edge. A straight line with a frayed edge was obtained from the notch-blade knife (knitted and jean) and the chisel (woven). A longitudinal hole with a frayed edge was produced by the bayonet (all fabrics), the notch-blade (woven), the Phillips head screwdriver (woven), the slotted head screwdriver (knitted and jean), the flat file (woven and knitted), scissors (knitted and jean) and the chisel (knitted). A circular hole with a neat edge was caused by the Waiter's Friend bottle opener (woven). A circular hole with a frayed edge was created by the Phillips head screwdrivers (jean), the slotted head screwdriver (woven), the round file (woven) and the bottle opener with a small, shallow, screwdriver-style head (woven). A horizontal hole with a neat edge was created by the Phillips head screwdriver (knitted), the bottle opener with a small, shallow, screwdriver-style head (knitted) and the Waiter's Friend bottle opener (knitted and jean). A horizontal hole with a frayed edge was obtained by the round file (knitted and jean) and the bottle opener with a small, shallow, screwdriver-style head (jean). A longitudinal groove was created by the flat file and the chisel on the jean fabric.

Keywords: Woven fabric / Knitted fabric / Neat edge / Frayed edge / Knives

MICROSCOPIC EXAMINATION OF DAMAGE TO TEXTILE CAUSED BY VARIOUS TOOLS

Kanchalee Sirimongkol[1], Suda Riengrojpitak[1], Taweechai Amornsakchai[1] and Somchai Chalermsooksant[2]

1. M.Sc. Programme in Forensic Science, Faculty of Science, Mahidol University, Bangkok, Thailand

2. Central Institute of Forensic Science Thailand, Ministry of Justice, Bangkok, Thailand

Introduction

Damage to clothing is commonly encountered in serious crimes of violence such as homicide and rape. Clothing damage analysis is carried out in sexual assault type cases [1, 2]. In cases of the instrument's penetration into the body through clothing the instrument characteristics related information may be supplemented by findings of the clothing damage investigation [3]. The examination of patterns of damage to textile fabrics reveal information about the way in which the damage occurred, such as the position of the damage relative to any body fluid staining; the ends of the yarn produced by a severance are neat or frayed; and the shape of each severed end of the fibres [4]. Morphologic and experimental comparative investigation of stab-cut injuries is significant and valuable for identification of a particular crime instrument [3].

The objective of this study was to establish the morphological characteristic damage on fabrics caused by sharp tools commonly used in Thailand. These information will help to reconstruct the dynamics of crimes in order to corroborate the declaration of a suspect of homicide which earn a great benefit on Thai forensic science.

Materials and Methods

1. *Materials*

Three types of fabrics (woven or cotton, knitted fabrics and blue jean) and thirteen types of new tools which commonly available in Thailand were used to produce damages in the present study. They were single sharp edge knife (kitchen knife, fruit knife and pocket knife), double sharp edge knife (M7 bayonet), notch (serrated) bladed knife, Phillips head screwdriver, slotted head screwdriver, round

file, flat file, round pointed bottle opener, Waiter's Friend bottle opener, scissors and chisel. All tools and cloth samples were kept in the laboratory room at 25°C, 65% moisture for at least 24 hr before performing the experiment.

2. *Photography the tools*

All new tools were cleaned with washing powder or detergent and tap water. They were dried at room temperature (25°C). Photography was taken with a measuring scale by a digital camera

3. *Photography the cloth samples*

Each piece of cloth sample was given an identifying number and photographed prior to the experiment in order to document the original condition.

4. *Stabbing methods*

The cloth samples were firmly held in place to a stainless steel beaker containing 15% set gelatin. Each cloth sample was stabbed perpendicular to the cloth surface with each type of tool by applying the same force to a right hand. Each experiment was performed three times. A total of 117 cloth samples were examined. After stabbing, the penetration part of the blade was marked, removed from a set gelatin, measured with a measuring scale and photographed with a digital camera (Figure 1).

5. *Examination of the damaged cloth samples*

5.1 *Macroscopic examination*

Specific features of the damaged area (both damage ends, knots) on each cloth sample were examined with the naked eyes. The dimensions (size, length, width, diameter) of the damaged area were measured and photographed with a digital camera.

5.2 *Microscopic examination*

Low power (26.8X) stereomicroscope (SZ-PT OLYMPUS) was used to examine the characteristics of each damaged area. Under microscope, planar array could be confirmed, pulled thread ends could be visualized. They were then analyzed and photographed with the Motic Images Plus 2.0 ML software.

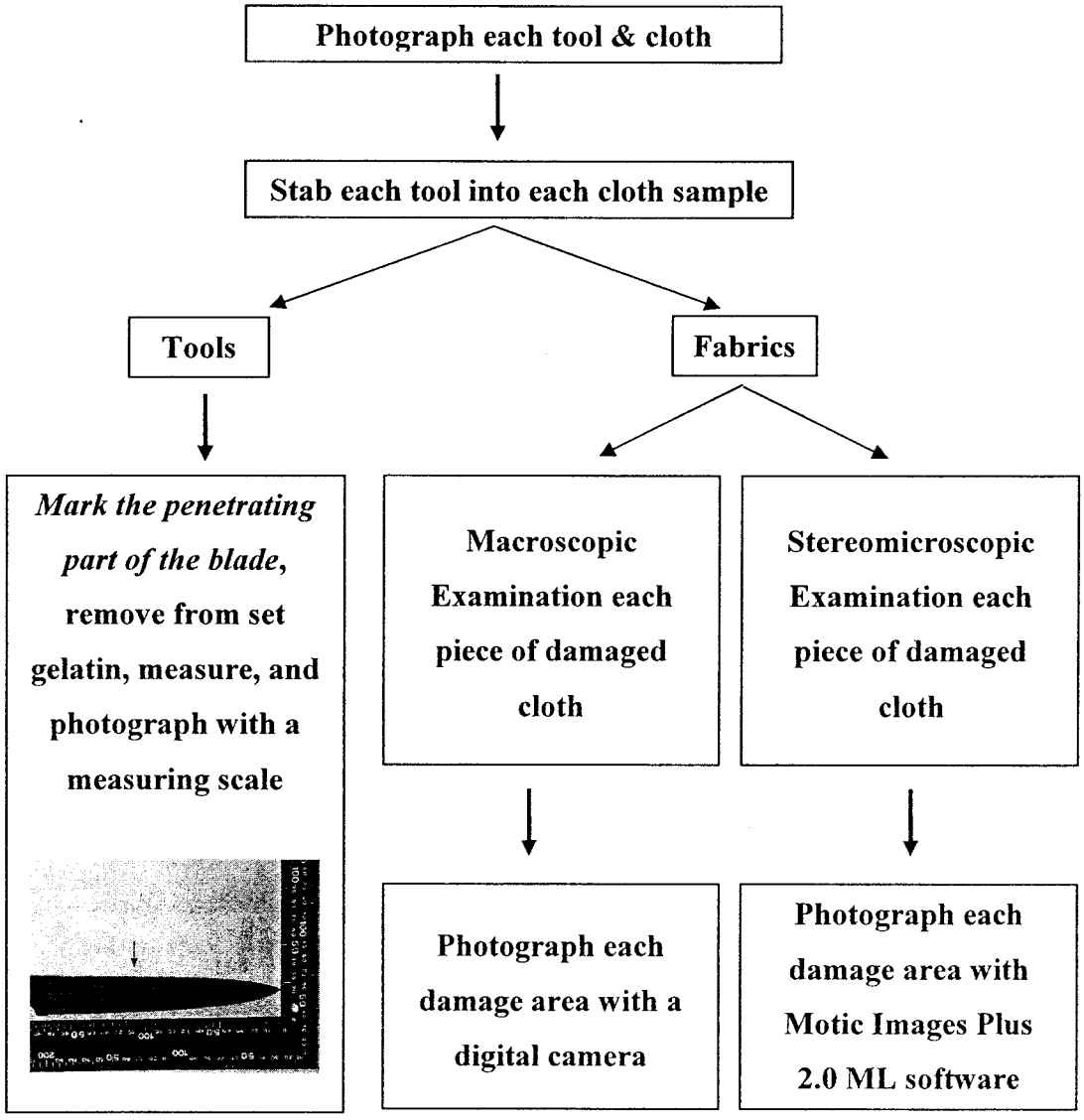


Figure 1. Sequence of methods used for each type of fabric and tool

Results

Stereomicroscopic examination of the damage area revealed clearly on the cutting edges (frayed edge or neat edge) compare to those observed by the naked eyes. In addition, the size of the damages measured by the Motic Image software give higher precision than those obtained by a measuring scale.

Seven patterns of stabbed damage on three types of fabrics produced by thirteen types of tools were illustrated in Figure 2.

The morphological characteristics of damaged fabrics caused by various tools were summarized in Table 1.

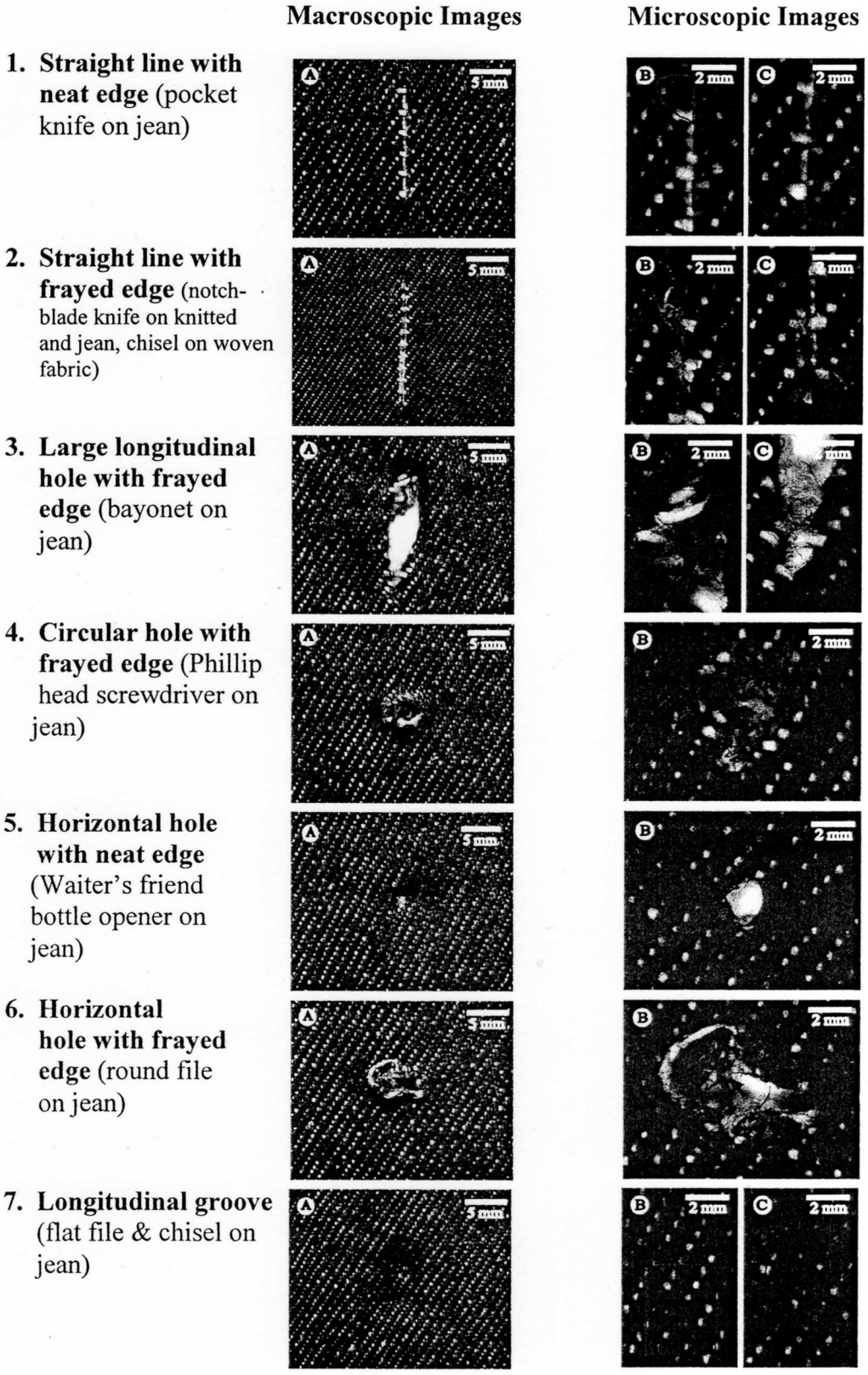
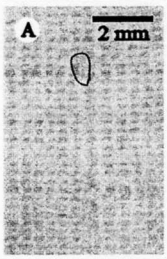
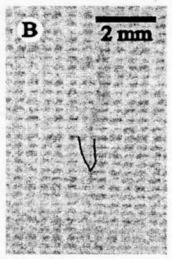
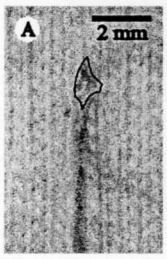
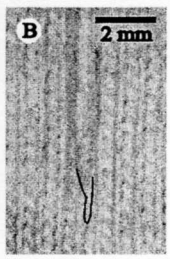
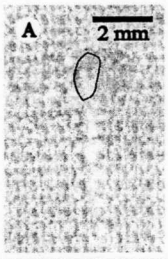
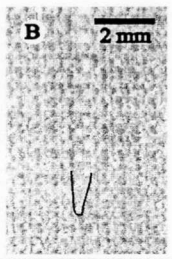
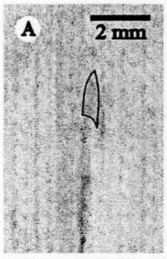
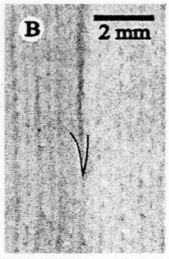
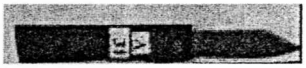
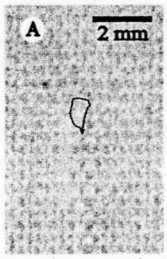
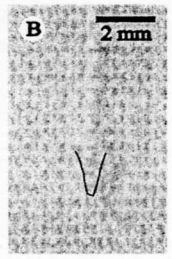
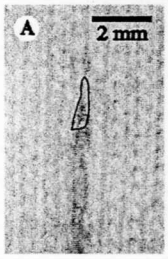
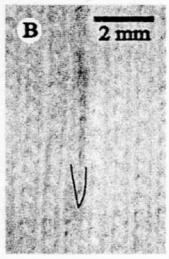
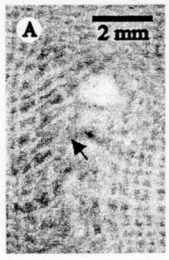
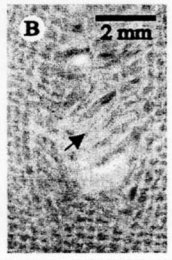
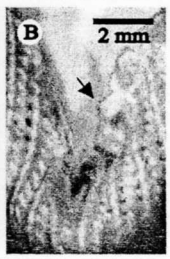
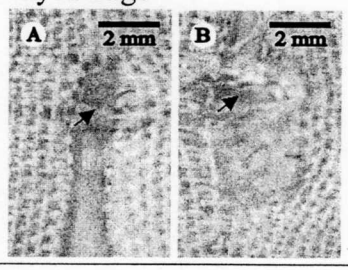
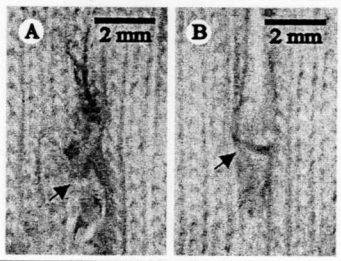
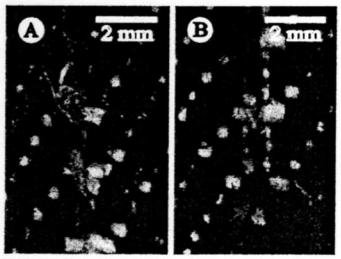
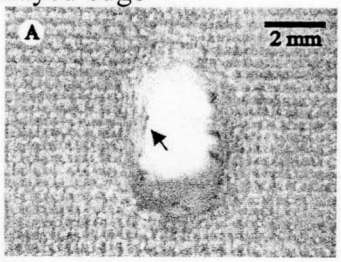
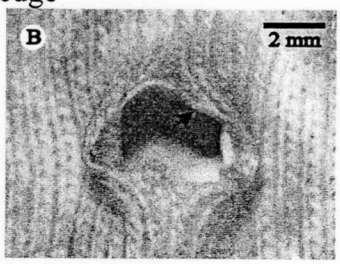
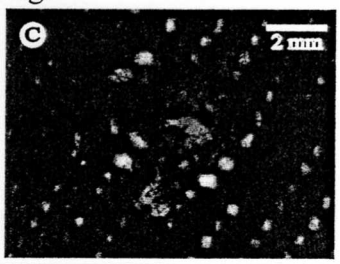
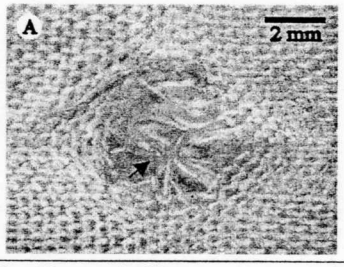
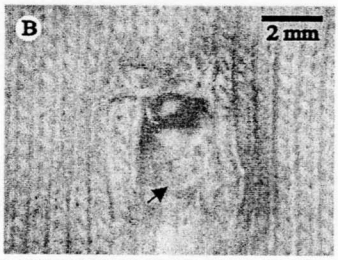
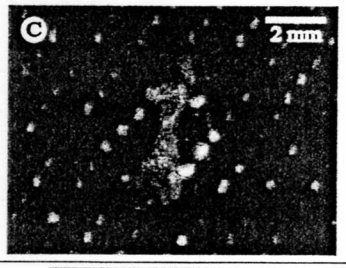
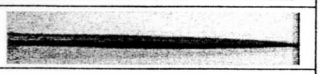
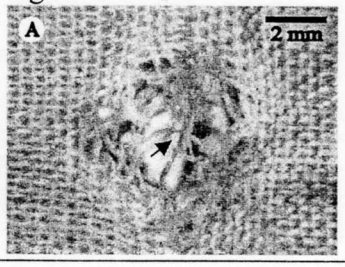
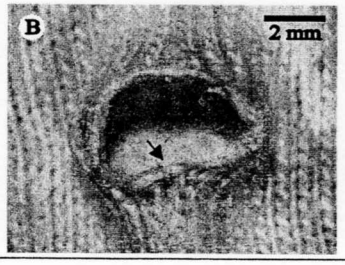
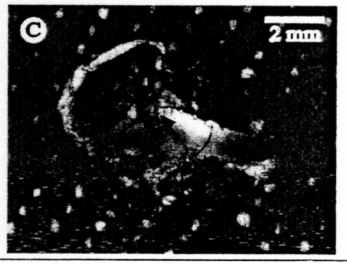


Figure 2. The patterns of stabbed damage on the fabrics

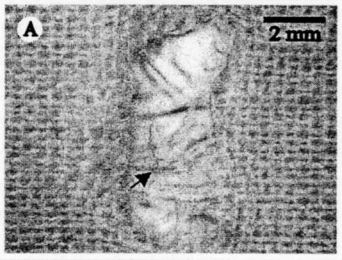
Table 1. Microscopic examination of the stabbed damage on the fabrics produced by thirteen types of tools. (A and B: upper and lower parts of the damage, respectively).
a. the width of the penetrating part of the blade b. damage size on woven fabric
c. damage size on knitted fabric d. damage size on blue jean

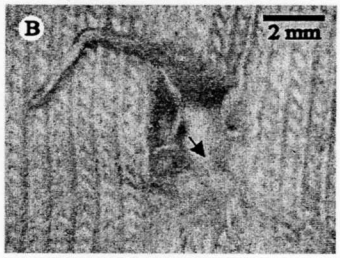
Single sharp edge knives: **Straight line with neat edge**			
1. Kitchen knife a. 25 mm b. 32 mm c. 25 mm d. 22 mm 			
Woven		**Knitted**		**Blue jean**	
					
2. Fruit knife a. 11 mm b. 10 mm c. 10 mm d. 9 mm 			
					
3. Pocket knife a. 15 mm b. 15 mm c. 14 mm d. 13 mm 			
					
Double sharp edge knife: **Longitudinal hole with frayed edge**			
4. Bayonet a. 22 mm b. 20x3 mm c. 15x5 mm d. 16x5 mm 			
					

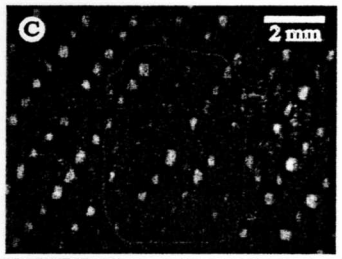
Imperfection knife		
5. Notch-bladed knife a. 33 mm b. 33x6 mm c. 29 mm d. 27 mm 		
Woven	**Knitted**	**Blue jean**
Longitudinal hole with frayed edge	Straight line with frayed edge	
		
Hand tools		
6. Screwdriver with Phillips head a. 5 mm b. 8x3 mm c. 8x3 mm d. 4x4 mm 		
Longitudinal hole with frayed edge	Horizontal hole with neat edge	Circular hole with frayed edge
		
7. Screwdriver with slotted head a. 4 mm b. 5x5 mm c. 4x2 mm d. 4x2 mm 		
Circular hole with frayed edge	Longitudinal hole with frayed edge	
		
8. Round file a. 5 mm b. 5x5 mm c. 3x5 mm d. 3x5 mm 		
Circular hole with frayed edge	Horizontal hole with frayed edge	
		

9. Flat file
a. 8 mm b. 8x3 mm c. 6x3 mm d. 8x3 mm

Woven	Knitted	Blue jean
Longitudinal hole with frayed edge		Longitudinal groove

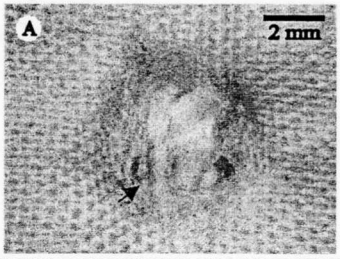


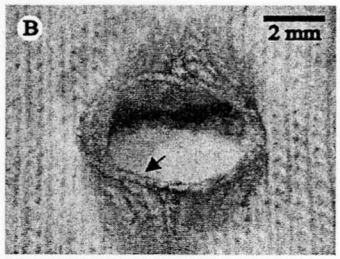


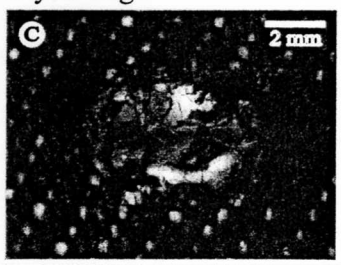


10. Bottle opener with small and shallow screw head
a. 5 mm b. 3x3 mm c. 3x6 mm d. 3x3 mm

Circular hole with frayed edge	Horizontal hole with neat edge	Horizontal hole with frayed edge

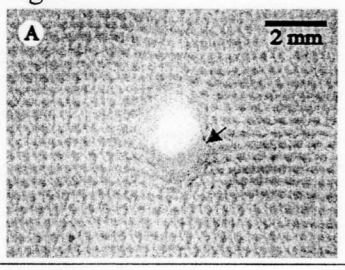


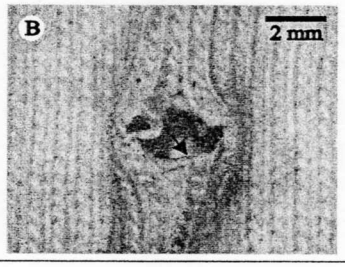


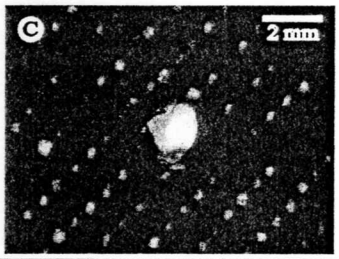


11. Waiter's friend bottle opener
a. 2 mm b. 2x2 mm c. 2x3 mm d. 2x3 mm

Circular hole with neat edge	Horizontal hole with neat edge	

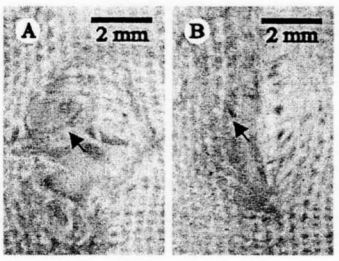


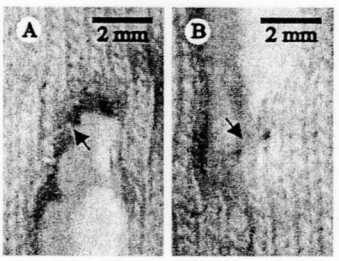


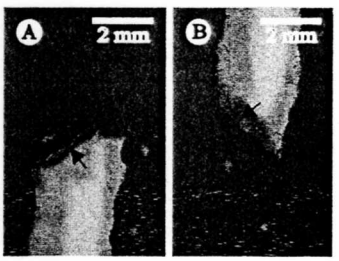


12. Scissors
a. 5 mm b. 10x4 mm c. 10x4 mm d. 10x4 mm

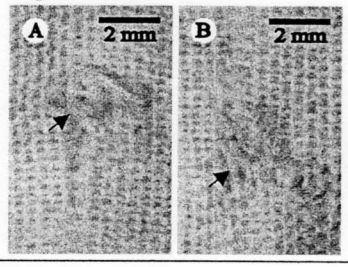
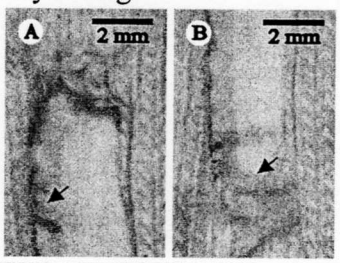
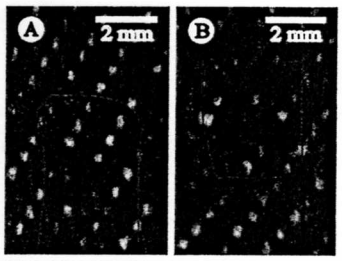
Longitudinal hole with frayed edge







13. Chisel a. 5 mm b. 15x4 mm c. 13x4 mm d. 13x4 mm 

Woven	Knitted	Blue jean
Straight line with frayed edge	Longitudinal hole with frayed edge	Longitudinal groove
		

For all three types of fabrics, the damage produced by the sharp pointed tools (single sharp edge knives) appeared as longitudinal straight line with neat edge or very regular cuts with two opposite edges close together; the double sharp edged knives produced longitudinal hole with frayed edge. The notch-bladed knives created longitudinal hole with frayed edge on woven fabric, and straight line with frayed edge on knitted fabric and blue jean. Small round rod hand tools such as screwdriver with Philips head or slotted head, round file and bottle opener with shallow screw head created holes longitudinally or horizontally depending on the type of fabrics. Flat rod tools include flat file and chisel created longitudinal hole with frayed edge which larger than those obtained from small round rod tools on woven and knitted fabrics, and longitudinal groove on blue jean. The damage produced by spiral or screw head of Waiter's friend bottle opener demonstrated small circular holes on all types of fabric tested. The damages produced by the long sharp pointed head scissors produced longitudinal hole with frayed edge on all fabrics.

Discussions

Fifteen percent gelatin was the optimum concentration used for stabbing purpose and could be simulated the human body. Too soft or too hard the gelatin could affect the penetration of the blade.

The type of fabric also affects the tool's penetration. If the same tool is used to create damage on different type of fabrics, it is more difficult for the tool to penetrate a dense and thick fabric like jean compare to an open structure material like the woven or knitted fabrics. The woven fabrics and knitted fabrics are predominantly

used for the manufacture of clothing and home textiles respectively. They play the most important role in forensic fibre examination [5].

The stabbed damages on three types of fabrics produced by thirteen different types of tool were shown in Table 1. The result obtained could be categorized into 7 patterns: straight line with neat edge, and frayed edge, longitudinal hole with frayed edge, circular hole with frayed edge, horizontal hole with neat edge, and frayed edge, and longitudinal groove. These patterns could be related to tool's characteristic as follows.

1. The tip of tool affects the fabric distortion near the point of penetration [5]. A blunt tip tool is more difficult to make the initial penetration of the fabrics. As the blunt tip engages the fabrics, it starts to push the thread away from the plane of fabric, resulting in the fabric distorts around the point of penetration as shown by the damage produced by the flat file and the slotted head screwdriver on woven and knitted fabrics. The broken yarns in this region create fray edges because of the tension developed in them. However, the fabric distortion does not appear in case the tool had a very sharp tip such as damage on three type of fabric created by a Waiter's friend bottle opener.

2. The sharpness of the blade affects the shape of the severance [5]. A sharp blade tool cuts the yarns neatly when it travels through the fabric as seen on the damage on three types of fabrics caused by single sharp edged knives (kitchen knife, fruit knife, and pocket knife), whereas the severed yarns fray in case the tool had a blunt blade because a blunt blade tend to pull the yarns rather than being cut the fabrics as shown by the damage on three types of fabrics produced by a double sharp edged knife (M7 bayonet). The presence of notches (serrated) on a blade increase fraying and distortion in the same way as the penetration of a blunt blade as illustrated by three types of fabrics and the notch-blade knife.

3. The dimension of the blade affects the size of the severance [5]. The thickness of the blade influences the width of the severance, due to the broken yarn ends are pushed by the passage of the blade as illustrated on three types of fabrics by M7 bayonet and a slotted head screwdriver. The width of the blade influences the length of the severance; however, this is also affected by the depth of penetration and whether there is any slashing in the stabbing action.

4. The surface area of the cutting edge affects the fabrics penetration. The narrow or small surface area of the cutting edge tool concentrates all the force onto a very small area, resulting in high amount of pressure which allows it to penetrate all types of fabrics as seen by round file, bottle opener with small and shallow screw head, and Waiter's friend bottle opener whereas this effect does not produce by the broad cutting edge tool as shown by the damage on blue jean caused by a flat file and a chisel.

Conclusions

For three types of fabrics tested, the damage produced by the sharp pointed tools (single sharp edge knives) was a straight line or regular cuts. Knives with double sharp edged or notch-bladed created frayed edge hole, non-pointed and non-sharp tools as a screwdriver produced stab-like damage appear as irregular and fringed holes.

Acknowledgement

This research was supported in part by the Thesis Grant, Faculty of Graduate Studies, Mahidol University.

References

1. Boland, CA, McDermott, D and Ryan, J. (2007). Clothing damage analysis in alleged sexual assaults - The need for a systematic approach. Forensic Science International. 167; 110-115.
2. James Robertson & Michael Grieve. (1999). Forensic Examination of fibres 2nd. Edition. Taylor & Francis Forensic Science Series.
3. Sitiene, R, Zakaras, A, Pauliukevicius, A and Kisielius, G. (2007). Morphologic, experimental-comparative investigation as an identification of the injuring instrument method. Forensic Science International. 167; 255-260.
4. Jackson, ARW & Jackson, JM (2004). Forensic Science, Pearson Education Limited, Edinburgh Gate, England. Pp.102-105.
5. Johnson, N. (1991). Physical damage to textiles. *Australian Institute of Criminology Conference Proceedings no 18*, 121-128.