Double-casting method for fixed prosthodontics with functionally generated path

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Statement of problem. The construction of precise fixed prostheses that are harmonious within the stomatognathic function has been regarded as a critical requirement for successful oral rehabilitation. However, techniques for construction have been unsuccessful in producing a prosthesis that can be inserted without intraoral occlusal adjustment.
Purpose. In this study, a new method of constructing a precise prosthesis that requires limited occlusal adjustment at the final seating is described.
Material and methods. The precision of this method was compared with a conventional method. Fourteen artificial crowns were fabricated on an experimental abutment by using both double-casting and conventional methods. The distances between the cusp tips and occlusal surfaces of the abutments, which were measured on wax/resin patterns and resultant crowns, were recorded to estimate clinical error for each method.
Results. Error for the double-casting method was markedly less than the conventional method. This study demonstrated that a new double-casting method was precise and sufficiently reliable for clinical application. (J Prosthet Dent 1998;79:120-24.)

CLINICAL IMPLICATIONS

This study presented an innovative technique for construction of fixed prostheses that require precise occlusion. This investigation also presented experimental data that supported the double-cast technique as a viable approach in accurately reproducing a difficult occlusal topography for a cast restoration. This method could be extremely useful for clinical conditions that require detailed occlusal adjustments of provisional restorations to ensure harmonious occlusion of the definitive restoration.

The construction of precise fixed prostheses should be in harmony with the stomatognathic system to ensure the quality of oral rehabilitation. Several special techniques, such as the functionally generated path (FGP) technique,[1,2] and CAD/CAM system[3,4] have been developed to meet these requirements.[5-7] However, there are no successful techniques for construction of cast prostheses that minimize intraoral occlusal adjustment.

DOUBLE-CASTING METHOD

The first step in a double-casting method is a base-crown made according to the conventional indirect method on a stone die (Fig. 1, *A*). A base-crown is a cast crown that has mechanical retention (retentive beads) on the occlusal surface rather than conventional occlusal anatomy. Proximal contact points are included in the base-crown. The base-crown is trial seated to the abutment and the proximal contact adjusted to the adjacent tooth.

After adjustment of the base-crown, the occlusion is functionally developed intraorally by molding autocuring acrylic resin (Uni-fast II, GC Corp., Tokyo, Japan) during mandibular excursions (Fig. 1, *B*). The function of the artificial crown can be verified by temporary cementation to the abutment for several days. After removal of the base-crown with the resin pattern from the mouth, it is sprued, invested, and cast. This second casting procedure is usually accomplished within a day and the final crown inserted the same day.

The purpose of this study is to report a new method of constructing a precise cast prosthesis that requires only limited occlusal adjustment at the final seating. The precision of this method is compared with a conventional method. A clinical situation is shown in Figure 2. Figure 2, *A* demonstrates the base-crown fitted to the abutment. The resin occlusal structure is illustrated in Figure 2, *B*, while the final crown cemented to the abut-

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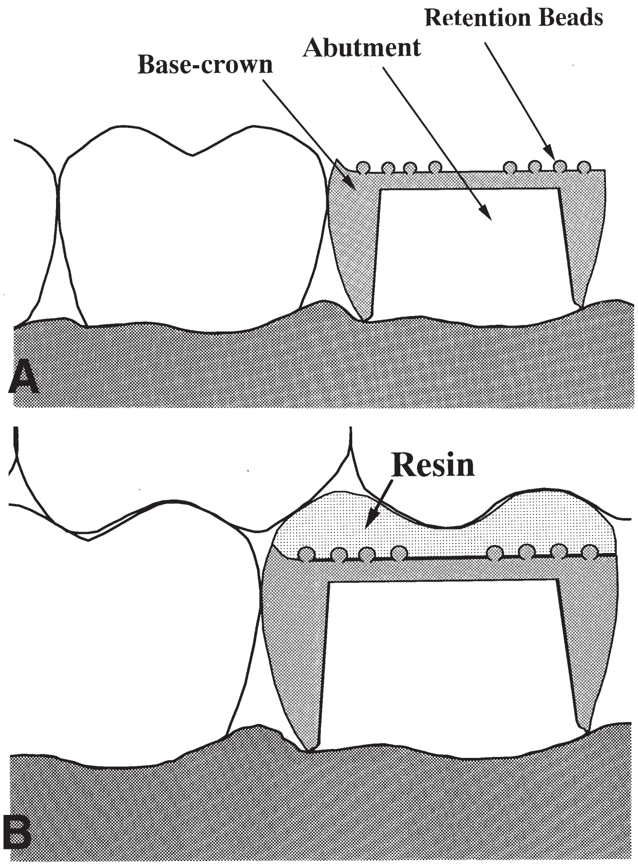

Fig. 1. Diagram of artificial crown fabricated by double-casting method. **A**, Base-crown fitted to abutment intraorally. Proximal contact with adjacent tooth was also adjusted. **B**, On occlusal surface of base-crown, occlusal structure is functionally developed intraorally by molding autocuring acrylic resin during functional movements of mandible.

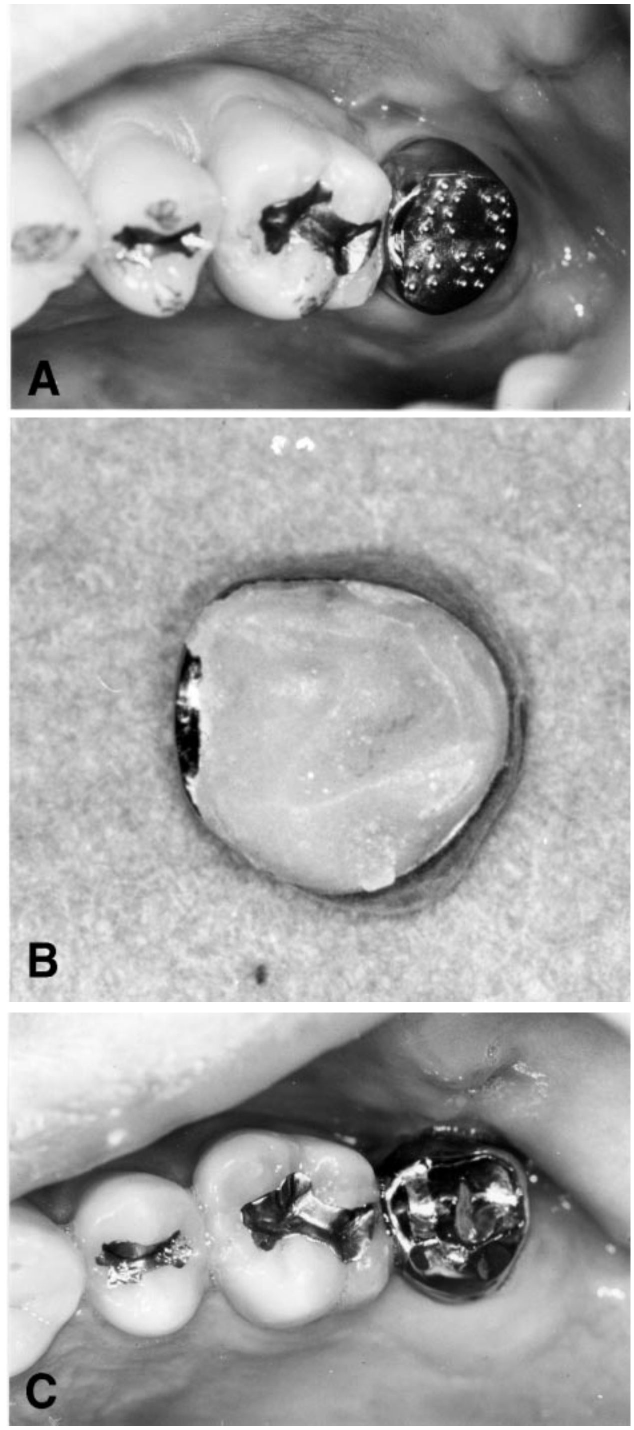

Fig. 2. Artificial crown fabricated by double-casting method. **A**, Base-crown fitted to abutment. **B**, Base-crown with resin occlusal structure. **C**, Final crown cemented to abutment.

ment is shown in Figure 2, *C*. Occlusal adjustment was unnecessary for this restoration.

MATERIAL AND METHODS

Master abutment

The master abutment was made of silver-gold-palladium (Ag-Au-Pd) alloy (Fig. 3) and was 4 mm in height with a taper angle to the axial wall of 6 degrees. Experimental artificial crowns were fabricated from this master abutment with the use of the conventional and double-casting methods. The accuracy of these two methods was evaluated by dimensional reproducibility of the occlusal anatomy.

Measurement of dimensional reproducibility

Double-casting method. Seven impressions were made of the master abutment with silicone rubber impression material (Exafine, GC Corp.) in individual trays. The impressions were cast in dental stone (Die Stone, Bayer, South Bend, Ind.), and seven working dies were made. The wax patterns of the base-crowns were developed on working dies with 28 gauge sheet wax to achieve an even thickness for the occlusal surface of each specimen. Retentive beads (Retention beads S, GC Corp.) were secured to the occlusal surfaces of the wax patterns. The wax patterns were then cast with Ag-Au-Pd alloy, and the casting of the base-crowns fitted to the master abutments.

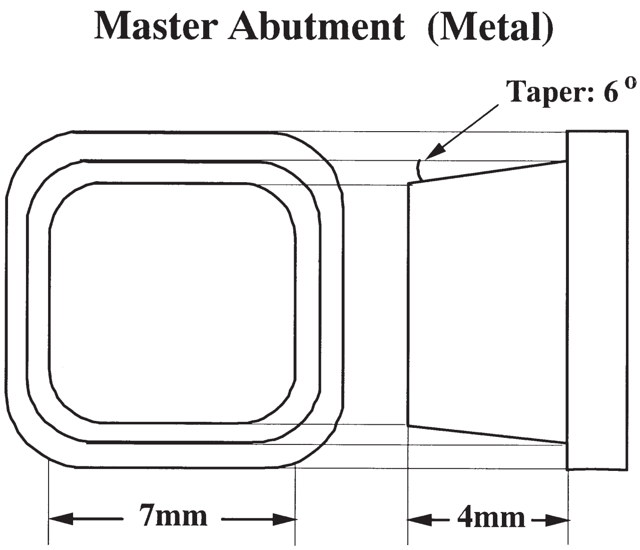

Fig. 3. Diagram of metal master abutment.

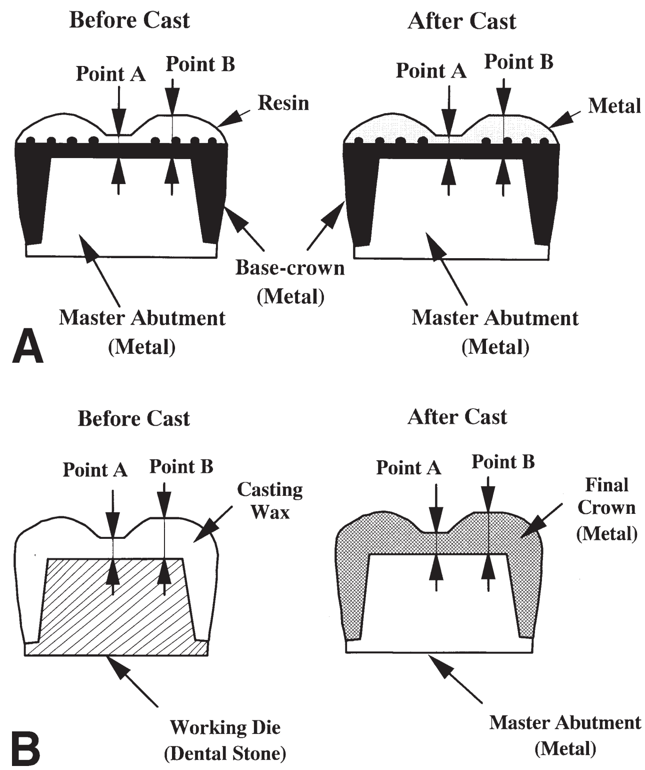

Fig. 4. Measuring points of vertical height of experimental cast crowns. **A**, Double-casting method. Heights of occlusal surface at points A and B were measured from superior surface of master abutment before and after second cast. **B**, Conventional method. Heights of occlusal surface of wax patterns at points A and B were measured from superior surface of working stone die before casting. Heights of metal crown at points A and B were measured from superior surface of master abutment after casting.

Each casting was fit to the master abutment until the shoulder margin of the base-crown fit the abutment. Nodules or imperfection inside the casting were detected with a stereomicroscope and were removed with carborundum points. A polyvinyl siloxane impression material (Fine Checker, Shofu Inc., Kyoto, Japan) was used to check the fit when necessary.

Autocuring resin (Uni-fast II, GC Corp.) was added to the occlusal surfaces of the base-crown to make the experimental occlusal surface (Fig. 4, *A*). The thicknesses at points A and B that included both base-crown and resin pattern were made approximately 1 mm and 1.5 mm, respectively. The heights of the occlusal surface at points A and B were measured from the superior surface of the master abutment with use of a Surfcorder instrument (SEF-30D, Kosaka Laboratory Ltd., Tokyo, Japan) whose measurement error was 0.25%. The master abutment was seated on the X-Y-Z table of the Surfcorder instrument with a relocating jig, and each height was measured with the contact rod. All height measurements were made by one examiner who was blind to the study design.

The resin patterns with base-crowns were sprued, invested, and cast with Ag-Au-Pd alloy after measurement of the heights. The double-cast specimens were seated on the abutment just after removing the investment without any additional fitting procedure. The heights of the occlusal surfaces were again measured on the double-cast specimens seated on the abutment. The accuracy was established as the difference at points A and B between heights and measurements recorded before and after the second casting.

Conventional method. Seven impressions were made from the master abutment with silicone rubber impression material (Exafine, GC Corp.) in individual trays. The impressions were cast in dental stone (Die Stone, Bayer), and seven working dies were made. A conventional wax pattern for a complete cast crown was formed on these working dies. The thickness of the wax patterns at points A and B were 1 mm and 1.5 mm, respectively. The heights of the occlusal surfaces of the wax patterns at each of the points A and B were measured from the superior surfaces of the working dies with use of the Surfcorder instrument. The wax patterns were sprued, invested, and cast with Ag-Au-Pd alloy after measurement of heights at point A and B. Each conventional crown was fitted to the working die until the shoulder margin of the crown fits to the die. Nodules or imperfection inside the casting were detected with stereomicroscope and were removed with carborundum point. Polyvinyl siloxane impression material for fit check was also used when necessary. Measurements were recorded again for the heights of the occlusal surfaces on the conventional crowns fitted to the master abutment.

Accuracy at points A and B was established as the difference between the height of wax patterns on the working dies and height of the cast crowns on the master abutment.

Statistical analysis

The F-test was used for evaluation of equal variance. The *t* test with Welch's correction was selected to estimate the difference of the mean value with different variance.

RESULTS

Dimensional change at point A before and after casting is shown in Figure 5, *A*. The mean dimensional change for the conventional method was 57 µm, and 3 µm for the double-casting method. The F-test revealed that variances for the two methods were unequal ($p < 0.05$). The *t* test with Welch's correction disclosed that the mean dimensional change for the double-casting method was significantly smaller than the conventional method ($p < 0.05$).

Dimensional change at point B before and after casting is displayed in Figure 5, *B*. The mean dimensional change for the conventional method was 48 µm and 7 µm for the double-casting method. Although no significant difference between the mean values were observed with the *t* test with Welch's correction, the F-test showed that the variances for the two methods were not recognized to be equal ($p < 0.001$). Therefore, for both points A and B, the double-casting method recorded substantially less variance than the conventional method.

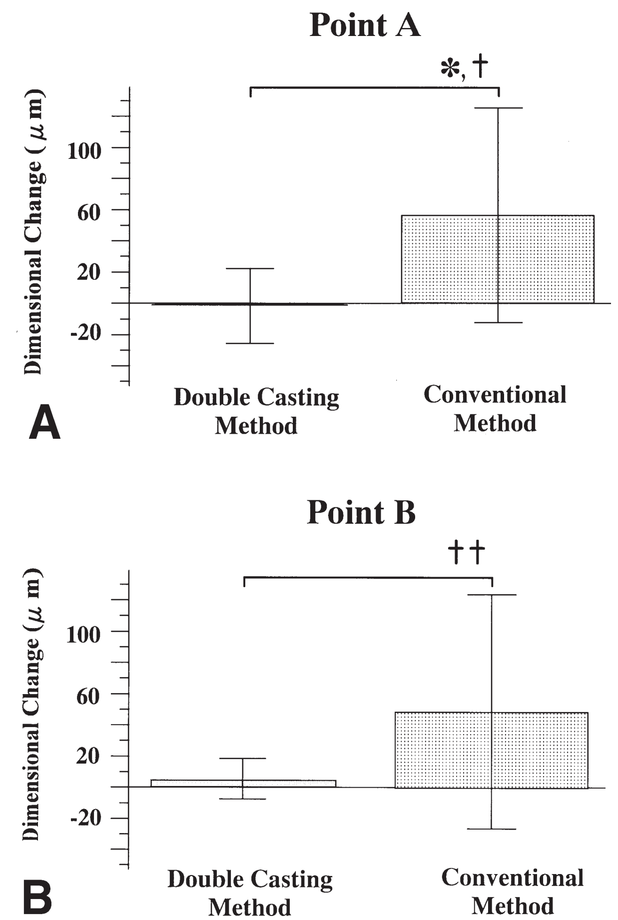

Fig. 5. Dimensional changes in height of occlusal surface. **A**, Dimensional change at point A. **B**, Dimensional change at point B. (*$p < 0.05$ by *t* test; +$p < 0.05$ by F-test; ++$p < 0.001$ by F-test.)

DISCUSSION

The indirect method of casting appears to be the most popular method for construction of cast prostheses. The conventional indirect method includes numerous steps, including impression making, occlusal registration, cast mounting, and so forth. Each step in the sequence of this method has inherent errors.[8] The merit of a double-casting method is inclusion of the error compensation step that enables achievement of a highly precise occlusion by eliminating inherent dimensional errors of the indirect method.

Error sources that affect the accuracy of occlusion and could be eliminated with use of a double-casting method are (1) deformation of impression, (2) distortion of occlusal registration material, (3) incorrect mounting of a cast to an articulator, (4) poor fit of cast prosthesis to an abutment, and (5) improper occlusion of the prosthesis. In this double-casting method, errors that originated from these sources can be addressed before occlusal surfaces were fabricated on the base-crown. Therefore errors that could affect final accuracy of the occlusion of double-cast restorations included only errors related to investing and casting of the second casting and the polishing process.

For the double-cast specimens, the reference measurement was first made on the abutment with occlusal resin structure after the fitting procedure of the base-crown to the abutment, and second on the abutment without any additional fitting procedure after the second cast. For the conventional specimens, the reference measurement was first made on the working die, and then on the abutment without fitting. However, each conventional specimen was fitted to the working die before the measurement on the abutment.

This study was designed to compare the overall clinical error in these two methods and to show how precisely the intentionally fabricated structures, which would be made on the abutment in the double-cast method and on the working die in the conventional method. This abutment would be reproduced on the final restoration in the mouth, which was simulated as the master abutment.

The dimensional change of the resultant prosthesis with use of the double-casting method was less than the conventional method (Fig. 5). In addition, the limited variance at points A and B not only verified the high accuracy of the occlusal surface but also the reliability of this method.

The disadvantages of this method are (1) surface roughness of the occlusal surface, which is an inherent property of the autopolymerizing resin, and (2) suffi-

cient space between the abutment and opposing teeth for a base-crown and metal occlusal structure. Cyanoacrylate adhesive was applied to the surfaces of the resin occlusal surface to remedy the first disadvantage. In a detailed study, Ghahremannezhad et al.[9] recorded the thickness of a cyanoacrylate layer on die stone in relation to the number of coats applied to the surface and reported the effect of cyanoacrylate adhesive on surface properties of die stone. According to this report, cyanoacrylate adhesive was applied four times to the resin occlusal surface to make a smoother surface and to provide space for polishing. The authors also stated that four applications of cyanoacrylates resulted in a film approximately 20 µm thick.[9] Although the second disadvantage could become critical with vital teeth, there are numerous situations where this method is applicable. Matsushita[8] evaluated the intraoral occlusal efficiency of conventionally constructed cast crowns and discovered the mean dimensional change of occlusal height was 111 µm, ranging from 32 µm to 217 µm. This value was almost twice the value recorded for the conventional method in this study. If the compensation for error of the double-casting method is considered, the dimensional change in occlusal height would remain less even with in vivo conditions. This improved occlusal accuracy was supported by this investigation. From this study, the double-casting method was accurate, reliable, and especially useful when precise reproduction of occlusion was anticipated.

CONCLUSIONS

The following conclusions were drawn from this study.

1. The clinical error for a double-casting method was significantly less than the conventional casting method.
2. The double-casting method was more reliable than the conventional casting method because of the minimal error observed for the double-casting method.

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