Pressure Transmission of Thermoplastic Nylon Denture Base Using Denture Teeth with Different Cuspal Angulations

Christ Angel Bayu Nababan¹, Hubban Nasution², Ika Andryas²

1. Clinical Student, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia.
2. Lecturer, Department of Prosthodontics, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia.

Abstract

The purpose of this study was to evaluate the pressure transmission of thermoplastic nylon denture base using denture teeth with different cuspal angulations.

Three different cuspal angulations [non-anatomic (0°), semi-anatomic (20°) and anatomic (33°)] of mandibular first molar acrylic denture teeth (BioEco) embedded on 15x15x3 mm³ thermoplastic nylon (TCS) as denture base were evaluated (n=10). A 100N force was applied on the specimen using universal testing machine and the pressure transmitted under the specimen was observed using pressure transducer. Data were statistically analyzed using One-way ANOVA, followed by Tukey’s HSD post hoc test (P<.05).

Non-anatomic denture teeth showed significantly lower pressure transmission than anatomic and semi-anatomic denture teeth (P<.001).

Pressure transmission value under thermoplastic nylon denture base varied among different denture teeth cuspal angulations.


Keywords: Cuspal angulations; denture teeth; pressure transmission; thermoplastic nylon.

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Introduction

Denture can improve the ability of mastication, speaking, support the facial muscles, improve appearance, and have to be designed properly to maintain oral tissue structure.¹,² Excessive pressure should not be transferred to the supporting tissue of dentures to maintain normal blood circulation.² Matsou et al suggested that a pressure of 27 to 68 g/cm² would cause fibroblasts to increase intercellular calcium resulting in the alveolar bone remodelling.³ If the pressure changes the blood circulation to the alveolar ridge or causes mucoperiosteum inflammation, it can contribute to pathological bone resorption.⁴

Along with the dental materials development, thermoplastic resins are increasingly popular as denture base material.⁵ Thermoplastic resins are favourable in esthetic, flexible, biocompatible and hypoallergenic properties.⁶ Nylon is a type of thermoplastic resin polyamide group, derived from diamine & dibasic acid monomers.⁷,⁸ Thermoplastic nylon is a monomer-free base material which act as an alternative for patients who are allergy to polymethyl methacrylate (PMMA).⁸,¹⁰ It has lower modulus of elasticity and hardness compared to PMMA.¹¹,¹² Nasution et al evaluated the correlation of modulus of elasticity and nanohardness to pressure transmission from thermoplastic and PMMA denture base. They reported that denture base with higher modulus of elasticity and nanohardness would transmit and distribute greater pressure.¹³

In addition, denture teeth selection need to be considered especially posterior denture teeth in order to get proper pressure distribution under denture base.¹⁴ The posterior denture teeth selection is determined based on the ideal occlusion for the patient.¹⁵,¹⁶ Based on cuspal angulations, the posterior denture teeth are divided into anatomic (33°), semi-anatomic (20°), and non-anatomic (0°).¹⁷ Posterior denture teeth would affect the magnitude of force that was transmitted and distributed through the denture base to the alveolar ridge.¹⁸,¹⁹,²⁰ Previous studies evaluated the effect of occlusal scheme on the pressure distribution of denture. They reported

*Corresponding author:
Hubban Nasution, DDS, MSc
Department of Prosthodontics, Faculty of Dentistry,
Universitas Sumatera Utara, Medan, Indonesia.
E-mail: hubban.nst@usu.ac.id
that denture teeth with less than $33^\circ$ cuspal angulations would distribute the pressure more vertically than $33^\circ$ denture teeth.\textsuperscript{3,21,22} Denture teeth with flatter cuspal angulations or less than $33^\circ$ would result in increased occlusal contact area.\textsuperscript{23,24} Thus, it was expected to reduce the magnitude of the force transmitted to the alveolar ridge.\textsuperscript{25}

Review articles on clinical application of removable partial denture using thermoplastic nylon suggested that according to prosthetic principles, thermoplastic nylon is not suitable as a definitive denture base except for patient with a metal allergy.\textsuperscript{26} Therefore, further studies and clinical guidelines are recommended.\textsuperscript{27}

The purpose of the present study was to evaluate the pressure transmission of thermoplastic nylon denture base using denture teeth with different cuspal angulations. The null hypotheses was that there would be no difference of pressure transmission of thermoplastic nylon denture base using denture teeth with different cuspal angulations.

**Materials and methods**

Three different cuspal angulations of mandibular first molar acrylic resin denture teeth (BioEco; New Stetic S.A, Antioquia, Colombia); non-anatomic ($0^\circ$), semi-anatomic ($20^\circ$) and anatomic ($33^\circ$) embedded on 15x15x3 mm$^3$ thermoplastic nylon denture base (TCS Unbreakable; TCS Dental Inc., Signal Hill, California, United States) (n=10) were evaluated. The non-anatomic denture teeth ($0^\circ$) were prepared manually by flattening the semi-anatomic acrylic resin denture teeth using abrasive paper grit number 800, 1000, and 1200 until the flat occlusal surface was achieved. To standardize the occlusal surface, there was only one operator and with the same forward and backward movement. The final servico-occlusal height of the non-anatomic denture teeth was 4 mm. After the denture teeth were flattened, there were still some grooves on the occlusal surface.

The acrylic resin denture teeth are listed in Table 1. The specimens were prepared by using a putty-type silicone impression materials (GC Flexceed; GC India Dental Pvt Ltd., Pashamylaram Patancheru, India) as a mold. Melted wax was poured into the mold, the denture tooth was attached to the wax by using a surveyor (Dentsply Ney Dental Surveyor; Ney Dental Inc., York, United States) to ensure that the occlusal surface of the denture tooth was parallel to the base of the specimen. Wax specimen molding is shown in Figure 1.

**Table 1. Denture teeth used in the present study**

<table>
<thead>
<tr>
<th>Type</th>
<th>Brand Name</th>
<th>Code</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-anatomic denture teeth (modified)</td>
<td>BioEco</td>
<td>PF</td>
<td>New Stetic S.A, Antioquia, Colombia</td>
</tr>
<tr>
<td>Semi-anatomic denture teeth</td>
<td>BioEco</td>
<td>PF</td>
<td>New Stetic S.A, Antioquia, Colombia</td>
</tr>
<tr>
<td>Anatomic denture teeth</td>
<td>BioEco</td>
<td>34M</td>
<td>New Stetic S.A, Antioquia, Colombia</td>
</tr>
</tbody>
</table>

**Figure 1. Wax specimen molding.**

Injection molding flask was used to fabricate the specimens. The specimens were invested into the flask, boiled out, and placed into the injection molding machine. The cartridge containing thermoplastic nylon materials was heated up according to the instructed temperature (288$^\circ$C for 11 minutes). Then the material within the cartridge was injected into the flask and allowed to bench cool. The same
method was used for maxillary denture teeth as the antagonist specimen. All specimens were then removed from the denture flask and the specimen’s surface were polished by using a rotary grinder (Metaserv 3000; Buehler Ltd., Illinois, United States) under constant water irrigation at 100 rpm. Abrasive paper grit number 500, 800, 1000, 1200 were used to polish the specimens. The specimens were immersed for 24 hours with distilled water at 37°C in the incubator before testing. The schematic drawing of the specimen is shown in Figure 2.

Figure 2. Schematic drawing of the specimen.

Universal testing machine (EHF-EB100KN-20L; Shimadzu Co., Kyoto, Japan) and pressure transducer were used to measure the pressure transmission under the specimens. The pressure transducer was connected to the universal testing machine’s table. The maxillary denture tooth specimen was placed at the indenter of the universal testing machine and the mandibular denture tooth specimen was placed at the pressure transducer following a Class I Angle occlusal relationship. A 100N vertical force with cross-head speed 0.5 mm/min was applied at the specimens and the pressure detected under the denture base was recorded. The schematic of specimen apparatus is shown in Figure 3.

Statistical software (SPSS Statistics V20; IBM Corp., New York, United States) was used for statistical analysis. Data were statistically analyzed using One-way ANOVA, followed by Tukey’s HSD post hoc test ($P<.05$).

Results

Significant differences in pressure transmission under thermoplastic nylon denture base using denture teeth with different cuspal angulations was founded using One-way ANOVA test (Table 2). Tukey’s HSD post hoc test was performed to determine comparison between groups. Non-anatomic denture teeth showed the lowest pressure transmission ($P<.001$). However, no statistically significant difference was found between semi-anatomic and anatomic denture teeth group ($P=.498$). Means of pressure transmission and Tukey’s HSD analysis are shown in Figure 4.

Figure 3. Schematic of pressure transmission apparatus.

Figure 4. Means and standard deviations of pressure transmission from all cuspal angulations denture teeth groups (vertical bars show standard deviation; bars with the same letter are not significantly different between groups at $P<.001$).
Pressure transmission difference occurred due to several factors such as denture base materials and denture tooth selection. The present study evaluated pressure transmission under thermoplastic nylon denture base using denture teeth with different cuspal angulations. Statistical analysis showed significant differences in pressure transmission under denture base using denture teeth with different cuspal angulations; therefore, the null hypotheses was rejected.

Various dental materials have been introduced in the market, especially thermoplastic nylon, but there is lack of study in terms of the mechanical properties. In the previous study, the TCS thermoplastic nylon have modulus of elasticity of 733.58±6.42 MPa. It indicated that TCS has low modulus of elasticity.11 Modulus of elasticity could affect pressure transmission under denture base.6,13,18,29 Denture material with a lower modulus of elasticity can flex and absorb the impact force, thus reduce stress on the underlying structure.13,20 Therefore, thermoplastic nylon denture base was expected to reduce the magnitude of the force transmitted to the alveolar ridge.13

The difference of pressure transmission values in the present study indicated that the angulations of the cusps influenced pressure transmission value under denture base. It was caused by differences in the width of the occlusal contact area between the cuspal angulations.14,24 Reduction in cuspal angulations caused a decrease in pressure transmission because the width of the occlusal contact area was increased.23,24 Greater pressure transmission would affect the shape of the alveolar ridge and can cause resorption.14

Denture base fabrication in the present study was controlled to be the same in each specimen. The denture teeth were selected from the same manufacturer and only non-anatomic denture teeth that were manually modified. The result showed that semi-anatomic denture teeth showed no significant difference in pressure transmission compared to anatomic denture teeth. It meant that the reduction of the cuspal angulations from 33° to 20° did not cause a significant increase in the occlusal contact area, thus it led to a statistically insignificant decrease in pressure transmission. The result of the present study corresponded to the previous study.2 Arksornnukit et al reported anatomic and semi-anatomic acrylic denture teeth had no significant difference in the maximum pressure transmission, but semi-anatomic acrylic denture teeth significantly showed smaller pressure distribution area compared to anatomic acrylic denture teeth. These results suggested that semi-anatomic denture teeth may be preferable to anatomic denture teeth.3

The results showed that non-anatomic denture teeth significantly the lowest pressure transmission compared to semi-anatomic and anatomic denture teeth. These meant the reduction of the cuspal angulations to 0° in non-anatomic denture teeth may result in a significant increase in the area of occlusal contact area.24 It led to a decrease in pressure transmission under denture base.23,24 Chowdhary et al suggested that using denture teeth with lower cuspal angulations might be a desirable option because it transfer less force and pressure to the supporting tissue.25 Non-anatomic denture teeth, which provide less force and better pressure distribution, should be used in highly atrophied residual ridges.21 Those denture teeth showed lower pressure to the buccal and lingual slopes of the residual ridge, thus it induced lower lateral forces than anatomic and semi-anatomic denture teeth.22

Berg et al. reported that to keep normal blood circulation, continuous mechanical pressure higher than 1.3 kPa should not be transferred to the supporting tissue of dentures.2,4 The pressure transmission values in present study showed higher score than the above value which attributed to the size of the denture base specimen in the present study was only 225 mm², thus the area to absorb pressure was limited. In addition, complete denture base area in the maxilla is about 2296 mm², while in the mandible is about 1225 mm².29 Therefore, to minimize the pressure to alveolar ridge, an extension of denture base within anatomical and

<table>
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<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
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<td>Between Groups</td>
<td>1150.726</td>
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<td>575.363</td>
<td>42.451</td>
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<tr>
<td>Within Groups</td>
<td>365.945</td>
<td>27</td>
<td>13.554</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1516.672</td>
<td>29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. One-way ANOVA results.

Discussion

Pressure transmission difference...
physiological limits is advised.\(^\text{16}\)

The limitations of the present study were that pressure transmission was evaluated in vitro with vertical load and limited denture base surface area, and the test equipment used could only measure the pressure without seeing its distribution pattern. Therefore, in vivo study with actual occlusal force and surface area is recommended.

**Conclusions**

Within the limitations of the present study, the following conclusions were drawn. Non-anatomic denture teeth showed significantly lower pressure transmission than anatomic and semi-anatomic denture teeth. Anatomic denture teeth is still a common choice as posterior denture teeth. Semi-anatomic and non-anatomic denture teeth are alternative denture teeth in denture fabrication in certain cases.

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**Declaration of Interest**

The authors report no conflict of interest.

**References**