Effect of the ultrasonic insertion technique on the seating of composite inlays

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The seating of MOD composite inlays was determined before and after cementation with one of three cements of different viscosities. The seating was determined by measuring the axial discrepancy. Inlays were seated by strong finger pressure or by the ultrasonic insertion (USI) technique. The axial discrepancy of luted inlays varied between 115 μm and 472 μm. The axial discrepancy of inlays luted with finger pressure increased with the viscosity of the cement (Duo Cement < Twinlook < Sono-Cem). Inlays luted with the cement of lowest viscosity (Duo Cement) had seating values of similar magnitude irrespective of seating procedure. As compared with luting by finger pressure, use of the USI technique improved the seating of inlays luted with Twinlook and Sono-Cem (the cement of highest viscosity) to such an extent that the values of seating were of the same magnitude as those of inlays luted with Duo Cement. Consequently, the seatings of inlays cemented with the USI technique did not depend on the viscosity of the cement. □ *Dental materials; luting; resin cements*

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The demand for more esthetic restorations and the growing concern about mercury toxicity associated with dental amalgams have led to an increase in the use of resin composites in posterior teeth. However, posterior composite fillings are still considered to have several limitations, which tend to shorten the longevity of the fillings. These shortcomings are, notably, consequences of polymerization shrinkage and inadequate wear resistance (1, 2). In an attempt to overcome these limitations, the composite inlay was introduced (3). The inlay fabrication technique causes the polymerization shrinkage to occur during the construction of the inlay before cementation, and the only shrinkage that may occur in situ is that of the relatively thin layer of resin cement. Also, it was anticipated that the extraoral cure would lead to improved mechanical properties and wear resistance in response to an increased degree of conversion (4).

It seems that by use of the composite inlay concept it is possible to do away with some of the limitations of composite fillings. Thus, the marginal quality of composite inlays has been found to be excellent and to exceed that of composite fillings (5, 6). Also, extraoral curing with heat has resulted in improvements in mechanical properties and in vitro wear resistance (7–10). The improvements found vary from minor to significant depending on the property and study in question.

Along with the other types of adhesive inlays, composite inlays are luted with resin cements. To ensure adequate wetting of inlay and tooth and proper seating, the viscosity of resin cements is reduced as compared with resin composites. This is usually obtained through a reduction of the filler content, although the viscosity is also determined by factors such as type of filler and monomer composition. Mechanical properties and wear resistance are greatly influenced by the filler content (11). It has been found that resin cements wear more than the inlay materials themselves, leading to marginal ditching in vivo (12, 13). Noack et al. (14) have described how insertion of inlays by an ultrasonic device (the USI technique) makes possible the use of highly filled resin composites as luting cements, thereby eliminating the problem of marginal ditching. Because of the thixotropy of composites, the viscosity is reduced during activation of the ultrasonic device. This presumably leads to adequate wetting of the tooth and inlay and to proper seating of the inlay.

It was the aim of the present study to determine the effect of the USI technique on the seating of composite inlays luted with resin cement. Inlays were luted with one of three dual curing cements of different viscosities. One cement has been developed especially for the USI technique.

Materials and methods

Seating was expressed by means of axial discrepancy of inlays. A large axial discrepancy means poor seating.

To measure axial discrepancy, inlays were fabricated on a standard MOD cavity milled in brass (Fig. 1). After application of a separating medium (Dentacolor ADS-Gel; Heraeus Kulzer, Wehrheim, Germany) to the MOD cavity, composite resin (Brilliant Dentin; Coltène AG, Altstätten, Switzerland) was applied directly and polymerized for four 60-sec periods with a Visilux 2 unit (3M Company, St. Paul, Minn., USA). The inlay was removed from the brass model and cured for 7 min in a DI-500 light- and heat-curing oven (Coltène). The inlay was then seated on the brass model, and the axial discrepancy measured by means of a stereomicroscope (Ernst Leitz GmbH, Wetzlar, Germany; ×8; accuracy, approximately 3 μm). This was done by measuring the marginal opening at three sites along the cervical margin of each approximal box (Fig. 1). A mean value and standard deviation were computed to give the value of axial discrepancy of the inlay material itself. After removal of the inlay, one of three cements (Table 1) was mixed for 30 sec and applied to the inside of the inlay and to the cavity. The inlay was seated in one of two ways: a) by strong finger pressure (approximately 10 kg) or b) by application of a CEM instrument mounted in an Odontoson ultrasonic device (A/S L. Goof, Hørsholm, Denmark) at three different sites on the occlusal surface of the inlay. The Odontoson device operates at a frequency of 42,000 Hz and an amplitude of 0.01–0.02 mm. Thus, compared with other ultrasonic devices the frequency is relatively high and the amplitude relatively low. The Odontoson device has six different levels indicating an increasing amplitude. At the recommendation of the manufacturer, level 2, with an amplitude close to 0.01 mm, was used. The cementation procedure was in both cases maintained until no new resin cement emerged along the inlay margins (30–40 sec). Excess cement was removed, and the axial discrepancy was measured once more. Contrary to clinical practice, light-curing of the dual curing resin cements was

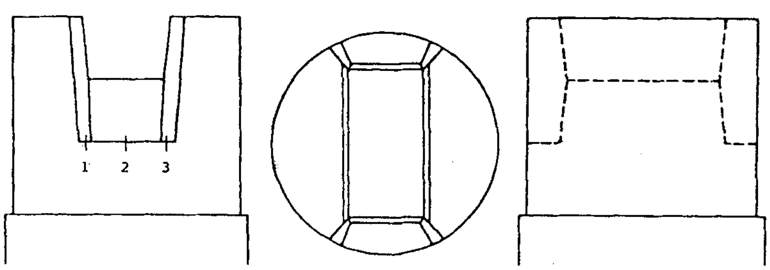

Fig. 1. Line drawing of MOD cavity milled in a brass cylinder with a diameter of 9.0 mm. MOD cavity: occlusal depth = 2.5 mm, approximal depth = 5.0 mm, occlusal width = 3.0 mm, and taper = 10°. Left = approximal aspect (marks 1–3 at the cervical margin indicate measuring sites), middle = occlusal aspect, and right = buccal aspect.

Table 1. List of resin cements used in the investigation

Name	Manufacturer	Filler content (% w/w)	Batch no.
Duo Cement	Coltène AG, Altstätten, Switzerland	74.0	Base: 230491-39
		74.0	Catalyst: 230491-39
Twinlook	Heraeus Kulzer GmbH, Wehrheim, Germany	76.8	Base: 032
		77.5	Catalyst: 032
Sono-Cem	ESPE GmbH, Seefeld, Germany	77.3	Base: 0001/1
		77.3	Catalyst: 0001

omitted to facilitate removal of luted inlays from the brass model.

Each of the six series consisted of five inlays. The statistical treatment of the results involved one-way analyses of variance and the Newman-Keuls multiple range test with $P = 0.05$ as the level of significance.

Results

The mean values and standard deviations of axial discrepancy of composite inlays before and after cementation are presented in Table 2 for both insertion techniques. Before cementation the axial discrepancy varied between 19 and 25 μm. The six mean values did not differ with statistical significance ($P > 0.05$) and were pooled to give 21 μm ± 4. After cementation the axial discrepancy varied between 115 and 472 μm. The six mean values were found to differ ($P < 0.005$). The Newman-Keul's multiple range test subsequently showed that the axial discrepancy obtained with Duo Cement without use of the USI technique did not differ from the axial discrepancy obtained with Duo Cement, Twinlook, and Sono-Cem *with* use of the USI technique. Without use of the USI technique the axial discrepancy was highest for Sono-Cem and lowest for Duo Cement.

Discussion

The axial discrepancy of inlays before cementation is a measure of the accuracy of the inlay itself. The axial discrepancy of 21 μm found in the present study agrees well with the axial discrepancy of 17 μm earlier measured with inlays of Brilliant Dentin (15). This implies that when using Brilliant Dentin one cannot produce cemented inlays with an axial discrepancy less than 21 μm in mean and that the axial discrepancy caused by the resin cements alone is 21 μm less than the values listed in Table 2.

Without use of the USI technique the highest degree of seating was, as expected,

Table 2. Axial discrepancy (μm) of composite inlays before and after cementation with or without use of the ultrasonic insertion (USI) technique; mean value and standard deviation

	Axial discrepancy (μm) – USA		Axial discrepancy (μm) + USI	
Cement	Before	After	Before	After
Duo Cement	19 ± 3	135 ± 19	20 ± 4	115 ± 21
Twinlook	24 ± 5	243 ± 17	25 ± 3	154 ± 11
Sono-Cem	20 ± 4	472 ± 45	22 ± 2	141 ± 25

obtained with the resin cement of lowest viscosity (Duo Cement). The poorest degree of seating was obtained with Sono-Cem, the most viscous cement tested. The USI technique did not improve the seating of inlays luted with Duo Cement as compared with seating by finger pressure. It thus seems that the viscosity of Duo Cement is sufficiently low to ensure maximum seating by finger pressure only. Use of the USI technique led to improved seating of inlays luted with either Twinlook or Sono-Cem. Consequently, inlays luted by use of the USI technique were seated to similar degrees irrespective of resin cement. This is well in agreement with the findings of Noack et al. (14) and reflects the fact that flow of the more highly filled cements was increased to a significant extent. It can be concluded that the USI technique resulted in a degree of seating of inlays luted with resin cements of high viscosity similar to that of inlays luted with a resin cement of lower viscosity. The present findings indicate that the USI technique may constitute a solution to the problem of marginal ditching caused by the use of resin cements of low filler content and inferior wear resistance.

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