

# Dimensional stability of two solder index materials

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## ABSTRACT

**Objectives:** This study aimed to compare the dimensional accuracy of two indexing materials, an acrylic resin (GC pattern resin) and a castable composite (Bredent). The effect of time lapse until investment was also investigated. **Materials and Methods:** Two standardized brass dies 15 mm apart were prepared and then 20 identical coping-bar assemblies were designed and fabricated by a rapid prototyping device. Each bar was sectioned at the center, and indices were fabricated from an acrylic resin or castable composite ( $n = 10$  per group). The distances between the reference points were measured with a digital microscope at  $\times 80$  magnifications at 15 min, 60 min, and 24 h after indexing. Data were statically analyzed using repeated-measure ANOVA ( $\alpha = 0.05$ ). **Results:** The distance between the reference points without the coping being joined was considered as the baseline measurement (control group). The mean distance was  $19.30 \pm 0.04$  mm between the reference points where the copings were not joined. When indexed with acrylic resin, the mean  $\pm$  standard deviation (SD) dimensions were  $19.27 \pm 0.087$  mm (15 min),  $19.25 \pm 0.09$  mm (60 min), and  $18.98 \pm 0.1$  mm (24 h). The mean  $\pm$  SD dimensions for composite were  $19.29 \pm 0.087$  mm (15 min),  $19.28 \pm 0.08$  mm (60 min), and  $19.26 \pm 0.08$  mm (24 h). All tested groups showed significant differences compared to the control group except when it was indexed with composite and where the distances were measured after 15 and 60 min ( $P > 0.05$ ). **Conclusions:** The most accurate indexed-assemblies belonged to castable composite at 15 and 60 min.

**Key words:** Acrylic resin, composite, dimensional stability, indexing, solder

## INTRODUCTION

One of the critical prognostic factors is the accurate fit of a fixed partial denture (FPD) framework.<sup>[1,2]</sup> An inadequate fit can result from both laboratory and clinical causes. Slight instabilities in the fit of frameworks are common, especially when magnification is used as an aid in evaluation.<sup>[3]</sup>

Researchers have attempted more accurately to determine the accuracy of this fit by using different measurement methods such as photogrammetry,

laser digitizers, and coordinate measurement devices.<sup>[4-6]</sup> Framework fit has been determined for different methods of fabrication including cast and machined frameworks. Although suggestions state that machined and cast frameworks have a comparable fit, casting is a common technique for fabricating frameworks.<sup>[6,7]</sup> Thus, sectioning and soldering methods are frequently used to improve the fit of a framework.<sup>[8]</sup> The segmental/solder assembly procedure is as follows: Casting the segments of

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the full-arch framework, clinically evaluating the fit of each segment, incrementally indexing, and then soldering these segments before progressing to full-arch fit evaluation. This protocol provides an alternate fabrication procedure to casting as a single piece.<sup>[9]</sup>

Relating or indexing materials are used to connect the individual parts of a sectioned casting intraorally before the casting is transferred to the laboratory for investing and soldering.<sup>[3,9]</sup>

Although several researchers<sup>[10-12]</sup> proposed plaster or stone indices for investment soldering, others<sup>[13,14]</sup> recommended sticky wax. Patterson<sup>[15]</sup> described a technique that used self-cure acrylic resin. Another guideline<sup>[16]</sup> suggested two self-cure acrylic resins - Duralay or Caulk's "Orthodontic" resin.

Harper and Nicholls<sup>[17]</sup> evaluated the three-dimensional discrepancy caused by different indexing materials. They specified that zinc oxide eugenol bite registration material was the most accurate indexing technique, followed by plaster and Duralay resin, and sticky wax as the least precise. Moon *et al.*<sup>[18]</sup> reported the least discrepancy with a plaster nonremoval technique followed by Duralay resin. These researchers<sup>[17,18]</sup> stated that assembled units should be invested as quickly as possible, and that thin resin indices were more accurate than thick resin indices. Others<sup>[3,19-22]</sup> determined the contraction of indexing resins and reported that the accuracy of resin indices decreased significantly with time.

Although there is information on the adverse effects of increased time lapse between indexing with acrylic resins and investment of an assembly of components for FPD,<sup>[3]</sup> similar data are lacking for composite materials and its comparison to resin index. There seems to be a need to assess the dimensional accuracy of solder index materials and to weigh the possible clinical importance of the polymerization effect. Therefore, the purpose of this study was to compare the relative dimensional accuracy of two commonly used materials, an acrylic resin, and a castable composite, for indexing prostheses assemblies and the effect of time lapse until investment for soldering.

## MATERIALS AND METHODS

For this experimental study, two machined brass dies were designed and prepared (CNC 350, Arix Co., Tainan Hsin, Taiwan) to simulate a full coverage

metal crown preparation with a chamfer margin around the entire circumference. Preparations were standardized at a height of 5.5 mm, width of 6 mm at the margin, a convergence angle of 6°, 0.7 mm chamfer width, chamfer radius of 2 mm, and anti-rotation surface. Dies were secured 15 mm apart to represent the distance for a three-unit FPD in a cast made by the stone of Type IV (whipmix GmbH, Dortmund, Germany).

A laser scanner (3shape D 810; 3shape, Copenhagen K, Denmark) was used to digitize the dies. The data were transmitted to a software program (3shape CAD design software; 3shape, Copenhagen K, Denmark). Two copings were designed with a bar. In addition, parallel cylindrical rods with discrete pinpoint indentations at the centers of rods were generated on the occlusal surfaces of the copings. Next, 20 identical wax patterns were produced by a rapid prototyping device (Solidshape, D76+, Solidshape Inc., Merrimack, NH, USA).

All wax patterns were invested and casted with nickel-chromium (Ni-Cr) alloy (4 All, Ivoclar-Vivadent, Schann, Germany). The internal surfaces of the copings were examined by binocular loupes (HEINE HR-C 2.5 X, HEINE, Herrsching, Germany) and disclosing pastes (FiT checker; GC Corporation) to remove nodules and pressure spots. The copings were subsequently placed on the master dies, and then for baseline measurement (control), the distance between two indentations was measured and recorded by a digital microscope (AM 413 Fit Dino-Lite Pro; Dino-light, Taipei, Taiwan) mounted on a desktop stand. The digital microscope was connected to a computer and photographs were taken at × 80 magnification. Then, the bars were sectioned carefully at the center by a disk (Keystone GmbH, Werner-von-Siemens, Germany) which produced a gap distance of 0.5 mm. A new disk was used for each individual bar.

Half of the specimens ( $n = 10$ ) were indexed by a castable composite (Bredent, America Inc.) and the others by acrylic resin (GC Pattern, America, Inc.). The pattern resin was prepared by adding the powder to the monomer according to the manufacturer's recommendation, and the composite resin index was set with a visible-light source (600 mW/cm<sup>2</sup>, Coltolux 50, Swiss). The coping-bar assemblies were seated on the abutments with firm finger pressure until the indices were polymerized. Each specimen in each of the two groups ( $n = 10$  per each group) was

subjected to measurement for 3 times (at 1 min, then at 15 min, and finally after 24 h). In other words on the same specimen of the two tested groups for each period, 10 measurements were performed. Afterward, the mean value of ten measurements for each period was calculated. The same microscope and software were utilized to measure the distances between indentations at 15, 60 min, and 24 h after indexing.

**Statistical analysis**

Data were analyzed by SPSS 18 software (SPSS Inc., Chicago, IL, USA). Several-sample repeated measure ANOVA (RM-ANOVA) was applied to assess the effects of the material on the dimensional stability over time ( $\alpha = 0.05$ ).

**RESULTS**

RM-ANOVA showed a significant interaction effect between materials and time ( $P < 0.001$ ). Therefore, sub-group analysis was performed. In this context, two materials were compared by Student’s *t*-test at each time point. One-sample RM-ANOVA/Sidak test was used for within-material analysis.

The mean distance between indentations as a reference point was  $19.30 \pm 0.04$  mm before the bar sectioning (baseline measurement). Less distance was caused by both composite and acrylic resin materials than measurements which lacked indexing materials. All tested groups had significant differences in comparison with the control group except when it was indexed with composite and where the distances were measured after 15 and 60 min.

According to Table 1, there was a significantly greater mean dimensional stability of acrylic resin specimens after 15 and 60 min than the specimens after 24 h ( $P < 0.001$ ). However, there was no significant difference between 15 and 60 min ( $P = 0.073$ ).

In composite specimens, there was a significantly greater mean dimensional stability after 15 min compared with 24 h ( $P = 0.002$ ). Likewise, this difference was significant after 60 min and 24 h ( $P = 0.003$ ). However,

Table 1: Mean±standard deviation distance (mm) between tested materials			
Groups	15 min	60 min	24 h
Acrylic resin	19.27±0.087 <sup>A,a</sup>	19.25±0.09 <sup>A,a</sup>	18.98±0.1 <sup>A,b</sup>
Composite	19.29±0.08 <sup>A,a</sup>	19.28±0.08 <sup>A,a</sup>	19.26±0.08 <sup>B,b</sup>

In each column, different capital letters show significant differences (Student’s *t*-test). In each row, different lower-case letters show significant differences (one-sample repeated-measure-ANOVA/Sidak *post hoc* test)

the mean dimensional stability after 15 and 60 min did not show any significant differences ( $P = 0.13$ ).

The mean dimensional stability of acrylic resin and composite did not exhibit a significant difference after 15 min ( $P = 0.49$ ). Similarly, this difference between acrylic resin and composite was not significant after 60 min ( $P = 0.36$ ). However, the mean dimensional stability of composite resin was greater than acrylic resin ( $P < 0.001$ ), after 24 h. Figure 1 demonstrates mean profiles of distances between reference points of the tested groups.

**DISCUSSION**

Few studies have compared the accuracy of composite materials with acrylic resins and the time lapse between indexing with composite and investing. Thus, this study evaluated the relative accuracy of a castable composite and a pattern resin used to make soldering indexes for FPD or for implant-supported prostheses at 3 time periods. The results showed that soldering index made with castable composite was more accurate than pattern resin. However, castable composite, as an indexing material, should be invested preferably within 60 min.

Mojon *et al.*<sup>[20]</sup> assessed standard mixes of two self-cure resins and observed a  $7.9\% \pm 1.4\%$  polymerization contraction for Duralay resin and a  $6.5\% \pm 0.5\%$  contraction for Palavit G at 24 h. Another study reported that a 3 mm thick Duralay soldering index was dramatically more accurate than a 6 mm thick index.<sup>[18]</sup> In agreement with our study, Moon *et al.*<sup>[18]</sup> suggested that FPD units slated for soldering and indexed with acrylic resin material should be invested

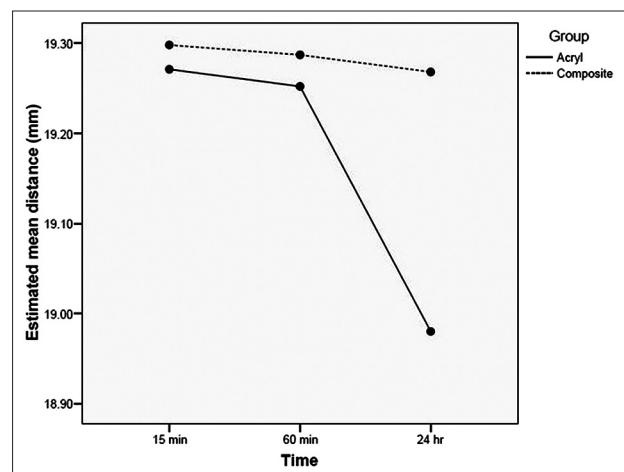


Figure 1: Mean profiles of distances between reference points of the tested groups

as soon as possible, preferably, within 1 h. Dixon *et al.*<sup>[21]</sup> concluded that the mean linear difference for 10 samples over a 24-h time interval was 0.373 mm. They also attributed such errors to polymerization contraction and possible dimensional change after polymerization that was related to stress release in the polymerized resin.

Ness *et al.*<sup>[22]</sup> determined that self-cure acrylic resin (Duralay) was less accurate in pattern fabrication than methyl methacrylate or ethyl methacrylate self-cure acrylic resins.

Cho and Chee<sup>[19]</sup> compared the dimensional accuracy and also the setting time of two self-cure resins (Duralay and GC pattern) and one light polymerizing resin (Unifast) used to connect castings for soldering. They obtained measurements immediately after polymerization of the materials. Although Duralay showed acceptable clinical results, one disadvantage was a prolonged setting time (7 min) compared to GC pattern (3 min). Therefore, GC pattern was used as indexing material in our study. In their study, the authors did not evaluate the dimensional accuracy of the tested indexing materials at other periods. However, in agreement with the current study, they found that all indexing materials immediately after polymerization resulted in a contraction of the distance between the resin-connected castings compared with the true distance. This difference was attributed to polymerization contraction of the indexing materials.<sup>[19]</sup>

In some previous studies, a gap distance of approximately 0.24 mm was considered for indexing and soldering of frameworks. Therefore, the resulted dimensional changes were considered too small to have a clinical significance.<sup>[3,18,19,21]</sup> These insignificant amounts of dimensional changes could be attributed to the small gap distances prepared in the laboratory (0.24 mm). However, due to the discrepancies in the framework's fit, their sectioning, and indexing protocol are occasionally mandatory in the clinic. Solder gap distances that range from 0.1 to 0.76 mm have been advocated for use,<sup>[21]</sup> because in most clinical situations, usually very narrow gap distances cannot be achieved easily. It is difficult to generate delicate gap distances in the clinic due to the number of insertions and removals of the disk along with vibration by the operator's hand and the disks. Therefore, a gap of 0.5 mm was chosen for this study. Further research is recommended to determine the clinical significance of this amount of gap distance.

The results of our study indicated that it is more efficient to select visible-light cure composites to index casting for solder because of the decreased setting time and dimensional accuracy of composite after 15, 60 min, and 24 h compared to acrylic resin. Faster setting time and dimensional stability during the indexing procedure could improve efficiency and productivity.

## CONCLUSIONS

Within the limitation of the present study it could be concluded that:

- Castable composite-indexed assemblies were more accurate in all tested periods of time compared to pattern acrylic resin
- Castable composite as an indexing material should be invested preferably within 60 min
- Because of the rapid setting time, it appeared more efficient to select composite as an indexing material.

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## Conflicts of interest

There are no conflicts of interest.

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