The thickness of the resin base needed to the top of copings -Examination by the three-dimensional finite element method-

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Introduction

Denture fracture is common complication in overdenture because the thickness of denture base is often not enough above the copings and copings become fulcrum.[1)] Very few attempts have been made at such study. In this study the correlationship between the thickness of resin base and stress concentration above copings was assessed using three-dimensional finite element (FE) method addition to model-testing.

Materials and Methods

1. Model

The outline of plunger, resin plate and coping were modeled using three-dimension data from ANSYS. (Rel 15.0, ANSYS Inc., U.S.A) and Space Claim Direct Modeler (Space Claim Corp.) The maximum principal stress and displacement of these models were evaluated using ANSYS. Table1 shows the Young's modulus and Poisson's ratio.[2)]

Material		Young's modulus (MPa)	Poisson's ratio
Plunger	Stainless SUS400C	1.930×10^5	0.31
Denture base	ACRON	1.896×10^3	0.30
Coping	Stainless SUS400C	1.930×10^5	0.31

Table 1: Material Properties

Figure 1 shows plunger, resin plate and coping models. The plunger as press a resin plate was a column with radius of 1.6mm according to JIS T6501.[3)] The resin plate was 10mm in length, 64mm in width, and 2.5, 3.0, 3.5mm in height. It makes hollows according to shape of copings. It is diameter of 6.0mm a part of thrusting it into resin plate is height of 2.0mm.[4)]

2 types bending test models as modified 3-point bending test (3PB) and modified 4-point bending test models (4PB) were constructed for assessing a thick of resin plate. Model A is 3PB of a dome shape coping and 3 different thickness of resin plate. Model B is 3PB of a trapezoidal shape coping and 3 different thickness of resin plate. Model C is 4PB of a dome shape coping and 3 different thickness of resin plate. Model D is 4PB of a trapezoidal shape coping and 3 different thickness of resin plate.

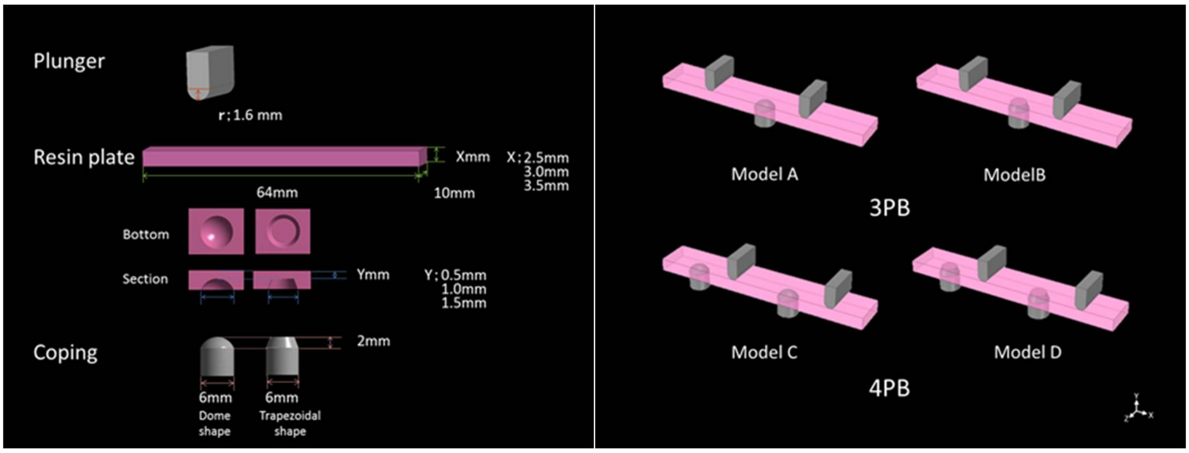

Fig.1: analysis model

2. Loading and boundary conditions

Figure 2 shows Loadings and boundary conditions. Loading amount is 110N, according to bending strength of ACRON. The surface of plunger was loaded each 55N, 110N in total. A complete constraint was applied to the bottom of copings in the all degree of freedom.

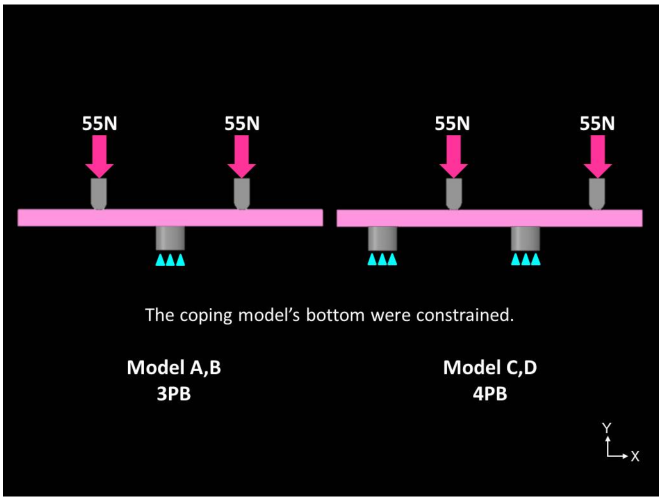

Fig.2: Loading and constraint conditions

3. Displacement

The measuring point was set on the surface of resin plate and the displacement was analyzed vertical direction.

Result

Figure 3 shows maximum principal stress of the section of 3BP and 4BP. The stress concentrated resin plate surface corresponding to top of copings in dome shape. The stress concentrated resin plate surface corresponding to the corner of copings in trapezoidal shape. An increasing of thickness of resin plate reduced stress concentration. The fracture part in model-testing was similar to the result of FE method.

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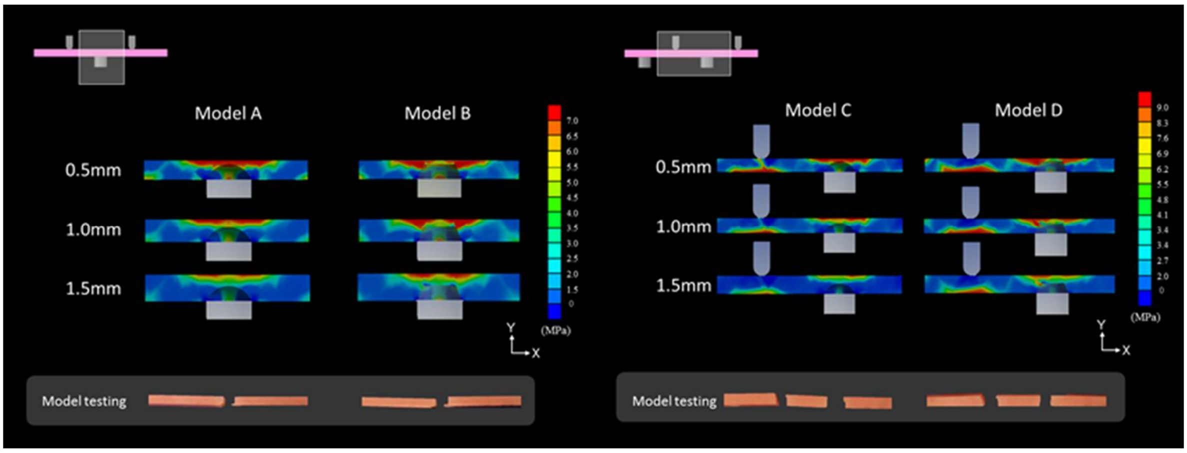

Fig.3: 3BP and 4BP maximum principal stress

Figure 4 shows the maximum value of maximum principal stress of 3PB and 4 PB. 3 different thickness of resin plate were investigated the maximum value of maximum principal stress in 4 models. An increasing of thickness of resin plate reduced the maximum value of maximum principal stress. There were no difference stress between dome shape and trapezoidal shape
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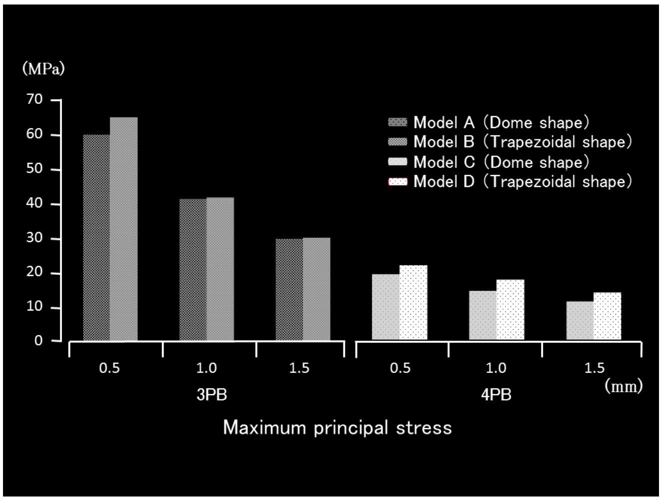

Fig.4: Maximum value of maximum principal stress

Figure 5 shows displacement of resin plate 3PB and 4BP. The arrows are plunger. The figure is coping. Resin plate was displaced equally on both side starting from coping both model A and B. An increasing of thickness of resin plate reduced the displacement in all models.

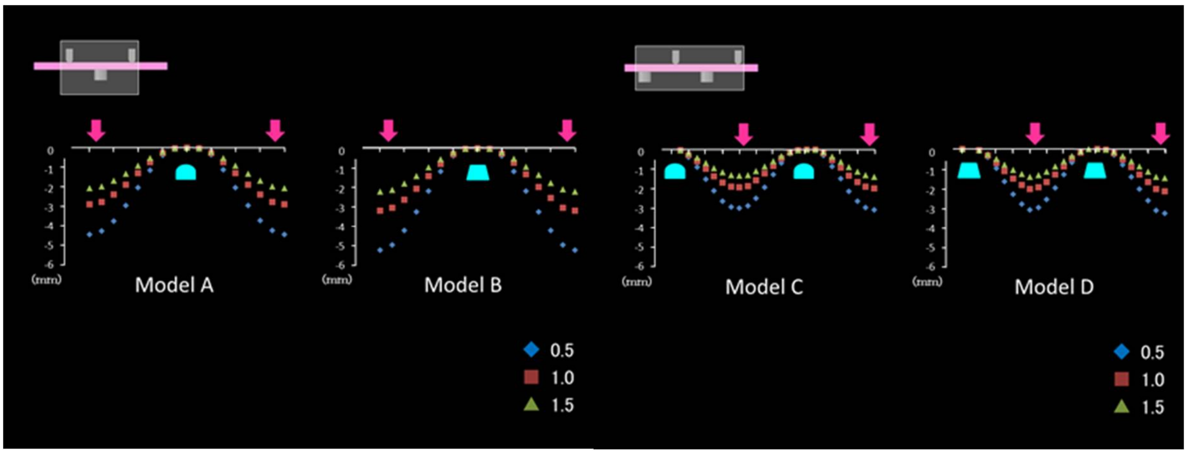

Fig.5: displacement of 3PB and 4BP

Discussions

It found that an increasing of thickness of resin plate reduced the maximum principal stress and displacement both 3PB and 4PB.

It found that the stress concentrated the center of resin plate in model A and C. It found that the stress concentrated the corner of copings in model B and D.

Tendency of denture fracture are suggested by FE method because model-testing by Kanazawa[5)] has the same evaluation as that.

Conclusions

Those results suggested that an increasing of thickness of resin plate reduced risk of fracture the same as model-test and it showed the effect of coping shape as invisible effect in model test. Further experiment is warranted to identify the required thickness of denture base.

Reference

1. N. Nozaki, Y. Tanaka, Y. Dezaki, et al: Effect of a Magnetic attachment on the Bending Strength of the Acrylic Resin Denture Base, J J Mag Dent, 8(1), 63-68, 1999.
2. Y. Takagi: Study by the difference of the abutment device mechanical analysis -Mandibular second molars one tooth remaining cases by three-dimensional finite element method of the prosthetic device-, Nihon Univ Dent J, 79,57-67, 2005.
3. JIS T6501: Acrylic denture base resins, 2012.
4. E. Kishimoto, K. Ogata, K. kawahara: The Effect of the Overdenture Abutment Teeth on Toothbrushing : Evaluation with a Simulator, J Dent Hlth, 47, 132-138, 1997.
5. T. Kanazawa, Y. Umekawa, T. Ishii, et al: Denture base strength influence of its thickness surrounding magnetic assembly -Examination by the model experiments-, The 24th Scientific meeting of Japanese society of Magnetic Applications in Dentistry, Atami, in press, 2014.