Strength Analysis of Human Skull on High Speed Impact

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Abstract – *This research has been carried out to identify the strongest and weakest part of the human skull on high speed impact condition by using finite element simulation approach. There are nine parts of skull model to be examined, i.e., frontal bone, front mandible, side mandible, maxilla, nasal bone, occipital bone, parietal bone, temporal bone and zygomatic bone. The parts are impacted by a small rigid ball at constant velocity of 20 m/s. Three dimensional Finite Element solver FEBio is employed to do the simulation. Four mechanical responses; acceleration, displacement, effective stress and effective strain are monitored after 1 ms the ball contacts with skull. When the response parameter shows the strongest part, it is scored 100 whereas the weakest the weakest is scored of 10. The total score from four parameters are then summed up. The results show the weakest among the cranial bones is the parietal bone. On the facial section, the front mandible and the nasal bone are the weakest parts among other facial bones. **Copyright © 2012 Praise Worthy Prize S.r.l. - All rights reserved.**

Keywords*: Human Skull Model, Finite Element, Strength Analysis, Impact Simulation, FEBio*

I. Introduction

Head as well as knee [1] can be considered as the most important part of the human body that must be protected well. In the human head, a bony structure and part of the skeleton which is human skull supports the structures of the face and forms a cavity for the brain. The adult skull is made up of 22 bones. These bones are separated into two categories which form the cranium and facial bones. All of the bones of the skull are joined together by structures which rigid articulations permitting very little movement except for the mandible. Eight bones include one frontal bone, two parietal bones, one occipital bone, one sphenoid, two temporals and one ethmoid form the brain case. Other fourteen bones form the splanchnocranium which is the bone supporting the face.

The function of the skull are protect the brain, fix the distance between the eyes to allow stereoscopic vision and fix the position of the ears to help the brain use auditory cues to judge direction and distance of sounds. The skull protects the brain from damage through its hard unyielding property and less deformable substances in nature. The bruised or injured of brain can be life-threatening.

A break in one or more of the bones in the skull that cause by a result of blunt force trauma is skull fracture. Skull fractures occur with head injuries. The direct impact force that excessive the bone will cause fracture at site of impact and damage the underlying physical structures contained within the skull.

The brain function can be affected directly by damage to the nervous system tissue and bleeding. The blood clots under the skull and then compress the underlying brain tissue which is subdural or epidural hematoma can disturb the brain's function.

Skull fracture is a frequently observed type of severe head trauma caused by blunt impact. Kleiven and von Hols [2] proposed skull fracture as an indicator of brain injury. The parameters included peak impact force, local skull deformation and absorbed energy until skull fracture. Experimentally, the fracture of the skull was first performed by Gurdjian et al. [3]. They used a free-fall method on dry human skulls instrumented with stress-coat, a strain-sensitive lacquer. Now, in this present research, the nine parts of skull are investigated to find the strongest and the weakest parts when the skull is impacted. Finite element approach is used to do the impact simulation and to observe the response of the parts on impact.

Although there has been a lot of research of head on impact but most of the skull fracture test is for impact from front, rear or side on skull [4]–[9]. Skull thickness is not uniform and the impact force that causes a fracture depends on the site of impact. The structure and the shape of the bones can have the effect on damping.

Hence, the objective of this research is to conduct an investigation to see the strongest and the weakest parts of the skull on impact. A protection system will then consider the results and put an extra attention to the weakest part of the skull.

II. Literature Review

The head impact response in terms of head acceleration and impact force depend on the inertia properties of the head and surface impacted. For a 50th