Fatigue resistance and crack propensity of novel "super-closed" sandwich composite resin restorations in large MOD defects

Pascal Magne, DMD, PhD
Associate Professor, The Don and Sybil Harrington Foundation Professor of Esthetic Dentistry, Herman Ostrow School of Dentistry, University of Southern California, USA

Silvana Silva, DMD, PhD
Private Practice, Florianopolis, Santa Catarina

Mauro de Andrada, DMD, PhD
Operative Dentistry, Federal University of Santa Catarina, Brazil

Hamilton Maia, DMD, PhD
Operative Dentistry, Federal University of Santa Catarina, Brazil

Correspondence to: Pascal Magne, DMD, PhD
Herman Ostrow School of Dentistry of USC, Division of Restorative Sciences, 925 West 34th Street, Room 382, Los Angeles, CA 90089; E-mail: magne@usc.edu

Abstract

Objectives: To assess the influence of conventional glass ionomer cement (GIC) vs resin-modified GIC (RMGIC) as a base material for novel, super-closed sandwich restorations (SCSR) and its effect on shrinkage-induced crack propensity and *in vitro* accelerated fatigue resistance.
Methods: A standardized MOD slot-type tooth preparation was applied to 30 extracted maxillary molars (5 mm depth/5 mm buccolingual width). A modified sandwich restoration was used, in which the enamel/dentin bonding agent was applied first (Optibond FL, Kerr), followed by a Ketac Molar (3M ESPE)(group KM, n = 15) or Fuji II LC (GC) (group FJ, n = 15) base, leaving 2 mm for composite resin material (Miris 2, Coltène-Whaledent). Shrinkage-induced enamel cracks were tracked with photography and transillumination. Samples were loaded until fracture or to a maximum of 185,000 cycles under isometric chewing (5 Hz), starting with a load of 200 N (5,000 X), followed by stages of 400, 600, 800, 1,000, 1,200, and 1,400 N at a maximum of 30,000 X each. Groups were compared using the life table survival analysis (α = .008, Bonferroni method).
Results: Group FJ showed the highest survival rate (40% intact specimens) but did not differ from group KM (20%) or traditional direct restorations (13%, previous data). SCSR generated less shrinkage-induced cracks. Most failures were re-restorable (above the cemento-enamel junction [CEJ]).
Conclusions: Inclusion of GIC/RMGIC bases under large direct SCSRs does not affect their fatigue strength but tends to decrease the shrinkage-induced crack propensity.
Clinical significance: The use of GIC/RMGIC bases and the SCSR is an easy way to minimize polymerization shrinkage stress in large MOD defects without weakening the restoration.
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Introduction

Adhesive dental restorative procedures rely on the use of modern bonding agents, which have been continuously improved. However, the high bond strength results, combined with the increased efficiency and intensity of polymerization lights, have added to the challenge of minimizing the effects of polymerization shrinkage on tooth structure.[1,2] Residual shrinkage stresses may in turn have detrimental effects when it comes to ensuring a high-quality, stable bonding layer.[3-5] Large intracoronal defects in posterior teeth are particularly challenging. This adverse configuration is explained by the high C-Factor,[4,6,7] reduced flow capacity,[8] and large volume of filling material.[9,10] Numerous clinical consequences are expected such as microleakage,[11,12] postoperative sensitivity,[13] cuspal deformation,[9,14] and the cracking of tooth structure.[15,16] It has therefore been suggested that the application of direct composite resin be limited to small and medium-size defects, and that luted restorations (inlays) be used for large, intracoronal restorations.[17,18] Direct restorations, however, remain a very successful socioeconomic alternative, even for large fillings.[19,20]

The sandwich restoration (SR), first introduced by McLean,[21,22] constituted a valuable solution that addressed the problem of shrinkage and poor dentin bond strength of earlier composite resin and adhesive formulations. By combining a glass-ionomer cement (GIC) as a dentin replacement with a composite resin as a covering "enamel," the amount of shrinking resin can be reduced, thus limiting the residual stress and contributing to better marginal sealing and interfacial adaptation,[21-24] as well as increased cuspal stability.[14] In the "open" SR, the glass ionomer is left exposed at the cervical margins. This localization is of particular importance because GIC has the capacity to release fluoride and inhibit dentin demineralization lesions compared to composite resin.[25] This specific feature was particularly useful during the 1980s due to the lack of efficient dentin adhesives.[26] Clinical studies about open SRs with traditional GIC demonstrated low success rates, and some authors advised against this type of treatment.[27,28] Several reasons account for those poor results. GICs suffer from dissolution and progressive volume loss due to their high susceptibility to early moisture contamination and to the proximal region's longer exposure to the acid environment, as compared, for example, to buccal restorations.[27,28] GIC also exhibits low flexural strength compared to composite resin materials, accounting for the many fractures found in the open SR group.[28] This prompted the replacement of GIC with resin-modified GIC (RMGIC) to improve the performance of SRs, resulting in even better marginal adaptation in dentin compared to teeth restored with compomers or dual-curing composite bases.[12,29,30,31] In some clinical studies, open SR with RMGIC yielded similar results to direct composite restorations after up to 9 years of evaluation.[13,32] Others have emphasized the low degree of postoperative sensitivity, and fewer incidence of caries recurrence.[33]

In the closed SR, the GIC/RMGIC base is totally confined within the preparation and does not extend to the margins. In a 6-year clinical evaluation, van Dijken[28] demonstrated the superiority of closed SRs (23.5% of failures) even when using a conventional GIC, compared to open SRs (needed replacement in 75% of cases). This configuration, when used with RMGIC, also demonstrates less microleakage compared to composite resin restoration alone.[34] From a practical standpoint, cracking of the GIC and internal gaps may develop as a consequence of dehydration before bonding procedures. Gaps may also result from the increased viscosity of the GIC/RMGICs, compared to resin bonding agents, which present optimal fluidity, intimate contact with dentin, and fewer gaps or voids.[14] Therefore, it was suggested to use a resin adhesive before the placement of the GIC/RMGIC.[35,36] Consequently, a logical evolution of the closed SR technique, suggested in the present article, is the so-called super-closed sandwich restoration (SCSR), resulting from the pre-hybridization of the dentin or immediate dentin sealing (IDS) technique[37,38] before placement of a base material. Not only has IDS proven to improve the bond strength of contemporary dentin adhesives, it also reduces gap formation and postoperative sensitivity in indirect restorations.[38,39] In the case of SRs, applying the low-shrinkage and low-thermal expansion GIC/RMGIC base after sealing the tooth with an enamel/dentin bonding agent (SCSR) presents the same advantages as with IDS, namely the isolation and separation of the bonded interface from the overlaying shrinking composite resin (Fig 1).

This research assessed the accelerated fatigue strength and shrinkage-induced enamel crack propensity of large class II mesial-occlusal-distal (MOD) SCSRs using GIC or RMGIC bases. The null hypotheses were that (1) no significant difference would be found between the two different base materials, and (2) no significant difference would be found between SRs and traditional composite resin restorations. These null hypotheses were tested by including previous data regarding large MOD composite resin restorations, and generated in strictly identical conditions by the same operators and authors.[16]

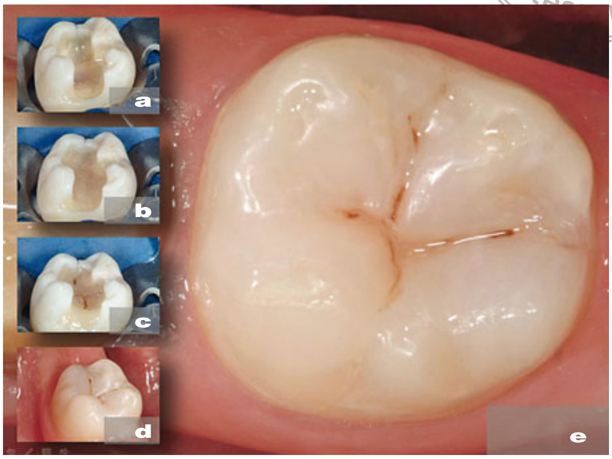

Fig 1 Clinical application of the SCSR. **(a)** Enamel-dentin bonding, **(b)** dentin buildup with a RMGIC, **(c)** dentin-like composite resin layer with stains, **(d)** enamel-like composite resin layer, and **(e)** postoperative view at 5 weeks, no cracks observed.

Materials and methods

Upon approval by the Ethics Committee of the Federal University of Santa Catarina, Brazil, and the Institutional Review Board of the University of Southern California, 30 extracted sound human third maxillary molars of similar size and shape were carefully selected from a large collection of teeth. They were scaled, pumiced, and stored in 0.1% thymol solution. Each tooth was mounted in a special positioning device using acrylic resin (Palapress, Heraeus Kulzer), embedding the root up to 3 mm below the cementoenamel junction (CEJ). For the purpose of "enamel crack tracking" during the experiment, each surface of each tooth was photographed at baseline under standardized conditions at x1.5 magnification (Nikon D50 and Sigma 105 mm macro lens) using a macro ring-flash (Sigma EM-140 DG). A second set of images was generated using transillumination (Microlux, AdDent) to detect existing cracks, and for the detection of new cracks following the subsequent procedures.

Specimen preparation

Standard preparations simulated the replacement of a large MOD restoration (Fig 2) using tapered diamond burs (313.029 and 314.021, Brasseler), and a 0.5 to 1 mm 45-degree bevel at the cervical and ascending proximal angles was created with a flame-shape fine diamond bur (274.011904U0, Brasseler) using continuous water cooling in a high-speed electric handpiece. After preparation, photographic enamel crack tracking was again performed to determine if preparation had caused any damage to the specimens. The teeth were then randomly distributed into two groups: KM (n = 15) – SCSR with GIC base (Ketac Molar, 3M ESPE) combined with direct microhybrid composite resin restoration (Miris 2, Coltène-Whaledent), and FJ (n = 15) – SCSR with RMGIC base (Fuji II LC, GC) and the same direct microhybrid composite resin restoration (Miris 2).

Restorative procedures

For both groups, a 3-step etch-and-rinse dentin bonding agent (Optibond FL, Kerr) was used, and light polymerized for 20 s at 1,000 mW/cm^2 (Valo, Ultradent). A standardized natural layering technique (enamel and dentin shades) was applied in seven increments (Fig 3). First, the proximal walls were raised with a 2-mm-thick dentin shade (Miris S2) increment, followed by a 2-mm-thick enamel shade (Miris NR) increment for the marginal ridge (Figs 3a and b). Approximately 50% of the remaining class I defect was then filled with either Ketac Molar (group KM) or Fuji II LC (group FJ) (Figs 3c and d). For both groups, the bases were delivered using encapsulated automixing systems, according to the respective manufacturers' instructions. To isolate and prevent desiccation of GIC/RMGIC bases, another layer of adhesive bond (bottle 2) was applied and light polymerized for 20 s (Figs 3e and f). Special care was taken to create a smooth GIC/RMGIC surface and obtain about 2 mm of occlusal clearance for the final layering with Miris 2 (oblique increments individually polymerized, first with dentin shade (Miris S2) increments, followed by enamel shade (Miris NR) (Figs 3g, h, i, and j). Special attention was given to strictly emulating the cuspal inclination and occlusal anatomy, with reference to CAD/CAM inlays from a previous study.[16] Each increment was polymerized for 20 s at

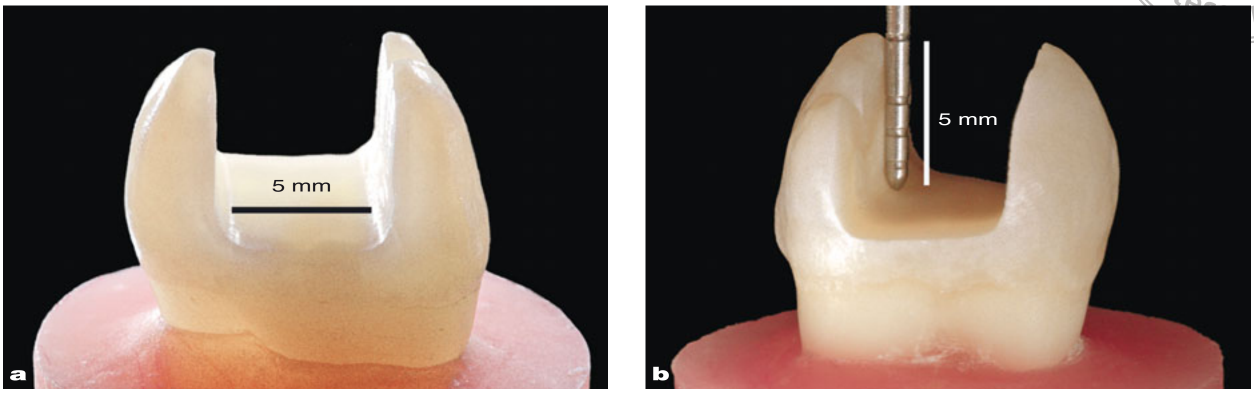

Fig 2 Standard MOD tooth preparation and corresponding measurements. **(a)** All preparations had 5 mm in buccopalatal width, and **(b)** 5 mm in depth.

1,000 mW/cm^2, and final light polymerization was performed for 10 s under an air-blocking barrier (KY Jelly, Johnson & Johnson). The restorations were finished and polished mechanically using tungsten carbide burs and composite resin polishers with diamond grit (kit 4477 Q-Polishing System, Komet).

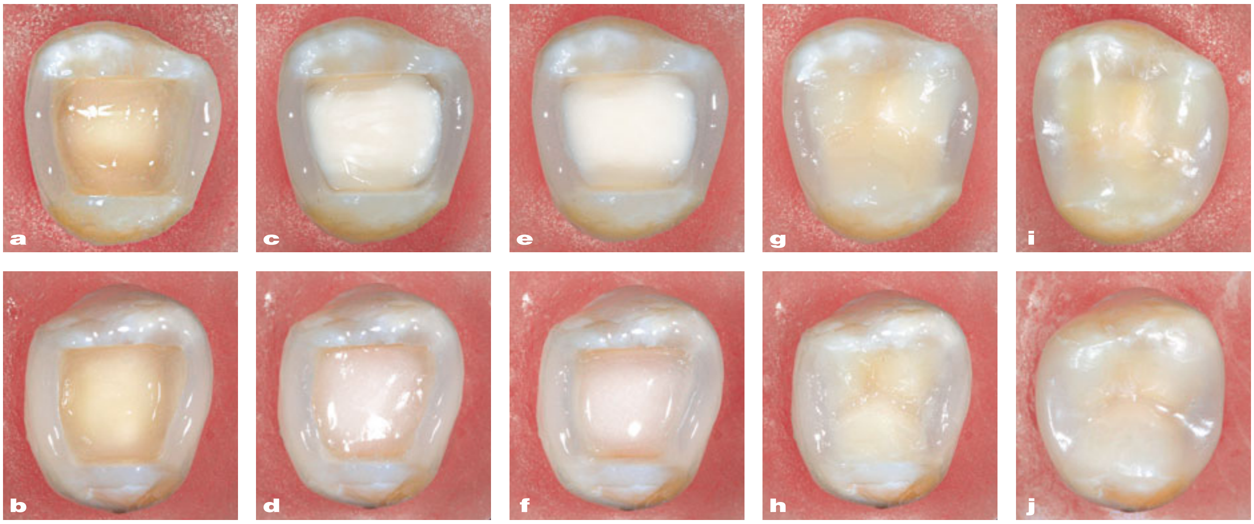

Fig 3 Standardized natural layering restorative technique for super-closed sandwich restoration (SCSR) groups (KM and FJ). **(a and b)** After the application of the dentin bonding agent (Optibond FL), the proximal walls were raised with dentin shade (Miris S2) and enamel shade (Miris NR) increments. **(c)** Approximately 50% of the remaining class I defect was then filled with either Ketac Molar (group KM) **(d)** or Fuji II LC (group FJ). **(e and f)** Application of adhesive bond (bottle 2) and light polymerization to prevent desiccation of GIC/RMGIC bases. The remaining occlusal clearance was built with oblique increments individually polymerized, first with dentin shade **(g and h)**, followed by enamel shade **(i and j)**, strictly emulating the models of reference.

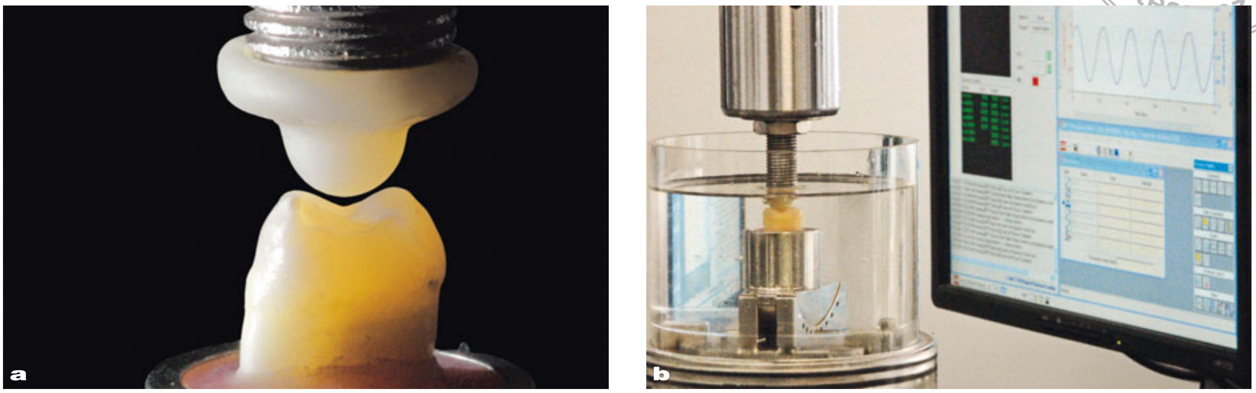

Fig 4 Fatigue test operation starts with **(a)** the positioning of the specimen under tripod contact using a post-polymerized antagonist composite resin sphere, and **(b)** the completion of the load chamber with distilled water to simulate a moist environment. During the isometric loading, the software in the attached computer controls the masticatory forces and records the endured cycles.

Fatigue testing

Restored specimens were kept in distilled water at ambient temperature for 1 week following adhesive procedures. Each tooth surface was then subjected again to enamel crack tracking (transillumination and photography). An artificial mouth using closed-loop servohydraulics (Mini Bionix II, MTS Systems) was used to simulate the masticatory forces with an antagonist 7-mm-diameter composite resin sphere (Filtek Z100, 3M ESPE) (Fig 4a) post polymerized at 100°C for 5 min.[40] These composite resin spheres contacted simultaneously and equally the mesiobuccal, distobuccal, and palatal cusps (tripod contact) with isometric chewing under a frequency of 5 Hz. The load chamber was filled with distilled water until the complete immersion of the specimens. The first 5,000 cycles was a warm-up load of 200 N, followed by stages of 400, 600, 800, 1,000, 1,200, and 1,400 N at a maximum of 30,000 cycles each (Fig 4b). Specimens were loaded until fracture or to a maximum of 185,000 cycles, and the number of endured cycles was registered. Under an optical microscope and with a two-examiner agreement, the distinction was made between restorable and nonrestorable fractures (Fig 5). A restorable fracture is usually above the CEJ, meaning that even in the case of major coronal substance loss, the tooth can be re-restored. A nonrestorable fracture involves a large portion of the tooth and extends below the CEJ.

Enamel crack detection and tracking

Specimens were evaluated 4 times during the experiment to detect new enamel cracks at x1.5 magnification in standardized conditions and with transillumination (Nikon D50 and Sigma 105 mm macro lens, using a macro ring-flash Sigma EM-140 DG or Microlux) before and after tooth preparation, 1 week after restoration, and at the end of the fatigue

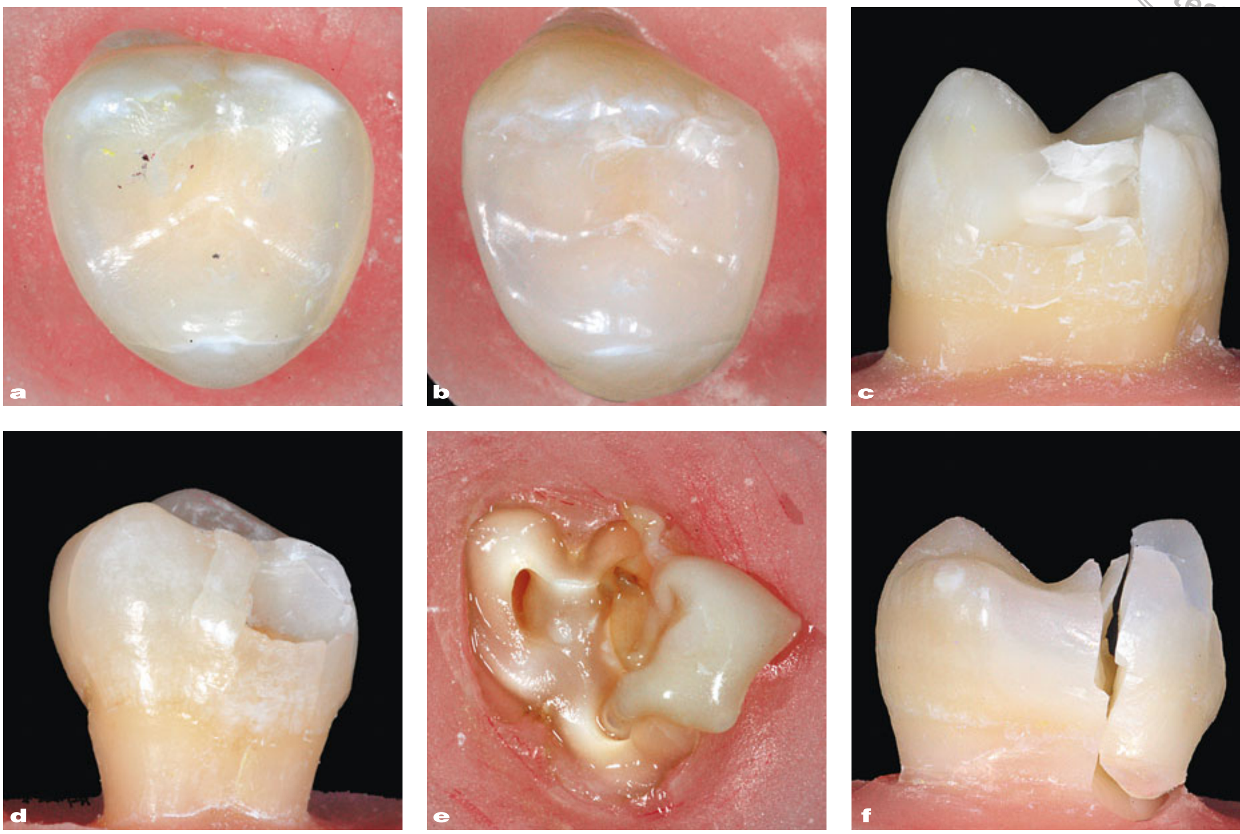

Fig 5 Examples of some specimens at the end of the fatigue test. **(a)** Survived sample of KM group, **(b)** survived sample of FJ group, **(c)** restorable fracture in KM group, **(d)** restorable fracture in FJ group, **(e)** nonrestorable fracture in KM group, **(f)** and nonrestorable fracture in FJ group.

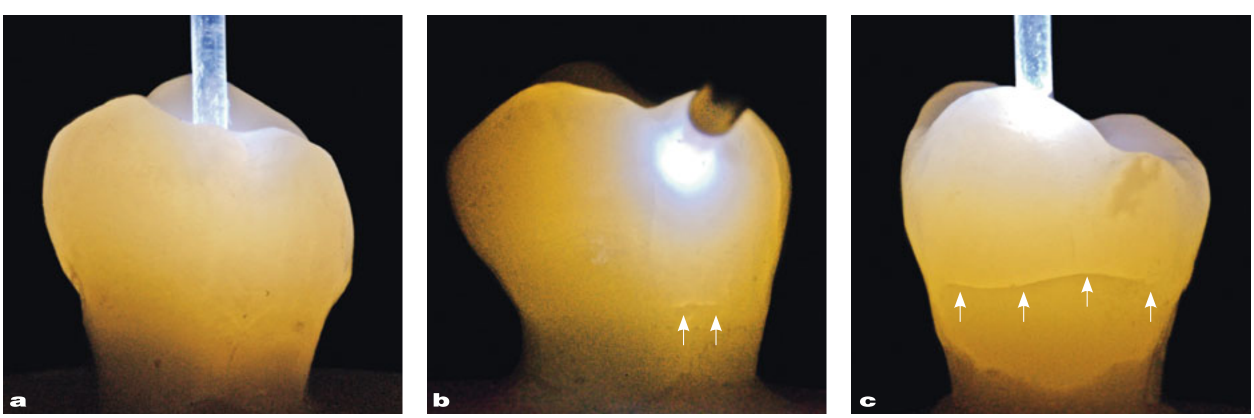

Fig 6 Examples of crack tracking with transillumination. **(a)** No visible cracks, **(b)** small visible crack measuring less than 3 mm, and **(c)** severe crack measuring more than 3 mm.

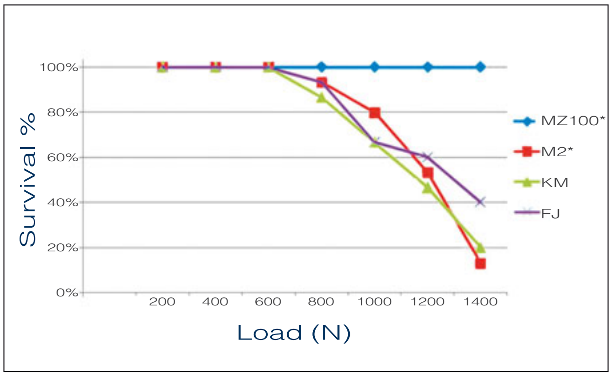

Fig 7 Life table survival distribution of groups at each load step (n = 15). *Data from previously published study.[16]

test. Where there was doubt, the sample was evaluated in a two-examiner agreement and analyzed under an optical microscope at 10:1 magnification (Leica MZ 125, Leica Microsystems). Special care was taken to differentiate between pre-existing cracks and those created by polymerization shrinkage. Since many different-sized cracks were observed, a classification with 3 categories was created: (a) no cracks visible, (b) visible cracks smaller than 3 mm, and (c) visible cracks larger than 3 mm (Fig 6).

Statistical analysis

The fatigue resistance of the two groups was compared using the life table survival analysis. At each time interval (defined by each load step), the number of specimens beginning the interval intact, and the number of fractured specimens during the interval were counted, providing the survival probability (%) at each load step. The influence of the base material on the fatigue resistance was observed, and the survival curves were compared using the log-rank test at a significance level of .05. Additional data were included from a previous study about large MOD composite resin restorations (generated in strictly identical conditions by the same operators and authors).[16] The life table survival analysis was used to compare the fatigue resistance of SRs (groups KM and FJ from the present study), traditional direct technique (group M2), and MZ100 CAD/CAM inlays (group MZ100). Pairwise post hoc comparisons were used to locate the differences at an alpha value of 0.008 (Bonferroni correction for 6 comparisons). The data were analyzed with statistical software MedCalc v. 11.6.1.0 (MedCalc Software).

Results

Life table survival analysis (Table 1) of groups KM and FJ did not reveal significant differences (*P* = .296). Inclusion of previous data (MZ100 and M2 groups), however, demonstrated significant outcomes (*P* <.001). Table 1 presents all the pairwise post hoc comparisons with the log-rank test. SRs made with RMGIC (group FJ) showed the highest survival rate among direct techniques (40% intact specimens) but did not differ from group KM (survival 20%, *P* = .296) or traditional direct restorations (survival 13%, previous data, *P* = .787) (Fig 7). Both SRs (KM and FJ groups) generated less shrinkage-induced cracks (Table 2). None of the direct techniques reached the performance of MZ100 inlays (no failures and almost no cracks). Most failures were re-restorable (above the CEJ) (Figs 5c and d), with only 1

Table 1 Pairwise post hoc comparisons with the log-rank test

	MZ100*	M2*	KM	FJ
MZ100*		< .001	< .001	< .001
M2*			0.787	0.205
KM				0.296
FJ				–

* From previously published data.[16]
Significant differences between materials for *P* values < .008 (Bonferroni – corrected for 6 comparisons).

Table 2 Crack propensity after 1 week of restoration and before fatigue test

Group	No cracks	Cracks of less than 3 mm	Cracks of more than 3 mm
MZ100 (n = 15)*	14 (93%)	1 (7%)	0 (0%)
M2 (n = 15)*	8 (53%)	1 (7%)	6 (40%)
KM (n = 15)	10 (67%)	3 (20%)	2 (13%)
FJ (n = 15)	9 (60%)	2 (13%)	4 (27%)

* From previously published data.[16]

Table 3 Failure types, numbers, and percentages

Group	Intact specimen	Fracture above CEJ or restorable	Fracture below CEJ or nonrestorable
MZ100 (n = 15)*	15 (100%)	0 (0%)	0 (0%)
M2 (n = 15)*	2 (13%)	10 (67%)	3 (20%)
KM (n = 15)	3 (20%)	9 (60%)	3 (20%)
FJ (n = 15)	6 (40%)	8 (53%)	1 (7%)

* From previously published data.[16]

specimen in group FJ fracturing below the CEJ (vs 3 specimens in group KM, and 3 for traditional direct restorations) (Table 3) (Figs 5e and f).

Discussion

Within the limitations of this *in vitro* study, the first null hypothesis was confirmed. No significant difference in survival was found between the three direct techniques, even though FJ presented 40% of intact specimens (vs 20% in KM, and 13% in M2), and only one nonrestorable fracture (vs 3 for KM and M2). The second null hypothesis can be rejected, in part because MZ100 composite resin inlays significantly increased the fatigue resistance of large class II MOD defects when compared to the direct composite resin restorations (traditional or SR) using Miris 2, and also because traditional composite resin restorations (M2) showed a higher crack propensity and more severe enamel cracks compared to all the other groups.

Based on the main reasons for failure of composites and the clinical experience derived from the use of these materials, the fatigue resistance mechanical test is important in predicting clinical performance, especially because it is likely that most materials fail due to accumulated damage from cyclic loading in the oral cavity rather than a single loading event.[41] The closed-loop servohydraulics used in the present study closely reproduces physiologic human mastication, since it provides constant feedback like the neuromuscular system and indicates an excellent agreement with clinical data.[42] Clinical studies are not only time-consuming and expensive but also challenging to design because of the influence of patients' masticatory and dietary habits, individual caries susceptibility, and the need for multiple operators and evaluators.[19,43] In the present study, due to the high level of standardization procedures (tooth dimensions, tooth preparations, loading protocol, occlusal anatomy developed by a single operator), it was possible to considerably limit the amount of confounding variables, and obtain significant results in an extremely timely fashion. The accelerated fatigue protocol, originally introduced by Fennis et al,[44] is an intermediate test between the simple load-to-failure experiment and classical fatigue tests.[40,45-47] In a hyperactive dental marketplace where new products are plethoric and often short-lived, it is extremely important to have such a bench test in order to obtain fast and valuable evaluations about the biomechanical behavior of new materials and techniques used with actual teeth and placed in a challenging simulated masticatory environment. The innovative load protocol covers physiological masticatory forces (8 to 880 N) in the first half of the test,[48] and extends with above-maximum bites forces[49,50] in the second half, accounting for extreme trauma and masticatory accidents.

Survival of specimens following 1,400 N of forces at the end of the experiment is also an indication of the behavior of the material/technique when used in more challenging situations, such as bruxism patients, where failures of inlays made of direct composite resins and SRs are observed.[28] In that sense, it appears that MZ100 inlays would stand as a reference, which is in agreement with existing data produced in similar conditions and showing the absence of catastrophic failures when using even thin MZ100 occlusal veneers.[51,52] Clinically, MZ100 even proved superior to ceramic inlays in their color-matching ability.[53] Despite their outstanding performances, luted indirect restorations must often give way to more socioeconomic solutions. Direct techniques, including SRs, are easier and faster to perform,[33] and have the ability to provide very good services.[19,20,54-56] Large direct restorations (excluding SRs) exceeded the performances of amalgams in a 12-year clinical study,[19] especially regarding their cumulated rate of tooth fracture, restoration fracture, and cracked tooth (2.3% vs 11.3% for amalgams). According to the results of the present study, it seems that the inclusion of a GIC/RMGIC base as a stress reliever for the polymerization shrinkage (or nonshrinking "megafiller") does not affect the survival of large direct restorations. This result is somewhat surprising, considering GIC and RMGIC have inferior mechanical properties compared to composite resins.[57,58] Possibly, the bad reputation of GICs regarding mechanical performance is due to an immediate occurrence of mastication stresses on restorations. The best mechanical properties are limited over time, as in Ketac Molar, which improves its mechanical properties during water storage.[59]

There are several elements that may explain the relatively good behavior of SRs in the present work. First, the clinical delivery of GIC/RMGIC has been improved significantly with the advent of encapsulated automixing systems, decreasing the porosity and improving the mechanical properties.[60,61] Intraoral delivery directly from the capsule with a fine tip also makes it very easy to place, even in undercut preparations. Second, the use of the SCSR technique may have improved the mechanical properties of the GIC/RMGIC when placed after bonding procedures. Cracking of the GIC and internal gaps commonly develop as a consequence of desiccation following enamel etching and drying, before bonding procedures. Dietrich et al[30,62] concluded that etching should be performed prior to the application of RMGIC, but advised about the problem of enamel contamination by the conditioner or primer of the RMGIC. These authors suggest that using a single adhesive system for both restorative materials would make the SR technique less complicated. For conventional GICs, inadvertent etching may also reduce the bond strength to dentin.[63] All these difficulties are resolved when using Optibond FL for dentin prehybridization (before GIC/RMGIC placement) because it acts like a flowable liner.[37] Dentin bonding agents present optimal fluidity, intimate contact with dentin, and fewer gaps or voids, unlike those resulting from the increased viscosity of GIC/RMGIC.[14] Optimal properties of GIC are obtained when it is placed under perfect moisture control. The preliminary enamel–dentin bonding assures a perfectly isolated field. The surface of the freshly placed GIC/RMGIC was immediately covered with Optibond FL adhesive, and light polymerized. This may have contributed to improving the mechanical properties of the GIC due to the heat generated by the polymerization light.[64] Third, the layering concept was carefully selected to facilitate the placement of the base. It is advisable to start building the proximal walls of the defect with composite resin (converting the class II into a class I defect), and defining a confined volume for the application of the GIC/RMGIC. At least 2 mm of occlusal clearance was kept for the overlaying composite resin. Lack of occlusal thickness of composite resin may explain some of the mediocre results of SRs reported in some clinical studies.[27,28] Fourth, accelerated water sorption of RMGIC, which is a known phenomenon of resin-based materials, may have compensated for the shrinkage stress, hence allowing for the reversal of the negative effects of shrinkage cracks. In fact, polymerization shrinkage can be totally compensated for by hygroscopic expansion within 4 weeks in teeth restored with hydrophobic composite resin, but can occur in only 1 week with RMGIC.[31,65] The "stress reversing" effect of water sorption might not have been possible in group M2 because specimens were tested in accelerated fatigue only 1 week after restoration placement. There is a concern that excessive water sorption-induced expansion of RMGIC might overcompensate for shrinkage deformation and cause serious structural challenge to the long-term survival of the restored tooth.[65] However, it can be hypothesized that the use of the SCSR in the present work limited this phenomenon due to the isolation of the RMGIC by the surrounding composite resin and dentin bonding agent.

Unlike fully bonded and fully layered large direct composite resin restorations, SCSRs allow the protection of the bond because, in case of excessive stresses, the failure site is unlikely to be located at the dentin–resin interface.[36] This concept, also called selective bonding,[66] seems to work well when using chemically cured GIC, to prevent adherence with the composite resin and allow a free surface to be created, reducing the C-factor and minimizing the risks of postoperative sensitivity. This did not seem to be a limitation with Fuji II LC in the present experiment, as is witnessed by the almost identical number of postoperative shrinkage-induced cracks when compared to Ketac Molar. Fuji II LC presents improved properties, which make it successfully applicable even for the open-sandwich technique.[31] With an elastic modulus of 10 GPa,[67] it seems to be an excellent dentin substitute. As far as failure mode is concerned, the FJ group resulted in the least amount of unrestorable failures (only 1 specimen). This result, along with its highest survival among direct techniques (40%), make it the first choice for closed SRs. Closed SRs using a RMGIC also represent a valuable method for securing peripheral sealing of the definitive restoration for pulp therapy, and prevent pulpal exposures when dealing with deep caries lesions.[68-70] Further studies should evaluate adaptation and microleakage of the novel SCSR compared to regular closed SR, as well as the use of newer "nano-ionomers" and bulk-fill low-stress flowable composites.[71]

Conclusions

It is suggested that the inclusion of GIC/RMGIC bases under large MOD direct composite resin restorations (SCSR) does not affect their fatigue strength and tends to decrease the shrinkage-induced enamel crack propensity. Most failures were re-restorable (above the CEJ), with only 1 specimen in group FJ fracturing below the CEJ (vs 3 specimens in group KM, and 3 for traditional direct restorations). None of the direct techniques tested in this experiment could match the outstanding behavior of composite resin inlays (MZ100), which remain the gold standard regarding strength and cuspal stability, although indirect techniques may cost 4 to 5 times the value of direct composite restorations.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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