

Changing Impact Angles: The Mechanics Involved in Blunt Force Cranial Trauma and Their Importance in Investigating Curb-Stomping Cases

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Introduction

The majority of studies on the infliction of blunt force trauma to the cranium assess only the initial impact site. This method can therefore result in a loss of essential data relating to the circumstances in which the injury was sustained. The goal of this study was to create an experimental model that would provide a more realistic picture of the damage sustained during a violent attack to aid investigators.

Popular culture and mass media have promoted the violent practice of “kerb-stomping” or “biting the curb” in recent years^{1,2,3}, as illustrated in a still from the film American History X (Figure 1). Originally a form of Nazi torture for punishing Jews it involves the victims being forced to place their mouth on the curb and bite down. They are then kicked in the head or stomped on causing serious injury or, in many cases, death⁴. Fractures are reported on the cranium and mandible, tooth loss and broken nasal bones⁵. Cases involving mandible fractures as a secondary fracture have demonstrated this is an area that requires further study⁶, but very little research currently exists.

Presented here is a pilot study that exhibits the need to further investigate the issues surrounding violent assaults using blunt force trauma, such as bludgeoning with a hammer; however, an unexpected finding was the secondary trauma inflicted to the mandible as a result of resting on the solid base plate, which mimicked the scenario faced by curb-stomping victims. Although the traditional “biting the curb” posture is not exhibited in this experiment, it provides information on how the transference of force can travel through the skull and exhibit in fractures elsewhere. This pilot study focuses on the secondary trauma exhibited to the skulls and the information presented during the analysis.



Figure 1. Cut scene from American History X, which caused controversy for showing a curb-stomping scene that was removed in later editions of the film.

Methods

Twenty one adult pig heads (*Sus scrofa domestica*) were placed on a solid base, resting on the mandible. The base could be angled so that the impact angle to the skull could be altered for each strike. Using a drop hammer rig, modified with a replica hammer head (modelled after a 16oz claw hammer), each pig head was struck once over the frontal bone from a height of one meter.

A total of six angles were assessed in this preliminary study (0°, 9°, 18°, 27°, 36° and 45°), with each angle tested a minimum of three times. It was not possible to strike the frontal region of the pig head at an angle greater than 36°. To monitor the acceleration, timing, and force of each strike, a piezoelectric accelerometer was attached to the drop hammer, with data recorded at a rate of 10,000 scans per second.

Following maceration, the fractures present were compared with previously published images and descriptions, with measurements taken of the width length and depth of each depression fracture⁷. It was noted that a number of mandibles had also fractured when struck, with differences in the fracture type observed as the angle increased. To establish that this was a result of the impact study, a further set of pig heads were radiographed prior to the strikes. A further radiograph following the impact confirmed that the mandibular fractures had caused a transference of the force through the cranium when struck from above.

Mandibular fractures were recorded by type, side, location on the mandible, angle and length, with the resultant data analysed using SPSS v.23 to look for relationships between the recorded data and impact angle.



Results

A total of 27 fractures were observed between the cranium and mandible. Depression fractures ($n=10$) demonstrated a decrease in size as the angle increased and radiating fractures ($n=4$) were present on angles from 18°. Mandibular fractures ($n=13$) were present up to 36° in this study, with the severity ranging from a complete break to shearing fractures as the angle increased. It was also noted that the position and side of the mandibular fractures changed as the angle increased.

Statistical Analysis

There was a significant positive correlation between the presence/absence of cranial fractures ($r=0.505$, $p=0.202$) and the presence/absence of mandibular fractures ($r=0.643$, $p=0.002$), when compared with the angle of impact. However, there was no relationship was observed between the presence/absence of cranial fractures and the presence/absence of mandibular fractures ($r=0.430$, $p=0.052$).

There was no significant difference between the angle of impact and the fracture angle or length for trauma to the inside or outside of the mandible ($p>0.05$). Significant positive relationships were noted between the angle of impact and the fracture type ($r=0.823$, $p>0.001$), side of mandible ($r=0.637$, $p=0.002$) and the anatomical region of the mandible the fracture occurred in ($r=0.634$, $p=0.020$). A visual representation of the relationships for fracture type and anatomical region is shown in figure 2.

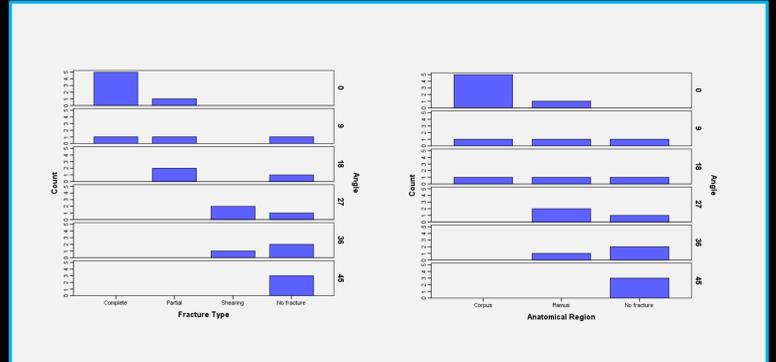


Figure 2. Bar charts demonstrating the relationships between impact angle and fracture type (left), and impact angle and anatomical region (right).

Discussion and Conclusions

The results demonstrate that there are relationships between the impact angle and several characteristics of the resultant trauma which could indicate the direction of force in violent cases involving secondary trauma. In this study, increasing the angle of impact has altered the behaviour of the force travelling through the skull following the initial impact. As the force will travel “the path of least resistance”, the position, type and side of the fracture enables the observer to infer the position of an assailant during an attack.

All the strikes in this study were direct from above or to the left side of the skull as the angle increased, resulting in an increased occurrence of damage to the right side of the mandible, as this force exhibited against the base plate would be greatest in this area. No mandibular fractures were recorded on the corpus once the angle increased past 18°, indicating that the force was directed through the ramus as it became the primary area in contact with the baseplate. This is also represented through the change from complete and partial fractures to shearing fractures for the impact angles of 27° and 36°.

There are increasing numbers of reports in the media of violent crimes involving blunt force trauma taking place that utilize everyday household objects⁸. It has also been highlighted in studies that blunt force trauma to the head is one of the most effective methods of murder, but that the weapons most commonly involved are hands and feet, also referred to as human strength⁹.

This study is limited by the small sample size, but has provided information that could direct further research into violent assaults using blunt force trauma. It would be beneficial to repeat the study using a larger sample size, bone substitutes to more directly simulate the cranial biomechanics of a human skull, and by modifying the drop hammer to investigate how increasing the surface area impact will affect the results.

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