INTRODUCTION

- Fractures to the zygomatic bones of the face are devastating injuries that may lead to permanent deformation. Zygomatic bones are also crucial in protecting the brain, so preventing their injury can aid in avoiding associated brain injuries. These injuries are common due to motor vehicle collisions (MVCS), assaults, and sports.
- Impact studies have previously been conducted for the frontal and facial regions of the skull in order to develop biomechanical response corridors of the head. These data were used to assess the biofidelity of Anthropomorphic Test Devices (ATDs), such as the Facial and Ocular Countermeasure for Impact Protection System (FOCUS) headform, developed by Virginia Tech. The FOCUS headform has the ability to measure forces applied to various facial and orbital structures.
- A classification scheme for fracture patterns that result from trauma to the zygomatic bone has previously been developed by Zingg et al. The application of such studies includes the manufacture of protective gear, surgical treatment decisions, and management of clinical complications associated with different fracture patterns.
- The objectives of this study are: 1) establish lateral injury criteria for the FOCUS headform, 2) classify zygomatic fracture severity with peak force and measures of skeletal morphology.

MATERIALS & METHODS

- Heads of 20 fresh male post-mortem human subjects (PMHS) were used in this study. Mean age was 74.4 ± 11.1 yrs.
- Tissue was prepared for testing by removing the scalp overlying the parietal and temporal regions to the non-impact side. Metal screws were inserted into the bone to provide structure for the casting material and each head was mounted to a semi-circular, polycarbonate support using Bondo. All were aligned using the Frankfort plane prior to mounting to provide consistent orientation.
- A free-falling 3.2 kg aluminum cylindrical impactor was used to systemically impact the body of each zygomatic bone from a height of 35 inches. The resulting impact velocity was 4.2 m/s and energy was 27.5 J. An accelerometer mounted on the impactor recorded peak force.
- Post-test computed tomography (CT) images were taken and gross dissection of the impacted regions was performed. Fracture patterns were documented with sketches and photography and classified based on the Zingg et al. classification scheme. 3D reconstructions of CT scans were used to measure zygomatic height (Figure 2), thickness, arch length, and width.

RESULTS & DISCUSSION

- All zygomatic fractures were consistent with types described by Zingg et al. Table 1 provides a summary of all relevant data. Data were not recorded for one impact (Test ID 46) because of a testing error.
- Two Type A fractures were recorded (Type 1 and 3). Type A, low energy, fractures are isolated to one location of the zygoma, and are differentiated into types 1 (zygomatic arch), 2 (infraorbital rim) based on individual fracture location. Figure 3 provides an example.
- Ten Type B fractures were recorded. Type B, middle energy, fractures include disruption of all four articulations of the zygoma with the frontal, maxillary, temporal and greater wing of the sphenoid. Figure 4 provides an example.
- Seven Type C fractures were recorded. Type C, high energy, fractures are type B with comminution and additional fragmentation of the zygomatic bone. Figure 5 provides an example.
- It was expected that fracture severity (A<B<C) would increase with peak force, however this trend is not supported (Figure 6).
- It was expected that zygomatic measurements from CT would be associated with peak forces. This trend is not supported for any measurements. Figure 7 displays this relationship with zygomatic height.

CONCLUSIONS

- Limitations in this study include: 1) the inability to ensure test repeatability because alignment of the impactor was slightly subjective, and 2) the force used to ensure failure was excessive, making it difficult to assess relationships between peak force, bone measurements, and severity of fracture.
- Future work will focus on calculating force at time of failure to compare with zygomatic measurements and fracture severity.

REFERENCES

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