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Methodology for determining accidental versus intentional injury afflicted by a chainsaw

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ABSTRACT

Forensic analysis is often required to determine whether an injury was inflicted intentionally or accidentally. We have developed a method for addressing this issue in the case of an injury to a limb inflicted by a chainsaw. We discuss the potential use of this methodology to the more general case of injuries inflicted by power tools.

1. Introduction

Injuries inflicted by chainsaws are typically accidental, affecting only the chainsaw operator. Rarely do these accidental injuries involve bone fractures [1,10]. However, a chainsaw may also be used as a weapon, in which case the intentional use of force can fracture bone (https://www.sun-sentinel.com/local/palm-beach/fl-pn-lantana-chainsaw-attack-20180227-story.html; https://www.independent.co.uk/news/uk/crime/chainsaw-attack-blackburn-west-lothian-attempted-murder-police-a9503496.html). Chainsaws have also been occasionally used to produce self-inflicted injury, particularly, in suicides [2,4,6,7,9]. In the context of murder, chainsaws have been employed in dismemberment. Forensic analysis in such cases often involves identification of the tool employed in dismemberment based on characteristic markings and patterns created by the tool when soft tissue is cut, as well as notches and fracture patterns in bone [3,5,8]. Forensic analysis may sometimes be required to determine whether an injury was inflicted by a chainsaw was the results of an intentional attack or an accident. The methodology described in this report was developed for such a purpose and follows from some of the principles for analyzing injury patterns to soft tissue and bone discussed by Symes et al. [8].

2. Methodology

2.1. Materials

Cases requiring forensic analysis often present differing accounts of events, where one party claims that an injury was inflicted intentionally whereas the other party claims that it was inflicted accidentally. One such case, investigated by GTD Scientific Inc. (GTD), involved a limb injury inflicted by a chainsaw. An investigative methodology was developed to compare the pattern of injury in relation to the force and time required to cut through a surrogate limb using a Husqvarna chainsaw (Model 445, 18 inch blade, Husqvarna Group, Stockholm and Husqvarna, Sweden). The premise underlying the methodology is that features of an injury, under conditions simulating intentional versus an accidental chainsaw contact with a surrogate limb, can distinguish between the two possibilities. The tests conducted to simulate the inflicted injury were recorded on video using two GoPro cameras (Hero 4, 120 FPS, GoPro Inc., San Mateo, California, USA), one mounted on a tripod and the other worn by the chainsaw operator, attached with a body harness, or fixed to the chainsaw.

To accurately replicate the effect of a chainsaw injury to a human arm, surrogate ballistic gelatin forearms were created. Soft tissue was replicated with 250-bloom gelatin using a ballistic purpose recipe (Holly North Production Supplies, Burnaby, BC, Canada). The bones were cast from high-density foam “bone simulant” (Coast Fiber-Tek Products Ltd., Burnaby, BC, Canada) in a mold, which matched anthropometric measurements for the ulna and radius of a

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Fig. 1. Complete arm replica. The bone simulant is surrounded by semi-clear ballistic gel. The blue wire is the break-wire and the clear tube is the bloodline. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

human male, 180 cm in height. Surgical tubing with a similar diameter to the ulnar artery (2.5 mm I.D.) filled with red dye was incorporated in the forearm mold to simulate the effect of a transected artery. A break-wire was added along the radius to determine the duration of the cut. Fig. 1 shows a completed ballistics gelatin forearm.

3. Test results

The first test investigated the amount of force required to transect the radius and ulna of the surrogate forearm, using a chainsaw under the condition of a forceful swing (intentional) and under a free-fall condition (accidental), where the chainsaw accelerated downward due to gravity alone. These tests were each repeated four times. The effect of releasing the chainsaw trigger before contact with a simulated tense arm (actively contracting muscles) was also compared to contact with a simulated passive arm (relaxed muscles).

For these tests, the surrogate forearm was securely mounted on a wooden frame constructed from 2″ x 2″ pieces and held in place securely with zip ties, as shown in Fig. 2. In tests which involved force measurement, the wooden frame was placed on a metal plate instrumented with 4 calibrated force sensors (PCB Piezotronics, Model 208C05). The time required to cause the injury was estimated from interval between force onset detected by the force sensors and the time at which the break-wire was transected. The force required to transect bone was estimated as the peak force recorded by the force sensors during impact with the surrogate forearm. In the first set of tests, the chainsaw was held approximately 30 cm above the arm and either swung down to cut through the arm (forceful condition) or released and dropped (free-fall condition). The results of these tests are summarized in Table 1 below.

Fig. 2. Ballistic gelatin arm mounted on test stand.

Table 1
Mean and standard deviation of four chainsaw laceration tests.

Condition	Force (N)	Duration (s)
Forceful	68.6 ± 23.22	0.68 ± 0.38
Free-fall	109 ± 48.6	0.57 ± 0.42

In general, the results of the tests indicated that transection of the bone would occur relatively quickly (in less than 0.68 s) and would require a relatively low force (below 110 N). The validity of the tests is supported by the bone fracture pattern, which replicated the characteristic breakaway notch that has been reported in cases of dismemberment with cutting tools [8].

In addition to comparing intentional versus accidental injury, a test was devised to differentiate between the type of injury which would be inflicted by a chainsaw on an arm with relaxed muscles compared to an arm with tensed (contracting) muscles. To simulate a relaxed arm, a surrogate forearm was attached to the wooden stand with zip ties on only one side of the cut as opposed to the previous test, in which the surrogate forearm was attached with zip ties on either side of the cut, which simulated a tensed forearm. Attaching the surrogate forearm on only one side of the cut allowed it move more than when attached on either side of the cut. When the chainsaw was lowered onto the "relaxed" forearm the saw created a jagged and spiraling diagonal cut as it pulled the forearm towards the operator and twisted it (Fig. 3).

A test was also conducted to determine whether releasing the chainsaw trigger prior to dropping under the free-fall condition would alter the injury pattern. The test revealed that releasing the trigger had little effect on the cutting potential of the chainsaw. The simulated bone was transected in 0.53 s with a peak force of 84 N.

To simulate dropping a chainsaw from a greater height, such as from a ladder, onto someone standing below, the chainsaw was clamped to a drop tower. For this test one GoPro camera was attached to the chainsaw and pointed along the blade while the other camera was mounted on a tripod (Fig. 4). Once the trigger was

Fig. 3. Laceration of "relaxed" forearm created a large spiral and jagged cut pattern.

Fig. 4. GTD Scientific's portable drop tower with ballistics gelatin forearm and chainsaw. The chainsaw is started and raised 136 cm above the arm, fully engaged throttle and then fully released causing the chainsaw to free-fall onto the arm.

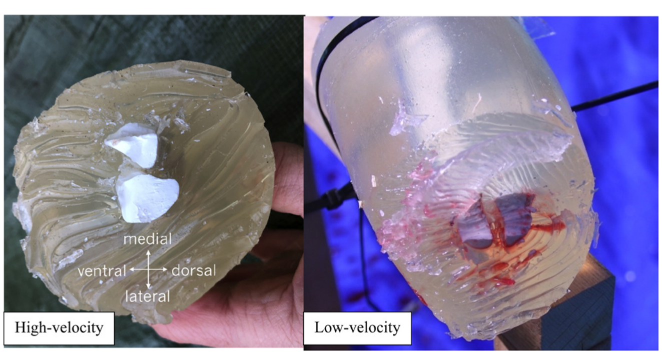

Fig. 5. Cut pattern showing the bone simulant was initially cut by the chainsaw before any breakaway fracture in all set-up cases. One differentiating feature is the depth of the cut prior to breakaway. High-velocity impact (left) creates less of a cut in the bone simulant prior to fracture while low-velocity impact (right) creates a larger cut.

released, the chainsaw was dropped 135 cm and contacted the surrogate forearm 0.52 s later. The velocity at impact was approximately 5 m/s. The chainsaw blade continued to turn after being released and cut through the surrogate forearm. Although the bone simulant fractured, as in the previous tests with less chainsaw movement, the chainsaw cut was less deep before the fracture occurred due to the greater impact force. Fig. 5 shows that the chainsaw created a partial cut of the bone prior to a breakaway fracture, similar to the cuts seen in the other laceration tests but cut less deep than impacts with lower impact velocity.

4. Discussion

The results of chainsaw laceration tests conducted with a surrogate forearm were validated by the fracture pattern which matched that previously reported for dismemberment with power saws [8]. However, it was not possible to distinguish an injury produced by an intentional attack (forceful condition) from that caused by accidental contact of the chainsaw with the limb (free-fall condition) when the chainsaw was dropped from 30 cm above the surrogate forearm. The laceration and fracture patterns were similar in both cases and occurred over similar time intervals. Because the force required to produce the injury was relatively low, either an intentional swing of the chainsaw or an accidental drop from a small height could cause an injury of similar severity. However, when dropped from a greater height (135 cm), the chainsaw cut was less deep before the bone simulant fractured, allowing for a distinction between an intentional injury inflicted at close range and an accidental injury inflicted by a chainsaw dropped from a significant height. Furthermore, there was a clear difference in the injury pattern between contact with a "tensed forearm" compared to a "relaxed forearm." Therefore, it might be expected that a victim in a defensive posture would sustain an injury with a different pattern than a victim in a neutral or relaxed posture. Of particular interest, is that releasing the chainsaw trigger prior to contact with the surrogate forearm produced an injury which did not differ qualitatively from an injury produced with the chainsaw at full throttle.

In the forensic case for which the methodology was developed, the similarity of the injury pattern under the forceful and free-fall conditions at 30 cm could not determine whether or not the injury was accidental. However, the fracture pattern of the bone simulant when the chainsaw was dropped from 135 cm could be differentiated from the trials at 30 cm, at least qualitatively. During the 135 cm drops the impact velocity was higher than drops at 30 cm (approx. 5 vs. 2.4 m/s) which did not allow the blade to cut as deep into the bone prior to fracture (Fig. 5). In combination with other evidence, it was possible to reach a supported opinion as to the nature of the injury. However, the potential of the methodology was not exploited to its full potential. For example, the potential exists to apply this approach to the interpretation of blood stain patterns, as well as comparing injury to nerves with break-wire patterns. Moreover, a surrogate limb (arm or leg) of the type developed for this investigation has the potential to be used in the investigation of a limb injury created by any type of power tool. The method provides information about the time and force required to produce the injury, as well as the pattern of injury.

Ethics approval and consent to participate

No ethics approval was required since the experiments did not involve testing with human or animal subjects. All testing was carried out on purely mechanical rigs. The acquired data have not been altered in any way other than being calibrated in appropriate units for analysis.

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Geoffery Desmoulin: Methodology, Project administration, Reviewing & editing, Resources. **Theodore Milner:** Writing manuscript draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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