Effect of freshly placed core buildup composites on setting of silicon impression materials

Mohammad A. Al-Rabab’ah, Muhanad M. Hatamleh¹, Sandra Al-Tarawneh², Ahmad El-Ma’aita, Ibrahim Abu Tahun, Issam S. Jalham³

Department of Conservative Dentistry, University of Jordan, ¹Department of Dental Technology, Luminus Technical University, Departments of ²Removable Prosthodontics and ³Industrial Engineering, The University of Jordan, Amman, Jordan

Abstract

Aim: The aim is to study the effect of freshly placed composite build-ups on setting of additional silicone impression materials.

Settings and Design: In vitro - experimental study.

Materials and Methods: Three composite materials; Build-It™ F. R™, Filtek™ Bulk Fill flow and Filtek™ Z350 and three light-bodied additional silicone impression materials; Elite HD+, Aquasil LV Ultra and Express™ were used. Cylindrical-shaped specimens were made of each material (diameter 15 mm and height 10 mm). The silicone specimens were brought into contact with the composite specimens, which were either freshly cured (9 groups, n = 90) or cured and then stored in normal saline for 1 week (9 groups, n = 90). Shore A hardness (SAH) scores of silicone surfaces were recorded following the ASTM D2240-5 standards for shore A Durometer testing. Six measurements were made per each silicone surface and medians were calculated. Kruskal–Wallis and Mann–Whitney tests (SPSS v20) were used to check statistical significant differences between all groups and paired comparisons, respectively (P < 0.05).

Statistical Analysis Used: Kruskal-Wallis and Mann-Whitney tests.

Results: The SAH scores of additional silicones in direct contact with freshly placed composites were significantly less than SAH scores of additional silicones in direct contact with composites specimens aged for 1 week in 7 out of 9 combinations (P < 0.05). Only when Express™ and Elite HD+ were applied over freshly placed Filtek™ Bulk Fill flow, the SAH scores difference was not statistically significant to SAH scores of matching combinations applied after 1 week of composite storage.

Conclusions: Freshly placed composite might affect setting of additional silicone impression materials. Dentists should carefully assess final impression on areas of prepared teeth that have received composite fillings recently.

Keywords: Additional silicon, composites, core build-up, shore A hardness

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INTRODUCTION

Resin composites are the preferred choice for direct fillings and core build-ups in vital and root canal treated teeth particularly when metal-free indirect restorations are planned.\(^1\)\(^2\) Resin composites and their flowable and bulk fill variants might be used to optimize the preparation design for an endocrown, seal endodontic access, fill small gaps or create an entire core build up with or without posts.\(^2\)

To shorten temporization period and provide better long-term seal final impression is usually made at the same visit of placing direct filling over endodontically treated teeth. The ability to take final impression directly after fillings/core buildup will reduce clinical time and any negative effect of provisional restorations on final impression.\(^3\) A highly accurate impression of prepared teeth is crucial to provide a successful indirect restoration. Many clinical steps affect setting of rubber impression materials. Freshly placed composites will have layer of unreactive resin monomer, which might interfere with the polymerization of the impression materials.

Currently, only additional silicones and polyether impression materials can attain the rigorous requirements to qualify for final impression of crowns, fixed partial dentures, and implant work. During the stage of final impression, dimensional accuracy and stability are important to achieve to produce a true replica of the prepared teeth, implants and vicinity. Although digital scanners can achieve “virtual” unlimited stability to the details of prepared teeth/implant vicinity their use is still limited by their expensive capital investment to any dental surgery. Digital dentistry also has different platforms that are sometimes not easily synchronized with the daily work of a dental practice and would require an elaborate learning curve that some dentists might find cumbersome. Intraoral scanners are used nowadays to capture details of prepared teeth and implants to construct restorations. The accuracy of scanners has been found to match that of additional silicone impression materials.\(^4,5\) Some studies have shown that intraoral scanners are less accurate when capturing details of full arch reconstructions or postpreparations.\(^6,7\) Scanners also are less suited for capturing subgingival details when preparations of teeth are cervical to the gingival margin.\(^8\)

Few clinical steps might affect the setting of additional silicone impression materials. Latex gloves have been implicated in delaying or completely inhibiting setting additional silicone impression materials. Vinyl Gloves showed no interaction with the setting of silicone impression materials.\(^9\) Hemostatic agents and retraction cords and retraction pastes were also tested for possible interactions.\(^10,11\) Interim resin materials and cements might also affect polymerization of elastomeric impression materials.\(^12\) Hardness of silicone materials might also change after setting when those materials are disinfected.\(^13–15\)

The aim of this study was to investigate if freshly placed composite might affect setting of additional silicone impression materials through testing of Shore A Hardness (SAH) test and to compare those specimens with additional silicone specimens made in contact with composites specimens that were stored for 1 week. Our null hypothesis indicates that freshly placed composite will not affect SHA of additional silicone materials.

MATERIALS AND METHODS

The study was approved by institutional review board. Transparent polylactic acid molds were 3D printed according to standard test method as set in ASTM D2240-5 for shore A Durometer testing. For Silicone molds cylinders were made (diameter 15 mm and 10 mm height) with 2 mm rim leaving 13 mm of hollow width to be filled with the additional silicone during testing [Figure 1]. Composite specimens were made using cylindrical molds of similar width but only 3 mm height [Figure 2]. Thirty silicone specimens were used as control without contact with composite (10 for each group). Composite materials used in this experiment are listed in Table 1. All composite materials were applied to their respective molds and covered by glass slides before irradiated with LED (starlight pro, mectron, Carasco, Italy) for 40s each side. The light intensity was 800 mW/cm\(^2\). Additional silicone materials were all light bodied variants and are listed in Table 2. All impression specimens were mixed using compatible Automixing cartridge and mixing tips and brought in direct contact with composite molds using digital pressure through firm application of glass slide for 8 min. A 180 specimens were in direct contact [Figure 3] with either freshly placed and cured composites (\(n = 90\)) or composites specimens that were stored in normal saline for 7 days (\(n = 90\)). Table 3 lists all groups tested in this study.

Shore A scores were recorded after 10 min of initial setting by a laboratory technician who was blinded to the nature of test groups. Type PG, W-Testor Otto, Wolpert-Werke (Ludwigshafen, Germany) was used to record the Shore A scores. 6 readings were made per each side of the silicone and medians of each side were calculated. Contacting sides with composites were plotted.
Table 1: Composite materials used in the study

| Material                        | Manufacture                      | Resins                               | Filler                                                                 |
|--------------------------------|----------------------------------|--------------------------------------|------------------------------------------------------------------------|
| Build-It™ F.R™ core material   | Pentron, Wallingford, CT, USA    | Bis-GMA, UDMA and HDDMA              | Barium borosilicate, calcium alumino-fluro-silicate, silica and chopped glass fiber |
| Filtek™ bulk fill flowable    | 3M ESPE, St.Paul, MN, USA        | Bis-GMA, UDMA, Bis-EMA and procryal resin | Yetterbium trifluoride, zirconia-silica micro particles                |
| restorative                   |                                  | Bis-GMA, UDMA, TEGDMA, PEGDMA and Bis-EMA | Non aggregated silica and zirconia nanofillers/ aggregated zirconia-silica nanofillers |
| Filtek™ Z350                  | 3M ESPE, St. Paul, MN, USA       |                                      |                                                                        |

Results of Mann–Whitney tests showed that the null hypothesis was rejected in seven combinations out of nine where SAH scores of silicone materials in direct contact with freshly placed composites were significantly lower than their counterparts made in direct contact with composite aged for 1 week.

DISCUSSION

Additional silicones are widely used as final impression material when capturing details of teeth, implants, and also edentulous jaws. Due to their high dimensional accuracy and stability, they can be considered as gold standards to which new techniques or materials are often compared. Their setting reaction involves mainly polymerization by chain lengthening and cross linking through additional reaction of Vinyl silicone group. The catalyst used is...
mainly platinum-containing compound. No by-products are produced apart from hydrogen gas (H₂), which is produced in some additional silicone variants by secondary reaction.[17] Setting of additional silicone is sensitive to moisture. Water can have detrimental effect on setting of those impression materials.[18]

SAH test was used to study the effect of different factors on setting reaction of additional silicones. Changes in SAH will also have impact on Young's modulus of the impression material and any decrease in SAH might affect setting and elastic recovery of impression material leading to inaccurate impression or low tear resistance.[19] In this study, the use of SAH provided a reliable quantitative comparison of setting of additional silicone materials. Previous studies had employed qualitative evaluation of the setting of impression materials.[13,12,20,22]

The degree of conversion of dental composites is well <100% and unreactive monomer will still be present in set composite.[21‑23] Immediate sealing of dentin of prepared teeth has been shown to adversely affect the setting of silicone and polyether impression materials alike.[21,22] Few maneuvers were attempted to alleviate this negative effect of an acclaimed superior technique. Applying glycerin gel[24] or alcohol and further curing the bonding agent or flowable composite might reduce the oxygen-inhibiting layer (OIL). Studies suggested that the unreactive monomer in the OIL was responsible for the incomplete setting of the silicone material but mechanism is still unknown.[21] It has been postulated that the acidity of OIL will affect the setting reaction of self-curing polymers.[25,26] The OIL layer is basically a photoinitiator-deprived uncured resin. OIL was found to promote better bonding in few studies while other studies have shown a negative impact of OIL on bonding.[25] The nature of the effect of OIL in bonding might be dependent on the adhesive molecule.[27,28] The OIL was found to be thicker with unfilled resin when compared to filled resins.[29] Normally OIL layer can be made thinner by air-blocking (application of glycerine gel) or with pumicing. It can also be reduced using water spraying or application of ethanol-soaked cotton pledget for about 20 s.[30]

In the present study, composite specimens were covered by glass slide and irradiated with the light cure before additional silicone impression materials applied. Even with the use of air blocking, OIL might still be present but is normally thinner.[21] Water spraying is thought to only minimize the OIL.[31] It can be postulated that water storage of composite specimens removed the OIL and thus SAH of impression materials specimens brought into contact with 1-week water aged composite were not significantly different than control groups. When composite specimens

Table 3: Groups tested in the study

| Group number | Description (silicone, composite, conditioning) |
|--------------|-----------------------------------------------|
| 1            | Elite, Buildit, same day                       |
| 2            | Elite, Bulkfill, same day                      |
| 3            | Elite, Z350, same day                         |
| 4            | Express, Buildit, same day                    |
| 5            | Express, Bulkfill, same day                   |
| 6            | Express, Z350, same day                       |
| 7            | Acquasil, Buildit, same day                   |
| 8            | Acquasil, Bulkfill, same day                  |
| 9            | Acquasil, Z 350, same day                     |
| 10           | Elite, Buildit, 1 week                        |
| 11           | Elite, Bulkfill, 1 week                       |
| 12           | Elite, Z350, 1 week                           |
| 13           | Express, Buildit, 1 week                      |
| 14           | Express, Bulkfill, 1 week                     |
| 15           | Express, Z350,1 week                          |
| 16           | Acquasil, Buildit, 1 week                     |
| 17           | Acquasil, Bulkfill, 1 week                    |
| 18           | Acquasil, Z350, 1 week                        |

Table 4: Percentage of reduction in shore A hardness of surfaces contacting composite specimens compared to rear side

| Group number | SAH (%) |
|--------------|---------|
| 1            | 7       |
| 2            | 3       |
| 3            | 9       |
| 4            | 6       |
| 5            | 4       |
| 6            | 4       |
| 7            | 12      |
| 8            | 7       |
| 9            | 9       |
| 10           | 0       |
| 11           | 0       |
| 12           | 0       |
| 13           | 1       |
| 14           | 1       |
| 15           | 1       |
| 16           | 1       |
| 17           | 0       |
| 18           | 1       |

SAH: Shore A hardness
Table 5: Shore A hardness scores medians (standard deviation) for tested groups

| Group                      | Shore A hardness (SD) |
|----------------------------|------------------------|
| Elite, Buildit, sameday    | 50 (1.8)               |
| Elite, Bulkfill, sameday   | 52 (2)                 |
| Elite, Z350, 1 week       | 46 (4)                 |
| Express, Buildit, same day| 44 (1.1)               |
| Express, Bulkfill, sameday| 44 (2.5)               |
| Express, Z350, sameday    | 43.5 (2)               |
| Acquasil, Buildit, sameday| 48.5 (4)               |
| Acquasil, Bulkfill, same day| 55.5 (2.4)          |
| Acquasil, Z 350, sameday  | 53.5 (4)               |
| Elite, Buildit, 1 week    | 53 (0.6)               |
| Elite, Bulkfill, 1 week   | 53 (0.3)               |
| Elite, Z350, 1 week       | 53 (0.6)               |
| Express, Buildit, 1 week  | 45 (1.3)               |
| Express, Bulkfill, 1 week | 46 (0.9)               |
| Express, Z350, week       | 46 (1.1)               |
| Acquasil, Buildit, 1 week | 59 (0.9)               |
| Acquasil, Bulkfill, 1 week| 62 (0.6)               |
| Acquasil, Z350, 1 week    | 59 (1.8)               |

Table 6: P values of Mann-Whitney tests

| Group                      | P value |
|----------------------------|---------|
| Elite, Buildit, same day   | 0.000   |
| Elite, Buildit, 1 week     | 0.000   |
| Elite, Bulkfill, same day  | 0.063   |
| Elite, Buildit, 1 week     | 0.000   |
| Express, Buildit, same day | 0.035   |
| Express, Buildit, 1 week   | 0.075   |
| Express, Bulkfill, same day| 0.001   |
| Express, Z350, same day    | 0.000   |
| Acquasil, Buildit, sameday | 0.000   |
| Acquasil, Bulkfill, sameday| 0.000   |
| Acquasil, Z 350, same day  | 0.001   |

Taking impression directly after placing composite fillings and core build-ups will reduce temporization time and aging of the composite material. Bonding strengths of adhesive cements to composite aged for more than 14 days was inferior when compared to bonding strengths for composites aged for a week or less. Deferring the impression stage to 1 week later will lessen the effect of OIL and free radicals on the setting reaction of impression materials. If clinician prefers to take final impression at the same visit of core build-ups any composite restoration should either be sprayed with water or soaked with alcohol or hydrogen peroxide. Dry preparation should be avoided. Clinician should always critically inspect impressions taken when composite fillings/build-ups are part of the prepared teeth. Special attention should be made to ensure complete setting of silicone impression materials and this should preferably be done under magnification. Further research is needed to provide maneuvers to remove OIL layer when attempting to take impression at the same visit while not affecting bond strength to resin adhesive luting cements later.

**CONCLUSIONS**

Within the limitations of this study, it can be concluded that freshly placed composite might affect setting of additional silicon impression materials. Water spraying or application of alcohol soaked cotton pellet is advised. Dentists should carefully assess final impression on areas of prepared teeth that have received composite fillings recently.

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Conflicts of interest
There are no conflicts of interest.

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