ACCURACY OF DIRECT COMPOSITE VENEERS VIA INJECTABLE RESIN COMPOSITE AND SILICON MATRICES IN COMPARISON TO DIAGNOSTIC WAX UP

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PURPOSE

The purpose of this study was to evaluate the discrepancy between the diagnostic wax-up and the resulting direct veneers with resin composite via different matrices. The null hypothesis of the present study was that there is no dimensional difference between the resulting restorations with the different techniques and the diagnostic wax-up.

MATERIALS AND METHOD

Casts Fabrication

For the purpose of the experiment, a unique plastic model with six misaligned anterior teeth (Dentalstore, Milano, Italy) was used to simulate a clinical case to be restored. The model was scanned with a laboratory scanner (3Shape E3, Copenhagen, Denmark). According to the manufacturer, the accuracy level was approximately □}7 µm. Then, the first cast was printed using a 3D printer (Asiga Max UV, Sydney, Australia) (Figure 4) with 62 µm pixel resolution and 100 µm layer thickness,

according to the manufacturer. The casting material was the 3D printer resin Optiprint Model, in golden brown color (Dentona, Dortmund, Germany).

G*Power 3.1.2 (Faul F., Erdfelder E., Lang A.G., Buchner A., Germany, Heinrich Heine University Dusseldorf, Germany) was used to compute the sample size needed for each group. For the sample size computation, the parameters used were: probability of type I error (two-tailed) 0.05; power 0.8; and effect size 0.5. The results indicated a mini- mum of 11 specimens in each group. Therefore, 12 specimens were fabricated for each of the 5 groups. The first printed cast was scanned and 48 identical specimens were 3D printed. Then, an additive digital wax-up was created on the 6 misaligned anterior teeth of the initial cast using EXOCAD. The next step was the 3D printing of 12 wax-up casts which constituted the control group and were used for the construction of the matrices (Figure 5). A second 3D-printed wax-up cast was produced by using the same software after the deactivation of every other tooth from the complete wax-up (Figure 6).

Before the restorative procedure, all specimens of the four researched groups and the control group were scanned, and the STL files were compared to the STL file of the initial printed cast, which was also scanned. This process was used for the measurement of the precision (repeatability) of the final measurements. Patient monitoring software (TRIOS Patient Monitoring 21.2 for Dental Desktop 1.7.27 3Shape, Copenhagen Denmark,) was used to compare STL files via superimposition. After the procedure, the inter-class corre- lation coefficient was estimated at 0.998, and the intra-class correlation coefficient was estimated at 0.882. The 3D-printed casts were stored in a dark room with stable temperature and humidity conditions. The temperature was adjusted to 20 °C and the humidity was 50%.

Matrices Construction

The 3D-printed casts that made up the control group were used for index construction. In an attempt to eliminate the effect of the matrix’s thickness on the final restorations, a clear tray designed in EXOCAD was 3D printed (Figure 7). The tray was designed to ensure a uniform matrix thickness of 6mm. A study regarding the effect of silicone thick- ness on the Shore hardness of elastomers showed that the

thickness should be at least 6 mm 43.
The tray had stops bilaterally on the first and second molars and one stop on the anterior palatal mucosa. The resulting matrices had a uniform thickness of 6mm and ex- tended to the second premolar at each side. All matrices were made of clear polyvinyl siloxane 60 Shore (Exaclear, GC Corporation, Tokyo, Japan). In total, 48 identical clear silicone matrices were constructed based on the complete wax-up models and 12 matrices based on the ‘every other tooth’ wax-up model. All matrices were constructed on the same day and were used for the restorations after 24 h for more complete polymerization reac- tion. The air temperature was 23 °C and the setting time on the model was 10 min.

Researched Groups

The restorative procedure for each technique was carried out as described below:

• Group 1: The direct veneers were made using the flowable resin composite GAenial universal injectable (GC Corporation, Tokyo, Japan) in A2 color. The matrices which were constructed on the complete wax up models were used. Small openings were made onto the matrices using a dispensing tip in the middle of the buccal surface, too close to the incisal edge, for the injection of

the flowable composite. After the fitting of the matrix the flowable resin composite was injected into the opening for every other tooth until the material filled the space for each veneer. The polymerization was performed (Bluephase Style light curing unit, Ivoclar, Vivadent) for 60 sec on each tooth at an intensity of 1100 mW/cm2. Then the matrix was removed to simulate the clinical procedure and additional polymerization was performed for 40 sec on each tooth. The matrix was seated again to restore the remaining three teeth.

• Group 2: The restorative procedure was as described above but there was one modification. The first three teeth were restored using the matrix constructed from the ‘every other tooth’ wax up model and the remaining three teeth restored by injecting composite through the matrix constructed from the complete wax up model.

• Group 3: In this group the matrices constructed on the complete wax up model were used. The matrices were cut at the interproximal of each tooth to achieve a matrix for every tooth and a small opening was created with the dispensing tip to allow the material flowing through. The veneers were constructed using the conventional hybrid resin composite Gradia Direct in A2 color (GC Corporation, Tokyo, Japan). The composite heating conditioner Ena Heat (MICERIUM, Italy) (voltage: 12V, current: 1A, power: 12W) was used to preheat the material. The selected heating temperature was 55°C and the weight of each resin composite dose was 0.15g, which was estimated via a pilot test to be enough for each veneer. The index loaded with composite was placed on the respective tooth by pressing palatally and buccally. Before light curing, the excesses were removed and after the polymerization process the same procedure was performed to restore the rest of the teeth.

• Group 4: The restorative procedure was as described above with an alteration. First, the silicone matrix was placed in the clear tray which was used for the matrix fabrication and then that combination loaded with composite resin was placed on each tooth.

• Group 5: The control group consisted of the printed wax-up models

The construction of the matrices, the execution of all restorative procedures and all measurements were accomplished by the same investigator (V.K.).

Quantitative Analysis
After the completion of the direct veneers of the four research groups, the specimens were scanned using the lab scanner and STL files were created. Those STL files were im- ported to the patient monitoring software (TRIOS Patient Monitoring) for data analysis. The superimposition process was used based on the unrestored posterior teeth's surfaces using three-point alignment. Best fit alignment was not used since it produced significantly higher alignment errors compared to the three-point alignment 44. The three points selected were on teeth #14, #17, and #26. By choosing the colorcoded 3D map, it was possible to verify the precise alignment of the two models. The posterior teeth had to be totally green, which meant differences between the models smaller than 0.30mm (Figure 8). Then, the width of the tooth was measured and a cross-section plane was vertically set to the labial surface and at the buccal-lingual direction, exactly in the middle of each anterior tooth (#13–23). At the tooth profile cross-section window, the contour tracings of the teeth were automatically carried out by the software and linear measurements of the aligned models were taken (Figure 9). This procedure has been previously published by Moldovani et al 45. Three measurements for each tooth were made at the labial surface: incisal, middle and 21 cervical. Finally, 1080 measurements were made. Three on every an- terior tooth (#13–23) for twelve models or each of the five groups. According to the manufacturer, the measurement uncertainty was 50 µm when the scans were materialized by using the intra oral scanner.
Statistical Analysis
The Shapiro-Wilk test was run to examine if the data were normally distributed ($p = 0.798$). As the data did not follow a normal distribution, the non-parametric Kruskal-Wallis test and the Dunn's post-hoc test were executed to compare the five groups for the incisal, middle and cervical thirds. The alpha level was set to 0.05 and significance values were adjusted by the Bonferroni correction for multiple tests. SPSS Statistics 26.0 (IBM Corp., Armonk, NY, USA) was used to carry out the statistical analysis.

CONCLUSIONS

1. The use of one or two clear silicone matrices and the injection of flowable resin com- posite (groups 1 and 2) resulted in direct veneers without statistically significant dis- crepancy compared to the diagnostic wax-up.
2. The technique with a clear matrix for each tooth combined with pre-heated resin composite (group 3) was the most inaccurate group at the incisal and middle third.
3. The use of the clear tray in combination with the matrix for each tooth and the pre- heated resin composite (group 4) improved the accuracy of the technique described in group 3.