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Metrical assessment of cutmarks on bone: Is size important?

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ABSTRACT

Extrapolating type of blade from a bone lesion has always been a challenge for forensic anthropologists: literature has mainly focused on the morphological characteristics of sharp force lesions, whereas scarce indications are available concerning the metrical assessment of cut marks and their correlation with the size of blade.

The present study aims at verifying whether it is possible to reconstruct the metrical characteristics of the blade from the measurements taken from the lesion.

Eleven blades with different thickness, height and shape were used for this study. A metallic structure was built, in order to simulate incised wounds and reiterate hits with the same energy. Perpendicular and angled tests were performed on fragments of pig femurs, in order to produce 110 lesions (10 for each blade). Depth, height and angle were measured and compared with metrical characteristics of each blade.

Results showed a wide superimposition of metrical characteristics of width and angle of lesions regardless the type and the orientation of blade: for symmetric blades a high correlation index was observed between the depth of the lesion and the angle of the blade in perpendicular tests (0.89) and between the angle of lesion and the height of the blade in angled tests (−0.76); for asymmetric blades in both the tests a high correlation was observed between the angle of the blade and angle and width of the lesion (respectively 0.90 and 0.76 for perpendicular tests, and 0.80 and 0.90 for angled ones).

This study provides interesting data concerning the interpretation of cutmarks on bone and suggests caution in assessing the size of weapons from the metrical measurements of lesions.

1. Introduction

Sharp force injuries have a relevant role in forensic pathology and anthropology. The forceful impact of an object against human tissue may create a recognizable patterned injury [1–3]. Sharp force injuries on skin may provide an indication concerning the blade type [4–6], and literature has provided with time several articles concerning the correlation between a specific lesion and morphological characteristics of the used weapon [7–24]. Among the others, articles by Alunni-Perret [25,26], Thompson and Inglis [27] and Shaw et al. [28], provide practical suggestions for the interpretation of lesions. Alunni-Perret [25,26] illustrated how a single-bladed knife and hatchet can make similar linear and narrow wounds with either a raising or a small depression near the edges, due to the pressure laterally exerted onto the bone. Thompson and Inglis' study on stab injuries reveals that non-serrated blades leave T-shaped stab marks, while serrated blades leaves Y-shaped stab marks [27]. Shaw used 2 symmetrical blades and performed perpendicular tests, correlating the angles of the lesion and the cutting edge [28]. This study showed how knife tool marks on bones often fail to reflect the knife shape and size due to the bone elasticity.

However, if from a morphological point of view literature provide detailed data for the reconstruction of the type of weapon, the same is not valid for what concerns the analysis of metrical assessment of lesions and the correlation with the size of the weapon. Not much research up to now has been dedicated to extrapolating the metrical characteristics of cut marks related to the type of weapon. Therefore, many questions still remain unanswered. For example, does the bone lesion reflect the size of the blade?

The few indications actually available in literature usually concern saw marks, and in detail the reconstruction of the tooth size [29]; other studies attempted at drawing indications concerning the size of the saw, but took into consideration lesions produced in wood [29]. Some additional indications are provided by case

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reports: Blake in 1985 correlated the kerf width and saw blade width in a serial murder case which occurred in Tennessee [30]. From an experimental point of view, the first contribution was given by Symes who in 1992 established that measurements of minimum kerf width closely correspond with measurements of blade width [31]. However, no precise metrical indication is provided concerning the minimum and maximum width of lesions produced by the same tool.

For what concerns cut marks, even fewer data are available: literature highlight that knife marks tend to be narrower than the knife width because lesions on fresh cortical bone usually close following withdrawal of the weapon because of its elastic property [29]. However, also in this case, more detailed metrical indications are lacking.

Also the most recent studies concerning the analysis of cut marks take into consideration only the morphological characteristics of lesions and ignore the metrical assessment [32].

The limited information on the metrical characteristics of cut marks may be explained by the risk of misinterpretation of the general size of the used weapon, which may have severe consequences in the forensic field: for example, the orientation of the blade may cause a relevant modification of the morphology and size of the lesions. However, no study has so far analyzed the modification of metrical characteristics of lesions produced in different orientation.

The present study was therefore devised to verify whether it is possible to somehow answer these questions. A special device on which blades were fixed was used to simulate cuts and reproduce them on bone with the same energy in order to verify if metrical characteristics of the lesions may be related to the general size of the weapon. This may partly give a contribution to the limited information actually available.

2. Materials and methods

Eleven blades (Fig. 1) with different thickness, height, shape and highness of the bevel were used for this study; 10 of these were specifically forged. Variables included: width of the blade, shape and highness of the bevel. Tools consisted in 4 thick blades (8 mm) (2 high bevel and 2 short bevel, of which 1 symmetric and 1 asymmetric); and 6 thin blades (3 mm) (2 high bevel, 2 medium and 2 short bevel, of which 1 symmetric and 1 asymmetric). For each blade the cutting edge angle was calculated: higher bevel has smaller angle, which increases with the bevel shortening.

The steel bars were cut with the Cinhell Lews 116 milling cutter. The bevel and the cutting edge were created first by a Cinhell Bavaria BD150 grinding wheel and then synthetic stones for sharpening. Blades were tempered in a muffle oven type MZ110 at about 800 °C and were left to cool in oil. The cutting edge was sharpened by stones. As a consequence, short blades showed a higher blade angle, whereas high blades had a sharper edge and a lower angle.

The chosen weapons were used on fragments of pig femoral diaphysis, which had been taken from the discarded bones of a butchery. No animal was sacrificed for the study. Femurs were chosen because in Saville's research [18] on tool marks of serrated knives on bone results showed that pig's femur gave a reasonable match with the hardness of human bone and reproduced the same type of marks as human bones when cut. Diaphyseal fragments were obtained from fresh femurs, which were cleaned carefully of their soft tissues. Twenty-five femurs were cleaned and cut, thus obtaining 50 fragments of which 47 were used.

A metallic structure was built, in order to simulate incised wounds and reiterate hits with the same energy. The device consisted in a base on which a rotating cylinder connected to a metallic bar was welded and a support for the blades on its top. A vertical rail fixed at the center allowed the metallic bar to fall in a perpendicular manner on the bone.

Diaphyseal fragments were fixed onto specific wooden and metallic bases to keep them still during the trials. This device was built to make cutmarks in a standardized and reproducible way. Since the aim of the present study is to verify if metrical characteristics of lesion may be related to the size of the weapon, all cutmarks were made with the weight force of the device, in order to obtain groups of lesions produced with the same energy.

Once blades and bone fragments were set, perpendicular and angled tests were performed: 11 blades were used for perpendicular

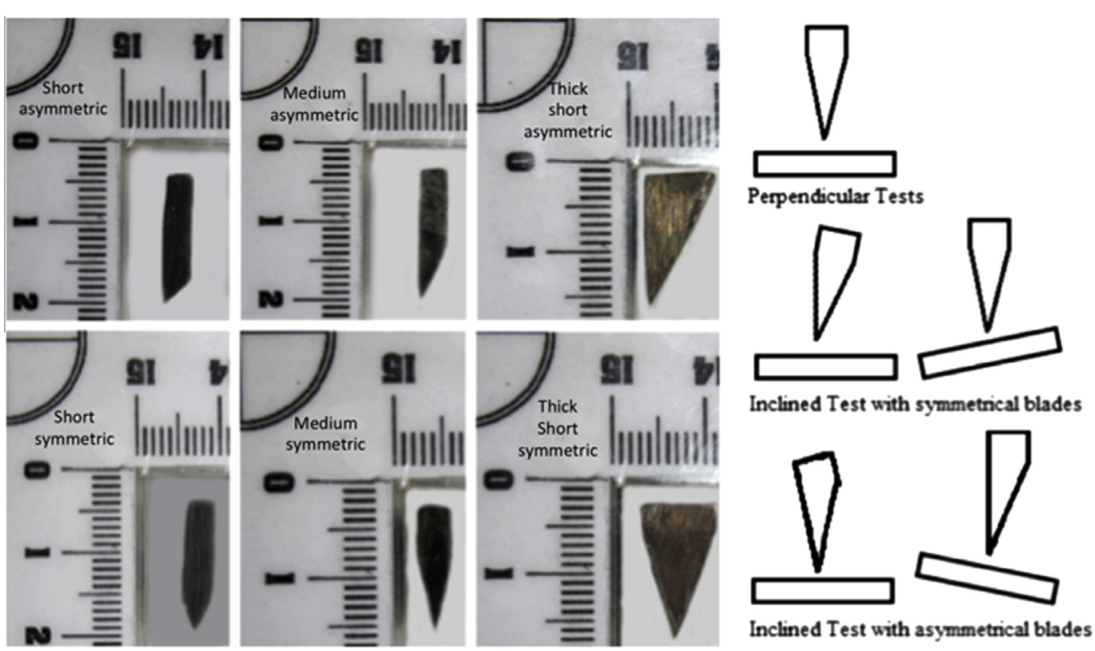

Fig. 1. On the left: examples of blades used: asymmetric blades (above), symmetrical blades (below); on the right: inclination of the blade and the bone in perpendicular and angled tests.