Pressure Transmission under Thermoplastic Nylon Denture Base Using Acrylic and Porcelain Denture Teeth

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Abstract

The purpose of this study was to evaluate pressure transmission under thermoplastic nylon denture base using acrylic and porcelain denture teeth.

Mandibular right first molar acrylic denture teeth (Bioeco) and porcelain denture teeth (SMIC) embedded on 15x15x3mm3thermoplastic nylon (TCS) as denture base were evaluated (n=16). 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 with Univariat test and followed by Mann-Whitney test (P<0.05) since the data were not normally distributed.

Porcelain denture teeth showed significantly higher pressure transmission than acrylic denture teeth (P<.001).

There was a significant difference of pressure transmission under thermoplastic nylon denture base using acrylic and porcelain denture teeth.

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Introduction

Denture fabrication requires expertise and appropriate methods in order to have a convenient denture and will not cause a pathological condition in the oral cavity.[1] Dentures must be designed properly to maintain oral tissue structure.[2] Berg et al. reported that to keep blood circulation normal, continuous mechanical pressure higher than 1.3 kPa should not be transferred to the supporting tissue of the dentures.[3,4] If the pressure changes the blood supply to the alveolar ridge or causes inflammation of the mucoperiosteum, pathological bone resorption can be occured.[5,6]

The most commonly used material for denture base is polimethyl methacrylate (PMMA).[7,8,9] PMMA denture base resins have low impact strength and poor fatique resistance.[8] This material also has been proven to have good biocompatibility and dimensional stability with less tissue irritation and toxicity.[7] However, along with the development of dental materials, thermoplastic resins are increasingly popular as denture base materials.[2,10] Thermoplastic resins have advantages such as favorable aesthetic, flexible, biocompatible and hypoallergenic properties.[10,11,12,13] Thermoplastic resins are divided into acrylic thermoplastic, acetal, polycarbonate and polyamide (nylon).[12] Thermoplastic nylon is a monomer-free base material which is an alternative for patients who are allergy to polymethyl methacrylate (PMMA).[14,15,16] Thermoplastic nylon have lower modulus of elasticity and hardness compared to PMMA.[16] Denture base with higher modulus of elasticity and hardness would transmit and distribute greater pressure.[17,18]

In addition to the denture base selection, denture teeth selection are needed to be considered.[19] Acrylic resin and porcelain are materials that quite popular for fabrication of denture teeth.[19,20] Generally, porcelain denture teeth show high abrasion resistance, excellent aesthetic and color stability, but it creates a

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clicking sound when in contact with the porcelain antagonist denture teeth and more expensive.[21,22,23] Acrylic denture teeth are more clinically used than porcelain denture teeth.[21] Acrylic denture teeth is indicated if the denture teeth in contact with natural teeth or metal crowns.[24] Mosharraf R et al reported that there were significant differences of pressure transmission under denture bases using denture teeth of different materials in direct and indirect tooth contacts.[2] This means that a suitable denture teeth materials should be selected for denture fabrication, especially when the pressure transmitted to the alveolar ridge is a concern.[2,5]

The purpose of the present study was to evaluate the pressure transmission of acrylic and porcelain denture teeth under thermoplastic nylon denture base. The null hypothesis was that there would be no difference in pressure transmission value of acrylic and porcelain denture teeth under thermoplastic nylon denture base.

Materials and methods

Preparation of the specimens

Two different mandibular first molar denture teeth; acrylic resin (BioEco, New Stetic, Bogota, Columbia) and porcelain (SMIC, Senju Metal Industry Co., Ltd, Tokyo, Japan) embedded on 15x15x3mm^3 thermoplastic nylon denture base (TCS, TCS, Inc., California, USA) were evaluated (n=16). The combination of materials are listed in Table 1. The specimens were prepared by using a putty-type silicone impression materials (Flexceed, GC India Dental Pvt Ltd., India) as a mold. Melted wax was poured into the mold, thedenture tooth was attached to the wax by using a surveyor to ensure that the occlusal surface of the denture tooth was parallel to the base of the specimen.
Injection molding flasks were used to fabricate thermoplastic nylon base specimens. Wax replica of specimen with attached denture tooth were invested into the flasks, boiled out, and placed into the injection molding machine. The cartridge containing thermoplastic nylon materials was heated up according to the instructed temperature (288^{0}C for 11 minutes). Then the material within the cartridge was injected into the flask and allowed to bench cool. The same methods were used for maxillary denture teeth as the antagonist specimen. All specimens were then removed from the denture flasks and any flash was removed with a carbide bur (CQ251, Jota, Swis).The basal surface of the specimens were polished by using polishing machine at 100 rpm (Metaserv 3000, Buchler Ltd, USA) under constant water irrigation with abrasive paper grit number 500, 800, 1000, 1200. The specimens were immersed for 24 hours with distilled water at 37^{0}C in the incubator before testing. The schematic drawing of the specimen is shown in Figure 1.

Type	Brand Name	Mold	Manufacturer
Acrylic Resin	Bioeco	34M	Bioeco, New Stetic, Bogota, Columbia
Porcelain	SMIC	24M	SMIC, Senju Metal Industry Co., Ltd, Tokyo, Japan

Table 1. Artificial denture teeth used in the present study.

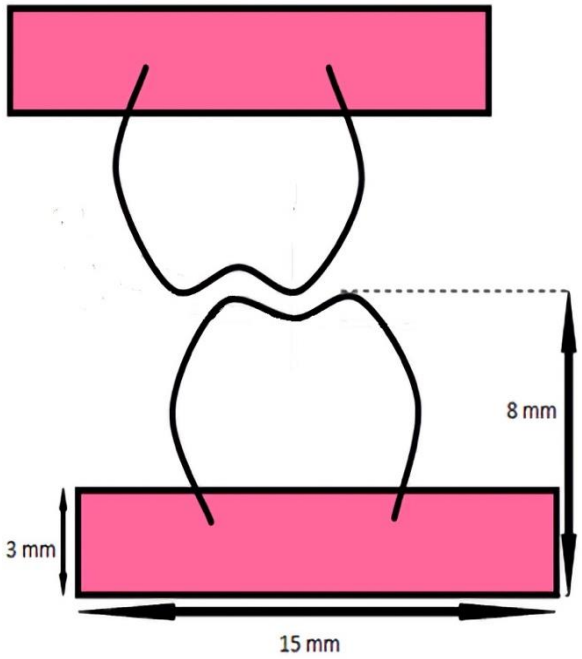

Figure 1. Schematic drawing of the specimen.

Pressure transmission measurements

The universal testing machine (EHF-EB100KN-20L, Shimadzu Co., Japan) and pressure transducer were used to measure the pressure transmission under the specimens. After preparing all specimens, each pair of maxillary and mandibular denture teeth was arranged in a Class I angle occlusal relationship. The pressure transducer was connected to the universal testing machine. The maxillary denture teeth specimen were placed at the indenter of the universal testing machine and the mandibular

denture teeth specimens were placed at the pressure transducer. A 100N vertical force with cross-head speed 0.5 mm/min was applied at the specimen and the pressure detected under the denture base was recorded. Three pressure test for each specimen were performed. Then, the average values were calculated. The pressure transmission apparatus is shown in figure 2. The data were analyzed with a statistical software (SPSS Statistics V20; IBM Corp., NY, USA). Pressure transmission data were analyzed using Univariat test and followed by Mann-Whitney test (P<.05) since the data were not normally distributed (P<.05).

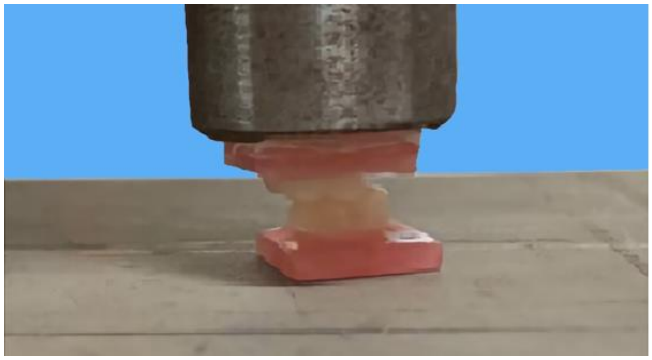

Figure 2. Pressure transmission testing apparatus.

Results

Groups	n	Mean	Sd	Mann-Whitney Test
Acrylic Resin	16	77.304	2.381	P 0.000 < 0.05
Porcelain	16	90.213	3.131	

Table 2. Mann – Whitney test for pressure transmission.

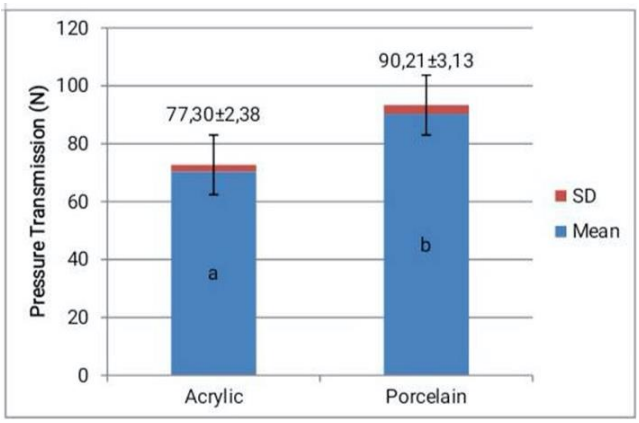

Figure 3. Means and standard deviations of pressure transmission for acrylic and porcelain denture teeth groups (vertical bars show standard deviation; bars with the different letter indicate significant different between acrylic and porcelain groups).

Statistical analysis indicated significant differences in pressure transmission value under thermoplastic nylon denture base using acrylic and porcelain denture. The means pressure transmission under the porcelain denture teeth ranged between 90.21±3.13 N, while the means of pressure transmission under the acrylic denture teeth ranged between 77.30±2.38 N. Porcelain denture teeth showed higher pressure transmission than acrylic denture teeth. Means of pressure transmission and Mann-Whitney analysis are shown in Table 2 and Figure 3.

Discussion

The present study evaluated pressure transmission under thermoplastic nylon denture base using acrylic and porcelain denture teeth. Statistical analysis showed significant differences in pressure transmission under denture base using different denture teeth materials; therefore, thenull hypothesis was rejected.

There are several factors that affect the pressure transmission,i.e.; properties of denture teeth material and cuspal angulations of denture teeth.[5,16,21] Properties of denture teeth material that affect the pressure transmission are modulus of elasticity and density.[16,21] There is a mismatch in modulus of elasticity between porcelain and acrylic resin denture teeth where the modulus of elasticity of acrylic resin is 2,5 GPa and porcelain denture teeth is 80 GPa.[21] Material with higher modulus of elasticity is more rigid, therefore, porcelain denture teeth which have higher modulus of elasticity would transmit greater pressure to the supporting soft tissue than acrylic resin denture teeth.[16,21] Porcelain denture teeth also have higher density value than acrylic resin denture teeth, porcelain denture teeth have density of 2.4gr/cm^2, while acrylic resin denture teeth have density 1.2 gr/cm^2. Thus, it led to increase the pressure transmission under the denture base.[21]

The results of the present study corresponded to the previous studies.[2,6] Mosharraf et al evaluated the effect of denture tooth material on load transmission under denture bases.[2] They reported that the porcelain denture teeth showed the highest pressure transmission compared to nanocomposite,

composite-acrylic resin, cross-linked acrylic resin, and polymethyl methacrylate denture teeth.[2] Phunthikaphadr et al analyzed the role of modulus of elasticity of denture teeth materials on the pressure transmission under denture base.[6] The results showed that porcelain denture teeth which have a higher modulus of elasticity, transmitted greater pressure compared to acrylic denture teeth.[5,6,16] Denture teeth with a lower modulus of elasticity can flex and absorb impact force and reduce pressure on the underlying structures.[6,16,17]

The selection of denture teeth cuspal angulations also affects the magnitude of forces that were transmitted and distributed through the denture base to the alveolar ridge.[5,6] Cuspal angulation less than 33º would distribute pressure more vertically than 33º.[6] The direction of force on the non-anatomic denture teeth is more vertical and less horizontal than anatomic denture teeth.[5,6] The present study used 33º cuspal angulations where the force transmission was greater and the pressure received through the denture base will be transmitted vertically and horizontally.[6]

Since the residual ridge has a maximum tolerance limit for the force and pressure that can be accepted, the value of pressure transmission of acrylic and porcelain denture teeth should be taken into consideration by the dentist when choosing denture teeth materials to be used.[2]

The limitations of the present study were that pressure transmissions were evaluated in vitro with only vertical load. The test equipment used could only measure the pressures without seeing its distribution pattern. Therefore, future study which reflects the real clinical situation is recommended.

Conclusions

Within the limitations of the present study, it can be concluded that:

1. Pressure transmission with porcelain denture teeth was significantly higher than acrylic denture teeth ($P<.001$).
2. Acrylic denture teeth still the choice of denture teeth to reduce the pressure under thermoplastic nylon denture base.

Declaration of Interest

The authors report no conflict of interest.

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