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Evaluating fracture toughness of provisional crowns cemented with different luting cements and removal of cement remnants by using chemical and mechanical methods at various intervals

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Abstract

Aim: The aim of this study is to determine the fracture toughness of provisional crowns by removing and recementation at various intervals.

Introduction: Provisional crowns are to be removed and recemented various times during the time period of permanent crown fabrication. i.e., during Metal trail, Bisque trail and during final cementation. There are various methods of cement removal such as mechanical and chemical. Mechanical methods include handpiece and burs, ultrasonic scalers and scrapping. Chemicals such as ethanol, acetone hydrofluoric acid is used for dissolution of cement remnants. So this study aims at testing the strength of provisional crowns by repeatedly removing the crown & cement remnants and recementing the same crown at various intervals (7 days, 14 days and 21 days).

Materials & Methodology: A metal die is fabricated. Commercially available temporary crown material is selected and provisional crowns are prepared. These are cemented by using IRM and ZOE. Later these crowns are dislodged and cement remnant is removed by using bur, scrapping and ultrasonic scaler and by chemical dissolution. After removal of cement remnants these crowns are recemented and again removed, cleaned and recemented and then these samples are subjected to fracture toughness testing by using Universal Testing Machine (UTM) at time periods of 7 days, 14 days and 21 days.

Results: When cemented with ZOE & IRM, the statistical analysis showed that the value of ethanol group possess better fracture toughness than the other three groups (Acetone, Burs, Scrapping & Ultasonic scalers) but less when compared to control group. As the days increases the fracture toughness decreases.

Conclusion: The conclusion of the study was the cement remnants removal through chemical dissolution shows better fracture toughness than the mechanical methods. The provisional crowns cemented with IRM shows better fracture toughness than the crowns cemented with ZOE. This infers that crowns cemented with IRM and cement remnants removal with chemical dissolution in that ethanol possess better fracture toughness.

Keywords: Provisional crowns, IRM, ZOE, Recementation, Cement Remnants, Chemical dissolution, Mechanical methods.

Introduction:

Provisional restorations in fixed prosthodontic rehabilitation are important treatment procedures, particularly if the restorations are expected to function for extended periods of time or when additional therapy is required before completion of the rehabilitation. They play a particular role in diagnostic procedures and continued evaluation of the treatment plan, as they should resemble the form and function of the definite rehabilitation that they precede.

Cementing a restoration on an interim basis is occasionally advised so that the patient and the dentist can assess its appearance and function over a period longer than a single visit [1, 2]. Zinc oxide-eugenol (ZOE) cements are commonly used for temporary cementation because of their sedative effect, ease of removal, low cost, and excellent sealing property [3]. After provisional cementation with temporary cement, the cast restoration has to be carefully cleaned and luted with more definitive cement [4]. The remnant debris of the temporary cement on the intaglio surface of cast restorations may have a negative effect on the performance of definitive cement [5, 6]. The mechanical removal of temporary cement using an excavator or a scalpel blade has been found to be not completely effective, and the remnants of the cement have been observed microscopically on surfaces that appeared macroscopically clean [7, 8]. Therefore, methods such as airborne-particle abrasion, ultrasonic cleaning, or the use of organic solvents may be needed for improved cleaning[9, 10, 11, 12].

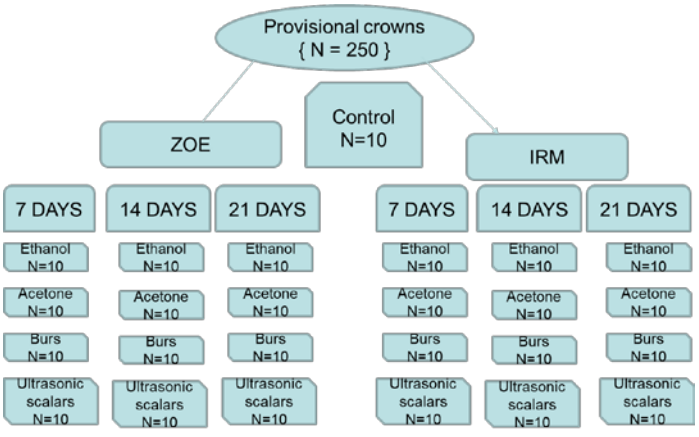
Several factors influence the retention of restoration, including the accuracy of fit, the taper of preparation, the ratio of the axial to the lateral dimensions, the auxiliary retention forms, the area of the bond, the surface texture, and factors related to the cement such as its adhesion, luting material type, and film thickness [4, 12, 13, 14, 15, 16, 17, 18]. When an ideal retentive configuration is achieved, a dentist may not be concerned with the dislodgment of the restorations even if they have remnants of the temporary cement on their intaglio surface; however, studies have shown that dental students, general dentists, and even prosthodontists have not been very successful in routinely creating an ideal taper, such as 3° to 6° [19, 20, 21].

Particularly when the prepared tooth has a minimally retentive design, the retention must be maximized by cleaning the debris or the contaminants.

Provisional crowns are to be removed and recemented various times during the time period of permanent crown fabrication i.e., during Metal trail, Bisque trail and during final cementation, if the final prosthesis doesn't fit properly. There are various methods of cement removal such as mechanical and chemical methods. The main aim of this study was to evaluate the fracture toughness of recemented provisional crowns by cementing with two different luting cements and cement remnants were removed by chemical dissolution and mechanical methods at various intervals.

Methodology

A metal die was fabricated with a bevel on one side and putty impression was made for the metal die and duplicated with die stone (Fig.1). Wax pattern with a thickness of 2mm was fabricated on metal die and putty impression was made for the die with wax pattern. Commercially available provisional crown material is selected (DPI self-cure tooth molding material) and provisional crowns were prepared (Fig.2). They were cemented by using IRM and ZOE on the duplicated die's. The sample size was about 250 samples. Each group contains 10 samples each.



Later these crowns are dislodged and cement remnants is removed by using burs, ultrasonic scalars and by chemical dissolution using acetone and ethanol at 7th day and were tested with UTM for fracture toughness (Fig.3). In chemical dissolution the crowns are kept in chemicals for a period of 5 minutes. The provisional crowns were cemented on the duplicated die's and dislodged at 7th day and removed the cement remnants by using chemical & mechanical methods and these crowns are recemented and again removed at 14th day, cleaned and the sample crowns were tested with UTM for fracture toughness. The provisional crowns were cemented on the duplicated die's and dislodged at 7th day and removed the cement remnants by using chemical & mechanical methods and these crowns are recemented, dislodged and removed the cement remnants at 14th day and these crowns were recemented, dislodged and removed the cement remnants at 21st day and the sample crowns were tested with UTM for fracture toughness.

Results

The mean fracture toughness value of the control group was 52.44MPa. The fracture toughness values of provisional crowns cemented with ZOE cement in which the cement remnants were removed by using chemical methods (Ethanol & acetone) and Mechanical methods (Burs & Ultrasonic scalers) at various time intervals (7days, 14days & 21days) were compared with the control group and were statistically analysed and P value is less than 0.01, which shows that there was more significance differences in between the groups at various intervals. As the time interval increases the fracture toughness value decreases for every group. The fracture toughness value is more for the ethanol group 48.96Mpa, 43.83Mpa & 39.16Mpa and less value observed for the ultrasonic scalers group 34.35Mpa, 27.63Mpa & 23.74Mpa at the 7days, 14days & 21days time intervals respectively

(Table-1). At 7 days the samples related to the chemical group and Mechanical group has the fracture toughness of 45.96MPa and 35.94Mpa respectively. At 14 days the samples related to the chemical group and Mechanical group has the fracture toughness of 39.91MPa and 30.19Mpa respectively. At 21 days the samples related to the chemical group and mechanical group has the fracture toughness of 35.40MPa and 24.71Mpa respectively. This shows that as the time interval increases, the fracture toughness value decreases. When compared with control group, both groups have less fracture toughness values but in between the groups, mechanical group has less fracture toughness when compared to chemical group (Graph-1).

The mean fracture toughness value of the control group was 52.44MPa. The fracture toughness values of provisional crowns cemented with IRM cement in which the cement remnants were removed by using chemical methods (Ethanol & acetone) and Mechanical methods (Burs & Ultrasonic scalers) at various time intervals (7days, 14days & 21days) were compared with the control group and were statistically analysed which shows that P value is less than 0.01, which indicates that there is more significance differences in between the groups at various intervals. As the time interval increases the fracture toughness value decreases for every group. The fracture toughness value is more for the ethanol group was 49.42Mpa, 44.67Mpa & 39.54Mpa and less value observed for the ultrasonic scalers group was 35.22Mpa, 27.82Mpa & 24.16Mpa at the 7days, 14days & 21days time intervals respectively (Table-2). At 7 days the samples related to the chemical group and Mechanical group has the fracture toughness of 46.39MPa and 36.69Mpa respectively. At 14 days the samples related to the chemical group and Mechanical group has the fracture toughness of 40.54MPa and 30.43Mpa respectively. At 21 days the samples related to the chemical group and Mechanical group has the fracture toughness of 35.96MPa and 24.98Mpa respectively. This shows that as the time interval increases, the fracture toughness value decreases. When compared with control group, both groups have less fracture toughness values but in between the groups, mechanical group has less fracture toughness when compared to chemical group (Graph-2).

Discussion

Restorations may be provisionally cemented to allow the patient and dentist to assess esthetics and function over a period of time. Provisional crowns and provisional fixed partial dentures are an essential component of prosthodontic therapy.

An optimum provisional restoration must satisfy many requirements, including protection of the pulp, maintenance of good gingival health via proper marginal fit, contour, and smooth surface, occlusal compatibility, esthetics, adequate retention, and ease of removal.

In the study we used IRM and ZOE cement for the cementation of the provisional crowns.

These crowns are cemented and removed from the die and the cement remnants are removed by using chemical dissolution using ethanol and acetone and by mechanical methods such as using burs and ultrasonic scalars.

In those the crowns cemented with IRM shows better fracture toughness than the crowns cemented with ZOE.

This is because the eugenol containing provisional cements with residual eugenol remaining after setting can results in inhibiting the polymerization of acrylic resin by interfering with free radical chemical reaction of resin and softens the acrylic resin which makes the provisional crowns weak.

The methods we followed for the removal of cement remnants in the crowns were chemical dissolution and mechanical methods.

Ramin mosharaff [2] conducted a study on provisional crowns by cementing the crowns with ZOE and dislodged them and cement remnants were removed by ultrasonic scalars and chemical dissolution. He found out that chemical method of cement removal crowns are more retentive.

Mi young song et al [22] conducted a study on the effect of temporary cement cleaning methods on the retention of crowns and found out that air abrasion shows greater retentive ability than other groups.

In the samples tested the chemical dissolution shows the highest fracture toughness than mechanical methods.

Among chemicals ethanol shows better fracture toughness than the acetone. This is because the acetone polymerizes the resin material which is used for the provisional crowns [23].

The mechanical methods used for cleaning cement remnants were using burs and ultrasonic scalars. The fracture toughness is less when compared to chemical dissolution because these mechanical methods create the internal stresses and microcraks which makes the provisional crowns weak.

As the days increases there is decrease in the fracture toughness because the cement remnants removal through mechanical methods like burs and ultrasonic scalars causes the provisional crowns thin and with chemicals they dissolve and gets weak.

Every time during dislodgement the force used to dislodge the crowns was increased because after removal of cement remnants it creates roughness in the intaglio surface which results in the interlocking of material.

Conclusion

The conclusion of study was that the cement remnants removal through chemical dissolution shows better fracture toughness than the mechanical methods. The provisional crowns cemented with IRM shows better fracture toughness than the crowns cemented with ZOE. This infers that crowns cemented with IRM and cement remnants removal with chemical dissolution in that ethanol possess better fracture toughness.

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Legend Tables

Table 1: Comparision of fracture toughness of provisional crowns cemented with ZOE and removed at various time intervals and the cement remnants were removed by using chemical methods (Ethanol & acetone) and Mechanical methods (Burs & Ultrasonic scalers)

Groups	ZOE						P-value
	7 days		14 days		21 days		
	Mean	SD	Mean	SD	Mean	SD	
Ethanol	48.96	2.22	43.83	2.61	39.16	1.43	<0.01*
Acetone	42.95	3.80	35.99	3.16	31.63	1.85	<0.01*
Burs	37.52	4.14	32.75	2.33	25.67	1.38	<0.01*
Ultrasonic Scalers	34.35	2.03	27.63	2.46	23.74	2.47	<0.01*

Control (Mean Value) – 52.44

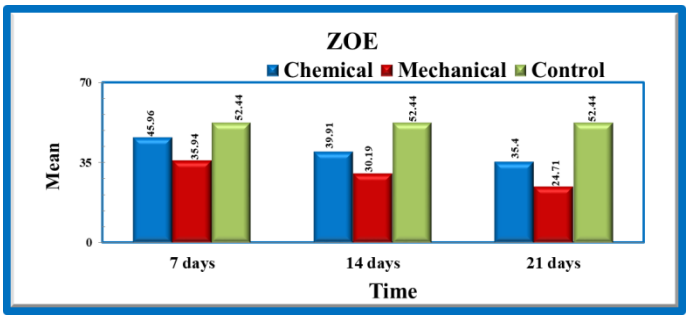
Table 2: Comparision of fracture toughness of provisional crowns cemented with IRM and removed at various time intervals and the cement remnants were removed by using

chemical methods (Ethanol & acetone) and Mechanical methods (Burs & Ultrasonic scalers)

Groups	IRM						P-value
	7 days		14 days		21 days		
	Mean	SD	Mean	SD	Mean	SD	
Ethanol	49.42	2.87	44.67	3.00	39.54	3.08	<0.01*
Acetone	43.36	4.09	36.40	2.34	32.37	1.94	<0.01*
Burs	38.16	4.55	33.03	2.53	25.80	0.92	<0.01*
Ultrasonic Scalers	35.22	1.76	27.82	3.25	24.16	1.18	<0.01*

Control (Mean Value) – 52.44

Graph 1: Comparision of fracture toughness of provisional crowns cemented with ZOE and removed at various time intervals and the cement remnants were removed by using chemical methods (Ethanol & acetone) and Mechanical methods (Burs & Ultrasonic scalers) with control group.



Graph 2: Comparision of fracture toughness of provisional crowns cemented with IRM and removed at various time intervals and the cement remnants were removed by using chemical methods (Ethanol & acetone) and Mechanical methods (Burs & Ultrasonic scalers) with control group.

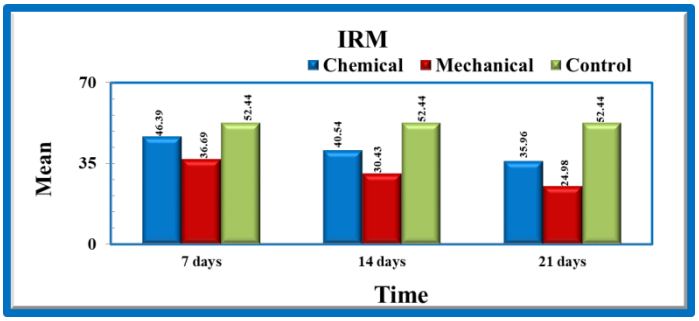


Figure 1: Die for Provisional Crown Preparation with Putty Index

Figure 2: Provisional crowns made with self-cure tooth moulding material

Figure 3: Universal Testing Machine (UTM)