An occlusion simulation system during virtual surgery based on collision detection and mesh editing

Liu X / Chen L / Zhang Y / Wang X / Xie Z
Peking University (China)
Project #: C-12-19L

Virtual simulation has been increasingly popular in preoperative plan of maxillofacial surgery, including pan facial fracture reduction, orthognathic surgery and maxillofacial reconstruction. Commercially available softwares such as Surgicase, SimPlant and VSP system, apply convenient tools for 3-D measurements, osteotomy, reposition and soft tissue prediction. However, none of them offers the tools for occlusion contact detection during the reposition of the teeth bearing bone segments. Up to now, no virtual tool for the simulation of occlusion modification and establishment has been reported.

The goal of present study is to develop an efficient virtual tool for the simulation of occlusion modification and establishment based on collision detection and mesh editing. Another goal is to evaluate the accuracy and conveniency of the daemon. Our research plan consists of the following elements:

(1) Employing a mathematic model based on the quasi-Monte Carlo method to calculate the highly irregular contact zones of the upper and lower dentitions;

(2) Proposing a novel algorithm for automatic optimal occlusion establishment based on the rule of largest contact surface;

(3) Implementing flexible and convenient mesh editing function to simulate the occlusion modification during surgical planning;

(4) Developing a prototype system for the reposition of teeth bearing bone segments based on a high-precision collision detection algorithm. Real-time interaction and occlusion contact will be obtained by GPU (Graphics Processing Unit)-based parallel acceleration;

(5) Performing a validation study to compare the difference between occlusion generated by virtual vs. manual procedure. The mathematic model and optimal matching algorithm will be optimized iteratively according to the results.

Occlusion design is highly important for the virtual design and execution of all types of maxillofacial surgery. However, the core work for occlusion modification and establishment still relies upon model surgery procedures. The proposed virtual environment in this project will help doctors design the occlusion as accurate as model surgery procedure, but more convenient and less time consuming than the later. Furthermore, a digital splint could be generated from completely virtual procedure, thus the time expense will be shortened and the accuracy of the preoperative design will be raised. In this way, 3D imaging and computer-aided planning will be brought one step closer into practice.