Acta Scientific Dental Sciences (ISSN: 2581-4893)

Volume 7 Issue 10 October 2023

Review Article

Effect of Fit Checking Materials and Cleaning Methods on the Contact Angle of Luting Agents- an *In Vitro* Study Conducted on Metallic and Ceramic Surfaces

M Jyothi[1], K Chandrasekharan Nair[2]*, Vahini Reddy[3] and Jayakar Shetty[4]

[1]*Associate Professor of Prosthodontics, M R Ambedkar Dental College, Bangalore, India*

[2]*Professor Emeritus, Department of Prosthodontics, Sri Sankara Dental College, Akathumuri, Thiruvananthapuram, Kerala, India*

[3]*Professor and Head of the Department of Prosthodontics, Oxford Dental College, Bangalore, India*

[4]*Former Professor and Principal, AECS Maaruti College of Dental Sciences, Bangalore, India*

***Corresponding Author:** K Chandrasekharan Nair, Professor Emeritus, Department of Prosthodontics, Sri Sankara Dental College, Akathumuri, Thiruvananthapuram, Kerala, India.

DOI: 10.31080/ASDS.2023.07.1723

Scopus Id: https://orcid.org/0000-0003-3114-3015

Received: September 04, 2023

Published: September 26, 2023

Abstract

Objectives: To compare the effect of two restorative surfaces viz. Nickel-chromium alloy and IPS Empress ceramic on the contact angle of two luting agents- Glass ionomer cement and Zinc phosphate cement. 2.To compare the effect of different fit checking materials viz. fit checker silicone and Occlusion spray on the contact angle of luting agents. 3.To compare the effect of different cleaning methods viz. Steam cleaning, Ultrasonic cleaning, Liquid detergent, water and alcohol on the contact angle of luting agents.

Materials and methods: Disc shaped specimens (20 x 2mm) were prepared in IPS Empress ceramic and Nickel chromium alloy. Glass ionomer and zinc phosphate cement were dispensed on the discs and the contact angle was measured using Contour and Roughness Tester with the help of Ultra contour software. Fit indicating materials - Fit checker silicone and Okklean occlusion spray were applied on the discs and subsequently cleaned with various cleaning methods mentioned above. The cements were dispensed again and the contact angle was measured. Data was statistically analyzed using factorial ANOVA.

Results: Ceramic surface recorded a mean contact angle of 77.57 ± 11.44o and metal surface recorded a mean contact angle of 84.12 ± 9.94o irrespective of the type of luting cement used. After the application of fit checker silicone mean contact angle recorded was 86.74 ± 9.57o and after Okklean occlusion spray the contact angle recorded was 78.95 ± 11.27o. Without the application of fit checking material, the mean contact angle recorded was 76.84 ± 10.21. With Glass ionomer the contact angle was 72.69 ± 8.030 and with zinc phosphate the contact angle was 89 ± 7.310. When no cleaning method was employed after the application of fit checking material, the contact angle was 83.98 ± 10.47o. After cleaning with alcohol, the mean contact angle was 74.30 ± 10.12o; with liquid detergent 79.21 ± 9.06o; steam cleaning 85.19 ± 10.32o; ultrasonic cleaning 81.68 ± 11.05o and with water the mean contact angle was 80.71 ± 12.62o. The results obtained were statistically significant ($p < 0.001$).

Conclusions: Wettability of metal and ceramic surfaces decreased when treated with fit checking materials. Glass ionomer cements have better wettability than zinc phosphate cement irrespective of the surfaces (ceramic/metal), fit indicating materials (occlusion spray/fit checker) and cleaning methods. Amongst the cleaning agents employed to restore the wetting properties of ceramic and metallic surfaces, alcohol proved to be superior. Detergents, water, ultrasonic cleaning and steam followed in a decreasing order.

Keywords: Nickel-chromium alloy, IPS Empress ceramic, contact angle, Glass ionomer cement, Zinc phosphate cement, Alcohol, Liquid detergent, Steam cleaning, Ultrasonic cleaning, Water.

Introduction

Clinical and laboratory skills in Prosthodontics ensure accurate fit of a fixed prosthesis on the carefully prepared tooth. The restoration should find its final placement through the predetermined path in the trial stage as well as during the cementation. The technician will take care of the unwanted nodules and overhangs to ensure a fit on the die. The internal morphology of the restoration should be devoid of any interfering contacts and at the same time it should contain adequate space for the luting cement. Convergence provided in the preparation will allow flow of the excessive luting cement during the initial stages of placement and the cement can resist the accurate placement if adequate cement space is not

provided. Complete seating of the fixed restoration is usually diagnosed by measuring the marginal gap.

Evaluating the fit of castings with the aid of fit indicating materials has been a subject of interest for many research workers. It was observed that elimination of internal interferences could considerably reduce the marginal gap. Many materials were tried in the past to check the fit of the restorations viz. disclosing waxes, mixture of chloroform and rouge and low viscosity poly vinyl siloxane impression materials. Exclusive products were later developed like fit checking silicones, alcohol-based pigments and pigment containing sprays which could successfully disclose the interferences. It is estimated that, by eliminating the interferences, the marginal gap can be reduced by fifty percent. Use of fit checking media has thus become an essential method of clinical prosthodontics [1-6].

If the tooth - restoration approximation is not ideal, bonding between them will be impaired and can result in poor prognosis. This may eventually cause staining, caries, occlusal interference and even fracture of the restorative materials like ceramics. The resin luting cements can ensure good bonding but cleanliness of the surfaces is a demanding pre requisite. Temporary luting cements used with provisional restorations, saliva and blood contamination were identified as inhibitors for the setting of resin cements. Many research workers have studied on the bond strength when temporary cements were used and when contaminants like saliva and blood have crept into the operating field. Employing an appropriate cleaning method in regaining the bond strength which was weakened by the contaminants was almost evident from their studies [7-10].

Cleaning the restorative surface is an essential step in removing the possible remnants left by the fit checking materials and the organic contaminants which get incorporated in the process of fit checking. Different cleaning methods viz. Steam cleaning, Ultrasonic cleaning, Liquid detergent, Alcohol and water were tried in the past with successful results. Most of the studies have focused on the bond strength provided by the luting cements as the test parameter [11]. The flow behaviour of luting cements, to be precise the contact angle made by them on the restorative surface has not been evaluated in the past as a critical test parameter. The role of metallic and ceramic surfaces and a comparison of commonly used luting cements should also be considered to complete the picture of evaluation. In this context the, the present study was undertaken with the following objectives

- To compare the effect of different restorative surfaces viz. nickel-chromium alloy (LiteCast B2) and ceramic (IPS Empress) on the contact angle of luting agents- Glass ionomer cement and Zinc phosphate cement.
- To compare the effect of different fit checking materials viz. Silicone fit checker and Occlusion spray on the contact angle of luting agents
- To compare the effect of different cleaning methods viz. Steam cleaning, Ultrasonic cleaning, Water, Liquid detergent and Alcohol on the contact angle of luting cements

Methodology

The present study was conducted to determine the effect of restorative materials, fit checking materials and different cleaning methods on the contact angle of luting cements.

Preparation of specimens

Disc shaped specimens of 20mm diameter and 2mm thickness were prepared in Nickel Chromium alloy (Super cast, Thermabond) and in Pressable ceramics (IPS emax press). 88 discs were prepared in each material. Finishing and polishing of the specimens were done according to the manufacturers' specifications (Figure 1,2).

Figure 1: Nickel Chromium alloy discs.

Figure 2: Ceramic discs (IPS e-max press).

Luting cements

Zinc phosphate (De Trey Zinc, Dentsply) and Glass Ionomer (G C America) cements were selected for the in vitro experiment. Cements were manipulated as per the manufacturers' instructions to obtain luting consistency. The mixed cement was loaded into a 2ml syringe. Drops of cement with 0.1ml volume were dispensed on to the disc specimens and the cement was allowed to set (Figure 3,4).

Contact angle measurement

Contour and roughness tester (Talysurf Intra**;** Taylor Hobson) was used for contact angle measurement which signified the wetting property. The specimens with the cement were placed on the table of the contour tester and the contact angle was measured using Ultra contour software (Figure 5-7).

Figure 3: Zinc phosphate cement.

Figure 4: Glass ionomer cement.

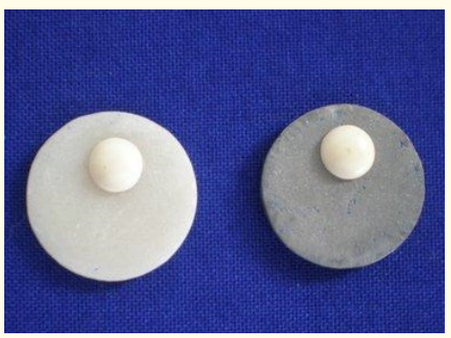

Figure 4a: Cement drops on the specimens.

Figure 5: Contour and roughness tester for contact angle measurement.

Figure 6: Contact angle measurement with chisel tip.

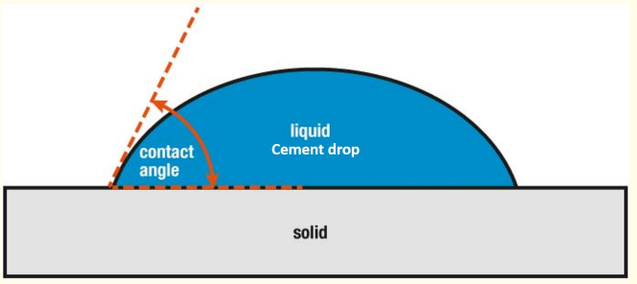

Figure 7: Contact angle measurement- schematic diagram.

Cleaning methods used

Five different cleaning methods were used in the present study.

- **Water:** Specimens were washed under tap water, wiped and allowed to dry
- **Ultrasonic cleaning:** Specimens were kept in an ultrasonic bath containing distilled water for ten minutes. They were then taken out and allowed to dry (Figure 8).
- **Steam cleaning:** Specimens were cleaned with a steam gun for five minutes and were allowed to dry (Figure 9).
- **Alcohol:** Specimens were cleaned with cotton pellet saturated with 70% alcohol and were allowed to dry (Fig 10).
- **Liquid detergent:** Specimens were washed with liquid detergent (Hand wash – Hindustan Lever, India) under tap, wiped with tissue and allowed to dry (Fig 11).

Figure 8: Ultrasonic cleaner.

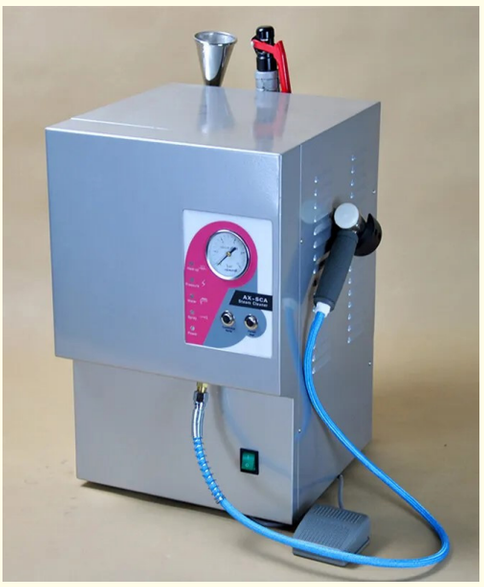

Figure 9: Steam cleaner.

Figure 10: Alcohol used for cleaning.

Figure 11: Liquid detergent used for cleaning.

Application of fit indicating materials

Two fit checking materials were used in the study viz. 1. Fit Checker Silicone (G C America) and 2. Okklean spray (DFS Diamon, Germany).

Fit Checker Silicone – Equal lengths of base and catalyst pastes were taken in a pad and mixed for 20 seconds. The mixed material was applied on the specimen discs and a glass slide was placed and finger pressure was applied to make the fit checker spread uniformly. Okklean spray – It was sprayed on the specimen discs from a distance of 5mm and was allowed to dry. Fit checker was peeled off from the metal and ceramic discs. The Okklean spray was wiped with tissue (Figure 12-15).

Figure 12: Fit checker silicone.

Figure 13: Okklean (Occlusion) spray.

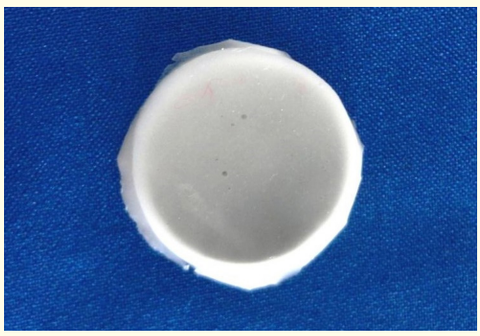

Figure 14: Fit checker coating on the disc specimen.

Figure 15: Okklean spray coating on the disc.

The specimens were grouped into four as shown below

- **Gr. 1:** 6 ceramic discs and 6 metal discs – 3 in each subgroup received Phosphate and Glass ionomer cement drops and contact angle was measured.
- **Gr. 2:** 30 ceramic discs and 30 metal discs – 6 in each subgroup was cleaned by one of the following five methods viz. water, steam, ultrasonics, detergent and alcohol. After cleaning, the discs received phosphate and glass ionomer cement drops equally and contact angle was measured.
- **Gr. 3:** 12 ceramic discs and 12 metal discs – 6 in each sub group were coated with Fit checker and the other 6 with Okklean spray. After removing the fit checking materials, the specimens received phosphate and CI cement drops for contact angle measurement.
- **Gr. 4:** 40 ceramic discs and 40 metal discs – 20 in each sub group received fit checker coating and the other 20 Okklean spray. After removal of the fit checking material, the specimens were cleaned by one of the cleaning methods as mentioned in the Gr.2. (4x5). The specimens received phosphate cement and glass ionomer drops for contact angle measurement (2x2).

Statistical analysis

The results obtained were statistically analysed using Factorial ANOVA.

The methodology is summarised in the flow chart (Figure 16).

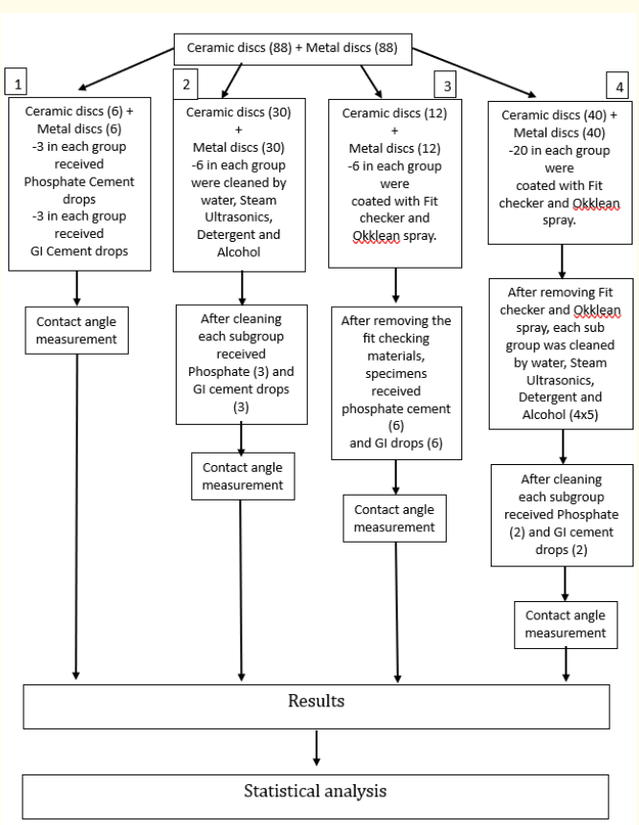

Figure 16: Flow Chart on Methodology.

Results

In the present experiment of comparing contact angles, four factors were found to influence viz. Restorative surfaces, Fit indicating materials, Cements and Cleaning methods. Surfaces were of two types – Ceramic and Metal; Fit indicating materials including control were of three types - No fit indicating material, Occlusion (Okklean) spray and Fit checker silicone. Cements were of two types - Glass ionomer and Zinc phosphate. Cleaning Methods including control were of six types – No cleaning method, Alcohol, Liquid detergent, Steam, Ultrasonic cleaner and Water. The factors and their levels are shown in table 1.

Factor	Levels
Restorative Surfaces	Ceramic, Metal
Fit indicating materials	No Fit indicating material, Occlusion spray, Fit checker silicone
Cements	Glass ionomer, Zinc phosphate
Cleaning Methods	No Cleaning method, Alcohol, Liquid detergent, Steam, Ultrasonics, Water

Table 1: Factors and their levels.

Null Hypotheses

- $H_{0(a)}$: There is no significant difference between the different types of surfaces.
- $H_{0(b)}$: There is no significant difference between the different types of Fit indicating materials.
- $H_{0(c)}$: There is no significant difference between the different types of cements.
- $H_{0(d)}$: There is no significant difference between the different types of cleaning methods.
- $H_{0(e)}$: The interaction (joint effect) of various factors is not significant.

Alternate Hypotheses

- $H_{1(a)}$: There is a significant difference between the different types of surfaces.
- $H_{1(b)}$: There is a significant difference between the different types of fit indicating materials.
- $H_{1(c)}$: There is a significant difference between the different types of cements.
- $H_{1(d)}$: There is a significant difference between the different types of cleaning methods.
- $H_{1(e)}$: The interaction (joint effect) of various factors is significant.

Level of significance: α = 0.05.

- **Decision Criterion:** p-values were compared with the level of significance. If P<0.05, the null hypothesis was rejected and accepted the alternate hypothesis. If P>0.05, the null hypothesis was accepted. If there was a significant difference, multiple comparisons (post hoc-test) using Bonferroni method to find out among which pair or groups there existed a significant difference.

Statistical technique used: Factorial ANOVA

Mean of the contact angles measured at the level of different factors are given in tables 2 to 5. Results of the ANOVA are given in table 6.

Surface	Mean	Std dev	SE of Mean	Median	Min	Max
Ceramic	77.57	11.44	0.55	78.0	58	105
Metal	84.12	9.94	0.48	84.0	59	105

Table 2: Mean Contact angle recorded at the level of different restorative surfaces (deg).

Fit indicating Material	Mean	Std dev	SE of Mean	Median	Min	Max
No Fit indicating Material	76.84	10.21	0.60	79.0	59	96
Occlusion Spray	78.95	11.27	0.66	80.0	58	101
Fit checker silicone	86.74	9.57	0.56	85.5	66	105

Table 3: Mean Contact angle recorded at the level of different fit indicating materials (deg).

Cement	Mean	Std dev	SE of Mean	Median	Min	Max
Glass Ionomer	72.69	8.03	0.39	73.0	58	90
Zinc Phosphate	89.00	7.31	0.35	90.0	69	105

Table 4: Mean Contact angle recorded at the level of different luting cements (degree).

Cleaning Method	Mean	Std dev	SE of Mean	Median	Min	Max
No cleaning method	83.98	10.47	0.87	83.0	60	105
Alcohol	74.30	10.12	0.84	75.0	58	96
Detergent	79.21	9.06	0.76	79.0	61	99
Steam	85.19	10.32	0.86	85.0	61	105
Ultrasonic	81.68	11.05	0.92	83.0	60	101
Water	80.71	12.62	1.05	81.0	60	105

Table 5: Mean Contact angle recorded at the level of different cleaning methods (degree).

Source	df	Sum of Squares (SS)	Mean SS	F	P-Value
Surface	1	9263.00	9263.00	1035.21	<0.001*
Fit indicating material	2	15674.00	7837.00	875.85	<0.001*
Cement	1	57477.10	57477.10	6423.52	<0.001*
Cleaning Method	5	10790.10	2158.00	241.17	<0.001*
Surface x Fit indicating material	2	1022.80	511.40	57.15	<0.001*
Surface x Cement	1	407.00	407.00	45.49	<0.001*
Surface x Cleaning Method	5	183.40	36.70	4.10	<0.001*
Fit indicating material x Cement	2	212.60	106.30	11.88	<0.001*
Fit indicating material x Cleaning Method	10	1948.10	194.80	21.77	<0.001*
Cement x Cleaning Method	5	834.80	167.00	18.66	<0.001*
Surface x Fit indicating material x Cement	2	78.40	39.20	4.38	0.013*
Surface x Fit indicating material x Cleaning Method	10	1281.80	128.20	14.33	<0.001*
Surface x Cement x Cleaning Method	5	237.10	47.40	5.30	<0.001*
Fit indicating material x Cement x Cleaning Method	10	1256.60	125.70	14.04	<0.001*
Surface x Fit indicating material x Cement x Cleaning Method	10	566.30	56.60	6.33	<0.001*
Error	792	7086.70	7086.70	8.90	---
Total	863	108319.90	---	---	---

Table 6: ANOVA.

Lower mean contact angle was recorded in ceramic surface when compared to that of metal surface and the difference between them was found to be statistically significant (P < 0.001). Fit checker silicone recorded a higher contact angle followed by occlusion spray and without any fit indicating material respectively. The difference in mean contact angle between the fit checking materials was found to be statistically significant (P < 0.001). Glass Ionomer cement recorded a lower mean contact angle when compared to Zinc phosphate cement and the difference between them was found to be statistically significant (P < 0.001) (Table 2-4).

Among the cleaning methods, lower mean contact angle was recorded by Alcohol followed by Detergent, Water, Ultrasonics, No Cleaning method and steam cleaning respectively. The difference between them was found to be statistically significant (P < 0.001). All the interactions between the various factors and their levels were also found to be statistically significant (P < 0.001) (Table 5, 6).

In order to find out among which pair of fit indicating materials there existed a significant difference multiple comparisons were carried out using Bonferroni test. The difference in mean contact angles obtained among three levels of fit checking materials viz. Fit checker silicone, Okklean spray and without the use of fit indicating materials was found to be statistically significant (P < 0.001) (Table 7).

Difference in mean contact angle obtained with different levels of cleaning methods viz. Alcohol, Detergent, Steam, Ultrasonics and without any cleaning method were compared, except between water and ultra sonics, all other comparisons proved to be significant (P < 0.001). (Table 8).

The most important factor which exhibited lowest mean contact angle was cleaning methods followed by fit checking materials and restorative surfaces (Figure 17). Lower contact angle indicates

(I) Fit indicating material	(J) Fit indicating material	Mean Difference (I-J)	P-Value	95% CI for mean difference	
				Lower Bound	Upper Bound
No Fit indicating material	Occlusion Spray	-2.108	<0.001*	-2.706	-1.510
	Fit checker silicone	-9.903	<0.001*	-10.501	-9.305
Occlusion Spray	Fit checker silicone	-7.795	<0.001*	-8.393	-7.197

Table 7: Comparison between different fit indicating materials – Post Hoc test/Multiple comparisons: (Bonferroni method).

(I) Cleaning Method	(J) Cleaning Method	Mean Difference (I-J)	P-Value	95% CI for mean difference	
				Lower Bound	Upper Bound
Alcohol	Detergent	-4.910	<0.001*	-5.948	-3.872
	No Cleaning method	-9.681	<0.001*	-10.718	-8.643
	Steam	-10.889	<0.001*	-11.927	-9.851
	Ultrasonic	-7.382	<0.001*	-8.420	-6.344
	Water	-6.410	<0.001*	-7.448	-5.372
Detergent	No Cleaning method	-4.771	<0.001*	-5.809	-3.733
	Steam	-5.979	<0.001*	-7.017	-4.941
	Ultrasonic	-2.472	<0.001*	-3.510	-1.434
	Water	-1.500	<0.001*	-2.538	-0.462
No Cleaning method	Steam	-1.208	0.010*	-2.246	-0.170
	Ultrasonic	2.299	<0.001*	1.261	3.337
	Water	3.271	<0.001*	2.233	4.309
Steam	Ultrasonic	3.507	<0.001*	2.469	4.545
	Water	4.479	<0.001*	3.441	5.517
Ultrasonic	Water	0.972	0.089	-0.066	2.010

Table 8: Comparison between different Cleaning Methods – Post Hoc test/Multiple comparisons: (Bonferroni method).

superior wettability. When cements were compared, glass ionomer exhibited lowest contact angle.

Ceramic surface always exhibited lower contact angle in its interaction with cements, fit checking materials and cleaning methods. When Fit checker silicone was used, contact angle recorded was high with both the restorative surfaces, cements and cleaning methods. Comparatively, Okklean spray and without the use of fit indicating material, contact angle was lower. Lowest contact angle was recorded with Glass Ionomer cement and Alcohol cleaning method. With any restorative surface and fit indicating material, the profile of lower contact angle was maintained by glass ionomer cement (Figure 17).

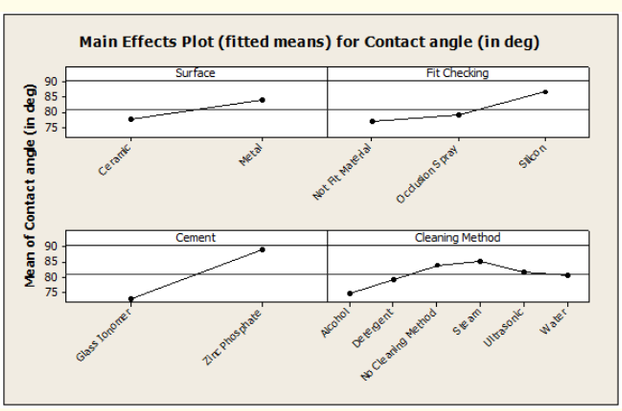

Figure 17: Main Effects Plot: (Shows the mean value of contact angles recorded with different levels of each factor – restorative surfaces, fit indicating materials, luting cements and cleaning methods.

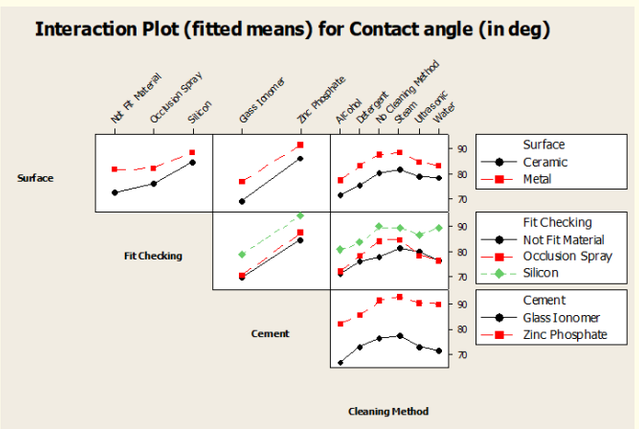

Figure 18: Interactions Plot: showing the mean contact angle values recorded in the combination of different factors and their levels.

Discussion

Fit of a fixed restoration is easily gauged by the marginal adaptation. This is applicable to restorations made of metals, ceramics and their combinations. If internal discrepancies are eliminated, the fit can be improved and thereby reduce the marginal gap. The effectiveness of internal adjustment technique is widely accepted and hence it has become an essential clinical procedure [1]. Precise identification of internal interferences is done by different materials and two of the popular products are fit checker silicone and okklean occlusion spray [12]. It is not clearly understood whether these materials leave behind residues, causing reduction in the property of wetting and thereby limiting the flow of the luting ce-

ment. The residue left behind by the fit checking materials, inhibit the cement flow, inhibits bonding and eventually reduces retention. It was in this context the present study was designed to find out the wetting properties of restorative surfaces which are commonly used in the clinic. An invitro study was planned utilizing processed ceramic and metallic surfaces viz. IPS Empress and Nickel chromium alloy. Two cements such as glass ionomer and zinc phosphate were selected to evaluate the wetting quality. Contact angle measurement was used as the test parameter [13]. Two fit checking materials were selected and different cleaning methods were employed to find out their cleaning efficiency. It was contented that the fit checking materials can leave a residue with inhibitory effect on the flow of luting cements and employing cleaning methods would remove the residues and restore the wetting quality of the restorative surfaces.

Commonly used dental materials including metals, resins and ceramics, in most of the experiments have exhibited contact angles ranging from 35^0 to 85^0 which indicate that they fall into the category of hydrophilic materials [13, 14]. In the present study ceramic surface recorded a mean contact angle of 77.57 ± 11.44 ^{0} and metal surface recorded a mean contact angle of 84.12 ± 9.94 ^{0} irrespective of the type of luting cement used (Table 2). Lower mean contact angle was recorded with ceramic surface when compared to metal surface at a statistically significant level.

Fit checker silicone and Occlusion Spray were the two fit indicating materials that were compared in this study. Silicone fit indicators are currently marketed as materials that can improve the fit of fixed restorations by detecting interfering spots on the internal casting surfaces before cementation [15]. Fit checker is supplied in two paste – base and catalyst – form and after mixing equal volumes, it is directly placed inside the restoration and pressed over the prepared tooth. Once cured the material gains rubbery consistency. Areas of the restoration that are shown through the fit-indicator denote the interfering points. By careful reduction of the interferences and by the repeating the fit checking, complete seating can be ensured. Advantages of the material are that the translucency can be measured by micro densitometer to numerically evaluate the fit and that it can be easily peeled off from the casting without leaving pigmented remnants. However, silicone indicators may leave a residue capable of inhibiting the cement flow [15,16].

Another fit indicating material which was included in the study was Okklean occlusion spray. It is available in various colors like red, blue and green in an aerosol form. It is insoluble in water and contains 1,1,1,2-Tetrafluoroethane (93 - 95%), Titanium dioxide (1 - 2%) and Colorants (2 - 4%) [14]. This pigmented layer highlights discrepancies, however if not removed completely, this layer may affect the esthetic outcome of the restoration and probably the wetting [17].

In the present experiments, it was observed that after the removal of fit checker silicone, luting cements produced a contact angle of 86.74 ± 9.57 ^{0} and with Okklean occlusion spray the contact angle was 78.95 ± 11.27 ^{0}, while restorative surfaces, which were not coated with fit indicating materials recorded a mean contact angle of 76.84 ± 10.21 (Table 3). This clearly indicates that fit indicators leave a residue that significantly reduces the wettability of the surfaces and thereby reduces the flow of the cements. This film may have been formed as a by-product of some of the SiOH groups present in the silicone paste and possibly bonded covalently to the oxidized metal or ceramic surfaces. Marchioro., *et al*. have evaluated the restorative surfaces after the application of fit checking materials and after applying different cleaning methods and established the presence of residues and found out the efficiency of cleaning methods [11].

In a previous study, it was observed that against silicone surface, die stone produced contact angles as high as 92° and also produced casts with greatest number of air bubbles due to the relative nonwetting characteristics, while polysulfide and polyether materials produced lesser contact angles of 67° and 49° respectively. Air bubble defects, occurred the least in casts produced from polyether impression materials [18].

Two popular luting cements used in fixed prosthodontics were compared in the present study. Contact angle values registered in previous studies with GC Fuji Plus was 56.59^o and Fuji IX GIC was 57^0 expressing the hydrophilic nature [14,19]. Surface contamination in the form of Al_2O_3 left after sandblasting, fit indicators or residual cleaning agents may change the wettability of these cements and the contact angle increases. In the present study glass ionomer recorded a mean contact angle of 72.69 ± 8.03 ^{o} and zinc phosphate recorded a mean contact angle of 89 ± 7.31 ^{o}. (Table 4). However, Glass Ionomer cement recorded lower contact angle when compared to that of Zinc phosphate cement.

Five methods of cleaning Alcohol, Liquid detergent, Steam cleaning, Ultrasonic cleaning and cleaning with water were compared for their cleaning efficiency. Shillingburg., *et al*. [17]. suggested that all disclosing materials must be completely removed from the internal surface of the restoration by swabbing with chloroform and by sandblasting prior to cementation so that retention will not be diminished. Rosenstiel., *et al*. [20] suggested that the internal surface of the casting should always be thoroughly cleaned before the luting procedure. The properties of all luting agents may get degraded if the material is contaminated. Cleaning of the luting surface of the restoration is the only option left with the operator to ensure the retentive properties of the cement. Various cleaning methods include steam cleaning, ultrasonics, and use of organic solvents. The substrate can be cleaned by immersing in a general-purpose cleaning solution stored in an ultrasonic unit. Residual

soap can be removed by rinsing the copings in distilled water. Some manufacturers recommended a rinse in 92% alcohol. Steam cleaning is considered as efficient in removing saliva. Millstein., *et al*. [15]. studied the effect of residual film of silicone fit indicator on the retention of cemented crowns and found that the retention strength was highest for control group where no pretreatment was provided (350 lbs) and lowest for fit indicator group (200 lbs). When the silicone fit-indicator was mechanically removed and chemically cleaned using an organic cleaning solution (Cavilax), retention strength marginally increased to 210 lbs. It was concluded that the application of a silicone fit-indicator leaves a residue that significantly reduces the retention of crowns cemented with zinc phosphate cement. As mentioned before, this film is a by-product of the SiOH groups present in the silicone paste. Quaas., *et al*. [21], Al-Zain [22] and Hammad*., et al.* [16] are authors who have extensively studied and endorsed the positive effect of cleaning in regaining retention or bond strength of fixed restorations.

In the present study when no cleaning method was employed after the application of fit checking material, the contact angle recorded was 83.98 ± 10.47°. After cleaning with alcohol, the contact angle was 74.30 ± 10.12°; cleaning with liquid detergent it was 79.21 ± 9.06°; after steam cleaning it was 85.19 ± 10.32°; after ultrasonic cleaning it was 81.68 ± 11.05° and cleaning with water recorded a mean contact angle of 80.71 ± 12.62°. Among the cleaning methods, lower mean contact angle was recorded by alcohol followed by detergent, water, ultrasonics, no cleaning and steam cleaning respectively (Table 5).

Use of fit indicating materials in identifying the interfering points present in the intaglio surface of restorations is acceptable. In order to remove the residues, the restorative surface must be thoroughly cleaned before cementation. An appropriate cleaning material, which is available in the clinic and tested in the present study can be selected by the clinician to improve the wetting of luting cements.

Conclusions

The following conclusions were drawn from the present study.

- Wettability of metal and ceramic surfaces decreases when treated with fit checking materials such as fit checker silicone and occlusion spray.
- Glass ionomer cements have better wettability than zinc phosphate cement irrespective of the surfaces (ceramic/metal), fit indicating materials (occlusion spray/fit checker) and cleaning methods.
- Amongst the cleaning agents employed to restore the wetting properties of ceramic and metallic surfaces, alcohol proved to be superior. Detergents, water, ultrasonic cleaning and steam followed in a decreasing order.

Author Contributions

Conceptualization-K. Chandrasekharan Nair, Vahini Reddy, M. Jyothi; Lab experiments-M. Jyothi, Vahini Reddy, Review of articles-M. Jyothi, K. Chandrasekharan Nair; Initial draft preparation- M. Jyothi, Vahini Reddy; Review and editing- K. Chandrasekharan Nair, Jaykar Shetty; Supervision K. Chandrasekharan Nair, Vahini Reddy.

All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

Acknowledgements

Lovely M Annamma, Visiting Faculty, Department of Clinical Sciences, College of Dentistry Ajman University, Ajman, UAE for providing valuable reference articles which are cited in this publication.

Bibliography

1. Piwowarczyk A., *et al*. "Microleakage of various cementing agents for full cast crowns". *Dental Materials* 21 (2005): 445-453.

2. Ushiwata O., *et al*. "Marginal fit of nickel-chromium copings before and after internal adjustments with duplicated stone dies and disclosing agent". *Journal of Prosthetic Dentistry* 83 (2000): 634-643.

3. DA Kaiser and HB Wise. "Fitting cast gold restorations with the aid of disclosing wax". *The Journal of Prosthetic Dentistry* 43.2 (1980): 227-228.

4. DB Evans. "Halothane and rouge: an alternative to chloroform and rouge as a disclosing medium". *The Journal of Prosthetic Dentistry* 74.2 (1995): 209-211.

5. GR Troendle and KB Troendle. "Polyvinyl siloxane as a disclosing medium". *The Journal of Prosthetic Dentistry* 68.6 (1992): 983-984.

6. Shetty MS and Shenoy KK. "Techniques for Evaluating the Fit of Removable and Fixed Prosthesis" *ISRN Dentistry* (2011): 348372.

7. Marfenko S., *et al*. "Treatment of surface contamination of lithium disilicate ceramic before adhesive luting". *American Journal of Dentistry* 33.1 (2020): 33-38.

8. Yoshida K. "Influence of cleaning methods on the bond strength of resin cement to saliva-contaminated lithium disilicate ceramic". *Clinical Oral Investigations* 24.6 (2020): 2091-2097.

9. Fagan Junior J., *et al*. "Evaluation of cleaning methods on lithium disilicate glass ceramic surface after organic contamination *Operative Dentistry* 47.2 (2022): E81-E90.

10. Lyann SK., *et al*. "Efficacy of various surface treatments on the bonding performance of saliva-contaminated lithiumdisilicate ceramics". *Journal of Adhesive Dentistry* 21.1 (2019): 51-58.

11. Marchioro RR., *et al*. "Influence of Fit-checking Material and Cleaning Protocols on the Bond Strength of Lithium Disilicate Glass-ceramics". *Operative Dentistry* 47-6 (2022): E264-E272.

12. Keys LG. "An alternate method of verifying the seating of all-ceramic restorations". *Journal of Prosthetic Dentistry* 87 (2002): 411.

13. Watanabe T. "Wettability of ceramic surfaces- A wide range control of surface wettability from super hydophilicity to super hydrophobicity, from static wettability to dynamic wettability". *Journal of the Ceramic Society of Japan* 117.12 (2009): 1285-1292.

14. Preoteasa CT., *et al*. "Wettability of some dental materials. Optoelectronics and advanced materials". *Rapid communications* 5.8 (2011): 874-878.

15. Millstein PL., *et al*. "Effect of a silicone fit-indicator on crown retention *in vitro*". *Journal of Prosthetic Dentistry* 62 (1989): 510-511.

16. Hammad IA and Amri MA. "The effect of two fit-indicating materials and various subsequent cleaning methods on the retention of simulated crowns". *Journal of Prosthetic Dentistry* 99 (2008): 46-53.

17. Shillingburg HT., *et al*. "Fundamentals of fixed Prosthodontics". 3rd edition, Canada, Quintessence Publications (2002): 392.

18. Lorren RA., *et al*. "The contact angles of die stone on impression materials". *Journal of Prosthetic Dentistry* 36.2 (1976): 176-180.

19. Moshaverinia A., *et al*. "Surface properties and bond strength measurements of N-vinylcaprolactam (NVC)-containing glass-ionomer cements". *Journal of Prosthetic Dentistry* 105 (2011): 181-193.

20. Rosenstiel SF., *et al*. "Contemporary fixed prosthodontics". 4th edition, India, Mosby publication (2010): 771-772.

21. Quaas AC., *et al*. "Influence of metal cleaning methods on the resin bond strength to NICR alloy". *Dental Material* 21 (2005): 192-200.

22. Al- Zain SA. "The effect of different metal cleaning methods on retention of cast crown". *Egyptian Dental Journal* 52 (2006): 2087-2092.