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# RESEARCH ON SPLACHNOCRANIAL INJURIES DUE TO BRACHIAL VIOLENCE

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**Abstract,** *this contribution gives a basic information about the mechanical behaviour of the frontal part of the human skull, i.e., the splachnocranium, linked with an external loads and damages caused mainly via brachial violence. Practical focuses are mainly on orbita, os frontale and os zygomaticum. As a first approach, the brachial violence is simulated via quasi-static compression laboratory tests. Cadaveric skulls are attached in testing machine and loaded till fractures occurs. The main results are acquired external forces which caused fractures of splachnocrania. According to the results, there are quite high variabilities of the acquired external forces. The results can be applied mainly in forensic science, facial surgery and ophthalmology.*

**Keywords: Blunt trauma, Cranio-maxillofacial trauma, Orbital trauma, Biomechanics, Experiments, Forces caused fracture, Brachial violence.**

## 1. Introduction

In clinical practice, eye and periocular region injuries are encountered in various trauma mechanisms that are accompanied by application of blunt force. It can be active violence on the part of the other person, i.e. hitting the face or the orbit with various types of punches or kicks. These are also connected with injuries caused by contact with solid protruding barriers or thrown objects. In addition to superficial injuries of the skin cover, fractures of the facial skeleton often occur. The proposed experimental pilot research should help to further clarify the biomechanism of some types of facial fractures and to quantify the forces that

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cause these fractures. For more details, see (Warwar et al., 2000; Hirjak et al., 2013; Timkovič et al., 2021; Kubíček et al., 2019; Klíma and Novobilský, 2018; Klíma and Madeja, 2018).

## 2. Methods and Experiment

For our initial experimental research of biomechanical behaviours of splachnocrania 8 cadaveric crania of adults were used. These crania were from the depository of Institute of Forensic Medicine, University Hospital Ostrava (Ostrava, Czech Republic). Before our experiments, all crania were osteologically processed according to the international standards. Handling with crania was conducted in accordance with ethical standards and scientific approaches similar to those in (Frydrýšek et al., 2022).

For the compression tests, the testing machine M500 – 50 CT was applied (producer: Testometric Co. Ltd., Rochdale, UK) at the Faculty of Mechanical engineering VSB – Technical University of Ostrava. The cadaveric skulls were fixed into the device. The device, together with the impactor, were proposed and fitted with a plush to simulate soft tissues of human body, see Fig. 1. The quasi-static loading velocity was 10 mm/min and the external load lasts till to fracture of splachnocranial bones. Acquired data from measurement were recorded and processed on a computer.


*Fig. 1: Cranium fixed in testing machine.*

## 3. Results

Eight quasi-static compression experiments were performed on chosen specimens of human crania. From each experiment was acquired the dependence of external force on displacement of impactor. During the test of each specimen, at first there was an initial partial fracture, see Fig. 2, which subsequently leads into full fracture of os zygomaticum and other parts of splachnocranium.

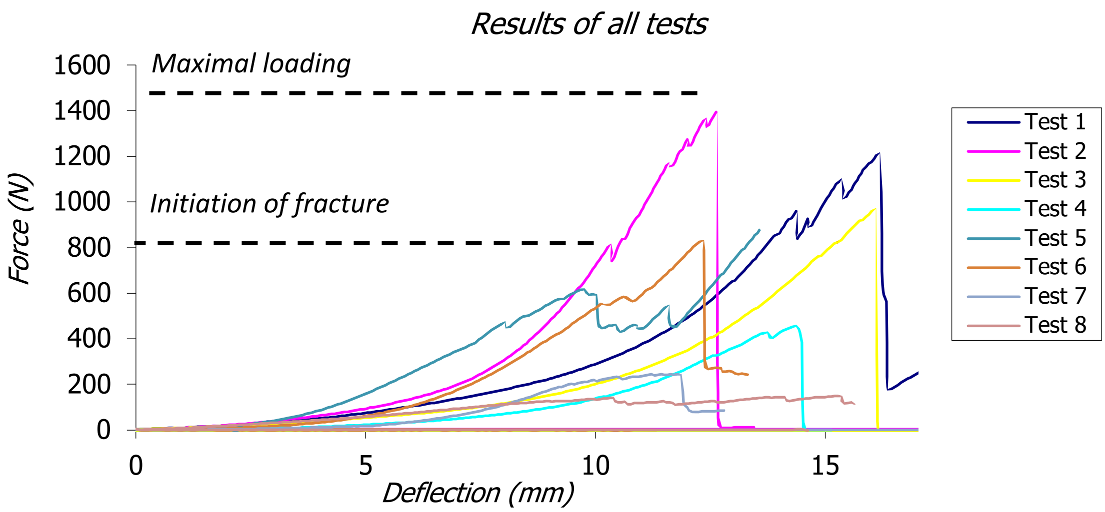



*Fig. 2: Dependencies of loading forces on displacement of impactor (loadings of cadaveric crania).*

Fracture and its initiation were always associated with sound effects of cracking. The initiation of the fracture was always the same, regardless of the chosen side of the human skull. Summary of the result is clearly displayed in Tab. 1 and Fig. 2. From the measured data a significant variability in the external force required to rupture the orbit was seen, ranging from 143.6 to 1403.6 N. Similarly, the variability of force for initiation of fracture is from 136 to 953 N. This variability is surprising and is caused by differences in skull anthropometry as well as age and sex.

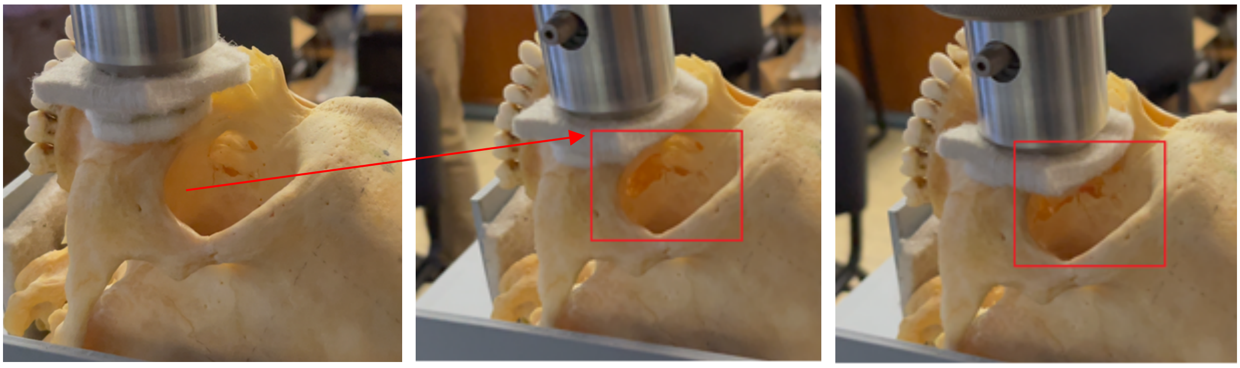
*Tab. 1: Maximal loading forces acquired from measurements.*

| Test no. | Force of initiation a fracture | Max. loading force | Place of fracture | Test no. | Force of initiation a fracture | Max. loading force | Place of fracture |
|---|---|---|---|---|---|---|---|
| 1 | 820 N | 1229.1 N | os zygomaticum close to orbital proc. | 5 | 461 N | 885 N | os zygomaticum close to orbital proc. |
| 2 | 953 N | 1403.6 N | | 6 | 389 N | 834.9 N | |
| 3 | 819 N | 977.5 N | | 7 | 129 N | 246.1 N | |
| 4 | 404 N | 461.9 N | | 8 | 136 N | 143.6 N | |

**Statistical evaluation for the force of initiation a fracture:** Minimum = 129 N, Mean = 513.9 N, Median = 432.5 N, Standard deviation = 296 N, Maximum = 953 N.

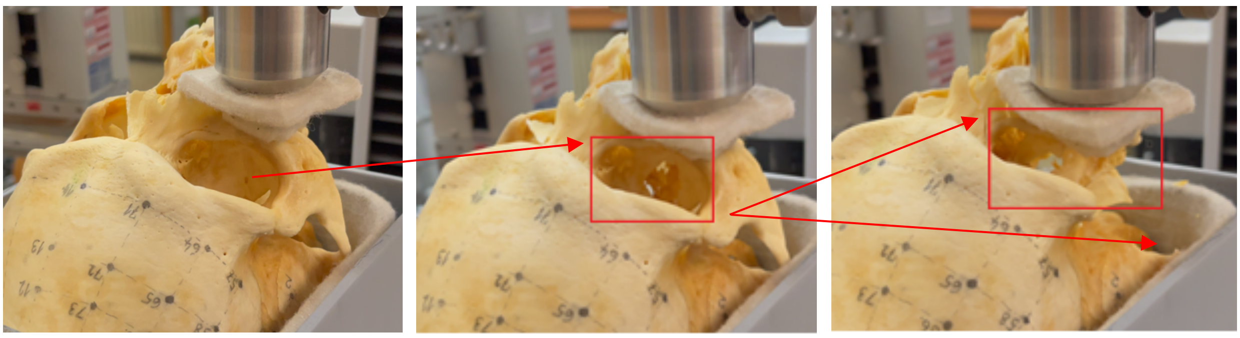
**Statistical evaluation for the maximal loading force:** Minimum = 143.6 N, Mean = 772.7 N, Median = 860.1 N, Standard deviation = 452.6 N, Maximum = 1403.6 N.

Below are figures from experimental tests No. 1-2. They represent three phases of the experiment. The first phase, Fig. 3(a) and Fig. 4(a), is the beginning of the test without any damage, then there are (b) and (c), which show us the initiation of fracture and the final fracture, respectively. In all tests, the first initiation of the fracture appears on the os zygomaticum and continues to the final fracture. The difference between phases (a), (b) and (c) are highlighted by red arrows and the fracture detail in the rectangle.



(a) Begining (b) Initiation fracture (c) Final fracture

*Fig. 3: Detail of human skull loading TEST No.1*



(a) Begining (b) Initiation fracture (c) Final fracture

*Fig. 4: Detail of human skull loading TEST No.2*

## 4. Conclusions

This paper reports on the initial results of our research. Human bones are a strongly anisotropic material whose biomechanical properties are dependent on material distribution, age, sex and method of loading. This variability is also evident in our statistical data. The data obtained provide a basis for further research on the biomechanical properties of the facial skeleton.

The data can be used for the application of numerical methods, further experiments, application of dynamic loads, stochastic loads and modelling, elastic foundation as a simple bone modelling, bone as a composite material and their eventual interconnections with clinical implications beyond one medical branch or biomedical engineering. The results are suitable for implantology too, i.e. applications for osteosynthesis of splachnocranial fractures etc. Hence, the acquired results can be applied mainly in forensic science, facial surgery and ophthalmology. In the future, the authors would like to perform the dynamic loading of crania too. Because the dynamic loading is much closer to the brachial violence.

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