"ESTIMATING THE RELEASE OF BISPHENOL-A FROM VARIOUS BULK-FILL COMPOSITES WITH AND WITHOUT POLISHING: AN IN VITRO STUDY"

"Bisphenol-A Release from Bulk-Fill Composites: Effect of Polishing"

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***Abstract*—**

BACKGROUND AND OBJECTIVES: This study estimates the in-vitro release of bisphenol-A (BPA) from Tetric Evoceram, Posterior EverX GC, and SDR Flow Plus bulk-fill composites: a) before polishing, b) 24h after polishing, and c) 72h after polishing.

MATERIALS AND METHODS: Twelve specimens (4mm diameter, 3mm height) from each composite were prepared. Polymerization was done using a 3M ESPE- Elipar LED light curing unit. Specimens were split into two groups:

- **GROUP 1 (n=6): Immersed in 2ml of 75% ethanol.**
- **GROUP 2 (n=6): Polished and then immersed in 2ml of 75% ethanol.**

Specimens were stored for 24h, then for 3 more days. BPA levels were measured using High-Performance Liquid Chromatography (HPLC).

RESULTS: All composites released BPA, with higher levels at 24h than at 3 days. Polished groups showed lower BPA release than unpolished. Tetric Evoceram released more BPA than EverX Posterior and SDR Flow Plus.

CONCLUSION: BPA release decreased over time and with polishing. Tetric Evoceram showed higher BPA release than the other composites.

***Index Terms*— (Keywords)**

Bisphenol A, BisGMA, TEGDMA, High Performance Liquid chromatography, EverX Posterior, SDR flow plus, Tetric Evoceram, Monomer release, ethanol, polishing

I. INTRODUCTION (HEADING 1)

Dental composite resins are frequently used to restore decaying, broken, and poorly shaped teeth. Their popularity has increased due to ongoing advancements in durability, resistance, aesthetics, ease of use, translucency, and polishability[1]. But the common drawbacks of dental composites include polymerization shrinkage and high residual monomer content[2]. Dentists use incremental placement techniques to manage polymerization shrinkage, but this method is time-consuming and risks contamination during each increment[3]

Recently, "bulk fill" resin-based composites have been introduced to save clinical chairside time. Their unique advantage is that they can be placed and cured in 4-mm increments without adverse effects on polymerization shrinkage[4]. These materials adhere well to tooth structure and set quickly, especially when photoactivated[5].

Bisphenol A (BPA) is a synthetic chemical used in the production of polycarbonates and epoxy resins. It is widely used in plastic products like food-storage containers, water bottles, bottle tops, and epoxy resin linings of metal food cans[6]. Toys, water bottles, eyeglass lenses, and CDs are made of polycarbonates. People are exposed to BPA daily, often without realizing it.[7]

Bisphenol-A (BPA), an endocrine-disrupting chemical, was first synthesized about a century ago. Its estrogenic effects were discovered in the 1930s[8]. Scientists first identified BPA leaking from polycarbonates in the early 1990s, prompting further investigation into its potential negative effects. [9] Due to varying toxico-kinetics between species, most BPA research is done experimentally, with debate over how well rodent study results apply to humans[10].

Dental filling products made of resin are another way to be exposed to BPA.[6] Olea et al. (1996) raised concerns about the potential estrogenicity of dental materials by studying significant BPA leakage from dental sealants into patients' saliva and called for further research.[11] A second study by Fung et al. found that BPA released from a dental sealant may either not be absorbed or be present in systemic circulation at undetectable levels. [12]

In 1999, Rueggeberg concluded that using a mild abrasive (pumice) with mechanical energy (such as a hand scrub with a cotton roll or an air-driven prophylaxis cup) is the most effective way to reduce monomer release.[13] However, at present newer composite polishing kits which produces better results are available in the market.

The objective of this in-vitro study is to measure the amount of bisphenol-A (BPA) released from three nanohybrid bulk-fill composite resins—Tetric Evoceram, Posterior EverX GC, and SDR Flow Plus—with and without polishing.

MATERIALS AND METHODS :

Three composite resins—Tetric Evoceram, Posterior EverX GC, and SDR Flow Plus—were used to prepare 36 specimens (12 each). Standard molds (4 mm diameter, 3 mm height) on a glass plate with a transparent matrix strip underneath were filled with the composite, covered with another strip, and polymerized using a 3M ESPE Elipar LED light curing unit (430-480 nm) for 40 seconds, with the light tip 1 cm from the strip.

FIGURE 1 – A. preparation of specimen, B. specimens from posterior everx gc, C. specimens from sdr flow plus, D. specimens from tetric evoceram, E. specimens from all the three bulk fill composites

Post-polymerization, specimens were divided into two groups for each composite:

- **Group 1 (n=6):** Immersed directly in 2 ml of 75% ethanol solution.
- **Group 2 (n=6):** Polished with pumice slurry and Shofu's silicone points for 30 seconds before immersion in 2 ml of 75% ethanol.

Samples were stored at room temperature for 24 hours, then the medium was changed and storage continued for an additional three days.

Bisphenol-A release was analyzed using high-performance liquid chromatography (HPLC) after 24 hours and three days. The mobile phase was acetonitrile/water (75/25% v/v), with detection at 254 nm over 30 minutes. Standard chromatograms were obtained by injecting 20 µL of the solution into the HPLC.

SAMPLE SIZE ESTIMATION

Based on Ankit R Sanjani's study on monomer leaching from bulk fill composites, to detect a 5.5 difference in mean monomer release between groups with 95% confidence and 80% power, and a standard deviation of 4.5, the required sample size is 12 per group. Thus, a total of 36 samples were used.

$$n = \frac{[Z_{1-\alpha/2} + Z_{1-\beta}]^2 \, 2SD^2}{(\text{Mean difference})^2}$$

RESULTS

All three bulk fill composites exhibited the release of Bisphenol A (BPA). The highest amount of monomer release was observed in the 24-hour samples regardless of the polishing process, compared to the 3-day samples. Groups subjected to polishing showed significantly lower monomer release compared to those directly immersed in ethanol solution. Tetric Evoceram bulk fill demonstrated marginally higher BPA elution compared to EverX Posterior and SDR flow plus, irrespective of polishing and storage time, followed by SDR flow plus and EverX Posterior, which showed the least monomer release.

Table 1 : Comparison of Mean BPA Release (µmol/L)

Table 2 : Comparison of Mean BPA Release within Groups Based on Polishing Procedure and Time

*Statistically Significant

The results indicate that Tetric Evoceram consistently exhibited the highest mean BPA release among the three composites, both with and without polishing, at both 24 hours and 3 days. SDR flow plus followed with intermediate BPA release levels, while Posterior EverX GC consistently showed the lowest BPA release across all conditions. Polishing significantly reduced BPA release compared to samples without polishing for all composites and time points tested.

These findings underscore the importance of considering both the material composition and surface treatment in dental composite restorations to minimize potential health risks associated with BPA release.

DISCUSSION

The use of resin-based composite (RBC) materials for repairing both anterior and posterior teeth has surged due to the growing demand for attractive, tooth-colored, and mercury-free restorations.[15] RBCs are adhesively bonded to the tooth, allowing for conservative cavity preparation. Research increasingly shows that RBCs are durable for filling Class I and II cavities[16].

However, there are limitations to positioning posterior RBC replacements. A gradual layering method is now recommended for proper tooth isolation.[17] Stacking RBCs improves light penetration and polymerization, reducing shrinkage strains. However, it can be labor-intensive and may cause voids or leave uncured resin, potentially weakening the restoration and leading to sensitivity or early failure.

To streamline and accelerate large posterior restorations, manufacturers have developed bulk-fill RBCs that can be placed in increments of 4 to 10 mm. These materials reduce the time and sensitivity of the procedure, making them ideal for time-sensitive posterior cavity repairs[18]. Thus, 4 mm was selected as the thickness for all bulk-fill composite resin samples in this study.

A 40-second polymerization period is generally sufficient to enhance the mechanical properties of composite resin. According to Polydorou et al., residual monomer levels in a 75% ethanol solution were not significantly reduced with polymerization times longer than 20 seconds.[14] Increasing the polymerization time to 80 seconds did not significantly reduce monomer release. Ankit Rajesh Sajnani's study found no significant difference in monomer release between 30 and 40 seconds of polymerization for bulk-fill composites[13]. Therefore, in the current work, the composite resin was polymerized for 40 seconds.

Although composite resins are considered durable, their structure can degrade over time, leading to leakage into the oral environment. Light polymerization converts 40% to 75% of the monomer into polymer. Olea et al. (1996) discovered significant BPA leakage from dental sealants, raising concerns about the estrogenicity of dental materials and calling for further research[19].

High Performance Liquid Chromatography (HPLC) is the most effective method for analyzing nonpolar monomers in composite resins, as it separates constituents by hydrophobicity and allows precise control. Unlike gas chromatography, which detects only degradation products, HPLC accurately identifies and quantifies released monomers. Thus, BPA release from the three bulk-fill composite resins was measured using HPLC.

Polymerization removes monomers from unpolymerized resins into organic solutions. Since the oral environment is between harsh solutions and water, the FDA recommends a 75% ethanol-water solution for research, as it closely mimics the oral environment. Thus, a 75% ethanol solution was used as the storage medium in this study.[20]

In the without polishing groups, mean BPA release was 0.437 ± 0.012 for Posterior EverX GC, 0.513 ± 0.016 for Tetric Evoceram, and 0.473 ± 0.019 for SDR Flow Plus. In the with polishing groups, mean BPA release was 0.355 ± 0.010 for Posterior EverX GC, 0.438 ± 0.015 for Tetric Evoceram, and 0.412 ± 0.012 for SDR Flow Plus.

This aligns with literature indicating that composite resins release the most monomers in the first 24 hours post-polymerization. Ferracane and Condon reported that 85-100% of residual monomer leaks within 24 hours, with 50% occurring in the first three hours. Recent HPLC studies confirm that monomer elution from resin-based composites lasts up to 24 hours.[21] To ensure most residual monomers were released, monomer release was measured after 24 hours of polymerization.

Multiple comparisons showed Tetric Evoceram had significantly higher mean BPA release compared to Posterior EverX GC and SDR Flow Plus, with p-values of <0.001 and 0.006, respectively. This could be due to its prepolymer fillers, which may leave more unreacted C=C double bonds, increasing monomer release.[22]

FA Rueggeberg found that using mechanical action with a mild abrasive, such as pumice, resulted in the greatest reduction of uncured resin components.[23] All three composites showed a significant reduction in BPA release with polishing at both 24 hours and 3 days. For Posterior EverX GC, BPA release was significantly higher without polishing ([0.437 ± 0.012] at 24 hours and [0.352 ± 0.012] at 3 days) compared to polishing ([0.355 ± 0.010] at 24 hours and [0.272 ± 0.019] at 3 days), with p-values <0.001.

In Tetric Evoceram, mean BPA release was significantly higher without polishing ([0.513 ± 0.016] at 24 hours and [0.417 ± 0.014] at 3 days) compared to polishing ([0.438 ± 0.015] at 24 hours and [0.352 ± 0.015] at 3 days). Similarly, for SDR Flow Plus, BPA release was significantly higher without polishing ([0.473 ± 0.019] at 24 hours and [0.390 ± 0.014] at 3 days) compared to polishing ([0.412 ± 0.012] at 24 hours and [0.312 ± 0.015] at 3 days).

Further in-vivo research is needed to estimate monomer release from composites after polymerization. Additionally, studies on methodologies and material adjustments are required to limit monomer release.

CONCLUSION

Based on the study's limitations, the following conclusions were made:

- More BPA was eluted after 24 hours than after 3 days.
- Polishing reduced BPA elution in all three bulk-fill composite groups, regardless of storage period.
- Tetric Evoceram released more BPA compared to EverX Posterior and SDR Flow Plus, regardless of polishing.

Further research is needed to explore changes to composite materials, curing lamps, or methods to reduce monomer elution.

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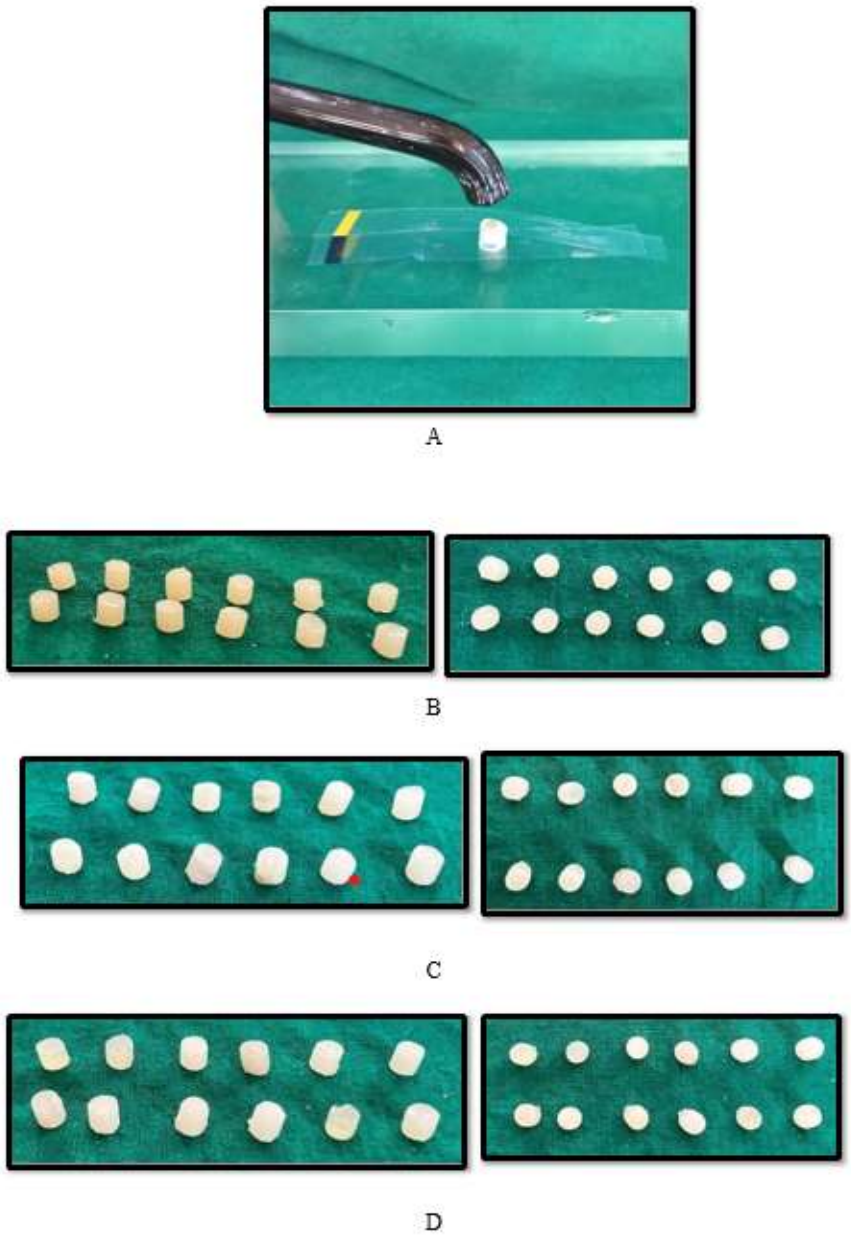

FIGURE 1 – A. preparation of specimen, B. specimens from posterior everx gc, C. specimens from sdr flow plus, D. specimens from tetric evoceram, E. specimens from all the three bulk fill composites

Table 1 : Comparison of Mean BPA Release (µmol/L)

Condition	Groups	N	Mean (µmol/L)	SD	Min	Max	p-value	Significant Difference
Without Polishing at 24 Hours	Posterior EverX GC	6	0.437	0.012	0.42	0.45	<0.001	P vs T: <0.001 P vs S: 0.003
	Tetric Evoceram	6	0.513	0.016	0.49	0.53		P vs S: 0.003
	SDR Flow Plus	6	0.473	0.019	0.45	0.50		T vs S: 0.002
Without Polishing at 3 Days	Posterior EverX GC	6	0.352	0.012	0.34	0.37	<0.001	P vs T: <0.001 P vs S: <0.001
	Tetric Evoceram	6	0.417	0.014	0.40	0.44		P vs S: <0.001
	SDR Flow Plus	6	0.390	0.014	0.37	0.41		T vs S: 0.009
With Polishing at 24 Hours	Posterior EverX GC	6	0.355	0.010	0.34	0.37	<0.001	P vs T: <0.001 P vs S: <0.001
	Tetric Evoceram	6	0.438	0.015	0.42	0.46		P vs S: <0.001
	SDR Flow Plus	6	0.412	0.012	0.40	0.43		T vs S: 0.006
With Polishing at 3 Days	Posterior EverX GC	6	0.272	0.019	0.24	0.29	<0.001	P vs T: <0.001 P vs S: 0.002
	Tetric Evoceram	6	0.352	0.015	0.33	0.37		P vs S: 0.002
	SDR Flow Plus	6	0.312	0.015	0.29	0.33		T vs S: 0.002

Table 2 : Comparison of Mean BPA Release within Groups Based on Polishing Procedure and Time

Composite	Polishing	Time	N	Mean (µmol/L)	SD	Mean Difference	p-value
Posterior EverX GC	Without	24 hrs	6	0.437	0.012	0.082	<0.001*
	Without	3 Days	6	0.352	0.012	0.080	<0.001*
	With	24 hrs	6	0.355	0.010	0.083	<0.001*
	With	3 Days	6	0.272	0.019	0.083	<0.001*
Tetric Evoceram	Without	24 hrs	6	0.513	0.016	0.075	<0.001*
	Without	3 Days	6	0.417	0.014	0.065	<0.001*
	With	24 hrs	6	0.438	0.015	0.087	<0.001*
	With	3 Days	6	0.352	0.015	0.086	<0.001*
SDR Flow Plus	Without	24 hrs	6	0.473	0.019	0.062	<0.001*
	Without	3 Days	6	0.390	0.014	0.078	<0.001*
	With	24 hrs	6	0.412	0.012	0.100	<0.001*
	With	3 Days	6	0.312	0.015	0.100	<0.001*