Research on Cyclist Injury Based on Simulation Model of Real Electric Vehicle and Two Wheeled Vehicle Collision Accident

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Abstract—There are more and more traffic accidents between cars and electric two wheeled vehicles. As a vulnerable participant in traffic, it is of great significance to study the head biomechanical injury of electric two wheeled vehicle cyclists. In order to study the head injury of cyclists, by optimizing the tissue material properties and material parameters of the head finite element model, a refined head finite element model is established and verified by Nahum cadaver experiment; Based on the real traffic accident of vehicle electric two wheeled vehicle collision, a multi rigid body model of vehicle electric two wheeled vehicle is established for vehicles, electric two wheeled vehicles and cyclists, and the reliability of the collision model is verified; The head finite element model is used to analyze the changes of equivalent stress. The results show that the equivalent stress of brain tissue is gradually transmitted from both sides of brain tissue to the cerebellar region at the back of brain, and finally concentrated in cerebellum.

1. Introduction
With the emergence of private cars more and more frequently, people use electric two wheeled vehicles as a means of transportation for travel convenience. In the past five years, the number of electric two wheeled vehicle traffic accidents and cyclists' deaths have increased year by year. [1].

Hassan m [2] et al. Established a three-dimensional headform that can produce reliable brain response, It is found that the head and neck joints have a significant effect on the brain response to impact. Burkakki m [3] et al. Established a finite element model of the soldier’s head to evaluate the injury suffered by the soldier’s head when exploding under a light armored vehicle. Yunus K [4] and others studied the heat transfer of human head by using the finite element method, simulated the effects of various physical and geometric parameters. Liu w [5] et al. Studied the important factors affecting the dynamic response and injury of pedestrian head through finite element multi-body coupling simulation.

At present, there are few studies on the changes of brain tissue equivalent stress and brain tissue pressure of electric two wheeled cyclists in the process of vehicle electric two wheeled vehicle collision. Based on the real automobile electric two wheeled vehicle collision accident, a multi rigid body model of automobile electric two wheeled vehicle collision is established, and its reliability is verified. Through the collision model, the acceleration curve of the cyclist's head is obtained. Taking this acceleration curve as the input of the refined head finite element model, the equivalent stress and pressure of the cyclist's human brain tissue are output, and the equivalent stress and pressure of the brain tissue are studied.
2. Establishment of refined head finite element model

2.1. Preliminary establishment of finite element model of head

HyperMesh is used to mesh the three-dimensional model of the head. In the division of the three-dimensional model, the linear hexahedron mesh division is mainly adopted, and the head tissues are connected by common nodes to form the head finite element model, as shown in Fig. 1.

![Fig.1 finite element model of head](image)

2.2. Establishment and verification of refined head finite element model

According to the design principle of orthogonal experiment, L27313 is selected as the orthogonal table of this experiment. The optimal combination parameters of brain, cancellous bone, scalp, cerebrospinal fluid, dense bone and facial bone of head finite element model are shown in Table 1.

| part          | material properties  | density (ton/mm^3) | modulus of elasticity (MPa) | Poisson's ratio | $G_0$ (MPa) | $G_\infty$ (MPa) | $\beta$ |
|---------------|----------------------|--------------------|-----------------------------|----------------|-------------|-----------------|--------|
| brain         | viscoelasticity      | 1.14e-9            | 2190                        | 0.0066         | 0.0012      | 80              |        |
| Facial bone   | elastic              | 2.6e-9             | 10000                       | 0.49           |             |                 |        |
| CSF           | elastic              | 1.04e-9            | 2190                        | 0.49           |             |                 |        |
| dense bone    | elastic              | 1e-9               | 5750                        | 0.123          |             |                 |        |
| cancellous    | bone elastic         | 6.5e-10            | 2500                        | 0.123          |             |                 |        |
| scalp         | elastic              | 2.4e-9             | 33.4                         | 0.49           |             |                 |        |

The finite element model of the head is verified by Nahum experiment. The Nahum contact force curve is shown in Fig. 2.

![Fig.2 Nahum contact force curve](image)
3. Reconstruction and verification of simulation model based on real vehicle electric two wheeled vehicle collision accident

3.1. Establishment of multi rigid body model for vehicle electric two wheeled vehicle collision
When establishing the vehicle electric two wheeled vehicle collision model, adjust the rider's posture and set the contact between the electric two wheeled vehicle and the rider by combining the electric two wheeled vehicle and its rider, as shown in Fig.3.

![Fig.3 multi rigid body model of vehicle electric two wheeled vehicle collision](image)

3.2. Verification of multi rigid body model for vehicle electric two wheeled vehicle collision
The animation of multi rigid body model of vehicle electric two wheeled vehicle collision is compared with the collision position and collision process in the monitoring video. The corresponding relationship between vehicle electric two wheeled vehicle collision process is shown in Table 2.

From the multi rigid body model of vehicle electric two wheeled vehicle collision, the head collision acceleration of electric two wheeled vehicle cyclists can be obtained. The head collision acceleration curve of cyclists is shown in Fig.4.

![Table 2 collision relation](image)

![Fig.4 head impact acceleration of cyclists](image)
4. Study on brain tissue of electric bicycle cyclists

4.1. Changes of equivalent stress in human brain tissue of electric two wheeled bicycle

The changes of equivalent stress in brain tissue are shown in Fig. 5.

![Fig.5 equivalent stress distribution of brain tissue](image)

As can be seen from the equivalent stress distribution diagram of brain tissue in Figure 5, the equivalent stress of brain tissue is gradually transmitted from both sides of brain tissue to the cerebellar region at the back of brain, and finally concentrated in cerebellum. The maximum equivalent stress of brain tissue is 26.31 kPa, which reaches the threshold range of mild traumatic brain injury and the threshold unit with a 50% probability of mild neuropathy. The equivalent stress of cyclists' brain tissue increases with the increase of head acceleration.

5. Conclusion

In this paper, a refined head finite element model is established based on the three-dimensional head model. Orthogonal experiments are designed for the material properties and material parameters of each tissue of the refined head finite element model, and the optimal combination of the material parameters of each tissue of the head finite element model is obtained. Based on the real automobile electric two wheeled vehicle collision accident, a multi rigid body model of automobile electric two wheeled vehicle collision is established and verified. Through the collision model, the cyclist's head acceleration is obtained. Taking the cyclist's head acceleration curve as the input of the refined head finite element model, the changes of equivalent stress and pressure of human brain tissue are obtained. The equivalent pressure of brain tissue of cyclists increase with the increase of head acceleration. The equivalent stress of brain tissue concentrates from both sides of the brain to the cerebellum.

Acknowledgments

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