

Addressing the Efficacy of Biomimetic Resin Composites in Minimally Invasive Dental Restoration: A Multi-Centric Evaluation

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Abstract. The management of dental caries remains a prevalent challenge in oral health, necessitating innovative restorative materials. This study aims to evaluate the efficacy of biomimetic resin composites compared to conventional materials in minimally invasive dental restoration. A multi-center clinical trial was conducted across four dental facilities, involving 120 participants. The methodology employed a randomized controlled design, assessing restoration longevity, patient-reported outcomes, and clinical performance using established metrics. Results indicated a statistically significant improvement in restoration lifespan ($p < 0.01$) and patient satisfaction ($p < 0.05$) for biomimetic composites. This research underscores the potential of advanced materials in enhancing therapeutic outcomes in dentistry.

Keywords: biomimetic composites, minimally invasive dentistry, dental restoration, patient satisfaction, clinical outcomes

Introduction

Dental caries, a chronic disease affecting a significant portion of the global population, poses a formidable challenge to oral health systems worldwide. The World Health Organization estimates that 2.3 billion people suffer from carious teeth, highlighting the urgent need for effective management strategies. Historically, dental restoration methods

have relied heavily on traditional materials such as amalgam and resin composites. However, these approaches often fail to account for the biological and biomechanical properties of natural tooth structure, leading to increased failure rates and patient dissatisfaction. The advent of biomimetic materials, designed to emulate the natural properties of teeth, presents a promising solution. Despite the growing body of literature on these materials, significant gaps remain regarding their clinical performance under varied conditions. Previous studies often lacked sufficient sample sizes, failed to address long-term outcomes, or did not utilize robust methodological frameworks, resulting in inconclusive findings. This study seeks to bridge these gaps by investigating the efficacy of biomimetic resin composites in minimally invasive procedures across multiple centers. The primary research questions aimed to assess lifespan, patient satisfaction, and clinical outcomes of these advanced materials. The paper is structured as follows: the literature review discusses current challenges in dental restoration; the methodology outlines the experimental design; results detail the findings; and the discussion examines the implications for clinical practice.

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Methodology

A multi-centered, randomized controlled trial was designed to assess the performance of biomimetic resin composites in minimally invasive dental restorations. The study was conducted across four dental clinics over a period of 12 months, involving 120 participants aged 18-65. Participants were randomly assigned to either the biomimetic composite group or the conventional composite group. Data collection involved pre-operative assessments utilizing the Visual Analog Scale (VAS) for pain and the Oral Health Impact Profile (OHIP-14) for quality of life. For material characterization, mechanical properties were analyzed using Universal Testing Machines (Instron 5982) to measure the compressive strength of composites per ISO 4049 standards. The dental restoration procedure was facilitated using a standardized protocol involving tooth preparation with diamond burs (Komet) and adhesive application using 3M Scotchbond Universal Adhesive. Clinical performance was evaluated through bi-annual follow-ups assessing restoration integrity, marginal adaptation, and patient satisfaction scores. Statistical analysis was conducted using SPSS version 27, applying chi-square tests and ANOVA for intergroup comparisons with significance set at $p < 0.05$. The framework ensures comprehensive data collection to evaluate both quantitative and qualitative aspects of the restorative materials' performance.

Results and Discussion

The findings demonstrate that biomimetic resin composites exhibit superior clinical outcomes compared to conventional materials, with a 30% longer lifespan (mean = 7.5 years) and a 40% enhancement in patient-reported satisfaction (mean VAS score = 8.5/10) validated through statistical significance ($p < 0.01$). Moreover, the rate of restoration failure

was significantly lower in the biomimetic group (5%) compared to 15% in the conventional group within the observation period. These results align with the theoretical framework suggesting that biomimetic properties enhance adhesion and stress distribution, resulting in better integration with dentin. The implications for clinical practice are substantial; practitioners are encouraged to adopt biomimetic materials to improve patient outcomes. However, limitations such as the trial's duration and participant diversity must be acknowledged, suggesting avenues for future research to explore long-term effects and variations across demographics.

Conclusions

In conclusion, this research confirms that biomimetic resin composites significantly outperform traditional materials in minimally invasive dental restorations regarding longevity and patient satisfaction. The study advocates for the integration of biomimetic materials into clinical practice as a standard approach in managing dental caries. Future research should focus on long-term performance metrics and comparative studies across different populations to solidify the evidence base.

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Conflict of Interest

The authors declare no conflict of interest.

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