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Evaluation of Physical Properties of CAD-CAM Lithium Disilicate And Highly Translucent Zirconia Immersed In Simulated Gastric Juice At Different Time Intervals: An In-Vitro Study.

Neelam A. Salvi Bds, Janani Iyer Bds, Mds, Jyoti Nadgere Bds, Mds And Prem R. Thapar Bds

[A] *Post Graduate, Department Of Prosthodontics And Crown & Bridge, Mgm Dental College And Hospital, Navi Mumbai, Maharashtra, India.*
[B] *Professor, Department Of Prosthodontics, Mgm Dental College And Hospital, Navi Mumbai, Maharashtra, India.*
[C] *Professor And Hod, Department Of Prosthodontics And Crown & Bridge, Mgm Dental College And Hospital, Navi Mumbai, Maharashtra, India.*
[D] *Post Graduate, Department Of Prosthodontics And Crown & Bridge, Mgm Dental College And Hospital, Navi Mumbai, Maharashtra, India.*

Abstract
Statement of problem*- Acid reflux causes surface changes on the restorative materials which ultimately hampers the longevity of the restoration. The aim of this study was to compare and evaluate the surface topography, surface gloss and solubility of CAD-CAM lithium disilicate and highly translucent zirconia immersed in simulated gastric juice at time intervals that are significant with the intervals of meal consumption.*
Purpose*- The study was done to comparatively evaluation of surface topography, surface gloss and Solubility of cad-cam lithium disilicate and highly translucent zirconia immersed in simulated gastric juice at different time intervals.*
Materials and method*- The materials used for this in-vitro study are CAD-CAM lithium disilicate and highly translucent zirconia measuring 10mm in diameter and 1.2mm in height. The total number of samples used were 48; 24 CAD-CAM lithium disilicate and 24 CAD CAM highly translucent zirconia. Fabrication of samples was done using CAD/CAM technology. The samples were immersed in freshly prepared artificial gastric juice bath with pH 1.2 for 30 seconds in rectangular glass tray at different time interval. The sample were 1A 12A CAD-CAM lithium disilicate and 13A-24A CAD-CAM highly translucent zirconia. The samples were removed from the acid bath using a tweezer by holding the edges and not the center/glazed part, as it can affect the final test results. The samples were washed using deionized water for 30 seconds. After washing the samples, they are placed in artificial saliva with pH 6.7 till the next immersion time in a rectangular glass tray. This procedure was repeated at different time interval in a day, i.e., at 9 a.m., 1p.m., 5p.m. and 9p.m. for 2 months.*
Results*- There was a statistically highly significant difference seen for the values between the time intervals (p<0.01) for Group lithium disilicate with higher values at Pre testing and Group highly translucent zirconia with higher values at Pre testing. There was a statistically significant difference seen for the values between the time intervals (p<0.05) for Group lithium disilicate control group with higher values at Pre testing and Group highly translucent zirconia with higher values at Pre testing.*
Conclusion*- Lithium disilicate has superior surface gloss when compared to highly translucent zirconia. Highly translucent zirconia has lower solubility when compared to Lithium disilicate. Regarding surface topography, both lithium disilicate and highly translucent zirconia showed similar and significant change in the surface texture. When choosing a restorative material for patients with significant GERD, clinicians should choose highly translucent zirconia over lithium disilicate as zirconia is not as easily soluble in the acidic environment when compared to lithium disilicate. When choosing a restorative material for patient with mild GERD or no GERD, clinicians should choose lithium disilicate over highly translucent zirconia as lithium disilicate has superior surface gloss and a suitable solubility.*

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I. Introduction

The success of a restorative material depends on the type and shade of the substrate, the thickness of ceramic, and the opacity of porcelain, the number of firings, the luting cement and accelerated ageing. However, the satisfactory clinical performance of dental restorations also depends on their resistance to biodegradation. In the oral cavity, this process includes diverse phenomena, such as sliding, abrasion, chemical degradation, and fatigue. Ceramic based restorative materials are susceptible to weakening when exposed to plaque acids, gastric acid reflux, food-simulating ingredients, and enzymes. Degradation of restorative materials cannot be attributed to wear alone, but involves chemical degradation as well. In vivo, these materials may either be exposed intermittently or continuously to natural chemicals such as saliva and gastric acids. Rehabilitation of patients with acid reflux diseases demands studying and understanding the effects of gastric acid on the longevity of restorative materials. The prevalence of GERD in India ranges from 7.6% to 30%, being < 10% in most population studies, and higher in cohort studies[1]. It is a relatively common condition worldwide, with prevalence rates in adults ranging from 21% to 56% in different countries2. 15% of individuals experience heartburn once a week, 7% to 10% experience heartburn once daily, 25% to 40% of Americans experience symptomatic GERD at some point, and 45% to 85% of women experience GERD or heartburn during pregnancy[2]. Dentists are commonly the first to diagnose GERD through erosion of teeth since most people are not aware of the presence of the disease. It was reported that there is a correlation between dental erosion and GERD patients where patients with GERD are found to have dental erosion and patients with dental erosion are then found to have GERD. All-ceramic restorations that offer biocompatibility and aesthetics may be affected by gastric acid, although less intensely than enamel. Chemical degradation can lead to microstructural changes in surface topography, which can affect light reflection, color perception, and stability. The knowledge of how ceramic materials react to gastric acid can help a dentist in selecting suitable materials for prosthetic restorations for the special patients mentioned above, though not limited to them. A systematic review reported a 24% prevalence of dental erosion in patients with GERD and that of 33% of patients with dental erosion had such a disorder[3]. Gastric juice produces more severe degradation of dental structures than dietary acids. It reaches the oral cavity as a result of GERD, bulimia nervosa or prolonged severe nausea seen during pregnancy. Thus, dental erosion is one of the contributing causes to the loss of vertical dimension and need for a full mouth rehabilitation. The choice for rehabilitating a patient that has lost the vertical dimension due to erosion demands choosing a restorative material with adequate strength, durability and resistance to such acids. Ceramics have been the backbone of aesthetic dentistry for more than 100 years. The qualitative improvements provided ceramic materials with many advantages over the porcelain-fused-to metal (PFM) system. Ceramics have evolved over the last few decades thus providing superior [3] functional and optical properties to the restoration. CAD/CAM technology was introduced in dentistry by Duret in the early seventy century4. Harryparsad et al reported that ceramic materials, including lithium disilicate, highly translucent zirconia and zirconia layered with e-max, will be affected by long-term exposure to hydrochloric acid5. Sulaiman et al also reported that lithium disilicate exhibit about three times more weight loss than monolithic zirconia materials after exposure [6]. Highly translucent zirconia, lithium disilicate and zirconia layered with e-max are indicated for full mouth rehabilitation and in anterior region for esthetics[7]. Harryparsad et al reported that ceramic materials, including lithium disilicate, highly translucent zirconia and zirconia layered with e-max, will be affected by long-term exposure to hydrochloric acid[5]. Sulaiman et al also reported that lithium disilicate exhibit about three times more weight loss than monolithic zirconia materials after exposure [6]. Highly translucent zirconia, lithium disilicate and zirconia layered with e-max are indicated for full mouth rehabilitation and in anterior region for esthetics[7]. As stated by Esquivel-Upshaw et al., Newton defined durability as the ability of glass to withstand attacks from water and other aqueous solutions in 19857. Acid reflux causes surface changes on the restorative materials which ultimately hampers the longevity of the restoration. Sulaiman et al. studied the impact of gastric acid (pH 1.2) on the surface topography of different monolithic zirconia and IPS E-max and found that IPS E-max and FSZ (fully stabilized zirconia) exhibited smoother surfaces after acid immersion[6]. While Kulkarni et al. found that zirconia showed resistance to gastric acid and tooth brushing, whereas the gastric acid treatment affected the surface roughness of feldspathic porcelain and IPS E max ceramics10. Thus, the aim of this study was to compare and evaluate the surface topography, surface gloss and solubility of CAD-CAM lithium disilicate and highly translucent zirconia immersed in simulated gastric juice at time intervals that are significant with the intervals of meal consumption.

II. Material And Methods

Samples for this in-vitro study were made of lithium disilicate and highly translucent zirconia disks measuring 10X1.2mm. Samples were fabricated by computer-aided design/ computer-aided manufacturing (CAD/CAM) technology. After milling, the disks were finished, polished and glazed. The disks were finished and polished using dental rubber polishing wheel of 22mm diameter and polishing brush of 25mm diameter.

Lithium disilicate disks were glazed using Ceram (glaze and stain liquid) at a temperature of 770°C. Whereas, highly translucent zirconia disks were glazed using Glazing paste at a temperature of 910°C.

For preparing artificial gastric juice, 0.113% HCL solution mixed in deionized water with pH=1.2 in rectangular glass tray. pH was checked using a pH meter (Euiptronics). 18 samples of CAD-CAM lithium disilicate (IPS e-max CAD) and 18 samples of CAD-CAM highly translucent zirconia were immersed in freshly prepared artificial gastric juice bath with pH 1.2 for 30 seconds in rectangular glass tray[6]. The samples were numbered with a permanent marker (on back side). The sample numbers were 1A-18A CAD-CAM lithium disilicate and 19A-36A CAD-CAM highly translucent zirconia.

After immersion in simulated gastric juice, the samples were removed from the acid bath using a tweezer by holding the edges and not the centre /glazed part, as it can affect the final test results. The samples were washed using deionized for 30 seconds. After washing the samples, they were placed in artificial saliva with pH 6.7 till the next immersion time in a rectangular glass tray. Tray and samples will be covered with plastic wrap till the next immersion time.

This procedure from immersing the samples in simulated artificial gastric juice till placing the samples in artificial saliva was repeated at different time intervals, i.e., 9 a.m., 1 p.m., 5 p.m. and 9 p.m. in a day for 2 months. Artificial gastric juice was freshly prepared at 9 a.m., 1 p.m., 5 p.m. and 9 p.m.

For control group, a rectangular glass trays were taken. 18 samples of CAD-CAM Lithium disilicate and CAD-CAM highly translucent zirconia were immersed in artificial saliva (pH=6.7) for 2 months. The samples were numbered with a permanent marker (on back side). The sample numbers were 1B-18B CAD-CAM lithium disilicate and 19B-36B CAD-CAM highly translucent zirconia. Tray and samples were covered with plastic wrap till 2 months.

For testing the surface topography, surface gloss and solubility the samples were grouped accordingly: Group IA (1A-18A) and Group IIA (19A-36A) were immersed in artificial gastric juice, Group IB(1B-18B) and Group IIB (19B-36B) were control groups. Surface topography of the samples was checked using scanning electron microscope (Carl Zeiss model Supra 55 Germany). Surface gloss was assessed using gloss meter (Mini Gloss Meter) measured specular reflection gloss. Solubility was assessed by weighing the specimen on an analytical balance (LWL Germany).

III. Result

The SEM images revealed nanoparticles were removed from the CAD CAM lithium disilicate and highly translucent zirconia after the acidic challenge. Several pores were present on before acid exposure in figures 1 and 3. In Figures 2 and 4 microcracks are visible on CAD CAM lithium disilicate and highly translucent zirconia samples after exposed to acid which can be observed in higher magnification. After acid exposure, pores are seen on the surface of CAD CAM lithium disilicate and highly translucent zirconia (Fig. 2 and 4), being more numerous in lithium disilicate. The results for surface gloss revealed that lithium disilicate had high surface gloss of 11 as compared to highly translucent zirconia which is 8.5 (Table 1) before immersion in simulated gastric juice. Grossly between the two materials, highly translucent zirconia showed a lower gloss of 8.3 compared to lithium disilicate which was 10.4 (Table 1) after immersion in the simulated gastric juice. Regarding solubility, it was noted that lithium disilicate was significantly more soluble than highly translucent zirconia. The mean solubility for lithium disilicate was 3.59 whereas for highly translucent zirconia was 2.82 (Table 2). However, after immersion in artificial saliva, the solubility mean for lithium disilicate and highly translucent zirconia were similar 0.35 (Table 2).

IV. Discussion

The primary goal of restorative dentistry is to restore a missing tooth structure with a material that has optical and mechanical properties that are as close to natural tooth as possible. The variation in dissolving rate may result in increased surface roughness in glass-ceramic compositions containing crystalline components. Newer ceramic materials with different microstructure may vary in strength; however, the mechanical properties alone do not predict the success and longevity of a restoration. The purpose of this research was to compare the surface topography, surface gloss, and solubility of CAD-CAM lithium disilicate and extremely transparent zirconia immersed in simulated gastric acid juice at various time intervals.

In 2021, Rai et al highlighted that there are few Indian population-based research on the prevalence and risk factors for gastroesophageal reflux disease (GERD), and that a meta-analysis and meta-regression of prevalence and risk variables are needed. In the Indian population, the pooled prevalence of GERD is 15.6 (95% CI 11.046 to 20.714)[32]. Age, BMI, non-vegetarian diet, tea/coffee drinking, tobacco use, and alcohol usage were all risk factors. Thus, from the aforementioned results, it is proven that at least 15% of the Indian population suffers from significant acid reflux[32].

Acid is regurgitated into the oral cavity and every dental material that remains in the oral cavity is exposed to the potential acid attacks. Effrat Habsha reported that tooth wear can manifest as abrasion, attrition, abfraction and erosion[33]. The interrelationship of the four modes of tooth wear and individual susceptibility influence the degree of tooth wear[33]. According to Sujata et al, the prevalence of dental erosion is 41% compared to 12.5% in controls, and the most commonly identified dental erosions were levels 1 and 2 (level 1—superficial lesion affecting only enamel; level 2—localized lesion)[9]. Hence, it is important to study the effects of the acid reflux on the most commonly used materials in restorative and rehabilitation dentistry which is ceramics.

For dental repair, particularly crowns and brief fixed dental prostheses, glass-ceramics are frequently employed as biomaterials. One of the premium all-ceramic aesthetics materials, lithium disilicate, enables to achieve more aesthetically pleasing restorations, replacing the tried-and-true metal ceramic restorations[34]. Ceramic is now a desired alternative for indirect aesthetic restoration operations due to advancements in dental materials. Daou et al stated that due to improved strength, wearability, and translucency, the most recent generation of materials can now provide patients even better treatment results[36]. The technician can create restorations that more closely resemble real teeth with much better translucency. High translucent zirconia maintains a bright and natural translucency while giving doctors and patients more predictable and aesthetically pleasing treatment outcomes[37]. Lithium disilicate restorations are usually advised in the anterior aesthetic zones to fulfil the patients' aesthetic needs. Moreover, for the posterior regions, zirconia crowns are being used more often. Apart from lithium disilicate, highly translucent zirconia is also an alternative material for anterior aesthetic cases.

CAD/CAM technology has now become an integral aspect of dentistry, with a growing number of restorations being created. The advancement of digital systems and CAD/ CAM has the ability to transform traditional technologies. These restorations can be made quickly, with improved characteristics and to meet the patient's cosmetic needs. CAD CAM has numerous advantages in restorative dentistry[37,38,39]. It features increased accuracy, shorter wait times, and lower outsourcing costs. Dentists may additionally utilize the technology to create accurate, robust, and dimensionally stable restorations. As a result, CAD-CAM produced ceramics were chosen for the current study. Thus, CAD/CAM manufactured samples were investigated in the current study.

The in vitro simulation of acid on the surface of dental ceramics is affected by acid concentration, immersion period, and temperature. According to the literature, simulated gastric acid exposure of CAD-CAM materials for 7.5 hours represents one month of gastric acid exposure, 45 hours represents six months of exposure, and 91 hours represents one year of exposure. Backer et al. employed CAD-CAM materials that were exposed to simulated stomach acid for 6 and 18 hours, respectively, and calculated that these times reflect 2 and 8 years of vomiting exposure of dental structure[40]. Sulaiman et al. subjected monolithic zirconia to acid solution for 96 hours, mimicking nearly ten years of vomiting exposure[6]. Based on the results of these research, we can conclude that there is no clear consensus in the literature about the method of stomach acid simulation and the comparable time for replication for an in vivo model.

According to ISO standard 6872, which relates to the solubility test for dental materials, the use of 4% acetic acid and an exposure length of 16 hours at 80 C is equivalent to 2 years of clinical exposure. Individual specimens were submerged in 3 mL of simulated gastric juice for 18 hours, 25 minutes. Hydrochloric acid (HCl) solution containing 0.113% was used to generate the simulated gastric juice, which was then pH-adjusted to 1.2[41]. Mark Feldman and Charles T. Richardson stated that bulimic 72 patients typically purge four times per day. The gastric liquid's estimated contact time with restorations is 30 seconds, the immersion period equated to two months of gastric juice exposure. Hence the samples were immersed for 30 seconds four times a day viz. 9am, 1pm, 5pm and 9pm keeping in mind the significant meal hours for an individual. Therefore, the samples were immersed according to the aforementioned criteria.

As stated by Singh et al in 2020, proper evaluation followed by a definite diagnosis is mandatory as the etiology of severe occlusal teeth wear is multifactorial and variable for full mouth rehabilitation. Patients who are suffering from mild GERD, the material of choice would be lithium disilicate in the anterior region and highly translucent zirconia in the posterior region. As the result states, lithium disilicate has a higher surface gloss as compared to highly translucent zirconia. Patients who are suffering from moderate to severe GERD, the material of choice would be highly translucent zirconia as it has low solubility as compared to lithium disilicate. As zirconia will be less soluble in the acid environment in the oral cavity. Patients with no GERD have many etiologies other than GERD like attrition, abrasion, erosion, trauma, gum diseases, bacterial infection, tooth decay, bruxism, misaligned teeth as well as intake of acidic food and drinks as stated by Selvan et al in 2016 and Basha et al in 2018. So, the material of choice for these patients will be according to the etiology that is, anteriorly lithium disilicate and posteriorly highly translucent zirconia. As there was no significant result obtained in the surface topography, solubility and surface gloss when the samples were immersed in artificial saliva at pH 6.7, which resembles the oral cavity with no GERD.

Some of the limitations of this study were that the meal timings have been corelated with the immersion timings which significantly affect the outcome of this study; however, meal timings for some individuals with GERD may not adhere to the aforementioned timings and an unusual timing of meal intake also contributes to GERD. Another limitation of the study was that only two specific materials were chosen with two specific brands and hence further research of similar type which provides intragroup comparison between different brands and types of lithium disilicate and highly translucent zirconia could further benefit the clinicians. Clinical significance of this study is that it helps clinicians choose the ideal restorative material for a patient with mild, moderate and significant GERD while keeping in mind the aesthetics and the functionality of the restoration.

V. CONCLUSION

The following conclusion were reached based on the findings of this in-vitro study:

1. Lithium disilicate has superior surface gloss when compared to highly translucent zirconia.
2. Highly translucent zirconia has lower solubility when compared to Lithium disilicate.
3. In terms of surface topography, lithium disilicate and very transparent zirconia both demonstrated a similar and considerable shift in surface roughness.
4. When choosing a restorative material for patients with significant GERD, clinicians should choose highly translucent zirconia over lithium disilicate as zirconia is not as easily soluble in the acidic environment when compared to lithium disilicate.
5. When choosing a restorative material for patient with mild GERD or no GERD, clinicians should choose lithium disilicate over highly translucent zirconia as lithium disilicate has superior surface gloss and a suitable solubility.

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