ผลของสารหน่วงการแข็งตัวต่อลักษณะการไหลของวัสดุพิมพ์พอลิอีเทอร์

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บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาผลของความยาวที่แตกต่างกันของสารหน่วงความแข็งตัวพอลิอีเทอร์ต่อลักษณะการไหลของวัสดุพิมพ์พอลิอีเทอร์

วัสดุอุปกรณ์และวิธีการ: ทดสอบวัสดุพิมพ์พอลิอีเทอร์ชนิดหนืดปานกลางโดยผสมและไม่ผสมสารหน่วงความแข็งตัวพอลีอีเทอร์ ความยาวของสารหน่วงความแข็งตัวที่แตกต่างกันจาก 0 0.5 1.0 1.5 และ 2 เท่าของความยาวของพอลิอีเทอร์เบสและคะตะลิสต์ กลุ่มละ 20 ชิ้น ด้วยการทดสอบครีบฉลามทุกๆ ช่วง 30 วินาที (30 60 90 และ 120 วินาที) ที่อุณหภูมิห้อง (32 ± 2 °C) รวมรอยพิมพ์ทั้งสิ้น 100 ชิ้น แล้วนำความสูงของครีบไปวิเคราะห์ด้วยสถิติการวิเคราะห์ความแปรปรวนแบบสองทาง และเปรียบเทียบเชิงซ้อนทีละคู่ด้วยสถิติทูกีที่ระดับความเชื่อมั่นร้อยละ 95

ผลการทดลอง: จากการวิเคราะห์ความแปรปรวนสองทาง พบว่ามีความแตกต่างอย่างมีนัยสำคัญของความสูงของครีบในแต่ละความยาวของสารหน่วงความแข็งตัว เวลาในการทดสอบ และพบความสัมพันธ์ระหว่างความยาวของสารหน่วงความแข็งตัวและเวลาในการทดสอบ (P<0.05) ไม่มีความแตกต่างอย่างมีนัยสำคัญระหว่างกลุ่มความยาวของสารหน่วงความแข็งตัวที่ยาวกว่า (1.5 และ 2 เท่า) ที่เวลา 30 วินาที และไม่พบความแตกแตกต่างอย่างมีนัยสำคัญระหว่างกลุ่มความยาวของสารหน่วงความแข็งตัว 0.5 และ 1.0 เท่า ที่เวลา 60 วินาที กลุ่มที่มีสารหน่วงความแข็งตัวที่ยาวที่สุดมีความสูงของครีบมากที่สุดอย่างมีนัยสำคัญที่เวลา 90 วินาที (P<0.05)

สรุปผล: สารหน่วงความแข็งตัวที่ยาวกว่า เวลาการไหลจะนานกว่า ดังนั้นสารหน่วงความแข็งตัวพอลิอีเทอร์สามารถปรับปรุงลักษณะการไหลของวัสดุพิมพ์พอลิอีเทอร์ได้ ในการประยุกต์ใช้ทางคลินิกนั้น สารหน่วงความแข็งตัวพอลิอีเทอร์สามารถนำมาใช้เพื่อยืดเวลาการไหลทำให้มีลักษณะการไหลของวัสดุพิมพ์พอลิอีเทอร์ดีขึ้น

คำสำคัญ: พอลิอีเทอร์ สารหน่วงความแข็งตัว ลักษณะการไหล การทดสอบครีบฉลาม

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Effect of a Retarder on the Flow Characteristics of Polyether

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Abstract

Purpose: To determine the effect of different lengths of a polyether retarder on the flow characteristics of polyether impression materials.

Materials and Methods: Medium-bodied consistency of polyether impression material (ImpregumTM Penta Soft, 3M ESPE, Seefeld, Germany) was investigated with and without polyether retarder (3M ESPE, Seefeld, Germany). The length of the strands of the retarder varied from 0, 0.5, 1.0, 1.5, and 2 times the lengths of the strands of the catalyst/base paste of polyether (n=20 each). All tests were carried out by shark fin test at 30s intervals (30s, 60s, 90s, and 120s) at room temperature (32 ± 2°C). One hundred impressions were made on shark fin model. Fin heights were analysed by Two-way ANOVA and Tukey-Kramer honestly significant difference (HSD) test at the 95% confidence level.

Results: Two-way ANOVA revealed significant differences among the lengths of the retarder, time of measurements, and their interactions ($P<0.05$). There was no significant difference between the longer length of the retarder (1.5 and 2 times groups) at the short working time (30s). At the 60s working time, there was no significant difference between the 0.5 and 1.0 times groups. The longest length of the retarder group showed significantly greatest fin height at the 90s working time ($P<0.05$).

Conclusion: The longer the retarder the lengthener the flowable time. Therefore, polyether retarder can improve the flow characteristics of polyether impression materials. In clinical application, it is suggested that a polyether retarder can be used to prolong the flowable time achieving better flow characteristics of polyether impression materials.

Keywords: Polyether, Retarder, Flow characteristics, Shark fin test

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Introduction

The quality of an impression constitutes one of the most important factors related to restorative success with indirect restorations [1,2]. Impression making is a critical step in the process of fabricating excellent restorations. Impression material used can also shape the reliability, accurate and esthetics of the restoration. The most common impression materials currently used for fixed prosthodontic works are the addition silicones (vinyl polysiloxanes) and polyethers [3].

Vinyl polysiloxanes reproduce fine surface detail and give excellent elastic recovery and dimensional stability [4]. The previous study exhibited their different impression techniques affect the penetration ability especially in narrow sulci [5]. However, they are intrinsically hydrophobic in nature produce voids at the margin of the abutment preparation in the impression and bubbles in master casts [6,7]. While polyethers exhibit superior flow characteristics, hydrophilic properties, and thixotropic behavior [8]. Moreover, previous studies stated that polyethers showed the best penetration ability in a simulated gingival sulcus when compared to other elastomeric impression materials [9,10]. Therefore, polyether is an impression material of interest. However, in a tropical country, it is difficult to handle materials within manufacturer's recommended working time (2 minutes 45 seconds) especially when full arch impressions are made, as the working time is affected by temperature. There are several factors that can influence the required working time for impression taking. These are: the number of preparations, utilization of automix or hand-mix material, and the viscosity of the material. The time required between mixing the impression material, syringing the material around the preparations, and seating in the tray are influenced by these factors. One method for extending the working time is to add retarder in the impression material. Hence, the polyether retarder is a key material in clinical applications when polyether was used.

It is important for dentist in tropical countries to have enough working time when making impression for fabricating successful indirect restorations. However, there is no data about the lengths of polyether retarder used in a tropical country.

A shark fin device was designed to determine the fin height of the impression materials after mixing and can use this to monitor flow of the impression materials during working time and used to compare flow properties of different impression materials [8,11,12].

The objective of this study was to determine the effects of different lengths of polyether retarder on the flow characteristics of polyether impression materials using shark fin test.

Materials and methods

Medium-bodied consistency, hand mixed, regular set of polyether impression material (ImpregumTM Penta Soft) was investigated with and without retarder (3M ESPE, Seefeld, Germany). The length of the strands of the retarder varies from 0, 0.5, 1.0, 1.5, and 2 times the lengths of the strands of the catalyst/base paste of polyether (n=20 each). All tests were carried out at 30s intervals within manufacturer's recommended working time (30s, 60s, 90s, and 120s) at room temperature (32±2°C). One hundred impressions were made. The shark fin measurement procedure involves placing the mixed impression material with or without the retarder in a receptacle and removing the excess material (Fig. 1A). After the upper component was placed on the bottom piece containing the receptacle, the pin was removed. The upper component with 147g weight (a 147g weight reflected the pressure applied during clinical placement in the mouth [8]) was placed over the receptacle. The pin was released allowing the weight to sink slowly into the material (Fig. 1B), which successfully simulates low compression on the impression material when the tray was seated. After waiting for the material to set, the components were separated and the sample trimmed using surgical blade to accurately measure the height (Fig. 1C). The heights of the completed shark fin were determined flow characteristics, with the greatest height meaning the most flowable. The shark fin at its highest point was measured using a caliper to an accuracy of 0.5 mm (Fig. 1D). Measurements were subjected to two-way ANOVA at a significance level of 0.05. Where significant differences in the groups were found, individual means were compared with the Tukey-Kramer honestly significant difference (HSD) test at $P < 0.05$.

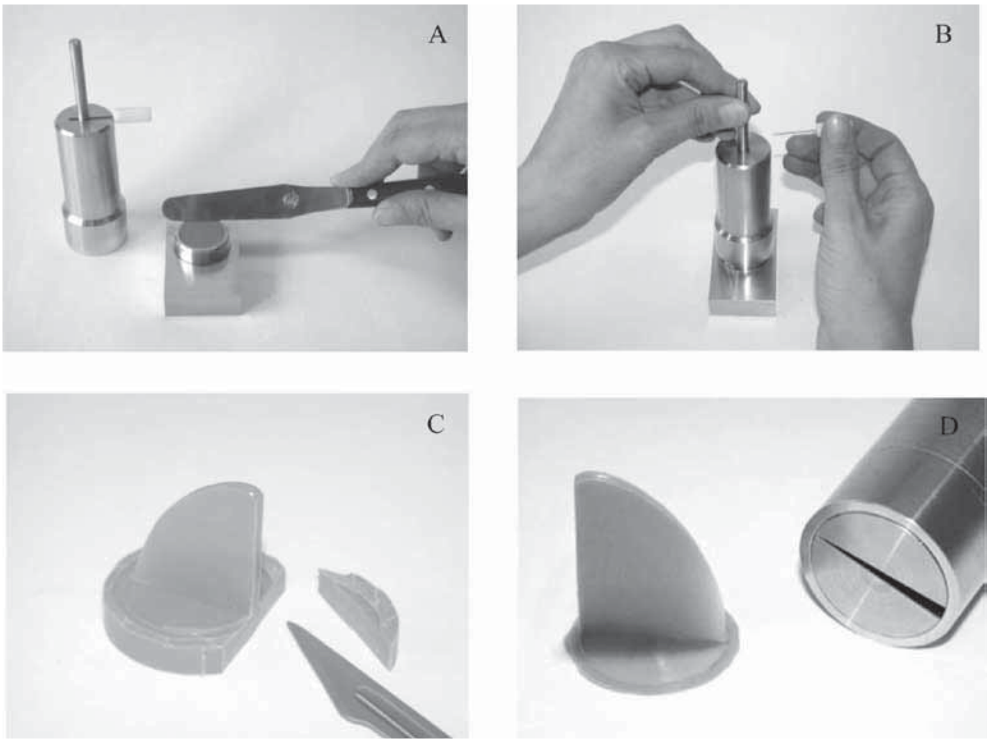

Fig 1. The shark fin measurement procedure

A: Impression material was mixed to fill the receptacle of the shark fin device.

B: The pin was released allowing the 147g weight to sink slowly into the material.

C: The material was set and trimmed using blade to accurately measure the height.

D: The shark fin at its highest point was measured using a caliper.

Results

Two-way ANOVA revealed significant differences among the lengths of the retarder, time of measurements, and their interactions ($P<0.05$). Table 1 shows the fin height at the different working time and the length of retarder. There was no significant different between the longer length of retarder (1.5 and 2 times groups) at the short working time (30s). At the 60s working time, there was no significant different between 0.5 and 1.0 times groups. The longest length of retarder showed significantly greatest fin height at the 90s working time ($P<0.05$).

Table 1. Shark fin height (mm) at the different time of measurement and the length of retarder which show in proportion of retarder to polyether.

The proportion of retarder to polyether	Fin height (mm)			
	30s	60s	90s	120s
0.0	4.40 ± 0.82	0	0^{d}	0
0.5	7.20 ± 0.45	1.4^{c} ± 0.42	0^{d}	0
1.0	8.80^{a} ± 0.67	1.5^{c} ± 0.35	0^{d}	0
1.5	$9.80^{a,b}$ ± 0.45	6.5 ± 0.50	0.70^{d} ± 0.27	0
2.0	10.90^{b} ± 0.42	7.9 ± 0.42	2.40 ± 0.65	0

Data is reported as mean ± SD.
Groups with the same superscripted letter indicate no significant differences at $P<0.05$.

Discussion

The goal in developing the Impregum Penta Soft by manufacture was to overcome the stiffness of polyether and to achieve ideal handling and convenience. The Pentamix Mixing Unit offers the dentists an alternative to hand mixing. However, there is no partition for the polyether retarder in the Pentamix Mixing Unit. Therefore, the dentists mix impression by hand mixing and a polyether retarder is required especially in tropical country such as Thailand.

Flow property is crucial to the impression process since it determines how well the impression flows into the gingival sulcus, which ultimately dictates the level of impression detail [8]. The rheological or flow characteristics of impression materials are also major determinant in the handling properties and adaptation to the soft and hard tissues [13]. The shark fin test theoretically allows the monitoring of the flow properties of the impression material in relation to clinically reliable impression taking. The result of this study showed that for all the length of retarder tested, a decrease in fin height when the working time is longer caused by a change in flow characteristics representing chain elongation and cross-linking reaction within the impression material after mixing. In contrast, the longest retarder resulted in an increased fin height because of better flow of the impression material.

The working time is measured from the start of the mix until the material can no longer be manipulated without introducing distortion or inaccuracy in the final impression. The impression material must be completely mixed and seated in position before the end of the working time [14]. This study found that polyether is not viscous enough to flow through the shark fin slit at the 120s working time for the entire length of retarder tested (Table 1). This is because a material that has developed some elasticity would undergo elastic deformation under the load of the shark fin device rather than penetrate into the slit. Comparing the polyether retarder to the working time shows that they are correlated: the longer the retarder the lengthener the flowable time. In addition, extending the insertion time to ensure that the material has completely polymerized indicates improvement in elastic recovery with decreased permanent deformation [15].

In many cases it is impossible to obtain the impression from a completely dry environment, particularly when the sub-gingival margins are unavoidable [16]. A previous study showed that there was a high prevalence of post-and-cores associated with the subgingival finishing line [17]. Once a wet environment is encountered, the hydrophobicity of the material will also affect impression accuracy [18]. Conventionally, the hydrophobicity of impression materials has been measured by using contact angle methods [19,20]. Hydrophobic materials exhibit a contact angle with water of 90° or greater, while hydrophilic materials have a contact angle of less than 90°. Polyethers are regarded as more hydrophilic than polyvinylsiloxanes. This is due to the differences in their chemistry, with polyethers containing carbonyl (C=O) and ether (C–O–C) functional groups which attract water into the back bone, whereas polyvinylsiloxanes contain hydrophobic aliphatic hydrocarbon groups [21,22]. Because of the hydrophilicity and flow characteristics of polyethers, impression with deep subgingival margins might be better captured with a polyether impression material [23].

In clinical application, it is suggested that a polyether retarder be used to lengthen the flowable time achieving better flow characteristics of polyether. Limitations of this study are that the impression taking of the materials was performed extraorally and that the errors in handling of impression materials are assumed to be minimal. Further studies are necessary to elucidate whether a polyether retarder affects other mechanical properties of polyethers such as elastic recovery, strain in compression, tear resistance, and tensile strength. Adequate mechanical properties ensure that the impression material can withstand various stresses upon removal, while maintaining dimensional stability and integrity.

Conclusion

Within the limitations of this in vitro study, it can be concluded that the longer the retarder the lengthener the flowable time. In addition, the polyether retarder can improve the flow characteristics of polyether impression materials.

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