INDIVIDUAL STRESS ANALYSIS OF THE HUMAN MANDIBLE UNDER BITING CONDITIONS

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INTRODUCTION

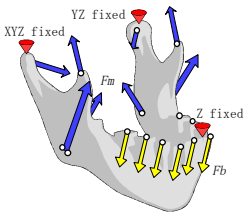
The purpose of this study is to examine biomechanical characteristics of the human mandible in occlusion. The mandibular body has a complicated shape and receives various masticatory forces under biting conditions. To obtain the exact mandibular model, an automated modeling method based on CT images was developed. Stress analyses were performed under bilateral and unilateral bitings. This research proposes a synthesized method to evaluate mechanical rationality of the bone using these computational results.

METHODS

The modeling method is composed of four processes. The first provides a voxel space of a bone from the CT images. The second distributes nodal points in the space. The third generates tetrahedral elements with the nodal points by use of Delaunay triangulation. The fourth finishes accurately the model by removing excessive elements.

For stress analysis in the biting condition, we consider four kinds of masticatory muscles. The masticatory forces were assumed to be proportional to sectional area of muscles. The muscular directions were determined from the reconstructed 3D image of the mandible.

The boundary conditions were set as follows. Condyles can turn in any direction like a pivot. One side of condyle can also move along the X-axis. The moments around the X-axis produced by reaction forces and muscular forces should adjust the balance as following equations.



$$\Sigma\, Rm_i \times Fm_i + \Sigma\, Rb_i \times Fb_i = 0$$

$$\Sigma\, Fm_i + \Sigma\, Fb_i + \Sigma\, Fr_i = 0$$

Figure 1: Boundary conditions

RESULTS AND DISCUSSION

Stress analyses were performed under bilateral and unilateral biting conditions. Reaction forces at the teeth in the bilateral biting conditions were measured by a pressure sheet. Reaction forces under the unilateral biting conditions were given to half side of the dental arch so that the total value of the reaction forces is nearly equal. Stress analyses were performed by CAEFEM (Concurrent Analysis Co.).

The analytical results were synthesized by choosing the highest value among the stresses for each nodal point. The obtained stressed map covers the wide area of the mandible. This suggests the mechanical rationality of mandible.

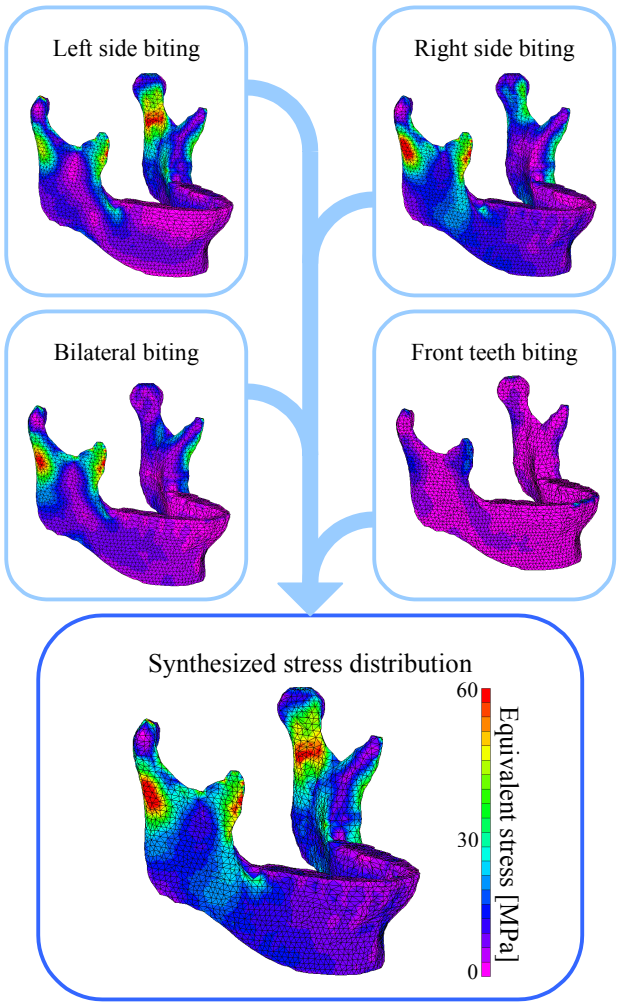


Figure 2: Calculated Stress distributions under several biting conditions and stressed map synthesized with these results

CONCLUSION

An individual simulation method of the human mandible based on X-ray CT data was proposed. An evaluation method to synthesize analytical results under multi-loading conditions was also proposed. The computational results showed that the mandible could be explained from biomechanical viewpoints. The proposed method will be applicable to other bones.