ORIGINAL ARTICLE

Evaluation of Microleakage of Temporary Crowns Made by auto mix and three dimensional Printing Methods using various types of temporary cements

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ABSTRACT

Background: The fabrication of temporary crowns is one of the necessary steps in the treatment of fixed prostheses. Marginal adaptation of the temporary crowns is one of the most important factors in maintaining the gingival and pulpal health of teeth. There are various factors affecting the microleakage of temporary crowns such as fabrication method, material type, and cement type.
Aim: To evaluate the microleakage of temporary crowns made by auto mix and three dimensional (3D) printing methods using various types of temporary cements.
Methods: In this study, 54 human maxillary premolars were selected according to inclusion and exclusion criteria. The specimens were randomly divided into two groups of made by the auto mixed method (27 specimens) and made through a3D printer method (27 specimens). Each of these groups was further divided into three subgroups (n=9)and cemented using temporary cements (zinc-oxidefreegenol; OlisemiCem (Olident, Germany), zinc-oxide eugenol; Temp-Bond (Kerr, Italy), and temporary resin cement; Bifix temp (Voco, Germany)). The results were analyzed using one-way ANOVA and independent t-test. Statistical analysis was performed using SPSS. v17 software.\
Conclusion: The results of this study recommend the use of Olisemicem (ZO) cement in temporary crowns made by a 3D printer. It also showed that the use of auto mix temporary crowns along with Temp bond cement (ZOE) seems to be justified in limited clinical conditions where advanced materials are not available.
Keywords: 3D printing, temporary crowns, microleakage, temporary coating

INTRODUCTION

The fabrication of temporary crowns is one of the necessary steps of fixed prosthesis treatments. Temporary crowns play a fundamental role in the biological and mechanical protection of the teeth and can also be used to provide beauty until completion of the treatment process[1,2]. Due to unforeseen events such as laboratory delay, unavailability of the patient, and necessary gingival treatments ortemporomandibular joint, temporary restorations must satisfy the requirements for providing patients' dental and gum health in the long term[3].Microleakageoccurs as diffusion and transfer of bacteria, saliva, ions, and molecules into the tooth and filling the available space between them[4]. Marginal adaption is an essential feature of provisional restoration materials and is the most important factor in maintaining gum and pulp health[5,6,7].Marginal failures result in microleakage (a major cause of tooth sensitivity) and post-operative sensitivity and caries.[3]In addition to the gap between the tooth and the restoration, microleakage is influenced by factors such as thermal expansion, solubility, and polymerization shrinkage[8,9,10]. On the other hand, water uptake increases restoration rate and in some materials, it can be a compensatory factor for polymerization shrinkage[6,7]. Water uptake and thermos-cycling have a detrimental effect on the marginal fit and thus, on the marginal microleakage of the temporary crown. Factors such as the presence of voids, polymerization stresses, residual unreacted monomers, crack propagation from thermal and occlusalstresses, and water uptake are involved in the aging of the material[3].Temporary crowns coated with temporary cement are susceptible to leaching and destruction, marginal liquefaction, bacterial infiltration and decay, especially when used in long-term[11].

Dental luting agents bond the restoration and shaved tooth through mechanical, micromechanical, chemical or hybrid bonding, which is essential to prevent microleakage[12].Early temporary cements were made of a combination of zinc oxide powder and eugenolliquid.Eugenol has a palliative effect on dental pulp but prevents the staining of acrylic resins and composites and resin cements if left unreacted.For this reason, eugenol-free zinc oxide cements introduced. Poly-organic acid and polycarboxylateare used in the formulation of eugenol-free zinc oxide cements, increasing firmness and seal, and are easily removed from the surface of the tooth[11].Tjanet al (1997) examined two temporary materials consisting of PMMA and Bis_Gma with different luting cements of ZOC, ZO+polycarboxylate, ZO+polyorganic acid. The result of their study showed that the cement samples containing eugenolhave more leakage, and the SC-10 temporary substance, or PMMA, had more microleakagethan Bis-GMA[7].

In their study on marginal microleakage in manual crowns using composite resin, Sayed et al (2014) examined 30 human molar teeth. The results of this study showed that the highest microleakagewas in the control group (Composite no bonding) and the lowest microleakage in the group with Composite bonded with

Adper single bond2[13].Bifix Temp is a resin cement which is the newest type of temporary cements. According to the manufacturer, this cement provides a bettercement for provisional restorations.

So far, no studies have been conducted on the microleakage of 3D-made temporary crowns. Moreover, the application of resin-based temporary cements, whichisrecently introduced, needs further investigation and the effect of these cements on microleakagehas not been investigated so far. Thus, this study aimed to evaluate the microleakage of temporary crowns made by auto mix and 3D printing methods using different cements.

MATERIALS AND METHODS

In this descriptive trial, 54 human maxillary premolars were evaluated according to the following inclusion and exclusion criteria.
Inclusion criteria:

- Human maxillary premolar teeth
- Absence of caries in radiography and clinicalexaminations.
- Minimum crown height of 6 mm [14]

Exclusion criteria:

- A tooth with evolutionary anomaly
- An evidence of crack on teeth
- A history of chemical therapy on teeth.[14]

Sample size: The sample size was determined using Gpower 3.1.0 software, considering the results of Arrora et al [11] study with alpha = 0.05 and power = 80%.Accordingly, a total of54 premolar teeth were included in this study according to inclusion and exclusion criteria. To disinfect the teeth, they were kept in a 10% formalin solution for 7 days. The teeth were then mounted in acrylic resin. [15]The specimens were randomly divided into two groups of a temporary crown made by the auto mix method (A) and by 3D printingmethod(B) with the same sizes of 27.Prior to shaving, the silicone index of the teeth in group A was made, and digital scans of the teeth in group B were obtained.To prepare full crowns, all the teeth were shaved in a milling machine with a 1mm radial shoulder finish line, 6mm axial wall with a 6° convergence angle, and an occlusal cervical height of approximately 4mm,and the occlusal surface was smoothed using small wheel shape milling.[11] Then, temporary crowns of group A teeth were fabricated by auto mix method using Visalys temp (Kaltenbach, Germany), which is made of bis-acryl composite resin (Bis-GMA). After mixing at the head of the automix, they were injected into the silicone indexes and placed on the shaved teeth to fully sealing. The shaved teeth of group B were first scanned and then reconstructed using CAD software.They were then transferred to a 3D printing machine to prepare temporary crowns using digital light processing technique and Photopolymer (Free print temp (Detax, Germany)[16]. Next, each group was randomly divided into three subgroups of a, b, c, each of which contained 9 specimens to be cemented using different temporary cements. Group a cemented with OlisemiCem cement (olident, Germany), group b cemented with Temp Bond cement (kerr, switzerland), and group c with Bifix temp cement (Voco, Germany).Each crownalongwith its cement was placed on the shaved tooth and held at a constant force of 15 N, and after initial staining, the additions were removed.[16] To provide a desirable oral environment, the specimens were immersed in distilled water, and thermocycling was done with 60 s of transfer time between 5 and 55 °C and 5 s of rest time to apply heat stress to the restorations.[17] The cemented crowns were then immersed in methylene blue solution 2% for 24 h, then rinsed for 10 min.The samples were then embedded into an auto-polymerized acrylic resin and cut from the middle of the buccolingual dimension. Microleakage level was measured based on T Jan scale using a 50x magnification stereomicroscope to evaluate the permeability of target color between the shaved tooth and the temporary tooth crown.

Microleakage level based on T Jan scale:
0 = No microleakage
1 = microleakage up to one-third of the axial wall surface
2 = microleakage up to two-thirds of the axial wall surface
3 = microleakage to the entire axial wall surface
4 = microleakageto the occlusal surface [11]

Statistical analysis of data: Statistical analysis was performed using SPSS v17 software. A P-value of less than 0.05 was considered to be statistically significant.In regards of normality of the data distribution, one-way ANOVA and independent samples t-test were used to compare the microleakage level.

Ethical considerations: This study has been approved by the Ethics Committee of Tabriz University of Medical Sciences under the issue No. IR.TBZMED. REC.1398.104.

RESULTS

Overall, the mean value of microleakage in the 3D printing method based on the T Jan scale was 2.22 and the Automix method was 2.37.

Pairwise examination of microleakage level in identical cements coated with the two crowns showed that Bifix temp (resin) cement resulted in a high level of microleakage in both groups of auto mix and 3D printing fabrication methods, and the microleakage level in this cement was independent of the type of crowns ($P < 0.05$), whereas the microleakage level of the other cements in this study was associated with the type of crowns ($P < 0.05$).

Table 1: The mean and standard deviation for a microleakage variable of temporary crowns in different fabrication methods and in different temporary cements

	Cement type	mean	Standard deviation
Automixed	ZOE (Tempbond)	1.78	1.09
	ZO (Olisemicem)	2.44	1.03
	Resin (Bifix temp)	2.89	1.05
3D-Printing	ZOE (Tempbond)	2.56	0.85
	ZO (Olisemicem)	1.44	0.73
	Resin (Bifix temp)	2.67	1

Table 2. The mean and standard deviation for a microleakage variable of temporary crowns in different fabrication methods

	mean	Standard deviation
Automixed	2.37	1.056
3D-Printing	2.22	0.87

Figure 1. Mean comparison for the microleakage variable of temporary crowns in different fabrication methods and in different temporary cements

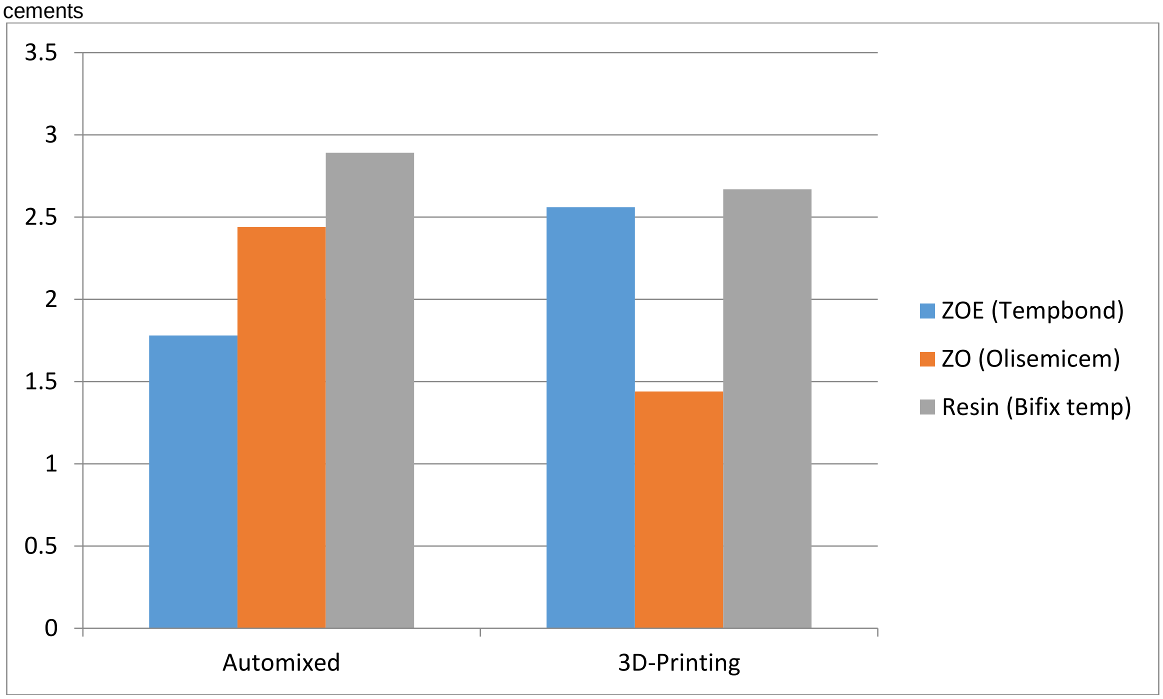
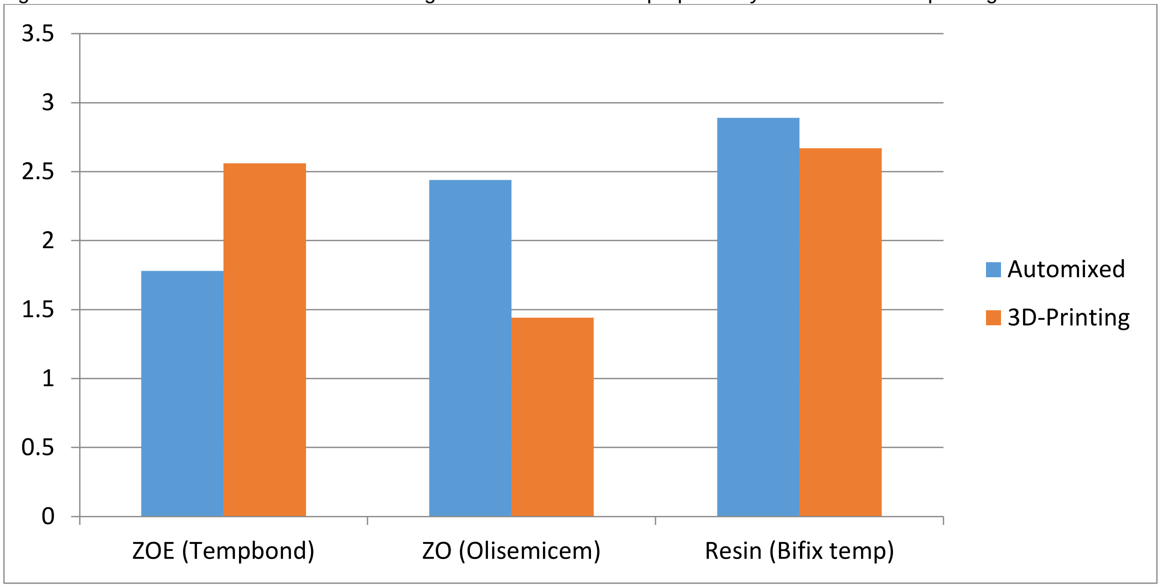


Figure 2. Pairwise examination of microleakage in identical cements prepared by auto mix and 3D printing fabrication methods.



DISCUSSION

In this study, 54 premolar teeth were divided into 2 groups of temporary crowns made by automixand 3D printing method (n=27).Each group was then subdivided into 3 subgroups of 9 specimens to be cemented using Olisemicem (ZO), Temp bond (ZOE), and Bifix temp (Resin Cement). After thermocycling, samples immersedin methylene blue solution 2%, then they were cutbuccolingually.The microleakage of specimens wereexamined based on using the T Jan scale using a light-scanning 50x magnification stereomicroscope.

Some studies have stated thatthe level of thermocycling is efficient in the marginal gap of restoration[18].Due to the lack of a standard for methodin studies evaluatingmicroleakage, there is disagreement among the results of various in-vitro studies[19].However, the results of the present study are compared (with some differences) with the studies which usedthermocycling.There are severalresearcheson dental cements and the results showed that various cements had different marginal gap and microleakage[20-26].

In the auto mix group, the microleakage in the Temp bond (ZOE) cement was significantly lower than in the Bifix temp (Resin cement).But no significant difference was found between the eugenol-free zinc oxide group and the eugenolgroup.This is similar to the results of Lewinstein et al[27]that found no significant difference between the microleakageof Temp bond NE, Freegenol, and Temp bond groups with the eugenol group. Similarly, Baldissaraet al[28]found no significant difference between the cements prepared by eugenol and without eugenolKerr.

Cements containing zinc oxide eugenol such as Temp bond (ZOE) are one of the most widely used temporary cements due to their palliative and antibacterial properties.However, due to the undesirable properties of this cement such as inhibition of resin polymerization and its low rigidity, eugenol-free systems such as polyorganic acid systems including polycarboxylic and polyacrylic acid have been introduced[26].

In the 3D printing group, Olisemicem (ZO) had significantly lower microleakage than the other two cements (i.e.,Temp bond (ZOE) and Bifix temp (Resin Cement). This is similar to the results of Aroraet al[29]that eugenol-containing cement had higher leakage than eugenol-free cement.The results of the present study confirmed the manufacturer's claim that Olisemicem (ZO) reducesthe microleakage caused by volumetric expansion[30].It should be noted, however, that further studies are needed to confirm the absence of volumetric changes of this cement over time and in the clinical conditions.Also, according to the results of this study, the microleakage level of Olisemicem (ZO) cement depends on the type of crown, so that the microleakage level of this cement was significantly higher in the crowns made by automix method.

BifixTemp (Resin Cement) cement had a high level of microleakage in both auto mix and 3D printing groups, and the level of microleakage in this cement was not affected by the type of crown. This is in contrast to the results of the study by Farrah et al[31] which argued that resin cements are the best for reducing the level of microleakage. This contradiction may be attributed to the lower number of thermocycling (100 cycles) in their study compared to the present study.It's also worth noting the use of resin cements are more technically sensitive, which can impact the microleakage level of these cements.

According to the results of this study on human maxillary premolars, it can be concluded that achieving the least possible microleakagedepends on multiple factors. Although the use of the 3D printing method in the fabrication of temporary crowns resulted in lower microleakage levelsthan of the automix method, the use of this method alone cannot guarantee the achievement of minimum microleakageand it is important to select the appropriate cement. In this regard, the use of Olisemicem (ZO) cement in temporary crowns made by the 3D printing method resulted in minimal microleakage, whileinthe automix method, the use of Temp bond (ZOE) resulted in lower microleakagelevel than the other cements.As a result, the results of this study recommend the use of Olisemicem (ZO) cement in temporary crowns made by a 3D printer. The]study also showed that the use of auto mix temporary crowns along with Temp bond cement (ZOE) seems to be justified in limited clinical conditions where digital methods are not available.

Although all aspects are taken into account to simulate the oral environment, it is difficult to obtain real clinical conditions.Here are some limitations of in-vitro microleakagestudies.First, the presence of occlusalforces in the oral environment and positive intra-pulp pressure, and a continuous discharge of dentinal tubules affect the microleakageand adhesion properties of the cement.Second, the soluble components of methylene blue are very small compared to typical bacteria, which increases the penetration of methylene blue compared to the bacteria, thus the level of microleakagein the in-vitro environment is not comparable to that of the real oral environment[17].

CONCLUSION

The results of this study recommend the use of Olisemicem (ZO) cement in temporary crowns made by the 3D printer to obtain the lower microleakage level. The results of this study also show that the use of auto mix temporary crowns along with Temp bond cement (ZOE) seems to be justified in limited clinical conditions where CAD-CAM is not available.

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