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Original article

A comparison of stress relaxation in temporary and permanent luting cements

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Abstract

Purpose: The stress relaxation and compressive strength of resin, resin-modified glass ionomer, glass ionomer, polycarboxylate, and zinc oxide eugenol cements were measured to determine the characteristics of these materials after setting.
Methods: A total of 19 luting cements including 12 permanent cements and 7 temporary cements were used. Cylindrical cement specimens (10 mm long and 6 mm in diameter) were obtained by chemical setting or light curing. The specimens were stored for 24–36 h in water at 37 °C and were then used for the stress relaxation and compression tests. The stress relaxation test was carried out using three constant cross-head speeds of 5, 50, and 100 mm/min. Upon reaching the preset dislocation of 0.5 mm, the cross-head movement was stopped, and the load was recorded for 60 s. Fractional stress loss at 1 s was calculated from the relaxation curves. The compressive strength and modulus were measured at a cross-head speed of 1 mm/min. Data were analyzed with the Kruskal–Wallis test and Holm's test.
Results: A zinc oxide eugenol cement [TempBOND NX] exhibited the largest fractional stress loss. A resin cement [ResiCem] showed the largest compressive strength, while a glass ionomer cement [HY-BOND GLASIONOMER CX] showed the largest compressive modulus among all tested cements ($p < 0.05$).
Conclusion: The fractional stress loss could not be classified by the cement type. Two implant cements [Multilink Implant and IP Temp Cement] showed similar properties with permanent resin cements and temporary glass ionomer cements, respectively. Careful consideration of the choice of cement is necessary.

Keywords: Stress relaxation; Luting cement; Compressive strength

1. Introduction

Temporary and permanent luting cements are placed between a tooth and a prosthesis to firmly attach the prosthesis to the tooth. Glass ionomer and resin cements are currently widely used as permanent luting cements. Many primers have been developed that are consistent with the chemical properties of the adherent and which are used with resin cements. Therefore, interest in cements and primers has increased, and many investigations have been reported [1–6].

Prostheses include inlays, crowns, fixed partial dentures, and implants. A limited amount of information is available to guide cement selection. Recently, the case of the implant is increasing. When an implant or fixed partial denture is fixed with cement, the durability of the prosthesis is affected by external forces. Some studies [7–9] have investigated implant choice in screw- and cement-retained restorations, but such implants lack a cushion layer, such as the periodontal ligament. Fixed partial dentures sometimes cause concentration of stress compared with a single crown. The release of stress when using these prostheses would reduce damage to the prosthesis, soft tissue, and teeth. The release of stress of cements can be obtained by measurements of stress relaxation.

Stress relaxation is defined as the time-dependent change in the stress of a material held at constant strain. Few studies have

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Table 1
Temporary and permanent luting cements used in this investigation.

Materials	Manufacturer	Type	Category	Code	Mixing ratio	Mixing time
Multilink Implant	Ivoclar Vivadent[a]	Resin	Permanent	MI	Isometry	20 s
CLEARFIL SA LUTING	Kuraray[b]	Resin	Permanent	CS	Isometry	20
Rely X Unicem2	3M ESPE[c]	Resin	Permanent	RU	Isometry	20
ResiCem	Shofu[d]	Resin	Permanent	RC	Isometry	20
SMARTCEM	Dentsply Sankin[e]	Resin	Permanent	SC	Isometry	20
Fuji LUTE	GC[f]	Resin modified GI	Permanent	FL	2.0 g:1.0 g	20
G-CEM	GC	Resin modified GI	Permanent	GC	2.0:1.0	20
HY-BOND RESIGLASS	Shofu	Resin modified GI	Permanent	HR	1.6:1.0	20
Fuji TEMP	GC	GI	Temporary	FT	Isometry	20
FujiISLOW SET	GC	GI	Permanent	FS	1.8:1.0	20
IP Temp Cement	Shofu	GI	Temporary	IT	1.8:1.0	15–15
HY-BOND GLASIONOMER CX	Shofu	GI	Permanent	HG	2.0:1.0	40
HY-BOND CARBO CEMENT	Shofu	Polycalboxylate	Permanent	HC	2.0:1.0	15–15
HY-BOND TEMPORARY (HARD)	Shofu	Polycalboxylate	Temporary	TH	1.8:1.0	10–10–10
HY-BOND TEMPORARY (SOFT)	Shofu	Polycalboxylate	Temporary	TS	2.2:1.0	15–15
LIVCARBO	GC	Polycalboxylate	Permanent	LC	2.0:1.0	15–15
HY-EUGENOL CEMENT	Shofu	Eugenol	Temporary	HY	1.1 g:0.25 ml	30
TempBOND	Kerr[g]	Eugenol	Temporary	TB	1:0.3	20
TempBOND NX	Kerr	Eugenol	Temporary	TN	1:0.3	20

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[b] Tokyo, Japan.
[c] Bavaria, Germany.
[d] Kyoto, Japan.
[e] Tokyo, Japan.
[f] Tokyo, Japan.
[g] Michigan, USA.

investigated stress relaxation in cements. Hertert et al. [10] reported on the temperature dependency of stress relaxation in three types of cement and Paddon et al. [11] studied the relaxation of three long-term cements. Subsequently, the effects of applying heat alone or heat and pressure on the compressive strength, modulus, stress relaxation characteristics, and fluoride release were examined using conventional and resin-modified glass ionomer cements [12]. The resulting stress relaxation times were long, ranging from 10 s to several hundred minutes. The relaxation time needed for the cushion layer must be shorter than these times, and the degree of stress relaxation is important. Rapid correspondence within 1 s is necessary for occlusal force and the prediction of accidental or impulsive force.

In this study, the stress relaxation behavior using three compression testing speeds and compressive properties of temporary and permanent luting cements, including resin, glass ionomer, polycarboxylate, and zinc oxide eugenol cements, were investigated. The hypothesis was that fractional stress loss depends on the type of luting cement.

2. Materials and methods

2.1. Preparation of test specimens

The 19 luting cements used in this study are shown in Table 1 with manufacturers, types, categories, codes, and mixing conditions. The materials were mixed according to the manufacturers' instructions. The mixed cement was then packed into a fluorocarbon polymer cylindrical mold (10 mm long and 6 mm in diameter) resting on polyethylene film. Once the mold was packed with cement, it was covered with another piece of polyethylene film. A glass plate was pressed onto the mold using manual pressure. The chemical-curing luting cement molds were kept in an incubator at 37 °C for 30 min. The dual-curing luting cement molds were placed in a light-curing unit (α-Light; Morita, Tokyo, Japan), lit twice from above and below for 3 min, and then kept in an incubator at 37 °C for 30 min. The test specimens were ejected from the molds, stored for 24–36 h in water at 37 °C, and then used for the stress relaxation and compression tests.

2.2. Stress relaxation test

The test specimens were placed in a water bath (ETB; TAITEC, Saitama, Japan) at 37 °C on a universal testing machine (TGE-5 kN; Minevea, Nagano, Japan), and the stress relaxation test was carried out by compressing the specimens using three constant cross-head speeds (5, 50, and 100 mm/min). After reaching the preset dislocation of 0.5 mm, the cross-head movement was stopped, and the load was recorded for 60 s. Fractional stress loss (SL) at 1 s was calculated from the obtained curves using the following equation [10]:

$$\mathrm{SL}\,(\%) = \frac{S_0 - S_1}{S_0} \times 100,$$

where S_0 is the maximum stress and S_1 is the stress at 1 s on the relaxation curves.