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DEVELOPMENT OF COSMETIC ORTHODONTIC BRACKET AND BRACKET COVER

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Summary. *Brackets used for orthodontics are generally made of three kinds of materials, namely stainless steel, plastics and ceramics. In addition, several kinds of orthodontic wire exist, that is, these are made from some materials and their sections are of different shape and size. Cost of stainless steel bracket (SB) is relatively low in comparison with plastics bracket (PB) and ceramics bracket (CB). And SB has superior mechanical properties (durability, toughness and strength) too. However, SB has an aesthetic problem due to its reflected light. The purpose of this study is to develop cosmetic SB (CSB) to reduce its reflected light. However its function and efficiency are still the same as (or more than) general SB. And a reduced reflected light bracket cover (BC) fit on general SB has been developed. The results obtained using an FEM, a CG software are that CSB and BC have highly efficient, lower reflected light. Therefore these are suitable for cosmetic orthodontics.*

1 INTRODUCTION

In recent years, a lot of people are hoping to cure their occlusion by orthodontics due to an aesthetic improvement. However some people are worried that brackets used for orthodontics are highlighted around their mouth and the cost of the treatment is too expensive in Japan.

Orthodontic brackets are generally made from three kinds of materials, namely stainless steel, plastics and ceramics. Cost of stainless steel bracket (SB) is relatively low in comparison with plastics bracket (PB) and ceramics bracket (CB). And SB has superior mechanical properties (durability, toughness and strength) too. Though SB is selected at orthodontics in most cases, SB has an aesthetic problem due to its reflected light.

On the other hand, the bracket has not only an aesthetic problem, it causes also inflammations and decayed teeth because of frictions between patient's oral mucus and the brackets, that is, these problems are due to the shape of bracket, orthodontic wire and rubber band (see Figure 1).

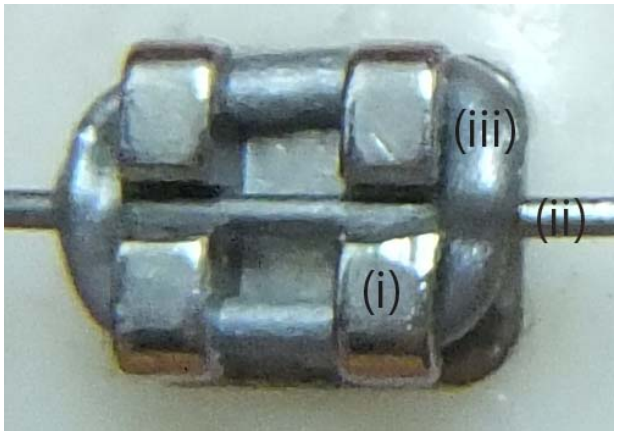


Figure 1: (i) Stainless steel bracket, (ii) wire and (iii) rubber band(silver color) on Tooth

The purpose of this study is to develop cosmetic SB (CSB) to reduce its reflected light. However its function and efficiency are still the same as (or more than) general SB, in addition, CSB need not rubber bands and become less frictions in oral mucus. And a reduced reflected light bracket cover (BC) fit on a general SB has been developed.

2 LOADS TO TOOTH (BRACKET) FROM ORTHODONTIC WIRE

In order to analyze the strengths of general SB and CSB by using finite element method (FEM), loads to a tooth through a bracket from some kinds of orthodontic circular wire (0.3 [mm], 0.36 [mm], 0.41 [mm] and 0.46 [mm] in diameter) made from Ni-Ti are measured by experiments. Moreover, enforced displacements set to orthodontic wire are from 1 [mm] to 5 [mm] (average distances between cured teeth of patients).

2.1 Experiment device and measurement method

Experiment device is illustrated in Figure 2 and loads are measured by the following a)-e) ((i)-(viii) are shown in Figure 2):

a) Fix two brackets (i) on the aluminum plate (ii), and put the other one (iii) on center between (i)s.
b) Let the orthodontic wire (iv) through (i)s and (iii), and put the rubber bands (v) on each brackets.
c) In order to effect enforced displacement to (iii), put iron plate (vi) under (iii). This (vi) has a thickness of one millimeter, therefore number of (vi) adjusts the enforced displacement.
d) Lift (iii) by using the spring scale (vii) through kite string (viii).
e) Load converted from value of (vii) is measured when (iii) floats from (vi).

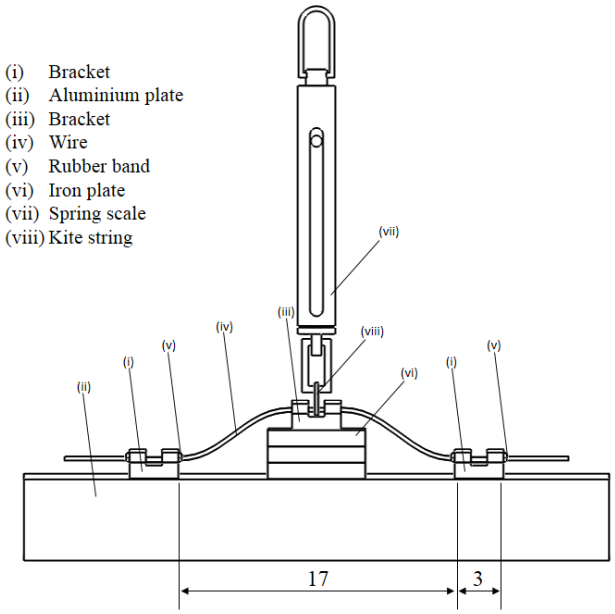


Figure 2: Experiment device to measure load of wire

2.2 Experimental results

The comparison of the loads according to the different diameters is shown in Figure 3 (the horizontal axis indicates the enforced displacements).

Figure 3 shows that the load to the bracket from the orthodontic wire is bigger when the diameter of the wire and the enforced displacement become large. And the maximum load is about 2 [N]. Therefore, the load to these brackets is defined to 2 [N] in order to analyze the strength of general SB and CSB by using FEM.

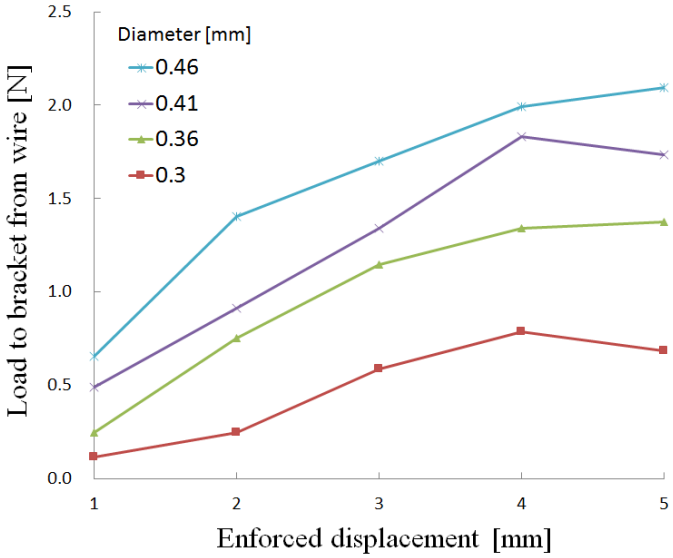


Figure 3: Experimental results to measure load of wire

3 DEVELOPMENT OF COSMETIC BRACKET

3.1 Proposal of CSB

In order to reduce a reflected light of the bracket and remove damages of patient's oral mucus, meanwhile the cost of orthodontics is between general SB and PB, moreover its function and efficiency are still the same as (or more than) general SB, CSB is proposed in this study. The shape of CSB is circular (diameter and height equal 3 [mm] and 1.6 [mm]) and it is smaller than general SB, in addition, it has an exclusive plastic cover as shown in Figure 4. Even if this plastic cover crushes under unexpected loads, it can be exchanged with new one in ease. On the other hand, rubber bands need not at orthodontics because the plastic cover is completely mounted on the bracket holding orthodontic wire.

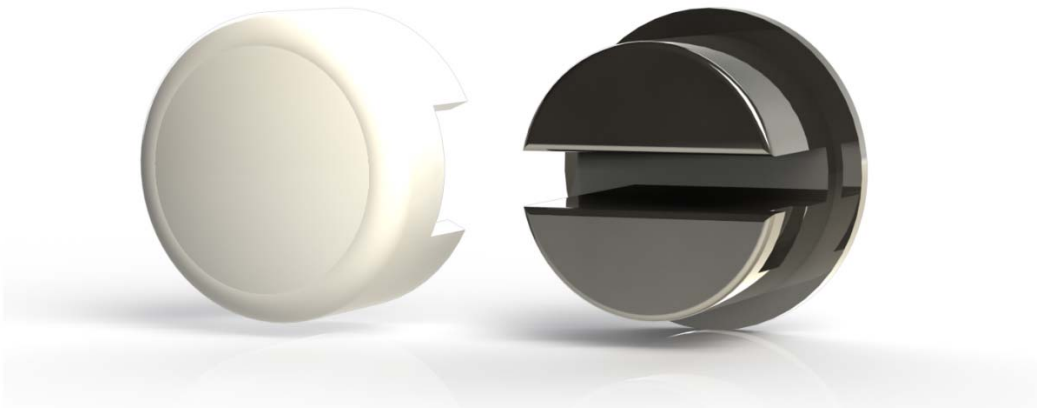


Figure 4: CSB (right is bracket, left is exclusive plastic cover)

3.2 Installation methods of plastic cover

The exclusive plastic cover is mounted on the bracket by using the exclusive instrument (the tip is made from rubber) shown in Figure 5.

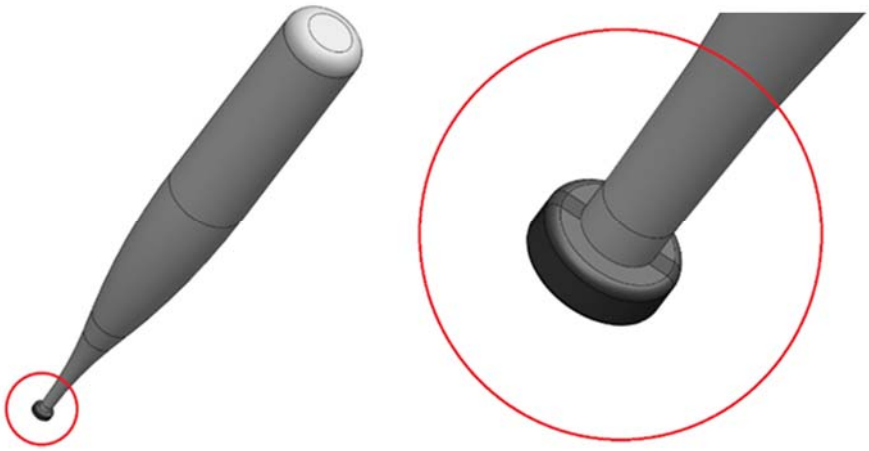


Figure 5: Instrument to mount plastic cover on bracket

Installation methods are as follows (see Figure 6):

i) Hold the instrument tip to the plastic cover.
ii) Take the plastic cover from a pedestal.
iii) Mount the plastic cover on a bracket using the instrument.
vi) Set the plastic cover on the bracket, rotate the instrument to lock the plastic cover at the bracket.
v) Remove the instrument from the bracket.

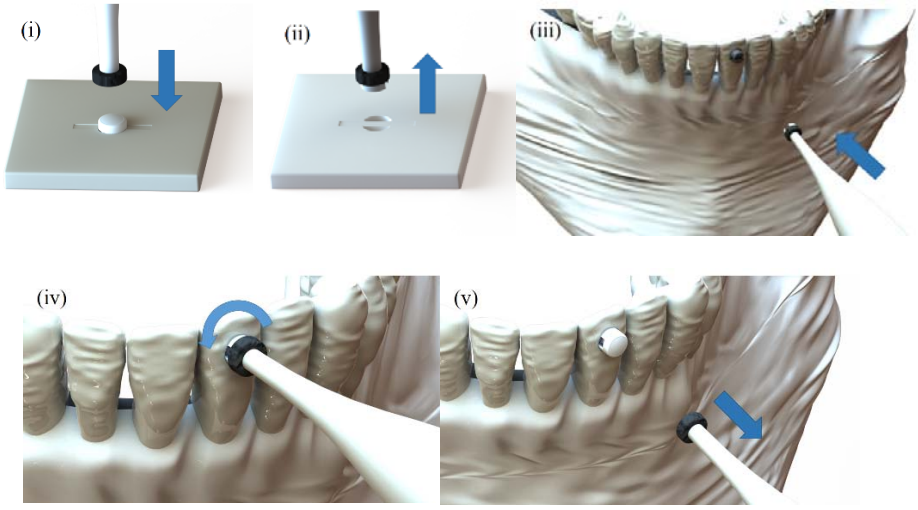


Figure 6: Installation methods for plastic cover using instrument

Mounting the plastic cover on the bracket is very easy and the tip of the instrument can be exchanged with new one.

3.3 Comparison of cosmetics between general SB and CSB using CG

After dimension of a general SB is measured (base:3.2 [mm] x 3.0 [mm], height equals 1.7 [mm]), its 3D model is created by using a CAD software (SolidWorks) as shown Figure 7, and both these models (for general SB and CSB) are imported into a CG software (Blender). As shown in Figure 8, aesthetic improvement of CSB is clearly recognized in comparison with general SB.

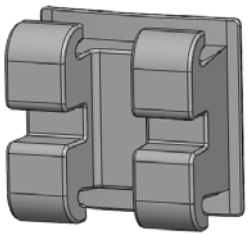


Figure 7: general SB model

Figure 8: Comparison between CSB and general SB

3.4 Analysis of strength comparing between CSB and general SB

Material properties shown in Table 1 are used for analyzing strengths of CSB and general SB by FEM. And FEA models for SolidWorks Simulation are assembled a bracket, an alveolar bone and an arch shown in Figure 9[1]-[3].

Table 1: Material properties

Material	Young's modulus [MPa]	Poisson's ratio
Tooth	19600	0.3
Bone	13700	0.3
Bracket	200000	0.3
Bracket cover (PPS)	9610	0.4

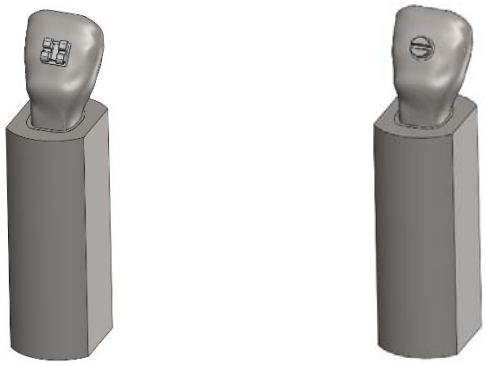
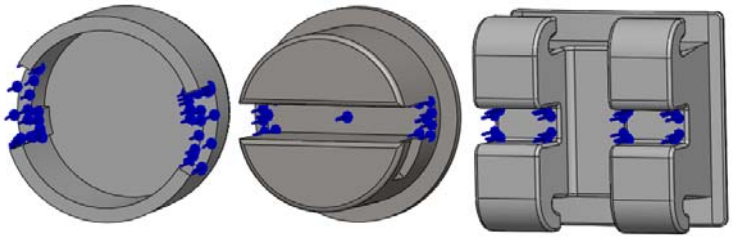


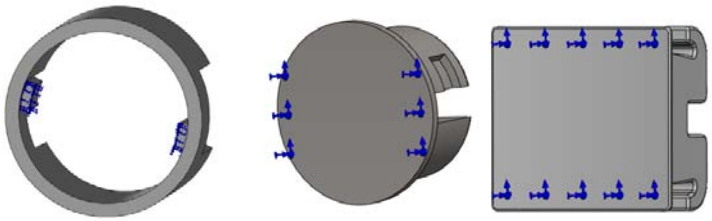
Figure 9: FEA models for SolidWorks Simulation

3.5 Results of analysis

Figure 10 shows boundary conditions of the CSB and its plastic cover.



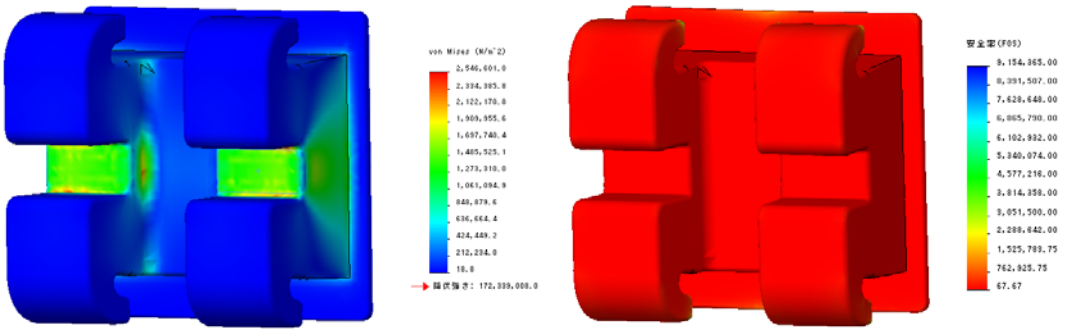
(a) Load conditions



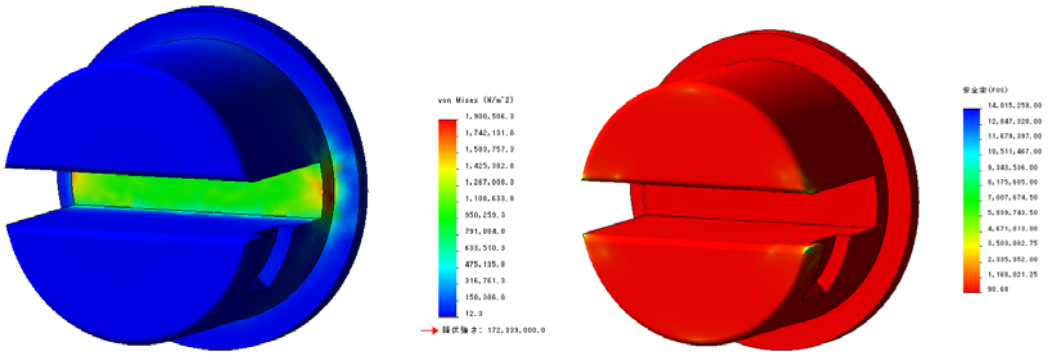
(b) Constraint conditions

Figure 10: Boundary conditions

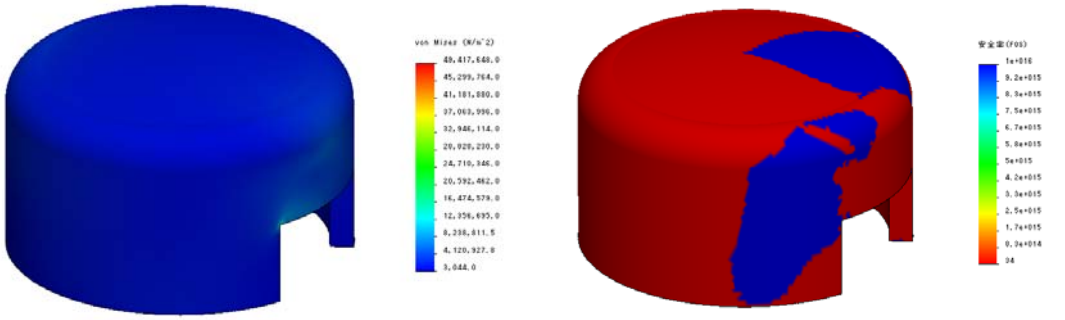
In Figure 11 (a), the maximum stress of the general SB is 2.5 [MPa], and the minimum factor of safety (FOS) is 10. The CSB indicates the maximum stress of 1.9 [MPa] and the minimum FOS of 90 shown in Figure 11 (b). Thus, these results show that the strength of the CSB is increased comparing to the general SB. Likewise the stress analysis of the plastic cover observes 49.4 [MPa] of the maximum stress and 34 of the minimum FOS in Figure 11 (c).



(a) Stress and FOS contor diagrams of general SB



(b) Stress and FOS contor diagrams of CSB



(c) Stress and FOS contor diagrams of plastic cover

Figure 11: Stress and FOS contor diagrams of CSB

Figure 12 shows stress distribution points, and Figure 13 shows internal stresses of location A-C at Figure 12. Both behaviors of stress bear a close resemblance.

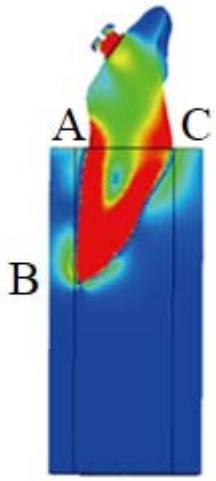


Figure 12: Stress distribution point

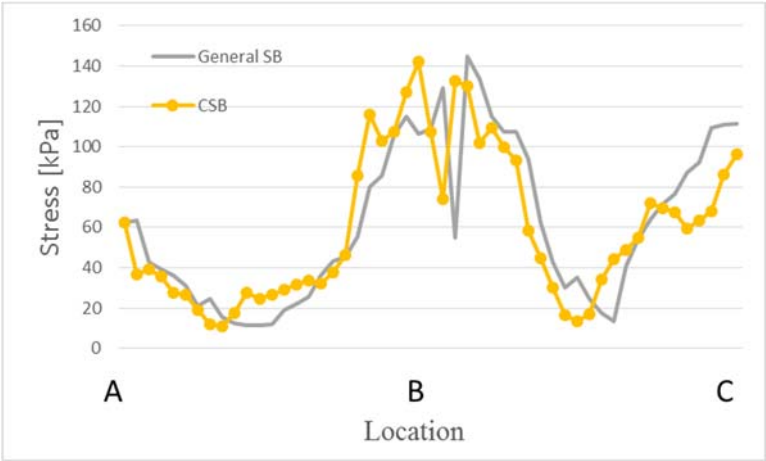


Figure 13: Stress distributions

4 DEVELOPMENT OF BRACKET COVER (BC)

4.1 Design of BC

As shown in Figure 14, a reduced reflected light bracket cover (BC) fit on general SB has been developed. This BC is put on bracket wings, thus color of metal is hidden. It is known that BC made from PPS is crushed, therefore material of BC is investigated now.

Figure 14: BC

4.2 Comparison of the image with/without BC by CG

Figure 15 shows the results comparing the image of with/without BC. Consequently, the BC can provide higher level of cosmetic impression.

Figure 15: Comparison of influences with/without BC

5 CONCLUSIONS

This study is to develop CSB to reduce its reflected light. And its function and efficiency are still the same as general SB. Moreover, a reduced reflected light bracket cover (BC) fit on general SB has been developed. The results obtained using an FEM and a CG software are that CSB and BC have highly efficient, lower reflected light. Therefore these are suitable for cosmetic orthodontics.

However, if BC is made from PPS, it is crushed by the maximum load (2 [N]) from orthodontic wire. So, a material and a shape of BC are investigated now.

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