Viscosity, Micro-Leakage, Water Solubility and Absorption in a Resin-based Temporary Filling Material

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Abstract

The purpose of this study is to examine viscosity, micro-leakage, water solubility and absorption by using various lines of the resin-based temporary filling materials that have flow-ability. The experimental group included 3 types such as Denkist, Korea), Once-fil flow (Mediclus, Korea), Temp-it flow (Spident, Korea). The control group was used composite resin (Filtek™ bulk fill, 3M, USA). Four groups by 5 pieces were classified by using the bovine tooth specimens. Viscometer (Wells Brookfield Cone/Plate, USA) was used for measuring viscosity. The measurement of micro-leakage was carried out thermo-cycling (Thermocycling, M.S.I Co., Korea) with giving a change in temperature totally 1000 times at 5 ℃ and 55 ℃. The specimen was penetrated the 2% methylene blue dye solution. The water solubility and absorption were gauged by using a precision scale (XS105, Mettler-toledo Inc., Germany). The following results were obtained. The viscosity in Filtek was the highest. Once-fil flow and Temp-it flow showed viscosity at a similar level. The viscosity in Quicks flow was the lowest, thereby having shown significant difference from other materials. Filtek had none with 0 in micro-leakage score, thereby having shown statistically significant difference from 3 groups. As for water absorption, the Temp-it flow group came to 58.96 (μg/㎜³ ± 1.63), thereby having indicated the largest water absorption. However, the significant difference wasn't shown in the remaining groups. In terms of solubility, the Quicks flow group amounted to 8.33 μg/㎜³ ± 0.32, thereby having shown the largest solubility. The significant difference wasn't shown in the remaining groups. In conclusion, the resin-based temporary filling materials, which were used in the experiment, couldn't be confirmed the material-based difference in viscosity, micro-leakage, water solubility and absorption.

Keywords: Micro Leakage, Viscosity, Water Absorption, Water Solubility

1. Introduction

In these days, an interest in aesthetics is growing. Along with the development in adhesion dentistry, a filling material is being continuously increased the restorative technique such as inlay or onlay with the use of composite resin or ceramic. This indirect restoration needs to allow the appropriately temporary filling material to be situated in the middle of being mounted as a permanent restorative material through forming cavity. This is certainly needed the temporary filling process before the final restoration in order not only to protect cavity for preventing contamination caused by saliva or foreign substance, but also to reduce a patient’s discomfort.

The requirement for a temporary filling material, which provisionally recovers the prepared cavity, includes
Viscosity, Micro-Leakage, Water Solubility and Absorption in a Resin-based Temporary Filling Material

a need to protect the ablated tooth from bacteria and physical and chemical damage. Also the materials to allow adjacent teeth and antagonistic teeth as well as the removed tooth to be situated properly, and to have appropriate strength and retention available for counteracting the applied external force.

Temporary filling materials include stopping, which was a thermoplastic material, zinc oxide-eugenol cement, the reinforced zinc oxide-eugenol cement, hydraulic temporary restorative material, and the resin-based temporary filling material. Many temporary filling materials have the complex manipulation, thereby being taken lots of time in being applied or being not easy for removal. Thus, there were also materials that are difficult to be used as a temporary filling material The research paper by Xie et al. and Terata et al. were reported that the cement including eugenol was decreased the bond strength in composite resin on dentin.

The flowable light-cured resin temporary filling material, which has merits such as convenient manipulation, short curing time, and easy removal, are being recently developed to be widely used. Flowable resin was introduced for the first time in 1996 as the restorative material of Class V lesion. This contains little inorganic filling material, thereby being low in viscosity and being good in wettability on a cavity wall along with flowability, resulting in being employed as diverse uses such as fissure sealant, temporary filling and relining. The resin-based temporary filling material with low viscosity was applied to cavity generally by using syringe, thereby having a merit called easy manipulation. However, they have a demerit such as micro-leakage due to a gap with a cavity wall caused by the low wear resistance and the polymerization shrinkage.

The existing temporary filling material is difficult to be removed and is long in curing time. On the other hand, the recently resin-based temporary filling material is made the temporary restoration with a simple method, thereby being much commercialized. However, the research paper, which evaluated the micro-leakage level by using the currently temporary filling material, are possessed the majority by a temporary restorative material for endodontic treatment. It is the real situation that a research on the resin-based temporary filling material with flow-ability is non-existent. Amidst a rise in the demand for the light-cured resin temporary filling material, the international standard isn’t arranged for the physical and mechanical properties of the currently light-cured resin temporary filling material. Thus, a product is being used relying upon a manufacturer.

Accordingly, this study evaluated viscosity, micro-leakage, water solubility and absorption by using various lines of the resin-based temporary filling materials that have flow-ability.

2. Materials and Methods

2.1 Materials

It selected 20 pieces in the anterior region of bovine without caries lesion and micro-leakage, removed foreign substance on the tooth surface, and kept those things in distilled water. After making the labial surface toward the bottom in order to prepare cavity on the labial surface of bovine, it was buried with epoxy resin. Cavity was formed by using high-speed carbide bur (#330, Mani, Inc., Tochigi-Ken, Japan) in the cervical area of the labial surface in teeth. The size of cavity was set to be 4mm in the cut gingiva width, 4mm in the mesiodistal diameter, and 2mm in the depth of cavity. Totally 20 specimens were classified into four groups by 5 pieces. The light-cured temporary filling materials with flow-ability that were used in a research were selected 3 types such as Quicks flow (Denkist, Korea), Once-fil flow (Mediclus, Korea), Temp-it flow (Spident, Korea) as the experimental group and 1 type of composite resin (Filtek™ bulk fill, 3M, USA) as the control group Table 1. The light curing equipment was carried out photopolymerization according to a manufacturer’s directions by using Elipar™ S 10 (3M EPSE, Germany).

Table 1. Materials used in this study

| Group            | Code | Batch No. | Manufacturer |
|------------------|------|-----------|--------------|
| Filtek™ bulk fill| FF   | 4862A1    | 3M, USA      |
| Once-fil flow    | OF   | OF121125  | Mediclus, Korea |
| Temp-it flow     | TF   | TFB12001  | Spident, Korea |
| Quicks flow      | QF   | 20111117  | Denkist, Korea |

2.2 Viscosity

To measure viscosity of temporary filling material, it was confirmed by using viscometer (Wells Brookfield Cone/Plate, USA). The value of viscosity was recorded by selecting and applying # 52 as for cone spindle with putting the specimen 0.5 mL in sample cup.
2.3 Microleakage
Thermo-cycling (Thermocycling, M.S.I. Co., Korea) was carried out while giving a change in temperature totally 1000 times at 5 °C and 55 °C with storing the specimen of being completed filling in physiological saline solution for 4 hours. It uniformly applied nail varnish twice on the whole surface of the dental crown excluding the marginal 1 mm of the filled cavity after Thermo cycling, dried fully, soaked the specimen in the 2% methylene blue dye solution for 12 hours, and then cleaned it in the flowing water for 5 minutes. The specimen was removed the filler after being cut with mesiodistal by using diamond saw. The use of microscope (Olympus Co., Japan) led to taking a photograph of the penetration level in methylene blue between cavity and temporary filling material with 20 magnification. The dye penetration level was judged according to the evaluation criteria in 4 stages from 0 to 3 Table 2.

Table 2. Scores of dye leakage observed for both substrates

| Score | Extent of dye penetration |
|-------|---------------------------|
| 0     | No dye penetration        |
| 1     | Dye penetration up to half of the cavity depth |
| 2     | Dye penetration more than half of the cavity depth |
| 3     | Dye penetration arriving to the cavity floor |

2.4 Water Solubility and Sorption
The specimen was made by using the mold with internal diameter (15 ± 0.1) mm and thickness (1.0 ± 0.1) mm. The completed specimen was stored in a dryer of being maintained at (37± 1) °C for 22 hours, was moved to a dryer of being maintained at (23 ± 1) °C to be kept for 2 hours, and then was measured and recorded weight with accuracy in ± 0.1 mg. This value was recorded with m1. After recording m, the diameter and the thickness in the specimen were gauged. The diameter was fixed the mean value by being measured twice to the direction of being crisscrossed rectangularly. The thickness was used the mean value by being measured in 4 places with the equal interval. The volume (v) of the specimen was calculated and recorded with the unit mm³ by using diameter and thickness that were obtained in this way. The specimen, which was measured m0 and volume, was deposited in distilled water by using a constant-temperature water tank at (37± 1) °C for 7 days. At this time, the specimen was erected in order to be vertical and then was maintained the interval in more than 3 mm between specimens. It removed water on the surface after 7 days, dried it in the air, took it out from distilled water, measured weight with accuracy in ± 0.1mg after 1 minute, and then recorded it with m2.

The same process was repeated until getting the certain weight by drying the specimen again according to the method of measuring m1 later. The definite weight, which was obtained in this way, was recorded with m3. The water absorption (Wsp) and solubility (Wsl) were calculated by being substituted in the following formula.

\[ Wsp = \frac{m2 - m3}{u} \quad \text{Wsl} = \frac{m1 - m3}{u} \]

2.5 Statistical Analysis
The verification of correlational significance on marginal micro-leakage between groups in each was used SPSS program (SPSS 12.0 for windows, Chicago, USA). The significance in each group was verified by using Kruskal-Wallis test and Mann-Whitney test (p < 0.05).

3. Results

3.1 Viscosity
The following are the results that gauged the viscosity in 3 temporary filling materials and 1 composite resin that were used in the experiment (Figure 1). The viscosity in composite resin FF was the highest. OF and TF showed viscosity at a similar level. The viscosity in QF was the lowest, thereby having shown significant difference from other materials (p<0.05).

![Figure 1. Result of Viscosity. FF: Filtek bulk fill, OF: Once-fil flow, TF: Temp-it flow, QF: Quicks flow. * There was statistically significant difference from other materials.](image-url)
3.2 Microleakage
The score and the mean value in the micro-leakage depth in each group are as Table 3. FF, which is composite resin, had no micro-leakage with 0 in score and showed statistically significant difference from 3 groups (p<0.05). OF and TF were same in the distribution of Score 2 and Score 3. QF showed 1 piece in Score 2 and 9 pieces in Score 3, thereby having indicated the highest micro-leakage score. However there was no significant difference from OF and TF (p>0.05). Accordingly, the aspect of reaching up a pulp wall will be sown when all the dye solutions are expanded even into the whole depth of cavity.

Table 3. Scores number of specimens in each score and mean microleakage score

| Group             | Score | No. | Mean score |
|-------------------|-------|-----|------------|
| FiltekTM bulk fill| 0 1 0 0 | 10 2 | 2.0 |
| Once-fil flow     | 0 2 8 | 10 2 | 2.8 |
| Temp-it flow      | 0 2 8 | 10 2 | 2.8 |
| Quicks flow       | 0 1 9 | 10 2 | 2.8 |

3.3 Water Solubility and Sorption
As for water absorption, the TF group showed the largest water absorption with 58.96 (μg/mm³ ± 1.63). The remainder was indicated to be in order of the QF group with 35.46 μg/mm³ ± 1.63, the FF group with 35.44 μg/mm³ ± 1.15, and the OF group with 30.04 μg/mm³ ± 1.66. The significant difference couldn’t be confirmed among groups except the TF group (Figure 2).

Figure 2. Result of water sorption. FF: Filtek bulk fill, OF: Once-fil flow, TF: Temp-it flow, QF: Quicks flow. * There was statistically significant difference from other materials.

4. Discussion
The contamination of teeth caused by temporary restoration may influence the pulp or reduce the adhesion to the final restoration. Thus, there is a need to fill with the final restoration as soon as possible or to select the temporary restorative material that has a proper binding effect or is easy for removal. Using the resin-based temporary filling material in the cavity of inlay or onlay is the biggest merit in convenient maneuverability. However, what is most important in the temporary restoration will rely upon shutting down the margin perfectly. The resin-based temporary filling material has a component of composite resin, thereby being likely able to be created the polymerization shrinkage. This causes a delicate gap between a cavity wall and a temporary filling material, thereby leading to micro-leakage. This micro-leakage comes to allow oral fluid, bacteria or toxic substance to penetrate into tooth structure after temporary restoration. This may lead to problems such as hyperesthesia, pulpitis, improper restoration. This

As for solubility, the QF group showed the largest solubility with 8.33 μg/mm³ ± 0.32 and was confirmed to be similar to the outcome that the QF group had been high in viscosity. OF amounted to 5.52 μg/mm³ ± 0.35. The TF group stood at 5.51μg/mm³ ± 0.48. The FF group came to 5.09 μg/mm³ ± 0.81. Thus, the significant difference couldn’t be confirmed in the remaining groups excluding QF (p<0.05).

Figure 3. Result of water solubility. FF: Filtek bulk fill, OF: Once-fil flow, TF: Temp-it flow, QF: Quicks flow. * There was statistically significant difference from other materials.
study comparatively researched into viscosity and micro-leakage with reviving the environment inside the mouth by thermo-cycling while giving a change in temperature totally 1000 times at 5 °C and 55 °C as for 3 kinds of the resin-based temporary filling materials that are being applied clinically in this study. The viscosity in composite resin was the highest. OF and TF showed viscosity at a similar level. The viscosity in QF was the lowest, thereby having shown significant difference from other materials (p<0.05). Low viscosity leads to good flow-ability, thereby being excellent in the detail reproducibility. A flowable resin lowers the content of filler, thereby being able to obtain flow-ability. This flow-ability can allow resin to be situated in the external wall, but comes to have a problem about the relative shrinkage after polymerization. Diverse experimental methods are being used for evaluating micro-leakage of restoration. However, a method of using dye penetration is being often used because of being available for directly observing the convenience and the dye penetration aspect. Youngson et al. reported that there is no difference in the penetrating depth as for coloring matters such as 2% methylene blue, 5% eosin, 50% silver nitrate, and Indian pink. This study used 2% methylene blue that is used the most out of the dye penetration technique. The existing research of using dye solution can measure only the section of the filled margin. On the other hand, the present experiment evaluated after measuring all the inside of the cavity after removing a restorative material in relation to a characteristic of the resin-based temporary filling material easy for removal. Accordingly, the penetration method of using dye solution can be said to be a proper evaluation method because of being simple and economical. The composite resin FF group had no micro-leakage at all. The lowest micro-leakage level was expected in the Quicks flow with the lowest viscosity. However, the significant difference wasn’t shown in micro-leakage between Once-fil flow and Temp-it flow. A research by Odabas et al. reported that there is excellent binding effect in Clip as a result of observing micro-leakage in primary teeth by using the temporary restorative materials such as IRM, Coltosol, Cavit, Adhesor, Clip with the use of dye solution. The inside of the mouth is always exposed to water due to saliva. Thus, the water absorption and solubility have relationship with stability in a material. A research by Pieper et al. compared weight through tooth brushing after soaking Cavit, IRM, Vidron R, Biologic in distilled water for 7 days and measured the water absorption and solubility. As a result, the biggest water absorption and solubility were shown in Cavit. Biologic, which is the resin-based temporary filling material, was reported to have a good binding effect of the margin and to have the lowest water absorption & solubility, and reduction in weight. Gohring et al. and Keyf et al. mentioned that the water absorption causes a change in physical property and that the water absorption mostly happens in substrate. In this study, the water absorption satisfied a condition in all the groups excluding the Temp-it flow group(58.96μg/mm²) according to the requirement (below 40μg/mm²) of resin for ISO 4049. In the requirement(below 7.5μg/mm²) of the water solubility, the Quicks flow group(8.33 μg/mm²) showed the largest solubility. It was similar to the outcome that the Quicks flow group had been high in viscosity. The remaining groups satisfied the requirement. Guzman et al. mentioned that the marginal leakage level around the filling material grows according to a rise in temperature based on the difference in thermal expansion coefficients between a tooth and a filling material and that carrying out thermo-cycling is a good method when observing a marginal effect. This experiment reproduced the environment inside the mouth by performing thermo-cycling in order to overcome the limitation of the in-vitro experiment. As a result of this study, it can be said to be similar between the viscosity of the resin-based temporary filling material, which is currently coming into market, and the micro-leakage level. However, in the researches by Qvist and Scotti et al. the micro-leakage was mentioned to happen less in the higher and stronger compression strength as the occlusion force is also an important variable for micro-leakage of the filling material.

5. Conclusion

Consequently, a research is needed on the influence of occlusion force upon the resin-based temporary filling material in the future.

6. References

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Viscosity, Micro-Leakage, Water Solubility and Absorption in a Resin-based Temporary Filling Material

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