HUMAN MANDIBLE RESPONSE TO IMPACT LOADING OF CHIN

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INTRODUCTION

Load versus deflection response of the human mandible has been evaluated in the testing of cadaveric specimens in three general impact orientations. The output of the study provides a comprehensive look at the mandible, temporomandibular joint (TMJ) and basilar skull response to impact loading at the chin. Three-dimensional tracking of the mandible coupled with measured loading from an impacting drop mass was used to define response corridors of the human mandible. These corridors are to be used in the development of a surrogate mandible for use in automotive and sports equipment testing.

METHODS

A 5.2 kg drop mass is dropped from various heights onto the chin point of cadaveric specimens. The specimens are potted in an adjustable stand that allows for testing in three pre-determined orientations. The drop stand, previously used by Walilko, et al [1] and refined for use in this study, supports a PVC tube that is used as the drop mass guide. The mass is secured using an electromagnet. Drop mass acceleration is measured with a pair of accelerometers whose data is collected using TDAS PRO™ (DTS, Inc.).

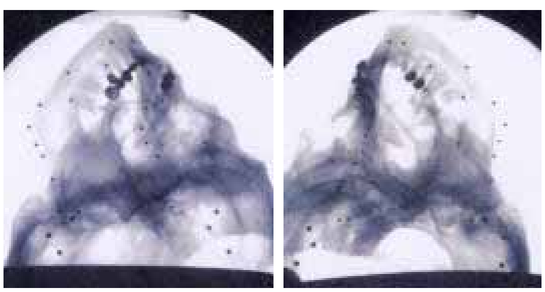

Figure 1: Images of bi-planar x-ray coverage of specimen prepared with markers

A high-speed bi-planar x-ray system was used for tracking displacements within the mandible and TMJ. The x-ray system emits an x-ray beam that is digitally recorded at a rate of 1000 frames per second by cameras at the rear of an image intensifier. The motion of lead markers (2-and 4-mm in diameter) placed on the surface of the mandible and skull are recorded and post-processed to produce x, y and z coordinates of the markers versus time (See Figure 1 for images of prepared specimen pre-test). The resulting three-dimensional motion of the markers is then used to evaluate motion between segments within the mandible and between the mandible and skull. That resulting motion is then plotted against drop mass impact force to develop force versus deflection response of the mandible.

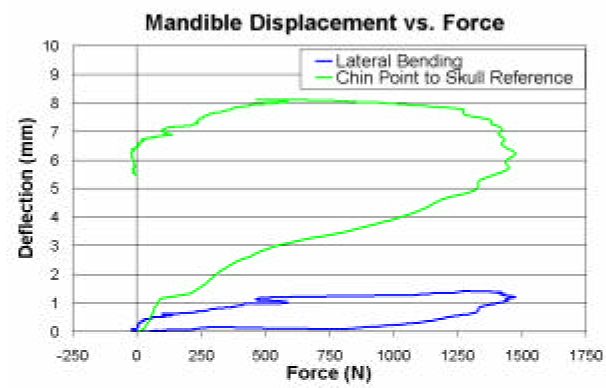

Figure 2: Load versus deflection for single test on cadaveric specimen.

RESULTS AND DISCUSSION

Load versus deflection was evaluated for a number of segments within the mandible and between the mandible and skull. Four key segments of deflection were evaluated: (1) chin point (point of drop mass impact) to a subcondylar marker just inferior to the condyle, (2) lateral deflection at 2nd molar, (3) sub-condyle to skull fixed reference, and (4) chin point to skull fixed reference. A sample output for the 1st and 2nd type of measurement listed above plotted versus the drop mass load can be seen in Figure 2. The output from the study is a set of load versus deflection corridors, one for each segment described.

CONCLUSIONS

The load versus deflection corridors produced in this study provide a complete picture of the response of the human mandible and TMJ joint to direct loading at the chin point under various loads and impact orientations. The corridors will form the basis for a work in process by the author to develop a human mandible surrogate that will be added to existing surrogate headforms for future use in sports equipment (mouthguard, helmet, chinstrap, etc.) testing and possible application in the anthropomorphic test devices used by the automotive industry.

REFERENCES

1. Walilko T, *Biomechanical response of the temporomandibular joint from impacts in boxing*, PhD Dissertation, Wayne State University, 2004.

ACKNOWLEDGEMENTS

National Football League Charities