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Research paper

Efficacy of experimental dual-cure resin cement for orthodontic direct bond system

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ABSTRACT

Chemical-cure resin cement has been widely used for orthodontics. To improve the clinical handling of chemical-cure resin cement, a dual-cure resin cement system composed of methyl methacrylate (MMA), urethane dimethacrylate (UDMA) and light activator was developed. The purpose of this study was to estimate the efficacy of an experimental dual-cure resin cement.

A composite bracket was bonded to the teeth with one of eight resin cements: (1) Unifast II (Uni II); (2) Unifast II containing camphor quinone (Uni II-CQ); (3) Transbond XT (TB); (4) Orthomite Superbond (SB); (5) Unifast LC (Uni-LC); (6–8) experimental dual-cure resin cement—Exp1, Exp2 and Exp3, respectively. Shear bond strength (SBS) of all of the bonded brackets was measured after the cementation.

The data were statistically divided, the highest cement (Uni-LC), the next group (Exp1, Exp2, Exp3 and SB) and the lowest group (Uni II, Uni II-CQ and TB).

The dual-cure resin cement exhibited a bonding efficacy comparable to that of Superbond.

1. Introduction

The direct bond system in clinical orthodontics was promoted by the development of the enamel bonding system. It was widely recognized that the enamel surface should be acid-etched prior to the direct bond to prepare the micro-undercut based on the enamel rod structure [1–6]. In addition, the adhesive surface treatment of the bracket should be varied depending upon the type of bracket materials. For acryl and porcelain brackets, the pretreatment using methylene chloride and silane-coupling agent was useful [7–9]. For metal brackets, the primer containing sulphate was reported to be useful [10,11]. However, clinical handling and the mechanical property of the cement still play an important role in the clinical performance of the direct bond system. Methyl methacrylate (MMA) containing 4-methacryloxyethyl trimellitate anhydride (4-META) activated by tri-butyl borane (TBB) has been widely used for the direct bond system. Recently, glass ionomer cement or resin composite cement was introduced in the market. From a clinical point of view, however, the initial polymerization of the

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4-META–MMA/TBB resin cement has required a long waiting time. Such a long setting time for chemical curing made the clinical manipulation of the direct bond system difficult and unwieldy.

The visible light curing system for resin composite was introduced to improve the clinical manipulation of resin composite restoration because the carving time of restoration was not limited until the start of irradiation. In addition, the dual-curing system, which contained tertiary amine and both of benzoyl per oxide and camphor quinone, was applied for the resin cement or the dentin bonding agent. The initial setting of the dual-cure resin cement was gradually started by mixing resin cement paste and then rapidly accelerated by light irradiation. These characteristics of dual-curing cement allowed for sufficient time to place the restoration in the right position and then rapid setting of the resin cement. Naturally, the question arose as to whether the dual-cure system could be applied for the direct bonding system for clinical orthodontics. The purpose of the present study was to examine the efficacy of experimental dual-cure resin cement for the direct bond system.

2. Materials and methods

Four commercially available resin cements and four experimental resin cements listed in Tables 1 and 2 were employed in this study. An experimental resin cement (Uni II-CQ) was prepared by adding camphor quinone in the Unifast II at the proportion of 7 wt.%. In addition, the three experimental resin cements (Exp1, Exp2 and Exp3) (GC, Tokyo, Japan) were prepared by MMA, urethane dimethacrylate (UDMA) and both of chemical and light activator. UDMA was employed as the component of the experimental resin cement because of the possibility that MMA was not polymerized by the light activator. In addition, UDMA did not increase the viscosity of the experimental resin cement significantly. The efficacy of these cements was evaluated by measuring the shear bond strength to flat human enamel.

2.1. *Shear bond strength measurement of the resin cement cylinder [12,13]*

An extracted human incisor was embedded in an epoxy resin with the flat facial enamel surface prepared on a silicone carbide paper with a grit number of 600 under running water. The enamel surface was etched with 35% phosphoric acid gel for 15 s followed by rinsing and drying. A split Teflon mold, inner diameter of 3.6 mm, outer diameter of 20.0 mm and 5.0 mm in height, was clamped on the enamel, and resin cement was used to fill in the center hole of the mold. For the light-cured and dual-cured materials, the cements were light irradiated with Candelux (J. Morita MFG Corp., Kyoto, Japan) from the top of the center hole of the mold for 15 s immediately after application of the resin cement. Five minutes after filling the resin cement, the Teflon mold was removed and the shear bond strength of the resin cement was measured by using a universal testing machine 1125-5500R (Instron, MA, USA) with a cross-head speed of 1 mm/min. Five specimens for each material were prepared.

Table 1 – Components of the commercial resin cement tested

	Components
Unifast II (Uni II)[a]	MMA, PMMA
Transbond XT (TB)[b]	Bis-GMA, TEGDMA, γ-MPTS, SiO_2, CQ
Superbond (SB)[c]	MMA, PMMA, TBB
Unifast LC (Uni-LC)[a]	MMA, PMMA

[a] GC, Tokyo, Japan.
[b] 3M Unitek, CA, USA.
[c] Sunmedical, Shiga, Japan.

Table 2 – Components of experimental dual-cured resin cements (Exp1, Exp2 and Exp3)

- Liquid
  MMA, N,*N*-DMPT, CQ
  UDMA 7.9% (Exp1), 13.2% (Exp2), 21.2% (Exp3)
- Powder
  MMA/EMA copolymer, BPO

2.2. *Shear bond strength measurement of the bracket bonded with resin cements*

The efficacy of using resin cement as a direct bond system was evaluated by measuring the shear bond strength of an orthodontic bracket bonded to human enamel with the resin cement. The flat enamel surface of an extracted human tooth was prepared as described above. The enamel surface was etched with 35% phosphoric acid gel for 15 s followed by rinsing and drying. The adhesive surface of the bracket was treated by ethylene chloride prior to the bonding. The resin cement was applied on the enamel surface, and the composite bracket was bonded on the resin cement using gentle hand pressure. Five minutes after cementation, the shear bond strength of the composite bracket with the resin cement was measured by using a universal testing machine 1125-5500R with a cross-head speed of 1 mm/min. Ten specimens were prepared for each of the eight resin cements that were described below.

The bond strength measured was statistically analyzed by Duncan's test ($p < 0.05$).

Key to types of resin cements tested:

1. Unifast II—Uni II;
2. Unifast II containing camphor quinone—Uni II-CQ;
3. Transbond XT—TB;
4. Orthomite Superbond—SB;
5. Unifast LC—Uni-LC;
6. Experimental dual-cure resin type 1—Exp1;
7. Experimental dual-cure resin type 2—Exp2;
8. Experimental dual-cure resin type 3—Exp3.

3. Results

For the SB specimen, the shear bond strength after 5 min was impossible to measure because the resin cement cylinder was