

Comparison of Flexural Strength of Acrylic Resin Processed by Conventional Processing and Injection Molding after Using Denture Cleansers

การเปรียบเทียบกำลังดัดขวางของอะคริลิกเรซินที่ขึ้นรูปโดยวิธีกดอัดแบบปกติและวิธีแบบฉีด
ภายหลังการแช่สารทำความสะอาดฟันเทียม

Somchai Pongkornkumpon (สมชัย พงศ์กรกัมพล)* Dr. Chaivut Prunkngarmpun (ดร. ไชยวุฒิ พุกภัยงามพันธ์)**

Dr. Subin Puasiri (ดร. สุบิน พัวศิริ)***

ABSTRACT

The purpose of this study was to compare the flexural strength between heat polymerized acrylic resin by compression technique and IvoBase hybrid with injection technique before immersion, and after immersion with different denture cleansing solutions. Sixty four rectangular samples (64 mm×10 mm×3.3 mm) were prepared and divided into 8 groups; heat and IvoBase before immersion (HB and IB), heat and IvoBase after immersion in tap water (HT and IT), Polident (HP and IP), vinegar 5% concentration diluted with tap water 1:6 (HV and IV). The flexural strength (S) was measured using a 3-point bending test. The independent sample t-test demonstrated that the flexural strength of IvoBase hybrid was significant higher than that of heat polymerized acrylic resin. Furthermore, One-way ANOVA analysis showed that Polident denture cleanser significantly decreased the flexural strength of heat polymerized acrylic resin and IvoBase hybrid after immersion for 180 days use.

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบกำลังดัดขวางระหว่างอะคริลิกเรซินที่ขึ้นรูปโดยวิธีกดอัดแบบปกติและวิธีแบบฉีดก่อนและหลังการแช่สารทำความสะอาด ฟันตัวอย่างรูปสี่เหลี่ยมผืนผ้าขนาด ยาว 64 มิลลิเมตร กว้าง 10 มิลลิเมตร และหนา 3.3 มิลลิเมตร จำนวน 64 ชิ้น ถูกแบ่งออกเป็น 8 กลุ่ม กลุ่มละ 8 ชิ้นดังต่อไปนี้ อะคริลิกเรซินแบบกดอัดและแบบฉีดก่อนแช่สารทำความสะอาด (HB และ IB) อะคริลิกเรซินแบบกดอัดและแบบฉีดภายหลังการแช่ด้วยน้ำประปา (HT และ IT) แช่ด้วยเม็ดฟู โพลีเดนท (HP และ IP) และแช่ด้วยน้ำส้มสายชูความเข้มข้น 5% เจือจางด้วยน้ำประปาในอัตราส่วน 1:6 (HV และ IV) จากนั้นทำการทดสอบกำลังดัดขวางด้วยการทดสอบการคดงอแบบ 3 จุด ผลการศึกษาพบว่า ก่อนแช่สารทำความสะอาด อะคริลิกแบบฉีดมีกำลังดัดขวางสูงกว่าอะคริลิกแบบกดอัดปกติอย่างมีนัยสำคัญทางสถิติ และเมื่อเปรียบเทียบภายหลังการแช่สารทำความสะอาดเป็นเวลา 180 วัน พบว่าเม็ดฟูโพลีเดนทที่มีผลให้กำลังดัดขวางของอะคริลิกแบบกดอัดปกติและแบบฉีดลดลงอย่างมีนัยสำคัญทางสถิติ

Keywords: Acrylic resin, Denture cleansers, Flexural strength

คำสำคัญ: อะคริลิกเรซิน สารทำความสะอาดฟันเทียม กำลังดัดขวาง

* Student, Master of Science Program in Prosthodontics, Faculty of Dentistry, Khon Kaen University

** Lecturer., Department of Prosthodontics, Faculty of Dentistry, Khon Kaen University

*** Assistant Professor, Department of Community Dentistry, Faculty of Dentistry, Khon Kaen University

Introduction

According to the 7th National Oral Health Survey; Thailand 2012, the survey findings showed that the percentage of partial tooth loss and total tooth loss in the age group of 65-74 years was 88.3% and 7.2 % respectively. The tooth loss has continuously increased depending on aging. The survey also found that 32.2% of the elder in the group of 80-89 has total tooth loss (Bureau of Dental Health in Department of Health, 2012), thus their pronunciation, taste, chewing, facial esthetics, social interaction, general health, and the quality of life is deteriorated. Therefore, those patients need to wear dentures to compensate those unpleasant conditions (Zarb et al., 2004).

The most common denture base material is polymethyl methacrylate (PMMA) due to its advantages including excellent esthetic properties, adequate strength, low water sorption, low solubility, lack of toxicity, facility of repair, and construction by simple molding and processing technique (Vojdani et al., 2015). However, the patients wearing dentures mostly are the elders who have the limitation of cleaning dentures. In the previous study showed that most denture patients have poor oral hygiene, poor denture cleanliness and wear denture at night. It can lead to denture-related stomatitis (Takamiya et al., 2011). Denture stomatitis is a common disorder affecting denture wearers. Main etiology of the disease is microbial (Figueiral et al., 2007; Gendreau et al., 2011).

A proper routine denture cleaning is necessary for preventing the denture stomatitis and maintaining the periodontal tissues integrity. There are two main approaches for removing microbial plaque and debris from dentures, which are mechanical and chemical method, or through a combination of these (Lee et al., 2011). Mechanical methods are the most effective procedures for removing biofilm from denture's surfaces. Chemical methods are usually used in association with mechanical methods. Their efficiency in removing stains and reducing biofilm formation on the surface irregularities of dentures has been reported. Combination of both mechanical and chemical method accomplished the best results for denture cleaning (Peracini et al., 2010). Denture cleansers provide adequate denture plaque control, reduce biofilm formation, prevent halitosis, remove discoloring, eliminate *Candida albicans* and other microorganisms and prevent denture-induced stomatitis (Pinto et al., 2008).

A variety of chemical denture cleansing products are commercially available. The immersion-type denture cleansers are commonly used in the form of tablets because of its feasibility in application (Jafari et al., 2012). Nevertheless, Denture cleansers was not used by the patient due to insufficient information provided to the patient, high cost, restricted market access, and patients prefer using products on shelf in the house which are easily available and inexpensive for cleaning dentures. A commonly available household product is vinegar, which is a liquid consisting of about 5-20% acetic acid, water, and other trace chemicals. This solution is cheap, easily available in the market, and seems to have antimicrobial potential. There are studies which support the antimicrobial effects of vinegar. Basson et al. (1992) showed the effectiveness of undiluted vinegar solutions in killing adherent microorganisms when used as disinfection agent for denture cleansing. In vitro experiments have already shown that low fungicidal doses of acetic acid induce programmed cell death in *Candida albicans* (Hashizume et al., 2015).

Unfortunately, daily use of denture cleansers can affect the physical and mechanical properties of denture base materials. In-vitro study has been done to evaluate the effect of commercial denture cleansers on physical properties of acrylic resin. Denture base materials can be degraded if the cleaning agents are not used following to the

manufacturers' instructions (Sato et al., 2005). It is clinically importance to determine whether denture cleansers alter the properties of acrylic resins. Immersion in denture cleansers and disinfecting solutions may decrease the flexural strength of acrylic resins. Therefore, avoidance the adverse effects on the properties of denture base resins, disinfectant that is compatible with the type of the material should be chosen with the type of material to be disinfected (Peracini et al., 2010).

Compression molding with heat activation in a water bath for resin polymerization is the conventional method which has been widely used for fabrication of denture bases. However, shrinkage and dimensional changes of denture bases during resin polymerization are inevitable and have been documented. Attempts to overcome the problems associated with processing of denture base acrylic resins have resulted in the development of the continuous injection system by Pryor in 1942. Recently, a new developed PMMA resins (IvoBase Hybrid) has been introduced with a new injection device (IvoBase Injector, Ivoclar Vivadent, Schaan, Liechtenstein). The advantages of this system are its simplicity and the quality of the resulting dentures, supply in predosed capsules that limit direct skin contact, shorter polymerization time (Cagino et al., 2015).

However, the previous studies have not evaluated the comparison of flexural strength between heat-polymerized acrylic resin and IvoBase Hybrid system after immerse in chemical denture cleansers. Therefore, this study evaluated the effect of chemical denture cleansers on physical properties of denture base material after immersion.

Objective of the study

The purpose of this study was to compare the flexural strength of heat-polymerized acrylic resin and IvoBase Hybrid system between before and after immersion in the chemical denture cleansers.

Materials and methods

1. Specimen fabrication

Rectangular metal molds, size $64 \times 10 \times 3.3$ mm. (International Organization for Standardization [ISO] 20795-1, 2008) (Fig 1) were invested with dental plaster of Paris into the lower half flasks in both conventional compression and injection molding techniques (Fig 2). Then, metal lids were closed off on metal molds before the upper half of dental flask was placed in position and then the dental plaster of Paris was poured.(Figure 3) After it was completely set, the upper and lower flask were separated. There had a room space inside the metal molds to fabricate the acrylic resin specimens for flexural strength testing.

For heat-polymerized acrylic resins, it was mixed powder and monomer liquid according to the manufacturer's instructions. After the resin reached the dough stage, it was adapted onto the lower flask. Then, the upper flask was placed in position, closed slowly in a bench compress to permit the flow of acrylic resin. The flask was opened and the excess resin flash was cut off. Continue trial packing was done until no more flash is apparent on opening the flask. Then, acrylic resin was cured in water at 74°C for 8 hours and left to cool to room temperature before deflasking.

For IvoBase system, the monomer and polymer were mixed in the capsule to a homogeneous mixture using the spatula for approximately 20-30 seconds according to the manufacturer's instructions. The capsule was immediately slide into the center with the light upward pressure until the capsule was locked in place with the funnel. Then, the flask with the capsule was inserted into the polymerization chamber of injector. The IvoBase hybrid program and the "RMR" (Residual Monomer Reduction) function were selected. This program had polymerization time of 45 minutes. When the program finished, the hot flask was removed from the injector. The flask was cool under running water for 15 minutes, and deflasking was performed.

After that, the specimens of both heat-polymerized acrylic resins and IvoBase hybrid were trimmed with a carbide bur and polished with 320, 500, 1000 and 1200-grit sandpaper. (Figure 4) Inclusion criteria was specimens that did not have porosity on their entire surface and had a rectangular prism shape, 64 x 10 x 3.3 mm in size thoroughly with an accuracy of ± 0.01 mm when measured by digital vernier caliper. The deviation between the three measurements along the long axis must no more than ± 0.02 mm. The specimens were flat and even height. The specimens were kept in distilled water at 37°C for 2 days before testing following the criteria of ISO 2008.

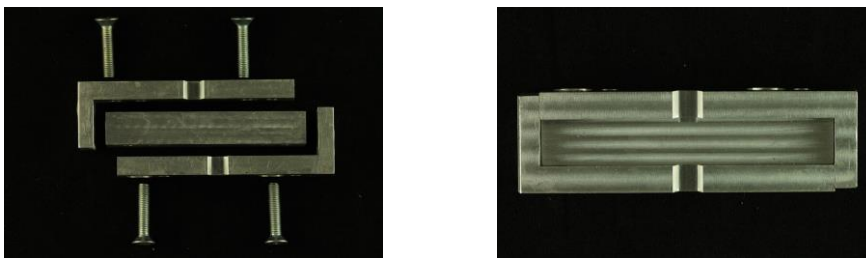


Figure 1 Rectangular metal mold for specimen fabrication of flexural strength testing



Figure 2 Flasking for heat polymerized acrylic resin with compression molding technique A. Lower half flask
B. Upper half flask

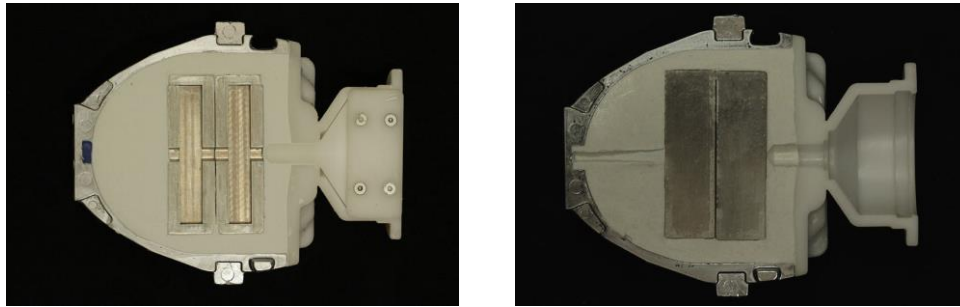


Figure 3 Flasking for IvoBase hybrid with injection molding technique A. Lower half flask B. Upper half flask



Figure 4 Finished specimen A. Heat compression technique, B. Injection molding technique

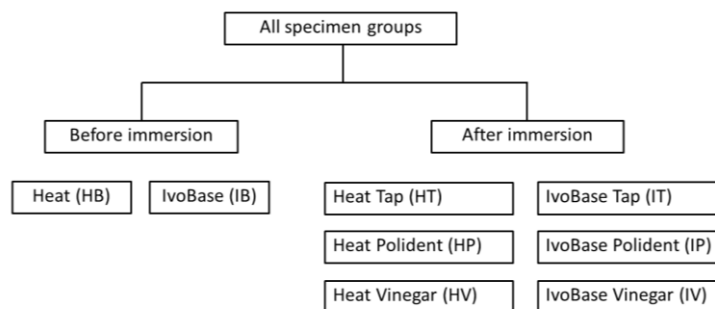
2. Denture cleansers immersion

Thirty-two specimens of heat polymerized acrylic resin and thirty-two specimens of IvoBase were randomly divided into 8 groups (n = 8). One group of each type of acrylic resin was served as control group, it was tested the flexural strength before immersed in denture cleanser. The other three groups of each type were immersed in tap water, Polident[®], or vinegar:

- Tap water 200 ml
- Polident[®] Fresh Active Cleanser 1 tablet was mixed with tap water 200 ml (according to the manufacturer's instructions)
- Vinegar (5% in concentration) was diluted with tap water at vinegar to tap water ratio of 1:6. So,

vinegar 28.6 ml was mixed with tap water 171.4 ml to get 200 ml of vinegar solution.

Specimens were divided according to diagram below;



In each group, the 8 specimens were immersed simultaneously in the same container which filled with their respective denture cleansing material. All groups were immersed in denture cleanser for 5 minutes and then rinsed with water running for 1 minute. The denture cleansing materials were changed every immersion cycle. One cycle of this method was assumed as 1 day of cleansing by the patient. The procedure of immersion was repeated for 180 cycles continuously. Therefore, it was supposed that the specimens were immersed for 180 days.

3. Flexural strength test

The flexural strength of the specimens were measured by using a three-point bending test in a universal testing machine (Llyod®, LR 30k, Leicester, England) with a 50 kilogram-force load cell at a crosshead speed of 5 mm/min (ISO 20795-1, 2008). A maximum load that makes the specimen breakout was recorded. The flexural strength of each rectangular specimen was calculated from the following equation:

$$S = \frac{3PL}{2bd^2}$$

In which: P is the maximum load

L is the distance between the supports (64 mm)

b is the specimen width (10 mm)

d is the specimen thickness (3.3 mm)

Note: Mean flexural strengths were calculated in MPa (megapascals).

Results

1. Comparison of flexural strength between heat polymerized acrylic resin with compression technique and IvoBase Hybrid with injection technique before denture immersion

The IvoBase hybrid system (106.986±2.630 MPa) had higher flexural strength than the heat polymerized acrylic resin (103.676±1.902 MPa) (Figure 5). Independent-sample t-test indicated that flexural strength of IvoBase hybrid system was significant higher than that of heat polymerized acrylic resin (p<0.05) regardless of denture cleanser immersion.

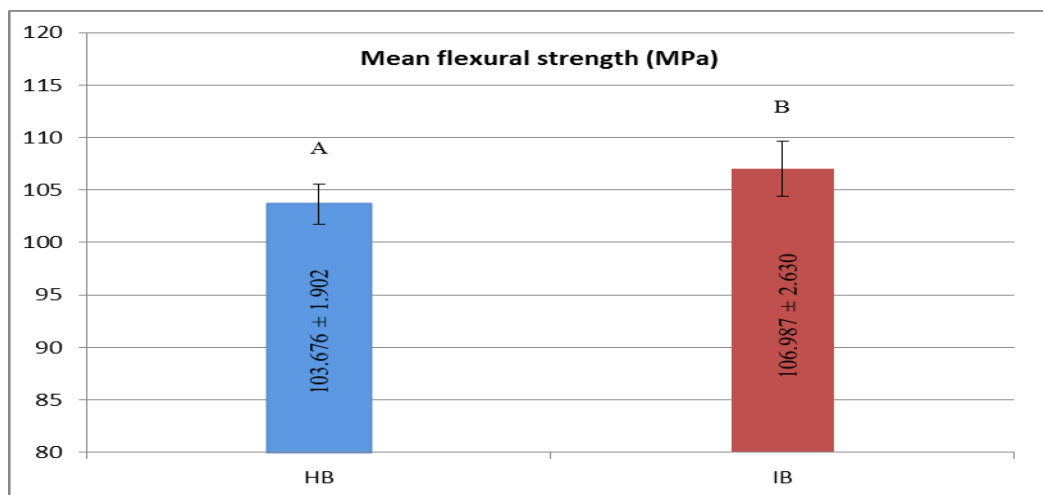


Figure 5 Means and standard deviations of flexural strength of heat polymerized acrylic and IvoBase Hybrid before denture immersion. Values with different letters are significantly different. ($\alpha=0.05$)

2. Flexural strength of heat polymerized acrylic resin with compression technique before and after denture immersion in 180 days used

The heat polymerized acrylic resin immersed with Polident (HP) had the lowest flexural strength (98.674 ± 2.217 MPa) following by HT (101.846 ± 2.957 MPa), HV (102.649 ± 1.935 MPa) and HB (103.676 ± 1.902 MPa). The Polident group was significantly lower the flexural strength than those other groups (Fig 6).

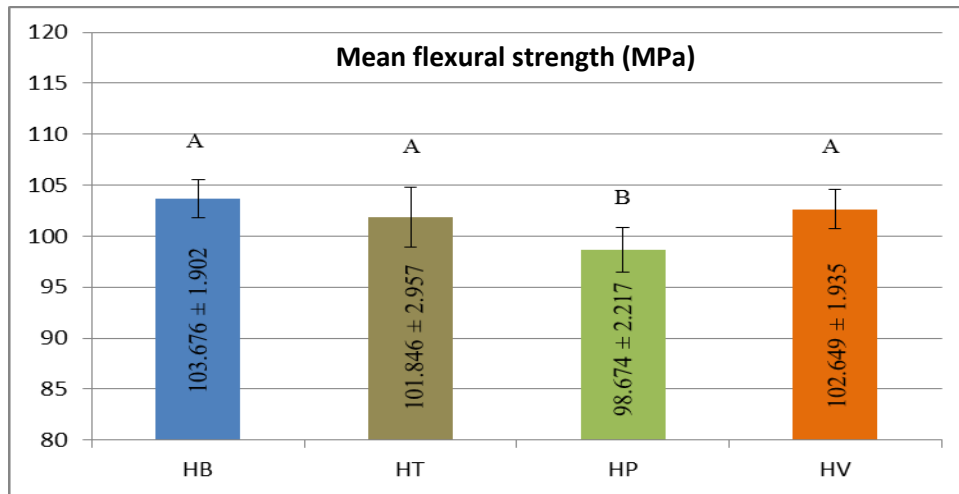


Figure 6 Means and standard deviations of flexural strength of heat polymerized acrylic resin groups before and after immersion. Values with different letters are significantly different. ($\alpha=0.05$)

3. Flexural strength of IvoBase hybrid with injection technique before and after denture immersion in 180 days used

The IvoBase hybrid immersed with Polident (IP) had the lowest flexural strength (101.052 ± 3.935 MPa) following by IT (105.921 ± 3.950 MPa), IV (106.374 ± 2.393 MPa) and IB (106.987 ± 2.630 MPa). The Polident group was significantly lower the flexural strength than those other groups (Fig 7).

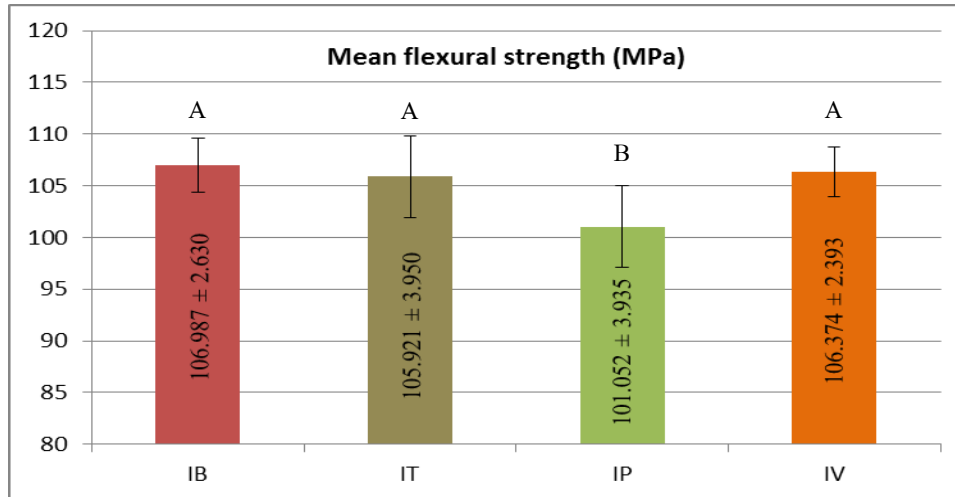


Figure 7 Means and standard deviations of flexural strength of the IvoBase hybrid groups before and after immersion. Values with different letters are significantly different. ($\alpha=0.05$)

Discussion

In this experimental study, the flexural strength of heat polymerized acrylic resin by compression molding technique and IvoBase hybrid with injection molding technique were compared, as well as the effect of denture cleansers immersion on the flexural strength of heat polymerized acrylic resin and IvoBase hybrid were determined.

Based on the results of this study, the null hypotheses were rejected due to statistical analysis showed significant difference in flexural strength of heat polymerized acrylic resin and IvoBase hybrid before immersion. In addition, there were significant difference on the flexural strength of both heat polymerized acrylic resin and IvoBase hybrid after immersing in Polident denture cleanser.

Conventional compression technique has been widely used and considered to be a gold standard for denture fabrication due to simplicity and precision. However, injection molding has been interesting for researchers due to continuous pressure is maintained to compensate for polymerization shrinkage during processing by injector (Yunus et al., 2005). For the result of this study, regardless of denture immersion found that the flexural strength of IvoBase hybrid with injection molding technique was significantly higher than that of heat polymerized acrylic resin with compression method. Similarly, previous studies demonstrated that the flexural strength of injection molding technique was higher than that of the conventional method. (Gharechahi et al., 2014; Ganzarolli et al., 2007; Hamanaka et al., 2011)

About polymerization process, the amount of residual monomer has close relationship with the polymerization condition and also the mechanical properties. Residual monomer can decrease flexural strength of denture bases due to its plasticizing properties (Jagger et al., 1978; Barbosa et al., 2007). To diminish the amount of residual monomer, the IvoBase system has an optional reduction of monomer residue (RMR) function that was selected in this study. Thereby, only 0.7% monomer residue is contained in the IvoBase resin which less than that in the conventional technique (Cagino et al., 2015). It results in polymerization of IvoBase is also more completed.

Therefore, the higher flexural strength of the injection molding technique might be attributed to less residual monomer and more complete polymerization.

Denture cleansers are widely used clinically as an effective method for preventing and removing denture plaque formation. However, it has been indicated that the continued use in long term and incorrect using according to the manufacturers' instructions may result in the deterioration of the denture base material (Sato et al., 2005). From the results of this study, the Polident denture cleanser decreased the flexural strength of both heat polymerized acrylic resin and IvoBase hybrid in comparison with diluted vinegar, tap water and even before immersion as a control. Polident is an alkaline peroxide type of denture cleanser. Peroxide-type denture cleansers include an effervescent component such as sodium perborate or sodium bicarbonate. When dissolved in water, sodium perborate decomposes to form an alkaline peroxide solution. This peroxide solution subsequently releases oxygen and loosens debris via mechanical means. Therefore, the use of these denture cleansers may cause hydrolysis and decomposition of the polymerized acrylic resin itself (Saraç et al., 2007). This result was similar with an in vitro study by Shah et al. (2016) who reported a reduction in flexural strength of acrylic resins when immersed to Clinsodent, Polident and Valclean denture cleanser. Furthermore, Ranher et al. (2016) demonstrated that Clinsodent, VI-clean and Clanden denture cleansers decreased the flexural strength of heat polymerized acrylic resins that endured soaking cycles which simulated 180 days of use. Similar finding was demonstrated in a study performed by Peracini et al. (2010), Robinson et al. (1987) and Arab et al. (1988) which also showed a reduction in flexural strength of acrylic resins when immersed to peroxides and hypochlorite solution.

Vinegar is regular household product which is available, inexpensive and has low toxicity as well. Basson et al. (1992) showed the effectiveness of undiluted vinegar solutions in killing adherent microorganisms when used as disinfection agent for denture cleansing. Furthermore, Yodsuwan et al. (2009) stated that vinegar concentrated 5% solution diluted with tap water 1:6 can effect to decrease the colonies of *Candida albicans* significantly in acrylic resin after soak for 1 minute.

In this study, diluted vinegar did not alter flexural strength ($p < 0.05$). This agrees with previous study which revealed that 100% vinegar did not reduced the flexural strength of acrylic resin after immersion for three months (Sharma et al., 2017).

However, at the application level, diluted vinegar should be evaluated the other effect on the acrylic resin such as dimensional stability, color change, surface roughness.

Conclusion

Within the limitations of the study, the following conclusions were drawn

- With regarding to the material and technique on flexural strength of denture base resin fabrication, the IvoBase hybrid with injection molding technique shown higher flexural strength than the heat polymerized acrylic resin with conventional compression technique.

- The Polident denture cleanser significantly decrease the flexural strength of both heat polymerized acrylic resin and IvoBase hybrid after immersion in 180 days use. Therefore, it should be used with caution when used for longer duration.

- Vinegar concentrated 5% solution diluted with tap water 1:6 can be used as a routine chemical cleansing agent for long term use which does not affect to flexural strength of acrylic resin.

Acknowledgement

This study was financially supported by Faculty of Dentistry, Khon Kaen University, Thailand.

References

- Arab J, Newton JP, Lloyd CH. The importance of water temperature in denture cleaning procedures. *J Dent* 1988; 16: 277-81.
- Barbosa DB, de Souza RF, Pero AC, Marra J, Compagnoni MA. Flexural strength of acrylic resins polymerized by different cycles. *J Appl Oral Sci* 2007; 15: 424-8.
- Basson NJ, Quick AN, Thomas CJ. Household products as sanitizing agents in denture cleansing. *J Dent Assoc S Afr* 1992; 47(10): 437-439.
- Bureau of Dental Health in Department of Health. The 7th National Oral Health Survey; Thailand 2012. 16-17.
- Cagino CG. Evaluation of IVOBASE[®] Automatic injector denture processing system residual monomer reduction function 2015 Master of Science in oral sciences. ProQuest LLC: University at Buffalo, State University of New York; 2015.
- Figueiral MH, Azul A, Pinto E, Fonseca PA, Branco FM, Scully C. Denture-related stomatitis: identification of aetiological and predisposing factors - a large cohort. *J Oral Rehabil* 2007; 34(6): 448-55.
- Ganzarolli SM, de Mello JA, Shinkai RS, Del Bel Cury AA. Internal adaptation and some physical properties of methacrylate-based denture base resins polymerized by different techniques. *J Biomed Mater Res B Appl Biomater* 2007; 82: 169-73.
- Gendreau L, Loewy ZG. Epidemiology and Etiology of Denture Stomatitis. *J Prosthodont* 2011; 20(4): 251-60.
- Gharechahi J, Asadzadeh N, Shahabian F, Gharechahi M. Dimensional Changes of Acrylic Resin Denture Bases: Conventional Versus Injection-Molding Technique. *J Dent (Tehran)* 2014 Jul; 11(4): 398-405.
- Hamanaka I, Takahashi Y, Shimizu H. Mechanical properties of injection-molded thermoplastic denture base resins. *Acta Odontol Scand* 2011; 69: 75-9
- Hashizume LN, Hoscharuk MF, Moreira MJS. Effect of affordable disinfectant solutions on *Candida albicans* adhered to acrylic resin for dental prosthesis. *Rev Gaúch Odontol* 2015; 63(3): 309-14.
- International Organization for Standardization ISO 20795-1:20008. Dentistry: denture base polymer. Geneva, Switzerland: 2008.
- Jafari AA, Falah-Tafti A, Lotfi-Kamran MH, Zahraei A, Kazemi A. Vinegar as a Removing Agent of *Candida albicans* From Acrylic Resin Plates. *Jundishapur J Microb* 2012; 5(2): 388-92.

- Jagger RG. Effect of the curing cycle on some properties of a polymethylmethacrylate denture base material. *J Oral Rehabil* 1978; 5: 151-7.
- Lee HE, Li CY, Chang HW, Yang YH, Wu JH. Effects of different denture cleaning methods to remove *Candida albicans* from acrylic resin denture based material. *J Dent Sci* 2011; 6(4): 216-20.
- Peracini A, Davi LR, de Queiroz Ribeiro N, de Souza RF, Lovato da Silva CH, de Freitas Oliveira Paranhos H. Effect of denture cleansers on physical properties of heat-polymerized acrylic resin. *J Prosthodont Res* 2010; 54(2): 78-83.
- Pinto TMS, Neves ACC, Leao MVP, Jorge AOC. Vinegar as an Antimicrobial Agent for Control of *Candida Spp.* In Complete Denture Wearers. *J Appl Oral Sci* 2008; 16(6): 385-90.
- Pryor WJ. Injection molding of plastics for dentures. *J Am Dent Assoc* 1942; 29: 1400-8.
- Ragher M, Vinayakumar G, Patil S, Chatterjee A, Mallikarjuna DM, Dandekeri S, Swetha V, Pradeep MR. Variations in Flexural Strength of Heat-polymerized Acrylic Resin after the Usage of Denture Cleansers. *The Journal of Contemporary Dental Practice* 2016; 17(4): 322-326.
- Robinson JG, McCabe JF, Storer R. Denture bases: The effects of various treatments on clarity, strength and structure. *J Dent* 1987; 15: 159-65.
- Saraç D, Saraç YS, Kurt M, Yüzbaşıoğlu E. The effectiveness of denture cleansers on soft denture liners colored by food colorant solutions. *J Prosthodont* 2007; 16: 185-91.
- Sato S, Cavalcante MR, Orsi IA, Paranhos HdeFO, Zaniquelli O. Assessment of flexural strength and color alteration of heat-polymerized acrylic resins after simulated use of denture cleansers. *Braz Dent J* 2005; 16(2): 124-8.
- Shah VR, Shah DN, Chauhan CJ, Doshi PJ, Kumar A. Evaluation of flexural strength and color stability of different denture base materials including flexible material after using different denture cleansers. *The Journal of Indian Prosthodontic Society* 2015; 15(4): 367-73.
- Sharma P, Garg S, Kalra NM. Effect of Denture Cleansers on Surface Roughness and Flexural Strength of Heat Cure Denture Base Resin-An In vitro Study. *J Clin Diagn Res* 2017; 11(8): ZC94-ZC97.
- Takamiya AS, Monteiro DR, Barao VAR, Pero AC, Compagnoni M.A., Barbosa D.B. Complete denture hygiene and nocturnal wearing habits among patients attending the Prosthodontic Department in a Dental University in Brazil. *Gerodontology* 2011; 28(2): 91-6.
- Vojdani M, Giti R. Polyamide as a Denture Base Material. A Literature Review *J Dent (Shiraz)* 2015; 16(1): 1-9.
- Yodsuan D. Effect of dilution of 5% vinegar on *Candida albicans*. *Khon Kaen University Dental Journal* 2009; 12(1): 23-32.
- Yunus N, Rashid AA, Azmi LL, Abu-Hassan MI. Some flexural properties of a nylon denture base polymer. *J Oral Rehabil* 2005; 32: 65-71.
- Zarb GA, Bolender CL, Eckert SE. *Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prosthesis*. 12th edn. St Louis: Mosby 2004: 6-23.