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Original Research Article

Clinical Performance of 3D-Printed Bioactive Resin Restorations Compared with Conventional Composite Restorations

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ABSTRACT

Background: Three-dimensional (3D)-printed bioactive resin restorations are emerging as an alternative restorative approach with potential advantages in clinical performance and surface quality.

Objective: To compare the clinical performance of 3D-printed bioactive resin restorations with conventional composite restorations over a 6-month clinical follow-up.

Methodology: This prospective, parallel-group comparative study was conducted in the Department of Operative Dentistry, from Jan 2025 to December 2025. A total of 120 adult patients requiring suitable posterior restorations were enrolled through consecutive sampling, with 60 patients allocated to 3D-printed bioactive resin and 60 to conventional composite restorations. Clinical outcomes were assessed at baseline and during 6-month follow-up, including restoration survival, marginal integrity, postoperative sensitivity, anatomical form, surface quality, secondary caries, fracture, and restoration loss.

Results: Restoration survival was 91.67% in the 3D-printed group compared with 85.00% in the conventional group (p=0.251). Clinically acceptable marginal integrity was observed in 86.67% versus 76.67% (p=0.155), while absence of postoperative sensitivity was recorded in 88.33% versus 78.33% (p=0.130). Acceptable anatomical form was present in 91.67% versus 81.67% (p=0.104). Acceptable surface quality was significantly higher with 3D-printed resin (90.00% vs. 75.00%, p=0.043).

Conclusion: 3D-printed bioactive resin restorations demonstrated favorable short-term clinical performance comparable to conventional composite restorations, with significantly better surface quality.

Keywords: 3D printing; bioactive resin; dental restorations; resin composite; clinical performance; surface quality.

INTRODUCTION

Dental caries is a dynamic disease with cycles of demineralization and remineralization and may eventually affect dental hard tissues, as a biofilm-mediated disease[1]. The goal of restorative treatment is to restore the anatomy, function and esthetics of affected teeth while maintaining as much sound tooth structure as possible[2]. Due to their tooth-coloured appearance,

adhesive bonding to enamel and dentin, and capability of minimally invasive restorative procedures, direct resin-based composite materials have gained wide acceptance[3]. However, traditional composite restoration is still prone to polymerization shrinkage, marginal gap formation, postoperative sensitivity, secondary caries, degradation of surface structure and fracture, especially in high occlusal and thermal stresses in the long term[4].

In recent years, digital dentistry and additive manufacturing has paved the way for the emergence of three-dimensional (3D) printing as an alternative method to fabricate a customized dental restoration[5]. The fabrication of 3D-printed restorative resins can be achieved by the process of layer-by-layer polymerization, which can achieve precise reproduction of complex geometries, and could lead to increased manufacturing consistency[6]. With the advent of bioactive resin materials, the applications of printed restorations have been further expanded. Bioactive restorative materials are engineered to actively engage with its oral environment by ion release or other mechanisms to encourage mineral deposition and help maintain the tooth–restoration interface[7]. In particular, calcium- and phosphate-releasing formulations have been of interest due to their potential in promoting remineralization and the biological effects of margins deterioration.

However, further examination of the clinical behavior of 3D printed bioactive resin restorations is needed[9,10]. Laboratory testing has shown that mechanical properties, surface characteristics, water sorption, wear resistance and marginal adaptation of the various materials used for restoration differ, but laboratory performance does not indicate how a material will perform in the more complex environment of the oral cavity[11]. Marginal integrity and longevity of the restoration can be affected by clinical factors, including mastication, dietary exposure, moisture, temperature changes, plaque, and patient factors[12,13]. It is therefore crucial to make direct comparisons with traditional composite restorations to establish if the proposed benefits of 3D-printed bioactive resins are borne out in daily clinical use[14].

During follow-up, prospective clinical evaluation can give data on restoration survival, marginal integrity, postoperative sensitivity, anatomical form, surface quality and other clinically relevant data. This type of assessment can also serve to help define the short-term properties of new printed restorative materials when compared with traditional direct composite techniques.

RESEARCH OBJECTIVE

To prospectively compare the clinical performance of 3D-printed bioactive resin restorations with conventional composite restorations by evaluating restoration survival, marginal integrity, postoperative sensitivity, anatomical form, surface quality, and other clinically relevant restorative outcomes during the follow-up period.

MATERIALS AND METHODS

Study Design

A comparative parallel clinical study was conducted as a prospective study to compare the clinical performance of 3D-printed bioactive resin restorations to the conventional resin composite restorations. The study provides the evaluation of the clinical behavior and the short-term success of the two restorative approaches in routine clinical conditions.

Study Setting and Duration

The study was carried out in Khyber College of Dentistry, Peshawar in the Department of Operative Dentistry during Jan 2025 to December 2025 for one year. Recruitment of the participants, restoration placement, clinical follow-up, data collection and data analysis were all done during the study period. Each restoration was followed clinically for 6 months.

Study Population

The study subjects were adult patients attending the Department of Operative Dentistry who needed restoration of appropriate posterior teeth. Patients were enrolled who met the inclusion/exclusion criteria and who gave informed consent in writing. One hundred and twenty (120) restorations were used, each set in 60 restorations for each of the groups of treatment.

Sample Size

Study participants were 120 restorations distributed into the 60 restorations per treatment group. The sample size was determined to make a balanced comparison of the two restorative practices and to examine if there were differences in their

clinical performance during the 6-month follow-up period. As appropriate, there was provision to allow for loss to follow-up.

Sampling Technique

Consecutive sampling was used for the recruitment of eligible patients within the recruitment period. The patients were screened based on the predetermined criteria and eligible restorations were included consecutively until the number of 120 restorations was reached.

Inclusion Criteria

Included were adults who needed to have appropriate posterior teeth restored. Selected teeth were judged to have adequate remaining tooth structure for placement of the restoration planned, and to be suitable for treatment with either of the two restorative materials used in this study. Participants were well able to be treated orally and had easy access to care, could have restorative treatment, agreed to follow up examinations and signed informed consent forms.

Exclusion Criteria

Patients who had uncontrolled systemic disease that could adversely affect restorative outcomes, severe periodontal disease, active untreated oral infection and severe parafunctional activity (uncontrolled bruxism) were excluded. Poor prognosis periodontal, endodontic and teeth with insufficient remaining tooth structure or teeth that would need an indirect restoration other than the study restoration were also excluded. Those patients who could not or would not come for the follow-up visits were omitted.

Randomization and Group Allocation

Eligibility was assessed and informed consent was obtained and restorations were then randomly assigned to one of two treatment groups using a computer-generated randomization sequence. The experimental group (Group A) received 3D-printed bioactive resin restorations and the control group (Group B) received conventional resin composite restorations. A suitable concealment method was used to ensure that selection bias was minimised for allocation. Allocation Sequence was created prior to treatment began.

Clinical Intervention

3D-Printed Bioactive Resin Restorations

A set of selected teeth from Group A were prepared using standardized MIR principles.Selected teeth from Group A were prepared following standardized MIR principles. Digital impressions or intraoral scanning were performed as appropriate to the clinical workflow to obtain the required digital information. This restoration was digitally designed and printed on a compatible 3D printing machine and with a bioactive restorative resin. The printing and washing, and post processing and post curing procedure was carried out in line with the manufacturer's recommended protocol. The fit/adaptation of the fabricated restoration was clinically checked prior to its placement. The appropriate bonding or luting procedures were performed as recommended by the manufacturer of the material and the finishing and polishing was conducted using a standardized clinical procedure.

Conventional Composite Restorations

The selected teeth were prepared for Group B following the prescribed principles of operation. The enamel and dentin surfaces were prepared according to the suggested bonding protocol and conventional resin composite was incrementally placed. Increments were properly light-cured following the manufacturers' recommendations. Finally, the restoration was completed and refined in a standardized manner and occlusion was verified and corrected as needed.

Clinical Evaluation and Outcome Measures

Standardized clinical assessment criteria were used to assess the clinical performance of each restoration at baseline and follow up. Clinical success/survival of the restoration at 6 months was the primary outcome. The secondary outcomes were marginal integrity, post-operative sensitivity, anatomical form, surface quality, secondary caries, restoration fracture, restoration loss and other restoration-related complications. The same clinical criteria was used throughout for both treatment groups. Consistency was achieved and observer related variation minimised through clinical examinations by a calibrated examiner.

Follow-up Protocol

Immediate clinical assessment of the restorations was conducted after restoration placement for baseline measurements and re-evaluated during the 6-month follow-up period on a pre-established follow-up schedule. Each assessment will evaluate the retention, marginal integrity, postoperative sensitivity, anatomical form, surface quality, secondary caries, fracture, loss, and any other clinically relevant issues that will arise from the restoration. All treatments for adverse clinical events, including repair, replacement and additional treatment were recorded and documented for analysis.

Data Collection Procedure

Data collection was done with a structured data collection form and recorded demographic and clinical data. Baseline characteristics, tooth-related, restorative treatment information and clinical evaluation findings were recorded for each of the restored teeth enrolled. Follow-up information was gathered on all scheduled assessments, such as postoperative symptoms, clinical changes, failure of restoration, repair or replacement, and loss to follow-up. The restoration studies were all given a study identification code, and all participant-identifying information was kept confidential.

Statistical Analysis

All the data were entered, coded and analysed with suitable statistical software. Normally distributed continuous variables were reported as mean and standard deviation and non-normally distributed continuous variables were reported as median and interquartile range. Categorical variables were displayed as frequencies and percentages. Before selecting parametric or non parametric tests, normality of continuous data was tested. Independent-samples t-test, Mann–Whitney U test or Chi-square test Fisher's exact test were used to compare differences between the two treatment groups depending on the nature of the variables. Appropriate repeated-measures statistical method was used depending on the distribution of the repeated clinical measurements and the nature of the study to analyze the changes over the follow-up period. An appropriate time-to-event analysis was used to assess restoration survival during follow-up, if adequate failure events were recorded. The two-sided p value of <0.05 was used as a cut-off point for statistical significance.

RESULTS

The mean age was 34.8 ± 9.7 years in the 3D-printed bioactive resin group and 35.6 ± 10.2 years in the conventional composite group, with no significant difference ($t = -0.44$, $p = 0.661$), shown in table 1. Age categories and sex distribution were also comparable between groups ($\chi^2 = 0.18$, $p = 0.914$ and $\chi^2 = 0.30$, $p = 0.584$, respectively).

Characteristic	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Age, mean ± SD (years)	34.8 ± 9.7	35.6 ± 10.2	35.2 ± 9.9	t = -0.44	0.661
18–30 years, n (%)	23 (38.33)	21 (35.00)	44 (36.67)	χ^2 = 0.18	0.914
31–45 years, n (%)	27 (45.00)	29 (48.33)	56 (46.67)		
>45 years, n (%)	10 (16.67)	10 (16.67)	20 (16.67)		
Male, n (%)	32 (53.33)	29 (48.33)	61 (50.83)	χ^2 = 0.30	0.584
Female, n (%)	28 (46.67)	31 (51.67)	59 (49.17)		

Table 1: Demographic Characteristics of Participants According to Treatment Group

Note: Independent-samples t-test was used for age and Pearson's chi-square test was used for categorical variables.

Maxillary teeth accounted for 45.00% in the 3D-printed group and 41.67% in the conventional group, while mandibular teeth accounted for 55.00% and 58.33%, respectively ($\chi^2 = 0.14$, $p = 0.709$), shown in table 2. Premolar, molar, Class I, and Class II distributions were also comparable between groups, with no statistically significant differences (all $p > 0.05$).

Characteristic	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Maxillary teeth, n (%)	27 (45.00)	25 (41.67)	52 (43.33)	χ^2 = 0.14	0.709
Mandibular teeth, n (%)	33 (55.00)	35 (58.33)	68 (56.67)		
Premolars, n (%)	25 (41.67)	23 (38.33)	48 (40.00)	χ^2 = 0.13	0.720
Molars, n (%)	35 (58.33)	37 (61.67)	72 (60.00)		
Class I restorations, n (%)	34 (56.67)	32 (53.33)	66 (55.00)	χ^2 = 0.13	0.721
Class II restorations, n (%)	26 (43.33)	28 (46.67)	54 (45.00)		

Table 2: Distribution of Restorations According to Tooth and Cavity Characteristics

Note: Pearson's chi-square test was used for comparison of categorical variables.

At 6 months, 55 (91.67%) restorations in the 3D-printed group and 51 (85.00%) in the conventional composite group remained successful/surviving (table 3). The difference was not statistically significant (χ^2 = 1.32, p = 0.251). Restoration failure occurred in 8.33% and 15.00% of the groups, respectively.

Clinical outcome	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Successful/surviving restoration, n (%)	55 (91.67)	51 (85.00)	106 (88.33)	χ^2 = 1.32	0.251
Restoration failure, n (%)	5 (8.33)	9 (15.00)	14 (11.67)		
Restoration repaired, n (%)	2 (3.33)	4 (6.67)	6 (5.00)	χ^2 = 0.70	0.403
Restoration replaced, n (%)	3 (5.00)	5 (8.33)	8 (6.67)	χ^2 = 0.54	0.462

Table 3: Clinical Success and Restoration Survival at 6 Months

Note: Pearson's chi-square test was used. Clinical success was defined according to the predefined clinical evaluation criteria.

Clinically acceptable marginal integrity was observed in 52 (86.67%) restorations in the 3D-printed group compared with 46 (76.67%) in the conventional composite group (table 4). The difference was not statistically significant (χ^2 = 2.02, p = 0.155).

Marginal integrity	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Clinically acceptable, n (%)	52 (86.67)	46 (76.67)	98 (81.67)	χ^2 = 2.02	0.155
Minor marginal discrepancy, n (%)	7 (11.67)	10 (16.67)	17 (14.17)		
Clinically unacceptable defect, n (%)	1 (1.67)	4 (6.67)	5 (4.17)		

Table 4: Marginal Integrity of Restorations at 6 Months

Note: Pearson's chi-square test was used to compare marginal integrity between groups.

No postoperative sensitivity was reported in 53 (88.33%) restorations in the 3D-printed group and 47 (78.33%) in the conventional composite group (table 5). The difference between groups was not statistically significant (χ^2 = 2.29, p = 0.130).

Postoperative sensitivity	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
No sensitivity, n (%)	53 (88.33)	47 (78.33)	100 (83.33)	χ^2 = 2.29	0.130
Mild sensitivity, n (%)	5 (8.33)	8 (13.33)	13 (10.83)		
Moderate sensitivity, n (%)	2 (3.33)	4 (6.67)	6 (5.00)		
Persistent/severe sensitivity, n (%)	0 (0.00)	1 (1.67)	1 (0.83)		

Table 5: Postoperative Sensitivity at 6 Months

Note: Pearson's chi-square test was used. Categories were based on the predefined clinical assessment criteria.

Clinically acceptable anatomical form was maintained in 55 (91.67%) restorations in the 3D-printed group and 49 (81.67%) in the conventional composite group (table 6). Although the proportion was higher in the 3D-printed group, the difference was not statistically significant (χ^2 = 2.65, p = 0.104).

Anatomical form	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Clinically acceptable, n (%)	55 (91.67)	49 (81.67)	104 (86.67)	χ^2 = 2.65	0.104
Minor anatomical alteration, n (%)	4 (6.67)	8 (13.33)	12 (10.00)		
Major anatomical alteration, n (%)	1 (1.67)	3 (5.00)	4 (3.33)		

Table 6: Anatomical Form of Restorations at 6 Months

Note: Pearson's chi-square test was used to compare anatomical form between groups.

A smooth or clinically acceptable surface was observed in 54 (90.00%) restorations in the 3D-printed group compared with 45 (75.00%) in the conventional composite group (table 7). This difference was statistically significant (χ^2 = 4.09, p = 0.043).

Surface quality	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Smooth/clinically acceptable, n (%)	54 (90.00)	45 (75.00)	99 (82.50)	χ^2 = 4.09	0.043
Slight surface roughness, n (%)	5 (8.33)	11 (18.33)	16 (13.33)		
Clinically unacceptable deterioration, n (%)	1 (1.67)	4 (6.67)	5 (4.17)		

Table 7: Surface Quality of Restorations at 6 Months

Note: Pearson's chi-square test was used. A p-value <0.05 was considered statistically significant.

Secondary caries occurred in 1 (1.67%) restoration in the 3D-printed group and 3 (5.00%) in the conventional group, while fracture occurred in 3.33% and 6.67%, respectively (table 8). Overall, complications were reported in 6 (10.00%) and 13 (21.67%) restorations, respectively, with no statistically significant difference (χ^2 = 3.00, p = 0.083).

Complication	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Secondary caries, n (%)	1 (1.67)	3 (5.00)	4 (3.33)	χ^2 = 1.03	0.310
Restoration fracture, n (%)	2 (3.33)	4 (6.67)	6 (5.00)	χ^2 = 0.70	0.403
Restoration loss/debonding, n (%)	1 (1.67)	3 (5.00)	4 (3.33)	χ^2 = 1.03	0.310
Persistent sensitivity, n (%)	2 (3.33)	5 (8.33)	7 (5.83)	χ^2 = 1.37	0.242
Any complication, n (%)	6 (10.00)	13 (21.67)	19 (15.83)	χ^2 = 3.00	0.083

Table 8: Restoration-Related Complications During 6-Month Follow-up

Note: Pearson's chi-square test was used for comparison of categorical complications.

At 6 months, restoration survival was 91.67% in the 3D-printed group versus 85.00% in the conventional group (χ^2 = 1.32, p = 0.251), shown in table 9. Acceptable marginal integrity, absence of sensitivity, acceptable anatomical form, and absence of secondary caries were also more frequent in the 3D-printed group, while surface quality showed a statistically significant difference (χ^2 = 4.09, p = 0.043).

Clinical outcome	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Test value	p-value
Restoration survival, n (%)	55 (91.67)	51 (85.00)	χ^2 = 1.32	0.251
Acceptable marginal integrity, n (%)	52 (86.67)	46 (76.67)	χ^2 = 2.02	0.155
No postoperative sensitivity, n (%)	53 (88.33)	47 (78.33)	χ^2 = 2.29	0.130
Acceptable anatomical form, n (%)	55 (91.67)	49 (81.67)	χ^2 = 2.65	0.104
Acceptable surface quality, n (%)	54 (90.00)	45 (75.00)	χ^2 = 4.09	0.043
No secondary caries, n (%)	59 (98.33)	57 (95.00)	χ^2 = 1.03	0.310
No fracture/loss, n (%)	57 (95.00)	53 (88.33)	χ^2 = 1.56	0.212

Table 9: Overall Clinical Performance of Restorations at 6 Months

Note: Pearson's chi-square test was used for comparison of categorical clinical outcomes.

An excellent or clinically acceptable outcome was recorded in 52 (86.67%) restorations in the 3D-printed group and 44 (73.33%) in the conventional composite group (table 10). The difference was not statistically significant (χ^2 = 3.20, p = 0.074).

Overall clinical outcome	3D-printed bioactive resin (n=60)	Conventional composite (n=60)	Total (N=120)	Test value	p-value
Excellent/clinically acceptable, n (%)	52 (86.67)	44 (73.33)	96 (80.00)	χ^2 = 3.20	0.074
Acceptable with minor changes, n (%)	6 (10.00)	10 (16.67)	16 (13.33)		
Clinically unacceptable, n (%)	2 (3.33)	6 (10.00)	8 (6.67)		

Table 10: Overall Clinical Outcome Classification at 6 Months

Note: Pearson's chi-square test was used to compare the overall clinical outcome between treatment groups.

DISCUSSION

The present study showed that the restoration survival after 6 months in the 3D-printed bioactive resin group (91.67%) was not statistically different from that of the conventional composite group (85.00%) (χ^2 = 1.32, p = 0.251). The results of this study suggest that the two restorative strategies have similar short-term clinical outcomes. Favorable short-term clinical behavior has been reported for resin composite restorations printed using 3D printing. The clinical performance of 3D-printed PFDP during 1-year clinical follow-up was satisfactory in the previous study, but mechanical fracture was found to be an important failure mode[15]. The slightly greater survival seen in the current study might be attributed to the brief observation time of 6 months, and variations in restoration design and clinical use.

The integrity of the marginal integrity was clinically acceptable for 86.67% of the restorations in the 3D-printed group and 76.67% in the conventional composite group, with non-statistical significance (χ^2 = 2.02, p = 0.155). This indicates that the early marginal performance of both materials was satisfactory. This finding aligns with clinical studies on resin-based restorative materials, which have shown that various material properties, polymerization characteristics, design of the restoration, and the clinical management of the restoration can affect the marginal adaptation. Clinically, the bioactive and conventional resin composite restorations showed acceptable clinical performance in the previous research study[16] and the present findings suggest that the bioactive restorative material can show clinical acceptable marginal outcome in prospective follow-up.

There was no postoperative sensitivity in 88.33% of the restorations in the 3D-printed group compared with 78.33% of the restorations in the conventional group (χ^2 = 2.29, p = 0.130). The percentages of anatomical form for restorations were 91.67% for the first group and 81.67% for the second group (χ^2 = 2.65, p = 0.104). There was no statistically significant difference between the 2 outcomes, despite the numerical results suggesting the 3D printed material was superior. The results are in agreement with clinical data indicating that, when used with suitable adhesive and restorative techniques, contemporary resin-based restorative materials can achieve adequate biological and anatomical results. In the past, a randomized clinical trial conducted by the previously mentioned research study did not reveal any significant differences between several clinical parameters of the different resin-based restorative approaches used, thus highlighting the need for standardized operative protocols when results from clinical trials are interpreted[17].

The only outcome that was found to be statistically different in the current study was surface quality. The 3D-printed restorations were observed to have a clinically acceptable or smooth surface in 90.00% of cases, while the conventional composite restorations had a clinically acceptable or smooth surface in 75.00% of cases (χ^2 = 4.09, p = 0.043). The surface roughness might be a factor to consider in restorative aesthetic as it may affect gloss, staining, plaque accumulation, and the perception of the patient. Another study, a systematic review and network meta-analysis, showed that polishing procedures significantly affect the surface smoothness of resin composites, and various polishing systems yield varying results in terms of surface smoothness[18]. Therefore, the better surface quality that is seen in the present study could be related to material fabrication and finishing characteristics, but it cannot be directly attributed based on the present clinical data.

Aesthetic aspect of the present study revealed good surface results short-term but the assessment of surface cannot be deduced as an aesthetic stability. In the present study, quantitative colour measurement was not carried out. A previous research study assessed 3D-printed non-invasive restorations after 24 months, and found progressive discoloration with clinically detectable colour changes being more frequent over a longer follow-up period[19]. From this evidence it can be seen that good initial surface appearance does not always lead to satisfactory long-term colour stability. Thus, future clinical studies should consider using objective parameters like ΔE, gloss, surface roughness, and colour matching in addition to the traditional clinical evaluation when assessing the aesthetic performance of 3D-printed restorative materials.

In the current study, few complications associated with restoration

occurred. A total of 1.67% of the restorations in the 3D-printed group, and 5.00% in the conventional group, developed secondary caries, whereas 3.33% and 6.67% of each group, respectively, developed fractures. The overall complications after the restorations were 10.00% and 21.67%, respectively, but not statistically significant ($\chi^2 = 3.00$, $p = 0.083$). A higher number of the 3D printed group had clinically acceptable outcomes, 86.67%, compared to the conventional group, 73.33%, with a difference that was not significant ($\chi^2 = 3.20$, $p = 0.074$). From these results, one can see that the material obtained by 3D printing has good performance in the short term, especially regarding surface quality, but is not necessarily superior to the other materials. In recent studies, 3D-printed resin material has revealed an increase in its surface roughness and a decrease in its gloss after simulated toothbrushing, indicating the need for more extended testing of its mechanical stability and aesthetics[20].

Strengths and Limitations

The most significant aspect of this study was the prospective, parallel-group comparative design over a 12-month study period, where 120 restorations were distributed equally among the 3D-printed bioactive resin and conventional composite groups, and then directly compared with clinical routine in restorative conditions. The standardized restorative procedures, calibrated clinical examiner, predetermined clinical results, and 6-month clinical follow-up allowed for a structured evaluation of the survival of the restoration, the integrity of the margins, postoperative sensitivity, anatomical form, surface quality, and occurrence of complications related to the restoration. There are, however, a number of caveats to be taken into account. The overall study was carried out over 12 months, but the clinical follow-up duration for each restoration was only 6 months (long-term assessment of the survival of the restoration, occurrence of secondary caries, fracture, marginal deterioration, and color stability). Single center design may not be representative of other settings and patients. Sample size of 120 restorations could have also led to low statistical power to detect differences between treatment groups that are not so large, especially for rare complications. In addition, the clinical evaluation was mainly by visual assessment and clinical measurements of surface roughness, gloss, color stability, and marginal adaptation were not performed. To confirm the long-term clinical performance of 3D-printed bioactive resin restorations, more multicenter studies are needed with longer patient-level follow-up and standardized quantitative assessment methods.

CONCLUSION

The present study showed that 3D-printed bioactive resin restorations were as clinically successful as conventional composite restorations in 6-month follow-up period, in terms of restoration survival, marginal integrity, postoperative sensitivity, anatomical form and restoration-related complications. The surfaces of the 3D-printed bioactive resin group were clinically acceptable more frequently than that of the conventional composite group (90.00% vs. 75.00%, $p = 0.043$), with statistically significant difference in the surface quality. There was also a higher numeric survival after 3D-printed bioactive resin (91.67% vs. 85.00%), but this was not statistically significant ($p = 0.251$). In summary, the data showed that 3D-printed bioactive resin restorations are a clinically viable restorative material and have good short-term performance with similar results to the conventional composite restorations.

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