Original Article

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

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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 rigors 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 elaborative 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 restorative	3M ESPE, St.Paul, MN, USA	Bis-GMA, UDMA, Bis-EMA and procryat resins	Yetterbium triflouride, zirconia-silica micro particles
Filtek™ Z350	3M ESPE, St.Paul, MN, USA	Bis-GMA, UDMA, TEGDMA, PEGDMA and Bis-EMA	Non aggregated silica and zirconia nanofillers/ aggregated zirconia-silica nanofillers

Table 2: Additional silicone impression materials used in the study

Type	Manufacturer	Chemical structure
Elite HD+light body, fast set	ZermackBadia polesine (RO), Italy	Vinyl polysiloxane
Aquasil LV ultra fast set	Dentsply Sirona, York, PA, USA	Vinyl polysiloxane
Express™ light body, fast set (blue)	3M ESPE, St. Paul, MN, USA	Vinyl polysiloxane

Figure 1: Silicone specimens

Figure 2: Composite specimens

against control and rear side. Shore A scores of freshly placed specimens were compared with those of 1 week specimens.

Statistical analysis was carried out using SPSS version 20 (IBM, Armonk, NY, USA). Kruskal–Wallis test was used to check for statistical significant difference. Mann–Whitney tests were used to compare individual combinations (same day vs. 1 week).

RESULTS

Control groups SAH medians were 47 (0.6) for Express, 60 (1.5) for Aquasil and 53 (0.4) for Elite. Table 4 shows the decrease in percentage of SAH for test specimens for sides in direct contact with composite specimens when compared to the rear side of each specimen. Rear sides scores of SAH did not have any significant difference to those of control groups There was a general tendency for decrease in SAH scores in the groups where setting silicone was brought into contact with freshly cured composites. When aged composite specimens for 1 week were used SAH scores of additional silicones there were no significant difference to the controls. Groups 1–9 were in direct contact with freshly placed composites while groups 10–18 were placed over composite specimens made 1 week before. Table 5 shows median and standard deviation of SAH for each group.

Nine runs of Mann–Whitney test for the combination of groups of the same silicone and composite materials tested at same day and 1 week respectively revealed that null hypothesis was rejected in seven combinations out of 9 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. Table 6 shows the results of Mann–Whitney tests.

DISCUSSION

Additional silicones are widely used as final impression material when capturing details of teeth, implants, and also edentulous jaws.[16] 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

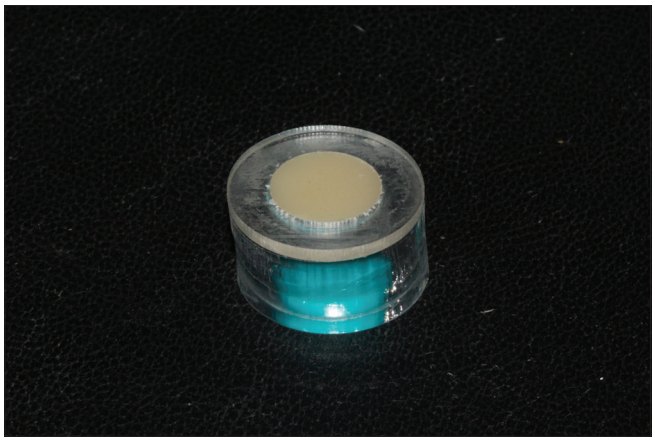

Figure 3: Silicone specimen brought in direct contact with aged composite

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

mainly platinum-containing compound. No by-products are produced apart from hydrogen gas (H_2), 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 and 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.[3,12,20-22]

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 photointiator-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 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 , same day	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, Bulkfill, 1 week	
Elite, Z350 , same day	0.000
Elite, Z350, 1 week	
Express, Buildit, same day	0.035
Express, Buildit, 1 week	
Express, Bulkfill, same day	0.075
Express, Bulkfill, 1 week	
Express, Z350, same day	0.001
Express, Z350,1 week	
Acquasil, Buildit, same day	0.000
Acquasil, Buildit, 1 week	
Acquasil, Bulkfill, same day	0.000
Acquasil, Bulkfill, 1 week	
Acquasil, Z 350, same day	0.001
Acquasil, Z350, 1 week	

were only air-aged bond interlayer strengths started to deteriorate only after 14 days.[28]

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.[28] 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.[3] Dry preparation should be avoided. Clinician should always critically inspect impressions taken when composite fillings/build-ups are part of the prepared tooth/teeth. Special attention should be made to ensure complete setting of silicone impression materials and this should preferably be done under magnification.[21] 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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