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Original Research Article

Pulpitis tendency in teeth with vital pulp restored with composite resins: a cross-sectional retrospective study

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ABSTRACT

Background: This study evaluates pulpitis tendency in vital teeth restored with composite resin after at least one year, focusing on the effect of cavity depth and the use of a base material on pulp status.
Methods: A retrospective analysis was conducted on 212 patients with one tooth restored by dental senior students. At the follow-up, periapical and bitewing radiographs, cold tests, percussion, and palpation were performed. Cavity depth was measured from bitewing radiographs, and the periapical index (PAI) was recorded. The restored teeth were compared with contralateral sound teeth to assess the impact of the resin on pulp tissue.
Results: Composite resin restorations significantly affected pulp status compared to intact teeth (p=0.002). Five out of 212 teeth became necrotic, and four developed symptomatic irreversible pulpitis (SIP). Four necrotic cases occurred in cavities deeper than 3.60 mm, and all SIP cases were associated with cavities deeper than 3.10 mm. Cavity depth was a significant predictor of adverse pulpal outcomes. However, using calcium hydroxide as a base did not significantly affect pulp health.
Conclusions: The study concludes that composite resin restorations, mainly in deep cavities, can negatively impact pulp vitality. Cavity depth is a key factor in the risk of pulp necrosis and SIP, while calcium hydroxide base did not reduce pulpitis incidence. Larger studies with longer follow-up periods are recommended to confirm these findings and explore potential protective factors.

Keywords: Pulpitis, Composite resin, Cavity depth, Pulp health

INTRODUCTION

The structural integrity of a tooth depends on three peripheral mineralized layers: enamel, dentin, and cementum. These layers surrounded a non-mineralized dental soft tissue located in the inner part of the tooth, the dental pulp.[1] The dental pulp is a connective tissue composed of a bundle of blood vessels and nerves entering the tooth from the apical region. The dental pulp nourishes the tooth and provides sensational responses to external insults. However, it is susceptible to various irritants that can cause pulpal inflammation, commonly known as pulpitis.[1]

Pulpitis can arise from mechanical, chemical, thermal, and microbial irritants that can cause damage to the dental

pulp, and this activates various types of inflammatory responses involving complex vascular, lymphatic, and local tissue reactions.[2] Over time, this can lead to pulp necrosis and periapical lesions if not properly managed. Among the most common causes of pulpitis are bacterial infections, such as caries, or in rare cases, periodontitis.[3] In addition, cracks, fractures, and open restoration margins can lead to micro-leakage and cause pulp inflammation, which, over time, can lead to pulp necrosis and periapical lesions if not managed properly.[4] Other factors contributing to pulpitis include pulp exposure through trauma, abrasions caused by aggressive tooth brushing, overheating from dental drills and use of light cure, or chemical erosion from dietary acids or acid reflux.[3] When the dental pulp becomes inflamed, the accumulative inflammatory exudate exerts pressure within the confined pulp cavity. Unlike other body tissues, where pressure from inflammation can dissipate through the surrounding soft tissues, the dental pulp is encased in rigid dentin. This lack of space for expansion exaggerates pain, as the increased pressure impacts the nerve fibers within the pulp. Pain intensity depends on the severity of the inflammation and the body's response.[3]

Composite resin has been a popular restorative material due to its adhesion to the tooth structure, high esthetic appeal, and good mechanical properties.[5,6] The primary component of resins is an organic polymer matrix reinforced with inorganic particles, providing superior function and appearance. Despite the previously mentioned advantages, resin composite has multiple adverse effects. Multiple studies evaluated its cytotoxic potential, which often irritates the pulp by releasing unreacted monomers, eliciting a toxic response.[7,8] In addition, studies have shown that composite resin demonstrates an allergic reaction to the skin if mishandled by Individuals who have sensitivity to the monomer component in the composite.[5] Additionally, the polymerization process of composite resin tends to shrink toward the light source, typically ranging from 2% to 5%.[5,9] This shrinkage might lead to the formation of a gap between the tooth structure and the restoration.[9] Hence, it may not only compromise the marginal integrity but also allow bacterial invasion through the gap to the dental pulp, leading to pulpal inflammation.[10] Based on the systematic review done by Dawson et al they concluded that more clinical studies should be conducted to determine the effect of the composite resin on the pulp tissue.[11] Therefore, the aim of this study is to evaluate the pulpitis tendency in teeth with vital pulp restored with composite resins after at least one year and the effect of the depth of composite filling on the pulp status after the same follow-up period. Also, to evaluate effect of using base under the composite resin restoration on pulp status.

METHODS

A retrospective study was conducted in the dental clinics at Taibah university dental college and hospital. The data were randomly selected from the R4 system patients' database at Taibah university dental clinics in January 2021.

Inclusion criteria included the patients who received class I composite resin restoration in permanent vital posterior teeth for over one year in the dental clinics at Taibah university dental college and hospital from July 2014 to July 2019 with complete medical and dental records. Exclusion criteria were non-vital teeth, teeth restored by resin restorations for less than one year, teeth that had recurrent caries other than resin restorations, and the presence of a preoperative periapical lesion.

Sample size calculation was performed to detect an effect. The effect size was 0.8, the significance level (α) was 0.05, and the power of the study was 90% based on previous studies.[12,13] The total sample size to detect the differences between the groups was 33. However, in this study, a sample size of 212 male and female patients was included.

The patients were recalled for re-evaluation, during the session, the medical and dental history, cold test, vertical and horizontal percussion, and palpation were performed for each patient.

Data was collected and recorded in the examination sheet, which included three sections. Section A is the socio-demographic information. Section B includes the radiographic examination using (PAI) system, measuring the depth of the cavity and if there is base or not under the resin restoration.[14] Section C includes clinical examination readings, which are cold test, percussion, and palpation.

The study was approved by the research ethical committee at Taibah university (Protocol no. TUCDREC/20200103/RBAlahmadi). To report the current retrospective study STROBE Statement was used. The privacy and confidentiality of the participants is protected. The participant signed a consent form after providing adequate time to answer questions. Participation is voluntary, and the participants have the right to withdraw from the study.

All collected data was categorized in an Excel sheet, which was transformed to (Statistical package for social science (SPSS) version 16.0 for analysis. Non-parametric data analysis using the chi-square test was used to test the hypothesis.

RESULTS

The 212 patients were included; 103 patients were males and 109 patients were females. Regarding the age, 90 patients were younger than 30 years old, and the rest were older. The 2.4% of them have hypertension. The highest PAI percentage was 75.5% for score 1, followed by 22.2% for score 2 (Table 1).

Regarding pulp response to cold test, only 9 cases (4%) had either no response to cold test (necrotic pulp)/sharp lingering pain SIP, 7% of cases different levels of response to percussion and 3% to palpation (Table 1).

The depth of the cavity had a wide variation from 1 mm to just above the pulp horns (Table 2). Four teeth with necrotic pulp were seen when the cavity was deeper than 3.60 mm, and only one tooth with necrotic pulp when the cavity is shallower than 3.60 mm.

Only 25 teeth (11.8%) of the cases have calcium hydroxide base under the composite resin. Six teeth out of 25 teeth that have a base became reversible pulpitis, and only one tooth was diagnosed as necrotic pulp with symptomatic apical periodontitis (Table 3).

The results show that the depth of the cavity has a significant effect on the pulp condition ($p \leq 0.0001$). However, the data analysis showed that using the base had no significant effect on pulpitis tendency.

Table 1: Descriptive data at the follow-up visit.

Patient variables	Patient response	N (%)
Presence of systemic diseases	Yes	11 (5)
	No	187 (88)
	He/She do not know	14 (7)
	Total	212 (100)
Distribution of PAI	PAI (score 1)	160 (75.5)
	PAI (score 2)	47 (22)
	PAI (score 3)	4 (2)
	PAI (score 4)	1 (0.5)
	Total	212 (100)
Response to cold test	Normal	171 (81)
	Sharp non-lingering (reversible pulpitis)	32 (15)
	Lingering (SIP)	4 (2)
	No response (necrotic pulp)	5 (2)
	Total	212 (100)
Tender to percussion	No pain	197 (93)
	Mild pain	8 (4)
	Moderate pain	6 (2.5)
	Severe pain	1 (0.5)
	Total	212 (100)
Tender to palpation	No pain	205 (97)
	Mild pain	5 (2)
	Moderate pain	1 (0.5)
	Severe pain	1 (0.5)
	Total	212 (100)

Table 2: Number of cases according to cavity depth in mm and pulp response for each category at follow-up visit.

Depth of cavity in (mm)	Normal teeth	Teeth with necrotic pulp	Teeth with SIP	Teeth with reversible pulpitis
1.00-1.50	14	0	0	0
1.60-2.00	22	0	0	2
2.10-2.50	24	0	0	2
2.60-3.00	31	1	0	1
3.10-3.50	25	0	0	5
3.60-4.00	28	2	2	6
>4.00	27	2	2	16

Table 3: Number and percentages of cases with and without calcium hydroxide base and the teeth with reversible pulpitis, irreversible pulpitis, and necrotic pulp.

Use of CaOH	N (%)	Number of teeth with necrotic pulp	Number of teeth with SIP	Number of teeth with reversible pulpitis
Yes	25 (12)	1	0	0
No	187 (88)	4	4	26
Total	202 (100)			

DISCUSSION

Several reasons can lead to a violation of tooth structure integrity, resulting in the need to restore these missed structures. One of the most common restorations filling this purpose is composite resin due to its functional and esthetic high-performance.[15] Therefore, composite resins have been widely used, but the long-term effects on the pulp are still controversial. While dental composite remains a common material to use, the long-term effect of this material on pulp health is still debated by clinicians and researchers. Many drawbacks related to resin-based composites, one of them being pulp irritation.[16] This is because the Bis-GMA, which is the main composition of the resin matrix, is cytotoxic to the pulp tissue.[17] Also, it was histologically explained in Grieve et al study as they found gram-positive bacteria in the interface between the composite resin and the dentinal cavity, which caused pulpal irritation.[7] Subsequently, these bacteria and their byproducts may diffuse through exposed dentinal tubules, which leads to pulpal inflammation.[18-20]

The results of this study agreed with Whitworth and Myers study, which showed a significant effect of composite resin restoration on the pulp status.[21] Our findings add further weight to the hypothesis that composite resins, particularly in deeper cavities, may compromise pulp vitality. The observed necrotic pulp cases and SIP cases in this study emphasize the need to carefully assess cavity depth during restorative procedures. On the other hand, multiple studies did not show any harmful effect of composite resin on the pulpal tissue.[22-24] Such discrepancy in the findings of these studies could be associated with the variation in the types of study materials, the method applied, or the nationality of the patients under consideration. Some of these studies reported that using a more advanced bonding agent or specific technique can reduce polymerization shrinkage, which increases the pulp health outcome.[25,26] However, there is still a lack of strong clinical studies to evaluate the effect of composite on the pulp condition of the tooth.

Cavity depth has an important effect on pulp health.[27] Our study demonstrated a clear correlation between cavity depth and adverse pulp responses, with deeper cavities (>3.60 mm) associated with higher rates of necrotic pulp and SIP. When the cavity depth is extensively shallow, this will result in a mild natural response, comparable to a remarkable response when the cavity preparation goes deeper, as the dentine thickness decreases, the pulp irritation increases.[14] A thinner dentin barrier relates to a deeper cavity, which can increase the irritation to the pulp and thermal conductivity during the procedure.[28,29] This result highlighted the need for minimally invasive restorative techniques to reduce the previous facts and protect the public tissue.

As the recently introduced bulk-fill resin restorations do not require incremental placement and can be cured only once for 4-6 mm depth, the curing light may not penetrate deeper, and this will result in insufficient polymerization and eventually cytotoxicity due to the number of uncured monomers.[30-32] In addition, a study has shown that bulk-fill composite resins exhibit more cytotoxicity at a 4 mm depth than at a 2 mm depth.[33] Although bulk-fill resins have several advantages, especially in being less time-consuming, root canal treatment and dental implants should be weighed in terms of benefits in reduced chair time versus possible increase in cytotoxicity of deeper restorations.

Different materials can be used for lining or as a base agent in indirect pulp capping (IPC) procedures, such as Calcium hydroxide, GIC type VII, and MTA. In Mathur and Dhillon the success rate was 93.5% with calcium hydroxide, with GIC type VII it was 97%, but with MTA was a 100% success.[34] All three groups have almost the same radiodensity after six months of follow-up. These results demonstrate that MTA is the best material compared to the other materials tested with regard to dentin bridge formation and pulp heating.

On the other hand, a study by Hashem and Mannocci aimed to compare Biodentine and Fuji IX on the dental pulp response in IPC on teeth that have reversible pulpitis clinically and radiographically, they found that there are no differences in the success rate between the two groups clinically.[35] However, CBCT results concluded that there are significant differences between the two groups. Most teeth with healing/healed lesions identified using CBCT had received Biodentine, whereas the majority of teeth with new/progressing lesions had received Fuji IX.[35] While both materials seem to perform equally, Biodentine exhibits much higher biocompatibility as well as a better ability to initiate reparative dentine formation in comparison with Fuji IX, especially when assessed with better diagnostic techniques like the CBCT.

Another histological examination study indicated that the pulp status was affected by using capping material, especially when it was a resin-containing material.[36] This shows that in deeper cavities or large restoration some materials may induce more irritation to the pulp tissue. Only 11.8% of the cases that were included in this study had calcium hydroxide liner. Therefore, this study failed statistically to show a significant effect of the presence of a base beneath the composite resin. This is possible because of the short follow-up period and the limited number of cases presented with calcium hydroxide base. To obtain a definitive conclusion, larger sample sizes and longer follow-up periods are typically better because they reduce the likelihood of sampling errors and provide a more accurate representation of the population.

CONCLUSION

This study highlighted the effect of the deep cavity depth on the pulp health of teeth restored with composite resin. The deeper cavities over 3.6 mm can increase the risk of

pulp necrosis and SIP. Although restoration with resin composites is widely used due to its esthetic and functional properties, the likely effect on the vitality of the pulp should be considered. In addition, using calcium hydroxide as a base under resin composites didn't show any important benefits in reducing pulp inflammation. For this reason, using calcium hydroxide may not be routine in all the scenarios.

This study shows the importance of precise preparation of the teeth and evaluates the cavity depth to reduce pulp inflammation. Using minimally invasive techniques and the proper restorative material to preserve pulp vitality is critical. Further investigation with larger sample size and longer follow-up periods can aid in exploring enhanced methods and better materials that may protect the pulp vitality in deep cavities.

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