Original Research Paper

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EVALUATION OF METAL ION RELEASE FROM LITHIUM DISILICATE AND COBALT CHROMIUM CROWNS: AN IN VIVO STUDY

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ABSTRACT To evaluate the amount of ions released from lithium disilicate and Co-Cr alloys in fixed partial dentures in vivo. 20 subjects of either sex divided into group L (lithium disilicate) or C (Co-Cr) were chosen for the study. Each of these groups comprised of 10 subjects each. Lithium Disilicate crowns were fabricated for 10 patients and Co-Cr crowns were fabricated for the other 10. Saliva samples were collected from each subject before and after cementation of the crowns. Approximately 5 ml of saliva was collected from each participant in sterile vials on the day of insertion and after four weeks post-insertion. Inductive coupled plasma atomic emission spectrophotometer was used to analyze the saliva samples. A highly significant increase in concentration (ppb) of lithium, aluminum, zinc and silica ions from before cementation to four weeks post cementation for lithium disilicate crowns was observed. Additionally, a highly significant increase in concentration (ppb) of cobalt, chromium and molybdenum ions was observed from before cementation to four weeks post cementation for cobalt-chromium crowns. The study, within its limitations, concluded that there is a time-dependent increase in the concentration of lithium, aluminum, zinc and silica ions up-to four weeks of cementation of lithium disilicate crowns. Similarly, there is a time-dependent increase in the concentration of cobalt, chromium and molybdenum ions up-to four weeks of cementation of cobalt-chromium crowns. The observed concentration of ions were more in lithium disilicate samples than cobalt-chromium samples. However, these values were within the physiological limit of trace elements in the human body.

KEYWORDS : Metal ion release; Metal ion concentration; Biocompatibility; Corrosion; Cytotoxic; Lithium disilicate crowns; Cobalt chromium crowns

INTRODUCTION

Dental materials are exposed to different conditions in the oral cavity daily. The humid, warm, and acidic intraoral environment constitutes an ideal condition for corrosion and chemical degradation of most dental materials. Foods and drinks are usually acidic or alkaline in nature. Different organic acids, such as lactic and pyruvic acids, created after the breakdown of food, decrease pH values inside the oral cavity and may cause ion release from dental alloys.

Identification and quantification of released elements into the oral cavity is the most relevant measure of biocompatibility. The amount and nature of released ions vary according to the type of alloy as well as the type of corrosion itself.1

Studies on metallic ion release from dental alloys in different conditions proved that it was not directly proportional to ion concentration in the dental alloy.2 Some elements are much more unstable than others, a phenomenon known as selective dissolving. High gold alloys appear to have the most stable surface compositions and release the lowest levels of elements.3 On the other hand, palladium alloys have a low critical current density due to the presence of gallium. Other studies mention that food, tobacco smoking, and Ni in air and water can affect metallic ion release.4

Cobalt chromium is a base-metal alloy. The use of Co-Cr-based alloys for metal-ceramic applications was first mentioned in the 1959 Weinstein patent for dental porcelain. This alloy is very economical, is rigid, and has relatively high elastic moduli. They are often used for the construction of removable dental prostheses (RDPs) and fixed partial dentures (FPDs) due to their castability and excellent mechanical properties. The disadvantages of this alloy are the markedly higher corrosion in acidic environments, extended chair-side time needed for finishing and polishing because of the hardness and casting difficulties. Another disadvantage is the limited knowledge of the longevity of Co-Cr alloys in fixed prosthodontics. Another concern related to Co-Cr is the risk for the dental technician to inhale grinding dust, during adjustments and polishing. Despite sparse clinical evaluation these techniques are applied to Co-Cr and are currently increasingly used in fixed prosthodontics. However, *in vitro* studies of these new manufacturing techniques show different material properties such as fit and metal release but similar porcelain adhesion and surface hardness.5

Ceramics based on lithium disilicate offer high strength, high fracture toughness, and a high degree of translucency. The use of lithium disilicate all-ceramic restorations is increasing as the techniques and materials improve to allow these ceramics to survive high stress-bearing situations such as posterior crowns. Although biological evaluations of dental ceramics are scant and biological compatibility is often assumed, several in vitro studies have reported different amounts of mass loss from ceramics and cytotoxicity of some newer formulations of all-ceramic materials. The cytotoxicity of this material improved with time but returned after re-polishing. In the same study, the second type of lithium disilicate material was less cytotoxic, implying that material processing or small compositional changes might be important factors influencing the biological response.6

Given the emerging importance of cobalt-chromium and lithium disilicate all ceramics crowns in dentistry, further study into their biological properties is needed and warranted.

The objective of this study was, therefore, to evaluate the in vivo ion leaching from Co-Cr and lithium disilicate crowns before and after cementation.

MATERIALS AND METHODOLOGY

The protocol for the present study was reviewed and approved by the Institutional Review Board of Coorg Institute of Dental Sciences.

A total of 20 subjects reporting to the Department of Prosthodontics at Coorg Institute of Dental Sciences were enrolled in the study.

20 subjects of either sex were divided into group L for lithium disilicate (Ivoclar IPS e.max Press, Liechtenstein, Germany) or C for Co-Cr crowns (Wironium plus, Bego, Bremen, Germany). Each of these groups comprised of 10 subjects each.

Oral radiographic records were also obtained for the tooth to receive the crowns. The tooth indicated to receive lithium disilicate and Co-Cr crowns were prepared using high-speed contra angled handpiece (NSK Pana Air, Tochigi, Japan) and diamond points (Shofu Dental Aisa-Pacific Pte Ltd, The Alpha Science Park Ⅱ, Singapore) (Figure 1).

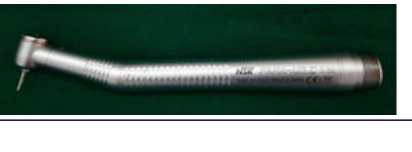

Fig 1: High speed Contra-angle handpiece and diamond points

The tooth reduction was completed and shoulder and chamfer finish lines were placed for lithium disilicate and Co-Cr crowns respectively. Addition silicone elastomeric material (Flexceed, Rajasthan, India) used to make the impression. A two-stage dual viscosity putty-wash method was used to make the definitive impression of the prepared teeth. Provisionalisation was carried out using self-cure tooth colored acrylic resin (DPI RR, Tamil Nadu, India) and cementation was done using a zinc oxide non-eugenol based temporary cement Deepak Enterprises, Mumbai, India). The subject was recalled for placement of the final restoration. The provisional restoration was removed and saliva sample was collected. Lithium disilicate crowns were to be fabricated for 10 patients and Co-Cr crowns were to be fabricated for the other 10 (Figure 2,3,4,5).

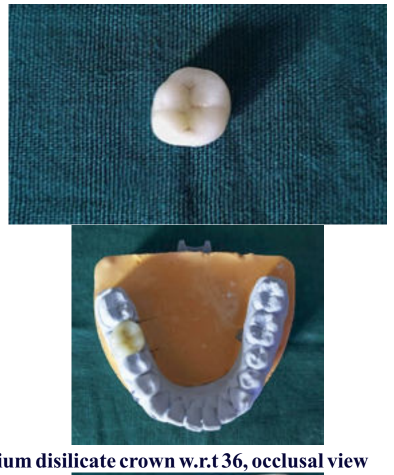

Fig 2: Lithium disilicate crown w.r.t 36, occlusal view

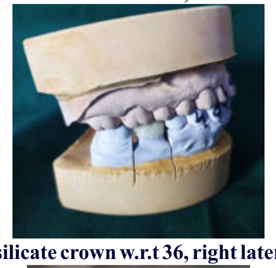

Fig 3: Lithium disilicate crown w.r.t 36, right lateral view

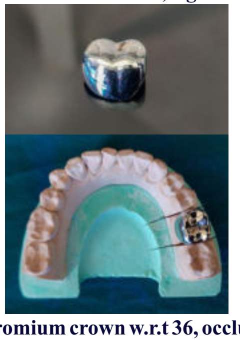

Figure 4: Cobalt chromium crown w.r.t 36, occlusal view

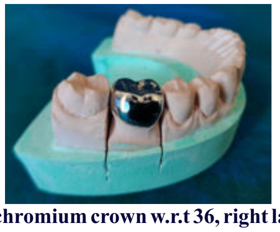

Figure 5: Cobalt chromium crown w.r.t 36, right lateral view

Saliva samples were collected from each subject after rinsing with 15 ml of distilled and deionized water for 30 seconds, before and after cementation of the crowns. Approximately 5 ml of saliva was collected from each participant in sterile vials (Abdos labtech, Uttarakhand, India) (Figure 6) on the day of insertion and after four weeks post-insertion.

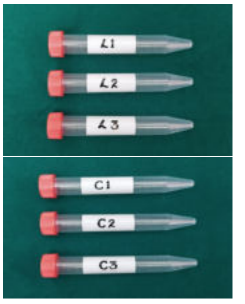

Fig 6: Sterile vials

The saliva sample was collected by using the passive drool method in a sterile glass vile (Figure 7).

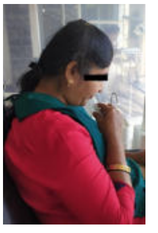

Figure 7: Saliva collection before, after and post one month of cementation.

One ml of saliva was diluted in 10 ml of deionized water. The samples were kept at $-20^{\circ}C$ (Blue Star Limited, Mumbai, India) until analysis. (Figure 8)

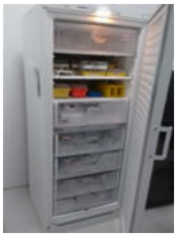

Figure 8: -20ºC Deep freezer.

An inductive coupled plasma atomic emission spectrophotometer (PerkinElmer, Massachusetts, USA) (Figure 9) was used to analyze the saliva samples for the ion release. The mean amounts of different elements released from the alloys were determined and presented in parts per billion (ppb).

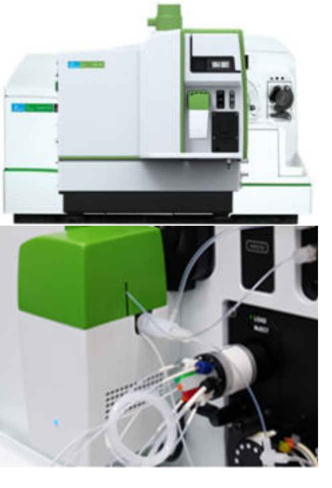

Figure 9: Inductive coupled plasma atomic emission spectrophotometer

The data was collected, coded and fed in SPSS (IBM version 23) for statistical analysis. The descriptive statistics included mean and standard deviation. The inferential statistics included ANOVA followed by post hoc Tukey's test. The level of significance was set at 0.05 at 95% confidence interval.

RESULTS

The data was collected, coded and fed in SPSS (IBM version 23) for statistical analysis. The descriptive statistics included mean and standard deviation. The inferential statistics included ANOVA followed by post hoc Tukey's test. The level of significance was set at 0.05 at 95% confidence interval.

Table 1: Comparison of ions released (ppb) at baseline, immediately after and four weeks after cementation of lithium disilicate crowns by One way ANOVA

		Mean (ppb)	Standard deviation	F	Sig.
Lithium	L1	0.4080	.05653	315.898	**0.000 (H.S)**
	L2	1.0029	.17640		
	L3	1.6800	.06446		
Aluminium	L1	.0000	.00000	3104.124	**0.000 (H.S)**
	L2	45.8120	2.69853		
	L3	87.4730	3.34948		
Silica	L1	17.4520	.49721	13341.234	**0.000 (H.S)**
	L2	119.1940	4.27848		
	L3	9223.7400	250.63176		

The ion release of all three groups was evaluated using one-way ANOVA. Highly significant data were obtained between baseline, immediately after cementation and four weeks post cementation of lithium disilicate crowns. Hence, it was followed by Post hoc Tukey test for individual group-wise comparison.

Table 2: Comparison of ion released (ppb) at baseline, immediately after and four week post cementation of lithium disilicate crowns analysed by Post hoc

			Mean difference (ppb)	Std. error	Sig.	95% confidence interval	
						Lower bound	Upper bound
Lithium	L1	L2	-.59490	.05064	**.000 (H.S)**	-.7205	-.4693
		L3	-1.27200	.05064	**.000 (H.S)**	-1.3976	-1.1464
	L2	L3	-.67710	.05064	**.000 (H.S)**	-.8027	-.5515
Aluminium	L1	L2	-45.81200	1.11059	**.000 (H.S)**	-48.5656	-43.0584
		L3	-87.47300	1.11059	**.000 (H.S)**	-90.2266	-84.7194
	L2	L3	-41.66100	1.11059	**.000 (H.S)**	-44.4146	-38.9074
Silica	L1	L2	-101.74200	64.72240	.275 (N.S)	-262.2159	58.7319
		L3	-9206.2880	64.72240	**.000 (H.S)**	-9366.7619	-9045.8141
	L2	L3	-9104.5460	64.72240	**.000 (H.S)**	-9265.0199	-8944.0721
Zinc	L1	L2	-2.56800	1.25344	.120 (N.S)	-5.6758	.5398
		L3	-5.93500	1.25344	**.000 (H.S)**	-9.0428	-2.8272
	L2	L3	-3.36700	1.25344	**.032 (S)**	-6.4748	-.2592

The lithium ions released showed a highly significant difference (.000) between the baseline, immediately after cementation and four weeks post cementation of lithium disilicate crowns.

The aluminum ions released also showed a highly significant difference (.000) between the baseline, immediately after cementation and four weeks post cementation of lithium disilicate crowns.

The silica ions released showed a highly significant difference (.000) between immediately after cementation and four weeks post cementation of lithium disilicate crowns, and baseline and four weeks post cementation of lithium disilicate crowns. A non-significant difference (.275) was observed between the baseline and immediately after cementation of lithium disilicate crowns.

The zinc ions released showed a highly significant difference (.000) between the baseline and four weeks post cementation of lithium disilicate crowns. A significant difference (.032) was noted immediately after and post four weeks of cementation of lithium disilicate crowns. Nevertheless, a non-significant difference (.120) was observed between the baseline and immediately after cementation of lithium disilicate crowns. The ion release of all three groups was evaluated using one-way ANOVA. Highly significant data were obtained between baseline, immediately after cementation and four weeks post cementation among all the groups. Hence, it was followed by Post hoc Tukey test for individual group-wise comparison.

Table 3: Comparison of ion released (ppb) at baseline, immediately after and four weeks after cementation of cobalt chromium crowns by One way ANOVA

		Mean (ppb)	Standard deviation	F	Sig.
Cobalt	C1	91.1950	3.48397	755.311	**0.000 (H.S)**
	C2	94.8860	4.24897		
	C3	177.2550	7.98997		
Chromium	C1	6.9895	.33973	1155.548	**0.000 (H.S)**
	C2	7.5470	.38790		
	C3	14.0020	.35851		
Molybdenum	C1	6.6513	.28661	176.155	**0.000 (H.S)**
	C2	8.2348	.72464		
	C3	13.8760	1.35968		

The ion release of all the three groups were evaluated using one-way ANOVA. Highly significant data were obtained between baseline, immediately after cementation and four weeks post cementation of cobalt-chromium crowns. Hence, it was followed by Post hoc Tukey test for individual group-wise comparison.

CONCLUSIONS

Within the limitations of this study, the following conclusions can be drawn:

1. The metallic ions released from lithium disilicate crowns from studied saliva samples showed a significant increase in the concentration (ppb) of ions till four weeks of cementation ($p<0.05$).
2. The metallic ions released from cobalt-chromium crowns from studied saliva samples showed a significant increase in the concentration (ppb) of ions till four weeks of cementation ($p<0.05$).
3. The ion elution values of lithium disilicate crowns were toxicologically not significant.
4. The ion elution values of cobalt-chromium crowns were toxicologically not significant.
5. Amount of ions released from lithium disilicate crowns had more concentration of ions than cobalt-chromium crowns.

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