INDIVIDUAL STRESS ANALYSIS OF THE HUMAN MANDIBLE UNDER BITING CONDITIONS

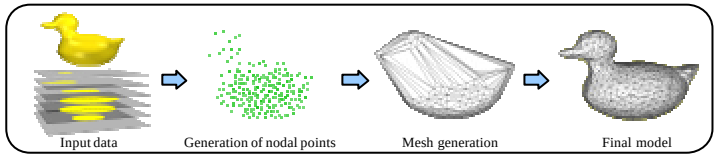
Norio INOU, Michihiko KOSEKI: Tokyo Institute of Technology
Koutarou MAKI: Showa University

1. Introduction

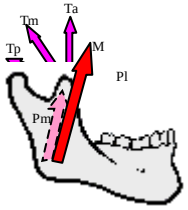
The purpose of this study is to examine biomechanical characteristics of the human mandible in occlusion. The mandibular body has a complicated shape and receives various masticatory forces under a biting condition. To obtain the exact mandibular model, an automated modeling method based on CT images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

2. Individual Modeling

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.



3. Masticatory Forces & Moment Balance

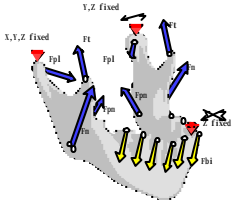


For stress analysis in the biting condition, we consider four kinds of masticatory muscles :
M: Masseter
Pm: Medial Pterygoid
Pl: Lateral Pterygoid
Ta, Tm, Tp: Anterior, Median, Posterior Temporalis

The masticatory forces were assumed to be proportional to sectional area of muscles. The muscular directions were determined from the reconstructed 3-D image of the mandible.

The moments around the condyles produced by the muscular forces and the biting forces should be balanced. Using the next equation, we adjusted muscular forces by proportional allotment to keep the moment balance

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

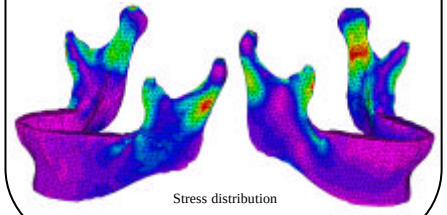


4. Computational Analyses

Left side biting

Muscles		Left	Right
Masseter		268.6	161.2
Medial Pterygoid		80.6	161.1
Lateral Pterygoid		53.7	134.3
Temporalis	anterior	134.3	134.3
	median	67.1	53.7
	posterior	67.1	53.7

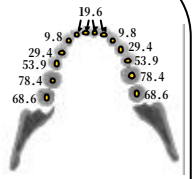
Masticatory forces & biting forces [N]



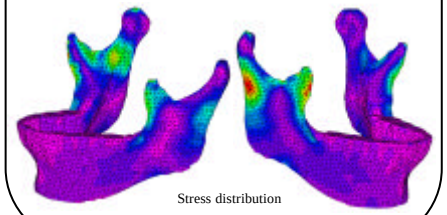
Stress distribution

Bilateral biting

Muscles		Left	Right
Masseter		268.6	268.6
Medial Pterygoid		161.1	161.1
Lateral Pterygoid		53.7	53.7
Temporalis	anterior	134.3	134.3
	median	67.1	67.1
	posterior	67.1	67.1



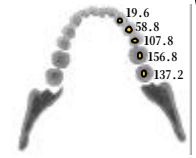
Masticatory forces & biting forces [N]



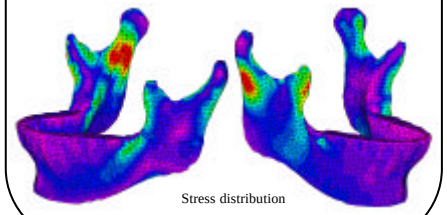
Stress distribution

Right side biting

Muscles		Left	Right
Masseter		161.2	268.6
Medial Pterygoid		161.1	80.6
Lateral Pterygoid		134.3	53.7
Temporalis	anterior	134.3	134.3
	median	53.7	67.1
	posterior	53.7	67.1

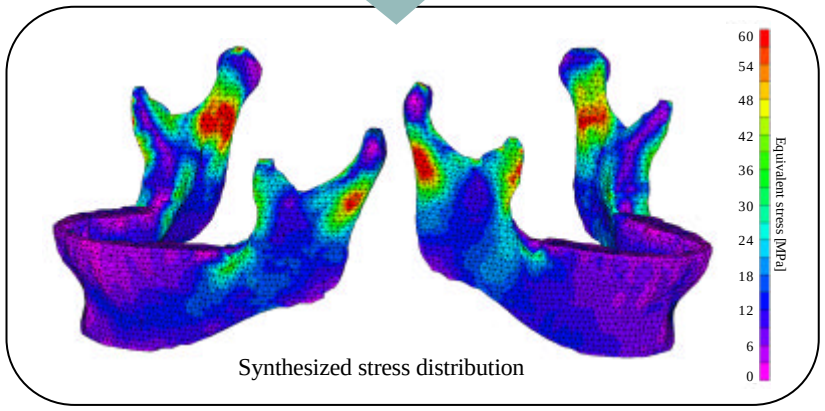


Masticatory forces & biting forces [N]



Stress distribution

SYNTHESIZE



Synthesized stress distribution

Stress analyses were performed under bilateral and unilateral biting conditions. Reaction forces of the bilateral biting conditions at the teeth 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 (Numerical Simulation Tech. Co., Ltd.). 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.

5. 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 mandiblecan be explained from biomechanical view points. The proposed method will be applicable to other bones.