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BULK FILL RESIN COMPOSITES IN RESTORATİVE DENTISTRY: A REVİEW ARTICLE OF IN VIVO STUDIES

RESTORATİF DİŞ HEKİMLİĞİNDE BULK FİLL REZİN KOMPOZİTLER: İN VİVO ÇALIŞMALAR ÜZERİNE BİR DERLEME MAKALE

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Abstract

Bulk fill resin composites (BFRCs) were developed to simplify restorative procedures and overcome the limitations of the incremental approach. Applicable in thicknesses of 4–5 mm, they reduce working time while providing satisfactory mechanical and clinical performance. This review article synthesizes in vivo evidence from the last decade on posterior teeth, focusing on the retention, marginal adaptation, marginal discoloration, postoperative sensitivity, and secondary caries of BFRC restorations. The findings indicate that BFRCs exhibit comparable annual failure rates and retention to composite resins placed incrementally. While marginal discoloration increased over time, no significant differences in marginal integrity were identified. Flowable BFRCs provided superior cavity adaptation, whereas high viscosity variants offered enhanced mechanical strength. Advancements such as sonic activation and thermo-viscous systems have contributed to improved viscosity and cavity adaptation. Overall, BFRCs represent a clinically reliable material, offering efficiency and acceptable longevity in restorative dentistry.

Keywords: *Bulk fill resin composite, Clinical trials, Resin composite, Retention, Marginal discoloration.*

Özet

Bulk fill rezin kompozitler (BFRK), restoratif prosedürleri kolaylaştırmak ve tabakalı yerleştirme yaklaşımının kısıtlamalarını ortadan kaldırmak amacıyla geliştirilmiştir. 4–5 mm kalınlıkta uygulanabilmeleri işlem süresini kısaltırken yeterli mekanik ve klinik performans sağlamaktadır. Bu derleme, son on yılda yayımlanan in vivo çalışmaları inceleyerek posterior dişlerdeki BFRK restorasyonlarının retansiyon, kenar adaptasyonu, kenar renkleşmesi, postoperatif hassasiyet ve sekonder çürük kriterlerini değerlendirmektedir. Bulgular, BFRK' lerin tabakalı yerleştirilen kompozit rezinlerle benzer yıllık başarısızlık oranları ve retansiyon yüzdeleri gösterdiğini ortaya koymaktadır. Zamanla kenar renkleşmesi artsa da kenar bütünlüğü açısından anlamlı farklılık bulunmamaktadır. Akışkan BFRK' ler kaviteye daha iyi adaptasyon, yüksek viskoziteli BFRK' ler ise daha yüksek mekanik dayanım sunmaktadır. Sonik aktivasyon ve termo-viskoz sistem BFRK uygulamaları gibi yenilikler, materyallerin viskozitesini ve kaviteye adaptasyonunu daha da geliştirmiştir. Genel olarak, BFRK' ler işlem süresini kısaltmaları ve kabul edilebilir uzun dönem performanslarıyla restoratif diş hekimliğinde güvenilir materyaller olarak öne çıkmaktadır.

Anahtar Kelimeler: *Bulk fill rezin kompozit, Klinik çalışma, Kompozit rezin, Retansiyon, Kenar renkleşmesi.*

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OVERVIEW / GENEL BAKIŞ

In the early 2000s, a significant advancement in resin-based composite technology was introduced with the development of low-shrinkage materials, which led to the concept of the bulk filling technique. This category has been introduced to address the limitations of the traditional composite resin (CR) layering technique and streamline the restorative process, particularly for large posterior cavities (1). The incremental layering technique is widely employed to minimize the adverse effects of polymerization shrinkage. This approach is based on reducing the cavity configuration factor (C-factor). Nevertheless, it is highly technically sensitive to operator skill (2,3).

Bulk fill resin composites (BFRCs) allow for placement in 4–5 mm increments, thereby reducing procedure time and complexity, and enhancing the user-friendliness of restorative procedures (4). Various manufacturers have implemented distinct techniques aimed at achieving a greater depth of cure while minimizing polymerization shrinkage. The challenges associated with polymerization shrinkage can significantly impact the longevity of the restorations, leading to concerns such as marginal deficiencies, secondary caries, and postoperative sensitivity (5). The BFRC must fulfill two key criteria: first, it should achieve sufficient monomer conversion by enhancing translucency and utilizing alternative photoinitiator systems. Second, it should reduce polymerization shrinkage stress at cavity margins through adjustments in monomer chemistry and improved interactions with fillers (6-8).

BFRCs are available in two viscosity forms: low viscosity (flowable) and high viscosity (full-body or sculptable). Low viscosity BFRCs are typically utilized as a base layer, primarily in the proximal part, or as a dentin replacement within a cavity. However, due to their limited wear resistance, mechanical strength, and color stability, they often necessitate coverage with high viscosity BFRCs or conventional CRs to ensure optimal performance (9,10). In contrast, high viscosity BFRCs serve as regular restorative materials. Despite the significant differences in their applications and properties, both types of BFRCs offer distinct advantages. Flowable BFRCs provide superior adaptation to cavity walls, thereby effectively reducing the risk of gap formation. Conversely, full-body BFRCs can be applied in a single increment, which enhances efficiency while simultaneously demonstrating enhanced mechanical properties (11).

One of the main advantages of BFRCs is the reduction in restorative time. A previous clinical study has shown that the use of BFRCs (SDR Flow, Dentsply; and Filtek Bulk Fill, 3M ESPE) significantly decreases the time required to perform Class I restorations compared with the incremental technique (12). In another clinical study reporting similar outcomes, BFRCs presented in both capsule (Filtek One Bulk Fill, 3M ESPE) and syringe forms (Filtek Bulk Fill Posterior Restorative, 3M ESPE) were also compared, revealing noteworthy differences. The operators noted that restorations utilizing capsule-

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formed BFRCs were more manageable, particularly during placement into the cavity, finishing, and polishing procedures. This enhancement in handling has been proposed as a contributing factor to the reduced clinical time noted in the study (13).

Additionally, the application of bulk fill placement techniques has been shown to significantly decrease the occurrence of voids and pulpal gap formation (14,15). Therefore, this approach not only enhances the reliability of the restorative procedure but also minimizes the potential for technical errors.

Numerous in vitro studies have examined various characteristics of BFRCs, such as degree of conversion, microhardness, polymerization stress, and both marginal and internal adaptation (16-19). However, these findings alone do not provide enough evidence to draw conclusions about their clinical performance. Therefore, this review article aims to evaluate the existing in vivo studies in the literature to offer a comprehensive assessment.

The development of BFRCs dates back to the early 2000s, when the first commercially available material, SDR (Dentsply Sirona), was introduced. SDR was a flowable composite incorporating stress-decreasing resin technology, designed for use as a dentin replacement material in 4-mm increments with a 20-second curing time (20).

Several clinical studies have compared the outcomes of CRs versus BFRCs, consistently reporting that BFRCs demonstrate clinically acceptable performance (21-23). In a randomized, prospective, split-mouth clinical trial, two flowable BFRCs—Filtek Bulk Fill Flow (3M ESPE) and SDR (Dentsply)—were compared with a conventional microhybrid CR (Amelogen Plus, Ultradent) placed with the incremental layering technique in Class II restorations (21). A total of 159 restorations (65 molars and 94 premolars) were placed in 53 patients. After a 4-year follow-up, restorations were evaluated according to modified United States Public Health Services (USPHS) criteria. The annual failure rates (AFRs) were comparable, reported as 3.6% for the conventional CR, 3.0% for Filtek Bulk Fill, and 2.3% for SDR. While both BFRCs displayed higher rates of marginal discoloration compared to the conventional CR, no significant differences were noted among the groups with respect to marginal integrity. Another randomized clinical trial evaluated a flowable BFRC (SDR, Dentsply) in posterior restorations and compared it intraindividually with a conventional 2-mm incremental CR (Ceram X Mono, Dentsply) over a 6-year follow-up (22). The AFR indicated that the 4-mm bulk fill technique provided similar longevity to the traditional layering approach. No failures were observed in Class I restorations despite the high C-factor, whereas Class II restorations demonstrated an AFR of 1.4%. They reported failures were attributed to the lower modulus of elasticity and hardness of the flowable BFRCs. Importantly, all failures were due to material fractures and occurred in patients with a bruxism risk. In another six-year clinical study, the performance of a high viscosity BFRC (Tetric EvoCeram Bulk Fill, Ivoclar Vivadent) was compared with a nanofill CR (Filtek Ultimate, 3M ESPE) in Class II restorations (23). The assessment of marginal discoloration criteria indicated that BFRC

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restorations demonstrated superior performance after six-years. At this time, 90% of the BFRC restorations displayed no staining at the margins, suggesting that specific modifications implemented during the monomer phase of the BFRC may have contributed to these favorable results. Moreover, they reported a 100% retention rate for BFRC, and one loss for CR. The higher retention rates in this trial were attributed to the use of an etch-and-rinse adhesive system and the strict inclusion criteria applied.

Recent studies have underscored the significant influence of the adhesive approach on clinical outcomes (24-26). A double-blind, randomized clinical trial was conducted to compare the clinical performance of posterior restorations utilizing two distinct methods: the bulk fill technique (Tetric N-Ceram Bulk Fill, Ivoclar Vivadent) and the incremental filling technique, which incorporated either an etch-and-rinse adhesive (Tetric N-Bond, Ivoclar Vivadent) or a self-etch adhesive (Tetric N-Bond Self-Etch, Ivoclar Vivadent), in accordance with the Federation Dentaire International (FDI) criteria (26). Following five years of clinical assessment, it was found that the overall AFRs were 1.2% for the bulk fill technique and 1% for the incremental technique. Notably, significant deterioration in marginal adaptation was observed in the self-etch groups at the 4- and 5-year follow-ups. Conversely, no significant differences were identified in terms of marginal staining or translucency criteria across the groups. Overall, the bulk fill restorative technique exhibited favorable clinical performance compared to the incremental filling technique, particularly when an etch-and-rinse adhesive was utilized.

Some BFRCs present challenges in manipulation due to their limited flowability. In response to concerns regarding the adaptation of high viscosity BFRCs, manufacturers have introduced advanced technologies designed to adjust the viscosity of the materials during placement temporarily. One noteworthy system is SonicFill, developed by Kerr Corporation. This high viscosity bulk fill system promotes efficient bulk placement through a specialized handpiece, Kavo SonicFill (Kavo Dental GmbH). The device utilizes sonic energy at adjustable intensities to optimize the consistency of the CR, thereby enhancing sculpting and contouring capabilities (27). Additionally, preheating the CR has garnered attention, as it effectively reduces viscosity, increases flowability, and facilitates insertion (28). A thermo-viscous BFRC, known as VisCalor Bulk, produced by Voco GmbH, has been introduced, integrating the benefits of bulk filling with the advantages offered by preheating (29). A clinical study focusing on Class I cavities with an 18-month follow-up period revealed that reducing the viscosity of BFRCs—achieved through either thermo-viscous technology or sonic activation—can significantly enhance the material's adaptation to the walls and margins of cavities (30).

In recent literature, studies have been conducted to evaluate the clinical performance of BFRCs with varying viscosities. One notable study, conducted by Goda et al., assessed various systems, including the Filtek Bulk Fill (3M ESPE), the Heated Filtek Bulk Fill (3M ESPE), the G-ænial BULK Injectable (GC), and the SonicFill3 (Kerr Corp) (31). The clinical evaluations of all restorations were performed using FDI criteria at 6, 12, and 24 months. The findings demonstrated no significant

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differences in aesthetic, functional, and biological properties among the four restorative materials across the different follow-up periods. Notably, the G-ænial™ Bulk Injectable Group achieved 100% excellent surface staining scores. This performance may be attributed to the presence of ultra-fine barium filler particles (150 nm), which are homogeneously and densely dispersed throughout the material. Their close packing may contribute to the protection of the surrounding resin matrix, effectively minimizing abrasion from adjacent particles.

Moreover, recent studies have expanded the application of BFRCs beyond Class I and Class II restorations to include non-carious cervical lesions (NCCLs). Notable studies with 6-month follow-up (32), 12-month follow-up (33) and 30-month-follow up (34) have provided valuable comparisons between BFRCs and conventional CRs in the context of restoring NCCLs. Additionally, research by Favoreto et al. investigated various preheating methods for a bulk fill thermo-viscous composite, specifically VisCalor Bulk (Voco) (35). The findings demonstrated that restorations made using this approach were clinically acceptable after a 12-month follow-up period.

Furthermore, the launch of a self-cured bulk fill restorative material called Stela (SDI, Victoria) offers significant advantages. This material is notable for not containing photoinitiators, eliminating the need for light activation, which is particularly beneficial for deep cavity restorations exceeding 5 mm in depth. Stela is available in two delivery forms: Automix and Capsule (36). A multicenter, double-blind, randomized controlled trial compared the clinical performance of Stela Automix and Stela Capsule (SDI) against a light-cured BFRC, Filtek One Bulk Fill (Solventum), after 18 months of service (37). All restorative materials demonstrated comparable functional and biological performance. However, the chemically cured BFRC in capsule form demonstrated a reduction in surface luster and exhibited a rougher texture when compared to the light-cured BFRC. These differences are likely attributable to variations in filler characteristics, specifically the Automix formulation containing smaller filler particles and a lower filler loading (61.2 wt%) compared to the Capsule formulation (76.8 wt%). Nevertheless, minor aesthetic differences did not adversely affect the overall clinical performance observed after 18 months.

A systematic review and meta-analysis revealed contradictory results in terms of postoperative sensitivity (38). There is a widely held perspective among clinicians that self-etch adhesive systems may help to decrease the incidence of postoperative sensitivity. However, a systematic review demonstrated that the choice of adhesive strategy employed in posterior restorations does not significantly impact the risk or severity of postoperative sensitivity that may arise immediately following the restoration (39).

A randomized clinical trial compared the postoperative sensitivity associated with different placement techniques (incremental versus bulk fill) in posterior restorations bonded with etch-and-rinse (Tetric N-Bond, Ivoclar Vivadent) or self-etch (Tetric N-Bond Self-Etch, Ivoclar Vivadent) adhesive systems (40). The results indicated that neither the restorative technique nor the adhesive

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strategy had a notable impact on the intensity of spontaneous postoperative sensitivity. Furthermore, the cavity depth did not influence postoperative sensitivity, cavities with three or four surfaces exhibited greater occurrence of postoperative sensitivity when compared to those of one or two surfaces.

Another critical criterion for evaluation is the presence of secondary caries, which is frequently associated with the biological properties defined in restoration assessment criteria. This type of caries may develop due to various factors, including microleakage resulting from marginal defects, inadequacies in proximal contacts that encourage plaque accumulation, and an increased risk of caries development (41). Additionally, it is noteworthy that most studies implement stringent exclusion criteria, primarily focusing on factors such as oral hygiene and caries risk. As a result, failures related to secondary caries tend to be relatively infrequent in clinical trials.

Most clinical trials included in the analysis employed the USPHS criteria (21-24,30,33,34). However, it is essential to note that the USPHS criteria have been shown to possess limited sensitivity and may not comprehensively capture the clinical success of restorations (42). Consequently, there has been a recent transition towards utilizing the FDI criteria, which provide several advantages over the USPHS method. The FDI criteria have demonstrated an ability to detect varying failure rates that differ from those identified through the USPHS criteria, and they offer a simplified scoring system. In the FDI system, scores ranging from 1 to 3 are considered "clinically acceptable" (41). The FDI criteria have also been widely adopted in the literature for the clinical evaluation of restorations (25,31,32,35,37).

Finally, a systematic review and meta-analysis indicated that rubber dams were used for moisture control in only a small number of clinical studies, while majority of the trials depended on cotton rolls and suction for isolation during restorative procedures (43)..

SUMMARY / SONUÇ

In conclusion, BFRCs have demonstrated commendable clinical performance, comparable to that of incrementally placed CRs. Evidence derived from short- and mid-term clinical studies supports their effectiveness; however, the longevity of these restorations is influenced by a variety of factors, including those related to the patient and to the operator. The criteria for inclusion in these studies also significantly impact the observed outcomes. While there were no substantial differences in marginal adaptation between the groups, an increase in marginal discoloration was noted over time. It is important to recognize that the operative technique, as well as the specific characteristics of patients and cavities of the tooth, also play vital roles in the durability of these restorations. Ultimately, the benefits offered by BFRCs, particularly in terms of reduced procedure time and enhanced clinical convenience, underscore their potential as a valuable option in restorative dentistry.

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