Impact of Gastric Acids on Surface Roughness of Dental Materials: A Systematic Review

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Authors’ contributions
This work was carried out in collaboration among all authors. All authors made best contribution for the concept, assessment and evaluation, data acquisition and analysis and interpretation of the data. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Dental materials whenever used for restorations in the oral cavity can be subjected to dental erosion because of the gastric juices and can cause roughness and act as a nidus for the growth plaque. Aim of this study was to evaluate impact of artificial gastric acid on surface roughness of dental restorations, examining scientific studies published from 2010-2020.

Materials and Methods: This study follows and complies with principles of PRISMA guidelines for a systematic review research methodology. In March 2020, an initial search was carried out in the MEDLINE (PubMed), Science Direct, Google Scholar, and Saudi Digital Library database of indexed journals from 2010-2020 using the keywords: impact, “effect,” “gastric acid,” “gastric juice,” “indirect restorations,” “dental materials,” “dental ceramics,” “crowns,”. Bibliographic materials from these articles were then utilized to find other sources.

Results: The MEDLINE (PubMed) search retrieved thirty articles, of which three were relevant to the study. Total articles found in Google scholar were 11,500 article, in which 11 were analyzed for

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further review and only seven matched the allocated inclusion and exclusion criteria. 512 articles were found in the Saudi Digital Library and only three of these articles followed the inclusion criteria of this study.

**Conclusions:** It has been proved by numerous studies that acidic exposure significantly affects the surface roughness of dental ceramics negatively. There is lack of evidence to support the claim that Zirconia is the dental ceramic of choice for patients with intrinsic acid regurgitation. Thus, it is recommended to conduct further studies in order to assess and confirm the best material that can withstand such acidic environment.

**Keywords:** Gastric acid; indirect restorations; dental materials; dental ceramics; crowns.

### 1. INTRODUCTION

Dental erosion is one of the most widely spread conditions of tooth surface loss seen nowadays. It can be caused either by intrinsic factors, such as gastro-esophageal reflux disease (GERD), or extrinsic factors like dietary habits [1]. The severity of erosive destruction is greater on teeth exposed to gastric acid than dietary acid due to the pH of the former [2]. Furthermore, it has been concluded by previous studies that the strength of ceramics decreases as the surface roughness increases [3], which in turn alters the clinical success of ceramic restorations. Moreover, the effect of acidic agents not only affects the surface of a natural tooth but also may accelerate the degradation of resin based restoration.

A study conducted by Elguindy et al. [4] stated that patients now were more gravitated toward the desire of a more esthetic restoration. Some examples of esthetic indirect restoration include Feldspar, Leucite-reinforced, Lithium di-silicate, Alumina based ceramic, and Zirconia. With the presence of different materials each with different strengths, advantages and disadvantages, the dental practitioner may have a difficult time choosing the best possible dental restoration for patients susceptible to experiencing dental erosion. Lithium disilicate IPS E.max (Ivovlar Vivadent AG, Schaan, Liechtenstein), a glass ceramic restoration, was utilized as an alternative to metal ceramic restorations which offers several advantages such as biocompatibility, increased esthetics and a more natural appearance [5] Another study in 2017 [6] found that the natural appearance and improved physical properties of IPS E.max crowns was achieved by alternative firing processes.

Another esthetic indirect restoration is high strength core Zirconia. Zirconium dioxide, a derivative of Zirconium element and known as Zirconia, has high flexural strength and fracture toughness [7]. A modified type of Zirconia known as modified yttria tetragonal Zirconia poly crystals (Y-TZP) is frequently used [8].

According to Dwivedi et al. [9], the first office based device of Computer Aided Design/Computer Aided Manufacture (CAD/CAM) was introduced in 1986 under the commercial name “CEREC”. CAD/CAM utilizes computers to design and mill indirect restorations [10] Over the past decade, the production of crowns using CAD/CAM has increased. A major advantage of using a CAD/CAM system is that it helps the practitioner save time in the fabrication of a crown [11]. Different materials are available as blocks such a Feldspar, Leucite and Lithium di-silicate [9].

The surface wear of dental restorations can be affected by the surface roughness which is known to be the measure of surface texture [12]. Another study [13] found that surface roughness and the amount of plaque accumulation are directly correlated. Although, there are various parameters utilized for measuring the surface roughness, the most often used parameter is roughness average; which is defined as “arrhythmic average of all deviation of the roughness profile from the central line[14] [15].

Which restorative material is least effected by immersion in acidic agent? Few evidences were provided about the effect of intrinsic acidic agents on ceramic restorations. Therefore, the purpose of this systematic review was to evaluate surface roughness of different restorative material after immersion in acidic agents and the null hypothesis is that Zirconia is the material least effected by intrinsic acids. The aim of the study was to evaluate the impact of artificial gastric acid on surface roughness of different dental restorations, examining scientific studies published from 2010 to 2020.
2. MATERIALS AND METHODS

This study follows and complies with principles of PRISMA guidelines for a systematic review research methodology, and it aims to examine the impact of artificial gastric acid on surface roughness of different dental restorations. A systematic search was conducted of available literature reporting the impact of artificial gastric acid on dental ceramics. Electronic databases such as PubMed, Science Direct, Google Scholar, and Saudi Digital Library (SDL) were utilized from March 11th, 2020 lasting for one week to identify all studies that evaluated the impact of artificial gastric acid on dental ceramics.

Original full text scientific papers on impact of gastric acid on dental restorations published in MEDLINE (PubMed), Science Direct, Google Scholar, and Saudi Digital Library database between 2010 to 2020 were included in this systematic review. The study compiled articles that were published in impact factor journals and peer reviewed publications. Furthermore, it included studies that had dental restorations immersed in artificial gastric acid/acidic agents of pH 2 or less. The study excluded articles not from MEDLINE (PubMed), Science Direct, Google Scholar, and Saudi Digital Library or abstracts without full-text availability, studies published earlier than 2010. It also excluded studies which were not published in impact factor journals; restorations immersed in acidic beverages more than pH of 2 and direct filled composite restorations.

Citations retrieved from electronic databases were imported into reference management software, EndNote Web of science (Clarivate Analytics).

3. RESULTS

The MEDLINE (PubMed) search had the following MeSH terms, search terms and their combinations were used: “impact,” “effect,” “gastric acid,” “gastric juice,” “indirect restorations,” “dental materials,” “dental ceramics,” “crowns.” Our search retrieved thirty articles, of which three were relevant to the study. Bibliographic materials from these articles were then utilized to find other useful sources. The total articles found in Google scholar were 11,500 article, in which 11 were analyzed for further review. Seven of these articles matched the allocated inclusion and exclusion criteria. Initially, three articles were found to be relevant to the impact of gastric acid on dental ceramics in Science Direct database; yet, only two were found to be useful in this study after further review of full materials and methods. 512 articles were found in the Saudi Digital Library and only three of these articles followed the inclusion criteria of this study. Table 1 summarizes the selected literature on the impact of gastric acid on dental ceramics. After meticulous review of the included literature, four studies were found in both Google Scholar and SDL, making them duplicates to each other.

Two studies were excluded for the reason that the materials tested were direct restorations. The third was eliminated because it measured the micro-hardness instead of surface roughness. Moreover, the fourth was related to the effect of micro-leakage of resin cement which does not follow the inclusion criteria of the systematic review.

4. DISCUSSION

The findings for the study do not support the rejection of the null hypothesis. The effect of acidic agents resulting from regurgitation of gastric acid not only affects the surface of a natural tooth, but they may also accelerate the degradation of resin based restoration [21]. An in-vitro study conducted in [20] concluded that the surface roughness (Ra) was not significantly altered prior and post exposure of all three materials. The minimal surface changes can be a significant attribute to the short term exposure to acids (24 hours). Similar exposure times were done by Backer et al. [18]; however, the results differed slightly. After 24 hours of exposure, Paradigm MZ100 (submicron CAD/CAM resin composites) showed no additional changes than the 6-hour exposure; yet, Lava Ultimate (Resin nanoceramic) exhibited higher surface roughness. However, another in-vitro study with a longer period of 91 hours of exposure showed different surface roughness of each material ([19]. CEREC VITABLOC Mark II CAD (Polymer-infiltrated ceramic network) and IPS Empress CAD (Lithium disilicate ceramic) had higher initial mean surface roughness than IPS E.max CAD. After subsequent exposure of all three materials, IPS E.max CAD expressed the least mean surface roughness; hence employing least affected by the erosive materials. Furthermore, another study with total of 108 hours of acid
Table 1. Summary of Literature Review—VITA PUPRINITY – Zirconia-reinforced lithium silicate cement

| Author                  | Year | Material                                                                 | Sample Size | Total Exposure Time | pH of Acidic Agent | Least Material Affected          | Most Material Affected          |
|-------------------------|------|--------------------------------------------------------------------------|-------------|---------------------|--------------------|----------------------------------|----------------------------------|
| Cruz, M. E. [16]        | 2019 | Lava Ultimate, VITA ENAMIC, IPS E.max CAD, VITA SUPRINITY*               | 48 (12 of each) | 18.25 hours         | 1.2                | VITA ENAMIC                      | IPS E.max CAD VITA SUPRINITY     |
| Alnasser et al. [15]    | 2019 | Lecite glass ceramic, Feldspathic porcelain, Resin matrix ceramic, Lithium disilicate, Zirconia | 90 (15 of each) | 91 hours           | 2                  | Lithium disilicate               | Lecite glass ceramic              |
| Kulkarni et al. [17]    | 2018 | Feldspathic porcelain, Lithium disilicate glass-ceramic, Monolithic zirconium oxide | 32 (8 of each) | 108 Hours          | 2                  | Zirconia Ceramic                 | Porcelain 1.66 Ra in um           |
| Backer et al [18]       | 2015 | Lava Ultimate, Paradigm MZ 100                                          | 28 (14 of each) | 24 Hours           | 1.2                | Paradigm MZ 100                  | Lava Ultimate                    |
| Suliman et al [2]       | 2015 | Prettau Zirconia (PRT), Prettau Zirconia (BRX), WidlandZenostar translucent (KAT), Prettau anterior Control (PRTA, IPS e.max CAD | 30 (5 of each) | 96 Hours           | 1.2                | PRT, BRX, KAT                    | PRTA, ZEN                         |
| Hpyerparasad et al. [19]| 2014 | CEREC VITABLOC Mark II CAD, IPS Empress CAD, IPS E.max CAD               | 18 (16 of each) | 91 Hours           | 2                  | IPS e..max CAD                  | CEREC VITABLOC Mark II CAD        |
| Matsou et al. [20]      | 2011 | High-fusing leucite-based feldspathic porcelain, Low-fusing leucite-based fluorapatite glass ceramic, Low-fusing leucite-based feldspathic porcelain | 3 (1 of each) | 24 Hours           | 1.2                | Low-fusing leucite-based feldspathic porcelain | One low-fusing leucite-based feldspathic porcelain |

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treatment established that Zirconia was the material least affected, while porcelain displayed the most surface roughness [17]. Similarly, these results were also supported by another study which states that IPS E.max showed a higher surface roughness than Zirconia after acid treatment [2]. Additionally, a study by Alnasser et al [15] who tested five different materials including Feldspathic porcelain, Leucite glass ceramic, Resin matrix system, Lithium disilicate and Zirconia. Both Lithium disilicate and Zirconia were the least affected materials to acid exposure. They demonstrated minimal changes to the surface roughness of the materials. The results of all the previous studies were contraindicated by a recent study in which it was stated that the surface roughness was decreased after acid treatment was performed [16]. This result could be a consequence to the reduction in the time of exposure to the acidic agent. A limitation of this study was that few present studies tested the difference between the surface roughness parameter of Lithium disilicate ceramic and Zirconia hence, a conclusion can’t be made which is more resistant to artificial gastric acid. An additional limitation is that an I2 test for meta-analysis was not conducted to assess the studies heterogeneity.

5. CONCLUSION

It has been proved by numerous studies that acidic exposure significantly affects the surface roughness of dental ceramics negatively. Thus, clinicians should be careful when selecting of any restorative material by considering their longevity, particularly among patients suffering from common conditions such as GERD, which alters the pH environment of the oral cavity. Based on the analyzed studies, there is lack of evidence to support the claim that Zirconia is the dental ceramic of choice for patients with intrinsic acid regurgitation. Thus, it is recommended to conduct further studies in order to assess and confirm the best material that can withstand such acidic environment without changes in surface topography.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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