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Original Research

Comparison of surface treatments on the flexural strength of different CAD-CAM materials

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ABSTRACT:
Aim: Evaluation of effect of surface treatments on the flexural strength of different CAD/CAM restorative materials. **Objective:** To evaluate the effect of 5% hydrofluoric acid (HFA) gel surface treatment on flexural strength of Vita Enamic. To evaluate the effect of 5% HFA gel surface treatment on flexural strength of Hyramic. To evaluate the effect of 5% HFA gel surface treatment on flexural strength of Mazic Duro. To evaluate the effect of 50µ Al_2O_3 surface treatment on flexural strength of Vita Enamic. **Methodology:** Choose the CAD-CAM materials you want to compare in terms of flexural strength. Examples of commonly used CAD-CAM materials include zirconia, lithium disilicate, and hybrid ceramics. Prepare rectangular-shaped specimens according to the standard dimensions specified for flexural strength testing. The dimensions may vary depending on the testing standards and requirements of the materials. Use a CAD-CAM system to mill or fabricate the specimens from the selected materials. Divide the specimens into different groups based on the surface treatments to be applied. Examples of surface treatments include polishing, glazing, airborne particle abrasion, and coating applications. Ensure that each group has an adequate number of specimens to ensure statistical significance. **Result:** The flexural strength of CAD-CAM materials without any surface treatment served as the control group. The mean flexural strength of the control group was recorded as X MPa (±SD), indicating the baseline strength of the materials. The surface treatments applied to the CAD-CAM materials had varying effects on their flexural strength. Each surface treatment group exhibited different mean flexural strength values compared to the control group, indicating the influence of surface treatments on the mechanical properties of the materials. **Conclusion:** In conclusion, the study comparing surface treatments on the flexural strength of different CAD-CAM materials provided valuable insights into the effects of various surface treatments on the mechanical properties of these materials. The findings contribute to our understanding of how surface treatments can influence the flexural strength of CAD-CAM materials and have important implications for clinical and manufacturing applications.
Keywords: Prepolymerized polymers; poly(methyl methacrylate); three-point bending.

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INTRODUCTION

The fixed partial denture is one of the standard treatments for replacement of missing teeth as it enhances patient comfort, function and self-image.Over the past few decades, comprehensive coverage restorations have been the most widely used fixed prosthetic method to restore the functionality and appearance of injured natural teeth[1]. Metal ceramic crowns are recognized as the gold standard for extensive coverage restorations because of their superior strength, fit, longevity, and marginal integrity[2, 3].These restorations still had biological problems, such as chipping and ceramic debonding[4], as well as a lack of a natural appearance[5]. Researchers started looking for alternatives as a result of patient's and doctor's worries and demands for biocompatible metal-free restorations[1,6]. These requirements have led to the development of all-ceramic restorations. These restorations have excellent light transmission properties, color durability, increased wear, and soft tissue biocompatibility[7].Anterior teeth were rebuilt using McLean[8] 1965 invention, alumina reinforced core ceramic. Dentistry began using computer-aided design and manufacturing (CAD/CAM) technology in early 1980s[9]. The very first CAD/CAM restoration was produced in 1985 using CEREC using a premade ceramic block. Since then, the process has developed, becoming even quicker, more accurate, and more economical. Increased CAD/CAM use has created new opportunities for dental treatments. Ceramic manufacturing time has decreased by up to 90% because to the advancement of CAD/CAM technology[10].Partially sintered ceramics to which heat treatment was done to ensure proper sintering have been included to the scope of CAD/CAM technology, which was originally developed in theory for fully sintered ceramics[11]. Newer groupings of ceramics and composite materials are described for applications involving monolithic and bi-layered structures[12]. Dental restorations may now be produced more uniformly and affordably thanks to CAD/CAM technology, which also have a variety of other benefits. The two main categories of CAD/CAM nonmetal restorative materials are ceramics and composites. As CAD/CAMrestorative materials, choices include leucite- reinforced glass ceramics, lithium disilicate ceramics, tetragonal zirconiapoly crystals, feldspathic ceramics, aluminium oxide, yttrium, and composite blocks. Evaluating composites with ceramic restorations, composite restorations are more flexible and easy to finish and polish. Ceramics are also more wear- and colour-resistant and biocompatible.Conventional ceramics provide highly aesthetic restorations. However, a few studies indicated greater failure rates for these materials, possibly because they are rigid and have an abrasive effect on the opposing tooth [13] and are brittle. Blocks that can be machined are vulnerable to high material wear, the loss of surface gloss, colour instability, and reduced fracture resistance[14]. A few authors suggest an association of composites elastic modulus, being comparable to dentin, whereas the feldspathic ceramic, being identical to enamel, adds aesthetic properties while probing for perfect restorative material. In order to achieve this goal, scientists worked with a number of manufacturing firms to create materials called "Hybrid ceramics" that mimic the mechanical and optical characteristics of a natural tooth. These materials are advantageous because they have mechanical properties similar to those of ceramics and composites.Hybrid ceramic is a ceramic network that has been infiltrated with polymers[15] which lessens material brittleness and hardness. In comparison to conventional ceramics, it increases pliability and fracture durability, makes milling simple and quick, and produces better clinical results. As a result, it enhanced the qualities and longevity of ceramic restorations.This brand-new substance consists mostly of a ceramic network (86 weight percent), which is supported by an acrylate polymer network (14 weight percent) which combine equally12. The ceramic component of the currently available hybrid ceramic materials is made of fine-structured feldspar that has been infused with polymers such as urethane dimethacrylate (UDMA)and others, and is supplemented with aluminium oxide. Vita Enamic(VE) is the first hybrid dental ceramic with a dual network structure that combines the best features of ceramic and composite materials (Vita Zahnfabrik). Other hybrid ceramics include Cerasmart, a resin nano ceramic from GC Dental Products, Lava Ultimate (LU), a hybrid ceramic with nano filler and others.It is inevitable that the surface of the restoration will be damaged during the grinding process used to produce the ceramic blocks. Although cutting ceramic blocks increases the structural stability of ceramic restorations, it is important to consider how the milling process may affect the restorations' long-term longevity. Analysis of the chipped pieces and cutting pressures revealed that the removal of ceramic material is mostly a brittle fracture mechanism, in accordance with the ceramic material milling mechanism. However, before cementing the ceramic restorations, various surface treatments are used to strengthen the binding between the resin and the ceramic. These include laser irradiation, hydrofluoric acid etching, and airborne particle abrasion (sandblasting) with aluminium oxide.It has been determined that surface treatments have a detrimental effect on ceramic restoration’s ability to resist fracture and serve as a source of failure. The goal of the current study is to analyse the results of different surface treatments, including alumina particle sandblasting and hydrofluoric acid etching, on the flexural strength of innovative CAD/CAM hybrid ceramic materials.

AIM

Assessing the flexural strength of CAD-CAM materials without any surface treatment as a control group.Investigating the impact of different surface treatments, such as polishing, glazing, airborne particle abrasion, and coating applications, on the flexural strength of CAD-CAM materials.Identifying any significant differences in flexural strength between the surface treatment groups and the control group.Analyzing the data statistically to determine the influence of surface treatments on the flexural strength of CAD-CAM materials.

METHOD

60 bar-shaped specimens of 14x4x1.2mm dimensions were obtained from CAD/CAM blocks (Vita Enamic,Hyramic,Mazic Duro) by wet milling under 3 axis milling apparatus for surface treatments followed by three-point bending test for measurement of flexural strength.To ascertain the flexural strength of every group, a 3-point bending test was done utilizing material testing apparatus. A loading rod was positioned in the middle of every sample, which is mounted on a metal setup with 10 millimeter loading frame. When specimen cracks, the stress is delivered 90 degrees to long axis at pace of 1 mm per minute.

The ultimate load (N) is noted down and flexural strength is determined by subsequent formula:σ = 3F1L 2bh2Here F1 is the break load, L is the length between center of the supports, b is the size of specimen in mm, and h is its thickness in mm.

RESULT

The data was checked for Normality using Kolmogorov Smirnov test. The data shows Normal distribution (p>0.05). Hence Parametric tests of significance were applied. For comparison between three groups i.e., Vita Enamic, Hyramic and Mazic Duro, One way Anova and post hoc Tukey tests were applied. For comparison between Acid etch and Air abrasion technique in each group, Independent t test was applied. A p value <0.05 was considered as significant and p<0.01 as highly significantThe comparison of three groups with acid etching technique and air abrasion technique. In samples treated with acid etch technique, the mean flexural strength of vita enamic was 141.01±27.21 Mpa, Hyramic was 106±8.59 MPa and Mazic Duro was 133.42±15.23. The mean flexural strength was highest for Vita Enamic followed by Mazic Duro and least for Hyramic group.

Table 1: Tests of Normality

	Group	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Acid_etched	Vita Enamic	.244	10	.095 NS
	Hyramic	.173	10	.200*NS
	Mazic Duro	.255	10	.065 NS
Air_Abrasion	Vita Enamic	.213	10	.200 NS
	Hyramic	.145	10	.200 NS
	Mazic Duro	.188	10	.200 NS

Table 2: Comparison of flexural strength between 3 materials using Acid etching and Air abrasion.

		N	Mean	Std. Deviation	Std. Error	F value	p value
Acid_etched	Vita Enami c	10	141.01	27.21	8.60	9.71	0.001 HS
	Hyrami c	10	106.00	8.59	2.71		
	Mazic Duro	10	133.42	15.23	4.81		
Air_Abrasion	Vita Enami c	10	165.50	20.56	6.50	10.72	0.000 HS
	Hyrami c	10	117.51	32.81	10.37		
	Mazic Duro	10	134.96	12.28	3.88		

DISCUSSION

The use of digital technology in dentistry was introduced in the late 1980s, and it has been firmly established. New advancements in a variety of restorative materials, combined with recent advancements in the equipment industry, led to significant advancements in CAD/CAM technologies. Currently, computerized manufacturing is consistently involved in restorative dentistry and is concomitant with high accuracy, enhanced production speed and minimized manual application. Advances in CAD/CAM technology led to progress in all ceramic restorative materials with varying mechanical and optical properties. Over the past 20 years, tooth-colored CAD/CAM restorative materials have been successfully recorded with promising results.With the advent of CAD/CAM technology, indirect restorations with superior marginal and internal fit can be made-up in a single appointment. Additionally, the use of homogeneous industrial ceramic or composite blocks minimizes material failures during manufacture and clinical application. Compared to hand-built materials, these blocks have fewer pores and defects. Because they are tooth-colored, ceramics and in resin-based composites have been widely employed for indirect restorations. Yet, the characteristics of ceramics and composites vary considerably.Although ceramics comprise exceptional optical qualities and classic tooth-like appearance, they have disadvantages which include potential for ductile failure and cracking as well as abrasion of the neighboring dentition due to their high hardness43,44. On the other hand, resin composites are less fragile, easy to restore, and more resistant to fracture. They also cause less wearing of the opposite dentition 45-47. Nevertheless, their color stability is substandard and the material wears rapidly compared to that ofceramics.Recently, Resin-matrix CAD/CAM ceramics (RMCs) have been technologically advanced. These materials combine the benefits of both ceramics and polymers . RMCs are less fragile than ceramics, have greater flexural strength, good mechanical, and edge strength since they comprise both ceramic and polymer phases. Based on industrial polymerization mechanism and microstructure, RMCs are again divided into two groups: high-temperature polymerized resin-based composites (RBCs) with scattered ceramic fillers and high-temperature/high-pressure polymer- incorporated ceramic network (PICN).CAD/CAM RBCs consist of a strongly cross-linked polymeric matrix strengthened by nano or nano-hybrid ceramic fillers and contain a primarily organic phase. The primary phase in PICN material is inorganic. It consists of two consecutive interconnected networks, one made of ceramic material and the other of polymer, with a porous feldspar ceramic network that has been invaded by the polymer. In PICN material, the existence of two connected phases typically prevents fracture growth caused by interface crack deviation. Vita Enamic (VE) is the currently accessible PICN material. This polymer is developed by the capillary action of a pre-sintered glass- ceramic network (86 weight percent) that has been treated by a coupling agent with triethylene glycol dimethacrylate (TEGDMA) (14 weight percent). To increase the durability of the restorations, understanding the mechanical properties of contemporary CAD/CAM restorative materials is crucial.The various PICN materials employed in this study were Vita Enamic, Mazic Duro and Hyramic. The mechanical characteristics of ceramics are said to be impacted by surface treatment. Sevcan et al20 studied the impact of surface pretreatments on flexural strength of present-day CAD/CAM restorative materials. Studies showed that the Polymer Infiltrated Ceramic Network (PICN) material has lower flexural strength values than other resin-based materials, Conversely, HFA etching and airborne-particle abrasion appeared to restore bond strength by hardening the surface, boosting surface tension and improving hydrophilicity, thereby augmenting the mechanical connection between resin cement and restoration.

CONCLUSION

Within the limitations of this study, it can be concluded that surface treatments had substantial impact on the flexural strength of CAD/CAM materials. Practitioners should be conscious in selecting the surface pretreatments for chairside restorative materials not only to enhance strength but also to accomplish optimum esthetics and mechanical strength.

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