

The Penetrating Ability of Elastomeric Impression Materials in Simulated Model with Different Sulcular Widths

Manopphun S¹ Uasuwat P² Hovichitr W² Sosakul T² Arwathanakan S^{2*}

Research Article

Abstract

Vinylpolyethersiloxane (VPES) has been developed by combining features of polyether (PE) and polyvinylsiloxane (PVS). Therefore, the study regarding to penetrating ability of this new material in clinically simulated model is scarcely. The purpose of this laboratory study was to evaluate and compare the penetrating ability of VPES, Soft PE, Hydrophilic and Hydrophobic PVS in three different sulcular widths. One hundred forty-four impressions were made from simulated model of sulcular width 0.1, 0.2 and 0.4 mm with four elastomeric impression materials using double-mixed single impression technique. Each impression was sectioned longitudinally then determined the penetrating depth of each specimen by measuring microscope starting from finish line. The data obtained were analyzed by descriptive statistics and two-way ANOVA. There was a statistically significant interaction between the effects of sulcus widths and material types on penetrating ability. VPES and soft PE groups had been shown statistically significant greater penetration than that of PVS groups. While there were no differences between VPES group and soft PE group when sulcus wide 0.4 and 0.2 mm. However, at sulcular width 0.1 mm, VPES was significantly higher penetrating depth than other materials. In conclusions, the penetrating ability of impression materials in wide sulcus was greater than narrow sulcus. VPES had been revealed superior sulcus reproduction in all sulcular widths.

Keywords: Penetration/ Sulcular width/ Impression material/ Vinylpolyethersiloxane

Received: Dec 13, 2023

Revised: May 03, 2024

Accepted: May 07, 2024

Introduction

Fixed restoration of teeth that have extensive loss of cervical tooth structure such as in cases of root caries, cervical abrasion, existing subgingival margins of restorations, short abutment tooth and esthetics improvement in the anterior region are often indicated to place subgingival margin.¹ Margins of restoration or finish line of prepared tooth are one of the most important and may be considered the weakest points in the success of restoration. More often, it is unavoidable to restore the teeth with subgingival margin, even though subgingival placement of these margins may be harmful to periodontal health. Prevalence of subgingival finish lines can be found up to 80% especially in the distal surface of endodontically treated molar.² Impression taking of the subgingival margin is considered a clinical challenge because of the difficulty to access and inadequate moisture control from oral fluid.

In order to access preparation margin placed subgingivally, gingival retraction is required. Gingival retraction provides to control of gingival crevicular fluid and also keeps tooth surface dry which is an important consideration for hydrophobic materials.³ Among gingival retraction techniques, the use of impregnated retraction cord is the most popular method.⁴ Although cords packing into gingival sulcus may cause minor trauma to sulcular epithelium and time consuming, wider sulcus has been provided by this method than the others.^{5,6} After removal of the cords from gingival sulcus, the displacement space changes from 0.3-0.4 mm to 0.2 mm within 40 seconds.⁷ This 0.2 mm space is the smallest crevicular width enabling consistent accuracy and defect-free impression. If sulcular width is smaller than this, the impression margin will be thin and may be predisposed to tearing or distortion on removal.⁸

¹ Dental Department, Nakhon Phanom Hospital, Amphur Muang, Nakhon Phanom.

² Department of Prosthodontics, Faculty of Dentistry, Khon Kaen University, Amphur Muang, Khon Kaen.

* Corresponding Author.

The narrow sulcus width from insufficient retraction technique or delayed taking impression after cord removal was clinically found. Especially in transition line angle and interproximal areas, the sulcus width was rapidly closed because there are thicker gingiva and richer in collagen fibers. Moreover, the groups of collagen fiber bundles; intergingival fibers, transgingival fibers, trans-septal fibers including semicircular fibers have an important relevance on the sulcus closure pattern.^{9,10}

Impression materials should have a low-viscosity to flow into the sulcus and capable to arrest the good detail of finish line. Polyvinyl siloxane (PVS) and polyether (PE) are now preferred materials due to their characteristics. PVS has a very high dimensional constancy over time because it does not release any by-product and has the best elastic behavior. However, the disadvantages of PVS are hydrophobic nature.¹¹ The new formula of PVS has been added nonionic surfactant to improve wettability, reduce contact angles and also pour stone cast without incorporating voids.¹² PE is hydrophilic in nature and can reproduce precise impression in the case of presence some saliva or blood because of low wetting angle. Nevertheless, this material may be likely to absorb moisture which resulting in dimensional change. Moreover, once the material has set, it becomes the most rigid impression material. Therefore, soft PE; a new generation of PE tries to improve these drawbacks by decreasing filler content and increasing plasticizers. However, the less rigidity improvement makes it difficult to control directional flow. Additionally, the soft PE has also been reported easier to stretch and higher deformation under pressure than former generation.¹³ To combine the advantageous features of PVS and PE, a new material so-called vinyl polyether siloxane (VPES) has been developed. To form VPES, the chemical compounds of PE polymer and vinyl groups of PVS are combined by organohydrogen polysiloxane via platinum catalyst.¹⁴ This material possesses better mechanical properties along with excellent flowability under pressure. The improved flowability makes it has greater competency to record finer detail of impression made on humid area of gingival sulcus.¹⁵ Nonetheless, the current literature determining the penetrating ability of this new material into subgingival narrow sulcus area is scarcely.¹⁶ Therefore, the aim of this study is to

examine the penetrating ability of PE, PVS and VPES using the single stage double-mixed impression technique made on a tooth and sulcus model simulating clinical condition with various sulcular widths.

The null hypothesis of this study was there would be no significant difference in penetrating ability among four impression materials and three sulcular widths.

Materials and Methods

This study is an experimental study to investigate penetration ability of different elastomeric impression materials into circumferential 2 mm deep gingival sulcus with three varying sulcular widths. The distance of sulcular extension of these impressions were determined by measuring microscope starting from finish line level of the impression as a reference point. The data obtained is analyzed by using two-way ANOVA.

The model used in this study was designed by software PLM NX version 11.0 and fabricated by computed numerical control technique via milling machine (Mikron model VCE 750, Germany). After the steel dummy rod and steel ring were placed in position on a shoulder of the base tool. The space occurred was filled up with reversible hydrocolloid solution served as artificial gingiva (Figure 1a) by mixing 7 g of reversible hydrocolloid powder (Vidhyasom, Thailand) with 10 ml of deionized water. The hydrocolloid solution was heated to liquid state by hotplate stirrer at 65°C then filled in the space within the steel ring. Three long steel rods were machined at one end with chamfer finish line 1 mm width, 10 mm height and 10° angle of convergence to simulate the prepared tooth. The finish line was placed 1 mm apical to the top surface of artificial gingiva thus defining as subgingival finish line. These steel rods served as metal abutment differed in their diameter at finish line level 7.6 mm, 8.0 mm and 8.2 mm so that generating 3 varying sulcular widths 0.4, 0.2 and 0.1 mm respectively. Each of metal abutment was delineated with 4 equal distance lines representing the reference points. The impressions were taken by double mixed-single impression technique using a cylindrical perforated impression tray with 19.6 N force (Figure 1b). The impression materials used in this study are listed in Table 1.

Double-mixed single impression technique was used for all four materials in the details as figure 2. After setting, the impression was removed from metal abutment with a quick jerk, rinsed the impression with running tap water. Then, the impression was air-dried and sprayed with 2.5% glutaraldehyde disinfectant which is no significant impact on the accuracy of the impression by this disinfectant method.¹⁷ The disinfected impression was stored at laboratory atmosphere for minimum 30 min prior to determine penetrating ability. Before another impression were done, the newly mixed reverse hydrocolloid solution (artificial gingiva) was prepared and replaced. The

twelve impressions were provided form each impression material. Thus, a total of 144 impressions were taken to investigate the penetrating ability. The impression was sectioned in occluso-gingival direction at the marking points using a thin blade to generate 4 pieces of each specimen. The penetrating ability into the simulated sulcus was determined by measuring microscope (Nikon® measurescope 20, Tokyo, Japan) with linear resolution 1 μm , a 30x magnification. Then, the mean penetrating depth of each material analyzed by two-way ANOVA in two parameters (sulcus widths and impression materials).

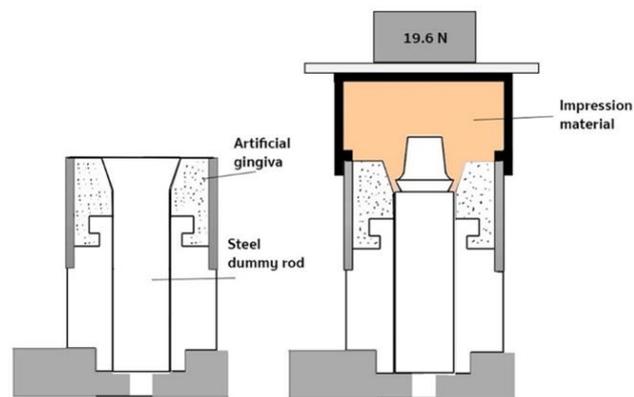


Figure 1 Schematic diagram of simulated model (A) longitudinal section through steel device for production of artificial gingiva tissue and (B) longitudinal section through impression of metal abutment

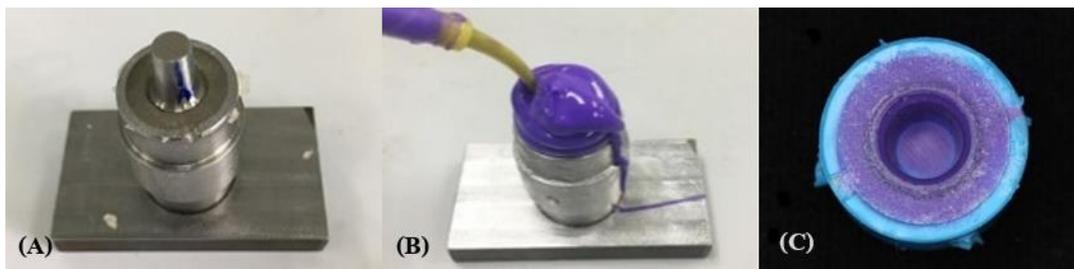


Figure 2 Impression taking procedure (A) Metal abutment was placed in artificial gingiva forming sulcular width (B) Injection of light body material around metal abutment and finish line within 60 s (C) Removed impression from abutment model after 10 min wait

Table 1 The materials used in this study

Brand	Type	Viscosity ISO 4823	Batch	Manufacturer
Identium®	VPES	Heavy Light	190941052 180221	Kettenbach GmgH, Germany
Hydrorise	Hydrophilic PVS	Heavy Light	307044 296174	Zhermack S.p.a., Italy
Variotime® dynamix	Hydrophobic PVS	Heavy Light	KA 10271 KA 10110	Kulzer Gmbh, Hanau Germany
Impregum™ Penta™ duosoft	Soft PE	Heavy Light	3770828 5459727	3M ESPE AG, Seefeld, Germany

Results

The result of two-way ANOVA indicated that there was a statistically significant interaction between the effects of impression materials and sulcular widths on penetrating ability ($P < 0.05$) (Table 2). When a cross-product interaction was significant, a one-way ANOVA was conducted separately for each sulcular width.

For sulcular width 0.4 mm, Soft PE group showed the greatest extension followed by VPES group and

hydrophilic PVS group. Whereas hydrophobic PVS group has been revealed the least penetrating depth. For the sulcus 0.2 mm width, VPES group reproduced the depth better than Soft PE group and hydrophilic PVS group while hydrophobic PVS group showed the least depth. For sulcular width 0.1 mm, VPES was significantly higher penetrating depth than other materials (Figure 3).

Table 2 Two-way ANOVA results

Source of variance	Sum of squares	df	Mean square	F	Sig
Type	0.004	3	0.001	40.337	0.000
Width	0.473	2	0.237	7830.078	0.000
Type*width	0.001	6	0.000	7.106	0.000
Residual	0.004	132			
total	163.079	144	3.021E-005		

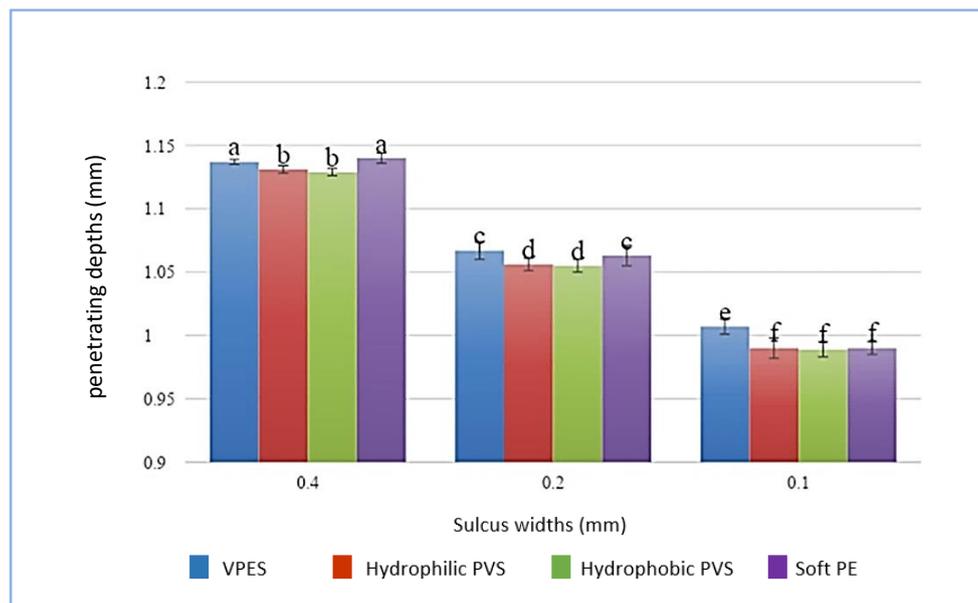


Figure 3 Mean differences and standard deviations in penetrating depth among four impression materials at three sulcus widths. Groups with same superscripted letter indicate no significant differences between impression materials at $P < 0.05$

Discussion

The null hypothesis, there would be no significant difference in penetrating ability among different type of elastomeric impression materials and different sulcular widths, is rejected. Both parameters have an influence on the penetrating ability of impression material. It is apparently that large sulcus (0.2 and 0.4 mm) provides better penetrating depth than narrower sulcular width (0.1 mm). The tearing specimens were belonging to only sulcular width 0.1 mm group according to previous study.⁸ Emergence profile is contour of tooth and restoration in relation to the gingival tissue.¹⁸ To create the suitable emergence profile, impression material should penetrate to unprepared tooth structure below finish line at least 0.5 mm within gingival sulcus.¹⁹ According to our results, all impression materials could penetrate more than 0.5 mm in all sulcular widths.

From the perspective of penetrating ability, it is assumed that the ability of material to reproduce sulcus depth related to its chemical nature, viscosity of mixed material, wettability on oral tissue and strain tolerance.²⁰ Soft PE group showed greater extension than all other materials group at sulcular width 0.4 mm and performed reproduction depth similar as VPES group at critical sulcular width 0.2 mm. A possible explanation for why Soft PE group exhibits the higher depth reproduction could be related to inherent hydrophilicity due to the chemical formula containing carbonyl (C=O) and ether functional group (C-O-C) which attract water into the backbone.²¹ In addition, rheological properties study on flow profile using shark fin test found that PE had a significantly high initial tan delta. The decreased of its tan delta with time is initially relatively smaller when compared with that of PVS.^{22,23} Tan delta is a property that gives the relative ratio of the viscous to the elastic component of a material behavior. A material with high tan delta value will have a long induction period. This period implies that material keep its plasticity to flow longer than other materials.²²

When considering the mean penetrating depth in PVS groups, the hydrophilic PVS group had been shown

greater value than that of hydrophobic PVS group. One explanation is the level of hydrophilicity of materials. Hydrophilic PVS was attributed to incorporation of non-ionic surfactants that change its surface properties. The non-ionic surfactant possesses different functional groups which are silicone-binding group (nonylphenoxy group) and water-binding group (polyethyleneoxy group) dispersible in prepolymer matrix. The surface property of hydrophilic PVS predominantly depends on the surfactant concentration at the silicone impression surface.²⁴ The mechanism of action that surfactant has an effect on impression material surface probably involves diffusion into wetting liquid and then reduces its surface tension. These surfactant molecules also increase surface energy of polymerized impression materials.²⁵ Therefore, the wettability of hydrophilic addition silicone was superior to that of conventional addition silicone.²⁶ In agreement with previous study, hydrophilic PVS was better sulcus-reproducing than hydrophobic PVS especially for the narrow sulcus width.²⁰ Practically, the clinical use of hydrophilic PVS still needs dry field preparation. In reality, this material remains hydrophobicity.

At critical sulcular width (0.2 mm and 0.1 mm), VPES showed the outstanding penetrating depth conflicting result with the previous study of Finger et al.¹⁶ It is speculated that the polyether backbone containing in the chemical formula of VPES would affect the wettability of VPES on moist surface. Another factor that would influence the penetration of VPES is the lowest contact angle with water and saliva. The lowest contact angle of VPES could be derived from its component Tenside I or Surface Tension Eraser Surfactant (STES) and Tenside II or Wetting Conditioner Surfactant (WCS), when the mixed paste exposed to moisture the hydrophilic quality was exhibited by STES hydrophilic heads align with the polar water then STES transits into water phase whereas the WCS accumulates at the material surface and dissolves the surface tension of water.²⁷ This assumption is consistent with the finding of Balkenhol et al.²⁸ and Meenees et al.²⁹ who found that the contact angle of VPES (Identium®) was lower than PE and VPS. Furthermore, the manufacturer claims that VPES material has

an unique “double-snap” effect which referred to the long working time together with short intraoral setting time. This effect arises from the desirable property of parent materials. The double snap effect consists of viscosity snap and networking snap. After being mixed, the VPES will behave similar to polyether in terms of flowability until the viscosity snap occurs. The viscosity snap is viscosity changing from viscous to visco-elastic phase. The visco-elastic phase is the gradual transition to develop elasticity in a short time. Subsequently, the networking snap occurs to reach final elastic consistency. With double snap effect, VPES material allows for a long working time so that maintaining fluidity throughout the process.¹⁴

Although, there were statistically significant differences in penetrating ability among four elastomeric impression materials. These materials were clinically acceptable to use for final impression procedure. The clinical implication of this study may be helpful for the dentists to make a decision in selection the proper material when taking impression of prepared tooth with subgingival finish line in narrow sulcular width such as delayed taking impression after cord removal in multiple preparation teeth for full mouth rehabilitation case. However, the limitation of this study is the simulated testing model has no adjacent teeth resembling in patients' mouth. Besides, the gingival fluid could not be imitated as same as oral condition. Therefore, the further in vivo study should be done to confirm the findings of our study.

Conclusion

1. Both Sulcular widths and material types have an effect on the penetration ability of all impression materials, the penetration ability is greater when sulcus width is wider.
2. Hydrophilic PVS had been evaluated to have higher penetration ability than that of hydrophobic PVS.
3. VPES and Soft PE have been performed greater extension into sulcus than PVS groups at the wide sulcular width. When the sulcus is narrower, VPES had been exhibited greatest sulcus reproduction among all impression materials groups.

References

1. Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 4th ed. St.Louis: Mosby Elsevier; 2006. 217-8.
2. Aimjirakul N. Prevalence of finishing line location of prepared teeth for cast post and cores and types of previous restoration. J Dent Assoc Thai 2009;59(1):22-8.
3. Massari C, Anfe ATE, Caneppele TMF, Agra CM. Gingival retraction: thickness measurement and comparison of different cords. Braz Dent Sci 2015;18(2):50-7.
4. Donovan TE, Gandara BK, Nemetz H. Review and survey of medicaments used with gingival retraction cords. J Prosthet Dent. 1985;53(4):525-31.
5. Prasanna GS, Reddy K, Kumar RK, Shivaprakash S. Evaluation of efficacy of different gingival displacement materials on gingival sulcus width. J Contemp Dent Pract. 2013;14(2):217-21.
6. Raghav D, Singh S, Kola MZ, Shah AH, Khalil HS, Kumar P. A comparative clinical and quantitative evaluation of the efficacy of conventional and recent gingival retraction systems: an *in vitro* study. Eur J Prosthodont. 2014;2(3):76-81.
7. Laufer BZ, Baharav H, Ganor Y, Cardash HS. The effect of marginal thickness on the distortion of different impression materials. J Prosthet Dent. 1996;76(5):466-71.
8. Laufer BZ, Baharav H, Cardash HS. The linear accuracy of impressions and stone dies as affected by the thickness of the impression margin. Int J Prosthodont 1994; 7(3):247-52.
9. Laufer BZ, Baharav H, Langer Y, Cardash HS. The closure of the gingival crevice following gingival retraction for impression making. J Oral Rehabil 1997;24(9):629-35.
10. Page RC, Ammons WF, Schectman LR, Dillingham LA. Collagen fibre bundles of the normal marginal g-ngiva in the marmoset. Arch Oral Biol. 1974;19(11):1039-43.
11. Mandikos MN. Polyvinyl siloxane impression materials: an update on clinical use. Aust Dent J. 1998;43(6):428-34.

12. Hamalian TA, Nasr E, Chidiac JJ. Impression materials in fixed prosthodontics: influence of choice on clinical procedure. *J Prosthodont*. 2011;20(2):153-60.
13. Perakis N, Belser UC, Magne P. Final impressions: a review of material properties and description of a current technique. *Int J Periodontics Restorative Dent* 2004; 24(2):109-17.
14. Shetty RM, Bhandari GR, Mehta D. Vinyl polysiloxane ether: a breakthrough in elastomeric impression material. *World J Dent* 2014;5(2):134-7.
15. Stober T, Johnson GH, Schmitter M. Accuracy of the newly formulated vinyl siloxanether elastomeric impression material. *J Prosthet Dent* 2010;103(4):228-39.
16. Finger WJ, Kurokawa R, Takahashi H, Komatsu M. Sulcus reproduction with elastomeric impression materials: a new *in vitro* testing method. *Dent Mater* 2008;24(12):1655-60.
17. Khatri M, Mantri SS, Deogade SC, Bhasin A, Mantri S, Khatri N, Jain P, Chauhan D. Effect of chemical disinfection on surface detail reproduction and dimensional stability of a new vinyl polyether silicone elastomeric impression material. *Contemp Clin Dent* 2020;11(1):10-14.
18. Goldberg PV, Higginbottom FL, Wilson TG. Periodontal considerations in restorative and implant therapy. *Periodontol* 2000 2001;25:100-9.
19. Madhok S, Rajput G, Singh G. Non-surgical gingival retraction past and current trends. *Guident* 2014; 7(11):26-30.
20. Takahashi H, Finger WJ, Kurokawa R, Furukawa M, Komatsu M. Sulcus depth reproduction with polyvinyl siloxane impression material: effects of hydrophilicity and impression temperature. *Quintessence Int* 2010; 41(3):e43-50.
21. German MJ, Carrick TE, McCabe JF. Surface detail reproduction of elastomeric impression materials related to rheological properties. *Dent Mater* 2008;24(7):951-6.
22. Lawson NC, Cakir D, Ramp L, Burgess JO. Flow profile of regular and fast-setting elastomeric impression materials using a shark fin testing device. *J Esthet Restor Dent* 2011;23(3):171-6.
23. McCabe JF, Arikawa H. Rheological properties of elastomeric impression materials before and during setting. *J Dent Res* 1998;77(11):1874-80.
24. Lee DY, Oh YI, Chung KH, Kim KM, Kim KN. Mechanism study on surface activation of surfactant-modified polyvinylsiloxane impression materials. *J Appl Polym Sci* 2004;92(4):2395-401.
25. Pratten DH, Craig RG. Wettability of a hydrophilic addition silicone impression material. *J Prosthet Dent* 1989;61(2):197-202.
26. Vassilakos N, Fernandes CP. Surface properties of elastomeric impression materials. *J Dent* 1993;21(5): 297-301.
27. Kettenbach. Product guideline Identium: 2018. Available from: <https://www.kettenbach-dental.com/products/impression-material/identium>.
28. Balkenhol M, Eichhorn M, Wostmann B. Contact angles of contemporary type 3 impression materials. *Int J Prosthodont*. 2009 Jul-Aug;22(4):396-8.
29. Menees TS, Radhakrishnan R, Ramp LC, Burgess JO, Lawson NC. Contact angle of unset elastomeric impression materials. *J Prosthet Dent* 2015;114(4):536-42.

Corresponding Author

Sukontip Arwatchanakan

Department of Prosthodontics,

Faculty of Dentistry, Khon Kaen University

Amphur Mueang, Khon Kaen, 40002.

Tel: +66 43 202 405 #45281

Fax: +66 43 202 862

E-mail: sukarw@kku.ac.th

ความสามารถในการไหลแทรกของวัสดุพิมพ์แบบอีลาสโตเมอร์ในแบบจำลองเสมือนจริงที่มีความกว้างร่องเหงือกที่แตกต่างกัน

ศตวรรษ มานพพันธ์¹ พิชิต เอื้อสุวรรณ² วชิรินทร์ หอวิจิตร² ชีรพันธุ์ สอสกุล² สุนทรทิพย์ อวชันการ^{2*}

บทความวิจัย

บทคัดย่อ

ไวเนล โพลีเอเทอร์ ไซลอกเซนเป็นวัสดุชนิดใหม่ที่ถูกพัฒนาขึ้น โดยเป็นการรวมกันของวัสดุพิมพ์แบบโพลีเอเทอร์ และ โพลีไวเนล ไซลอกเซน ดังนั้นข้อมูลเกี่ยวกับการไหลแทรกเมื่อเปรียบเทียบกับวัสดุพิมพ์แบบอีลาสโตเมอร์ชนิดอื่นยังคงมีไม่มากนัก โดยเฉพาะในแบบจำลองการศึกษาที่ใกล้เคียงกับสภาพในช่องปาก การศึกษานี้มีวัตถุประสงค์เพื่อประเมินและเปรียบเทียบความสามารถในการไหลแทรกของวัสดุพิมพ์แบบไวเนล โพลีเอเทอร์ ไซลอกเซน ซอฟท์โพลีเอเทอร์ โพลีไวเนล ไซลอกเซนที่ชอบน้ำ และ โพลีไวเนล ไซลอกเซนที่ไม่ชอบน้ำ ในร่องเหงือกเสมือนจริงที่มีความกว้างแตกต่างกัน 3 ขนาด เตรียมรอยพิมพ์จากแบบจำลองร่องเหงือกเสมือนจริงที่มีความกว้างร่องเหงือก 0.1 0.2 และ 0.4 มิลลิเมตรด้วยวัสดุพิมพ์แบบอีลาสโตเมอร์ 4 ชนิด โดยใช้เทคนิคการพิมพ์วัสดุพิมพ์ชนิดหนึ่งคืบมากและชนิดหนึ่งคืบน้อย 1 ขั้นตอน รอยพิมพ์แต่ละชั้นถูกนำมาตัดแต่งตามแนวตั้งออกเป็น 4 ส่วนแล้วนำไปวัดค่าความลึกการไหลแทรกโดยใช้กล้องจุลทรรศน์วัดระยะชั้นงานแต่ละส่วนเริ่มจากเส้นสิ้นสุดเป็นจุดอ้างอิงในการวัด ข้อมูลถูกนำมาวิเคราะห์ด้วยสถิติเชิงพรรณนาและใช้สถิติการวิเคราะห์ความแปรปรวนแบบสองทาง ผลการศึกษาพบว่าเมื่อพิจารณาความกว้างร่องเหงือกและชนิดของวัสดุพิมพ์ต่อความสามารถในการไหลแทรกของวัสดุพิมพ์อย่างมีนัยสำคัญทางสถิติ ไวเนล โพลีเอเทอร์ ไซลอกเซนและซอฟท์โพลีเอเทอร์แสดงค่าการไหลแทรกที่มากกว่ากลุ่มโพลีไวเนล ไซลอกเซนอย่างมีนัยสำคัญทางสถิติ ขณะที่ไม่มีความแตกต่างระหว่างกลุ่มไวเนล โพลีเอเทอร์ ไซลอกเซนและกลุ่มซอฟท์โพลีเอเทอร์ เมื่อร่องเหงือกมีความกว้าง 0.4 และ 0.2 มิลลิเมตร อย่างไรก็ตาม ที่ความกว้างร่องเหงือก 0.1 มิลลิเมตร ไวเนล โพลีเอเทอร์ ไซลอกเซนมีการไหลแทรกได้ลึกกว่าวัสดุพิมพ์ชนิดอื่นอย่างมีนัยสำคัญ กล่าวโดยสรุปได้ว่า ความสามารถในการไหลแทรกของวัสดุพิมพ์ในร่องเหงือกที่กว้างมีมากกว่าร่องเหงือกที่แคบ ไวเนล โพลีเอเทอร์ ไซลอกเซนเผยให้เห็นว่ามีการลอกเลียนแบบได้ดีในทุกความกว้างของร่องเหงือก

คำใบ้รหัส: การไหลแทรก/ ความกว้างร่องเหงือก/ วัสดุพิมพ์/ ไวเนล โพลีเอเทอร์ ไซลอกเซน

ผู้ประพันธ์บรรณกิจ

สุนทรทิพย์ อวชันการ

สาขาวิชาทันตกรรมประดิษฐ์

คณะทันตแพทยศาสตร์ มหาวิทยาลัยขอนแก่น

อำเภอเมือง จังหวัดขอนแก่น 40002

โทรศัพท์ : 043 202 405 #45281

โทรสาร : 043 202 862

จดหมายอิเล็กทรอนิกส์ : sukarw@kku.ac.th

¹ กลุ่มงานทันตกรรม โรงพยาบาลนครพนม อำเภอเมือง จังหวัดนครพนม

² สาขาวิชาทันตกรรมประดิษฐ์ คณะทันตแพทยศาสตร์ มหาวิทยาลัยขอนแก่น อำเภอเมือง จังหวัดขอนแก่น

* ผู้ประพันธ์บรรณกิจ