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Original Article

Dentistry Section

Flexural Strength of Recently Advanced Lithium Disilicate Glass-ceramic CEREC Tessera: An In-vitro Study

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ABSTRACT

Introduction: Ceramic materials are quickly becoming the preferred materials for indirect restorations. The improvements in digital impression technology and manufacturing processes have led to the broad spectrum use of Computer-aided Design/ Computer-aided Manufacturing (CAD/CAM) in the fabrication of indirect restorations.

Aim: To assess the biaxial flexural strength of the CAD/CAM Advanced Lithium Disilicate (ALDS) glass-ceramic CEREC Tessera and compare it with that of LDS IPS e.max CAD.

Materials and Methods: An in-vitro study was conducted at the Department of Restorative Dental Sciences, College of Dentistry, King Saud University, Riyadh, Saudi Arabia from September 2022 to September 2023 to assess the flexural strength of advanced LDS (CEREC Tessera; Dentsply Sirona) in comparison with LDS (IPS e.max CAD; Ivoclar Vivadent). A total of 10 specimens of each material were tested for flexural strength using an Instron universal machine. The data were analysed using a t-test with a significance level of α=0.05.

Results: A significantly lower mean flexural strength was observed in the ALDS group compared to the LDS group, with a p-value of 0.00008.

Conclusion: The LDS exhibited greater flexural strength than advanced LDS.

Keywords: Computer-aided design/computer-aided manufacturing, Glass-ceramic material, Restoration

INTRODUCTION

Ceramics are used as a posterior and anterior restorative materials in the oral cavity. Ceramics, especially glass-matrix ceramics, have quickly become the preferred materials for indirect restorations [1]. Various ceramic materials can be used, including feldspathic, glass, and zirconia [2]. Dental glass-ceramics are highly attractive for indirect restoration due to their enhanced strength, chemical and physical resistance, translucency, low thermal conductivity, outstanding aesthetics, biocompatibility, and hardness, equivalent to natural teeth [3].

The introduction of computerised technologies in restorative dentistry has brought about a significant transformation for dentists and dental technicians. Dental practices, laboratories, and production centres are now capable of producing indirect restorations [4,5]. In the 1980s, CAD/CAM systems were introduced to the market. These systems are utilised for the creation of dental prostheses, offering improved results and greater user-friendliness compared to earlier methods [5]. Utilising digitally generated data sets, computer-aided design, and Numerical Control (NC) technology enables researchers to manipulate silicate and oxide ceramics in an efficient and precise manner. This allows authors to work with new, pre-made industrial materials that have minimal defects [6].

Both glass-ceramic and glass-matrix ceramics have crystalline layers inside an amorphous matrix. However, they vary in terms of their processing and features. The improved mechanical properties, including increased crystalline strength and fracture toughness, make glass-ceramic a more modern alternative to the traditional one [7]. Similarly, glass-ceramics are categorised based on their potential use and/or chemical composition [8]. The glass-ceramic material LDS became famous after being introduced to dentistry in the 1990s [1]. Ivoclar Vivadent, under the name IPS Empress 2, was introduced to the market as ingots [9]. ALDS glass-ceramic (CEREC Tessera; Dentsply Sirona) is a more contemporary variation of glass-matrix ceramics [10]. IPS e.max LDS is composed of quartz, phosphorous dioxide, lithium dioxide, potassium oxide, and other constituents [8].

In 2021, ALD was introduced to the market by Dentsply Sirona under the brand name Tessera [11]. This material is specifically designed for use in full-coverage crowns, inlays/onlays, and laminates [12] and consists of 90% LDS crystals and 5% virgilite content by volume [10]. CEREC Tessera utilises two primary crystals in its blocks: virgilite crystal ($Li_{0.5}\ Al_{0.5}\ Si_{2.5}\ O_6$), which is lithium aluminum silicate, and LDS ($Li_2\ Si_2\ O_5$) [13]. According to the manufacturer, ALD offers several benefits, including rapid crystallisation, completing in just four and a half minutes, which speeds up the manufacturing process. Additionally, it allows for faster glaze firing while also providing high aesthetics and flexural strength. These advantages are achieved through a distinctive chemistry that combines two complementary crystal structures within a glassy matrix containing zirconia 700 MPa [11].

Restorative materials with pleasant aesthetics are desired for dental restorations, such as inlays, onlays, crowns, and veneers [14]. However, the aesthetic requirement should not compromise the strength and durability of the material. Mechanical and chemical properties depend on the material used for the restoration. All the properties of the material being used for restoration must be properly tested and evaluated to obtain a highly sustainable, aesthetic, and safe restorative dental material [15]. Among the various mechanical properties of ceramic materials, flexural strength testing has gained popularity. Flexural strength is defined as the maximum stress in a material just before it yields in a bending test [16]. It is the material's ability to resist deformation under load [17]. As all the restorative materials used for dental restoration will undergo occlusal stress while chewing and biting, good flexural strength becomes important. Previous studies have shown that, compared to leucite-reinforced ceramic or feldspathic porcelain, several recent ceramic materials, like LDS, have substantially increased flexural strength [18-20]. However, there is limited information available on the flexural strength of LDS and ALDS [10,12,20]. In an attempt to fill this gap in the literature, the present study was planned with the aim to evaluate the flexural strength of the CAD/CAM ALDS glass-ceramic CEREC Tessera and compare it with LDS IPS e.max CAD.

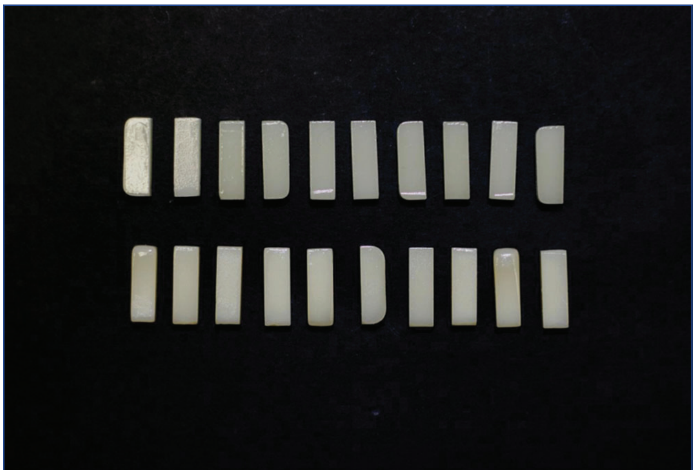
MATERIALS AND METHODS

This in-vitro study was conducted at Department of Restorative Dental Sciences, College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia from September 2022 to September 2023. The study was registered with the College of Dentistry Research Center (No. IR0439).

Inclusion and Exclusion criteria: The inclusion criteria included blocks of standard dimensions measuring 3×4×12 mm, and the block dimensions were verified using a digital caliper. Furthermore, the blocks were visually inspected to ensure they were free from visible defects, cracks, or fractures on their surfaces. The presence of potential cracks and fractures on the surfaces of the samples was examined using an EK3ST stereoscopic magnifying glass manufactured by Eikonal Equip. (Optics and Analytical, located in São Paulo, Brazil). Any sample with non-standard dimensions was excluded. Additionally, samples with visible defects, cracks, or fractures on their surfaces, as determined by visual examination, were excluded.

Study Procedure

Two groups were formed, each consisting of 10 blocks of ALDS (CEREC Tessera; Dentsply Sirona) and LDS (IPS e.max CAD; Ivoclar Vivadent). The samples in each group were prepared for flexural strength testing, following the guidelines specified in International Organisation for Standardisation (ISO) 6872:2015 [19]. Bar-shaped specimens measuring 3×4×12 mm were obtained from CAD/CAM blocks using a high-speed Isomet® 5000 linear precision diamond saw metallographic cutter while water was flowing (Buehler, Lake Bluff, IL, USA) [Table/Fig-1]. Subsequently, the samples underwent crystallisation and were coated with a glossy finish by a dental technician.

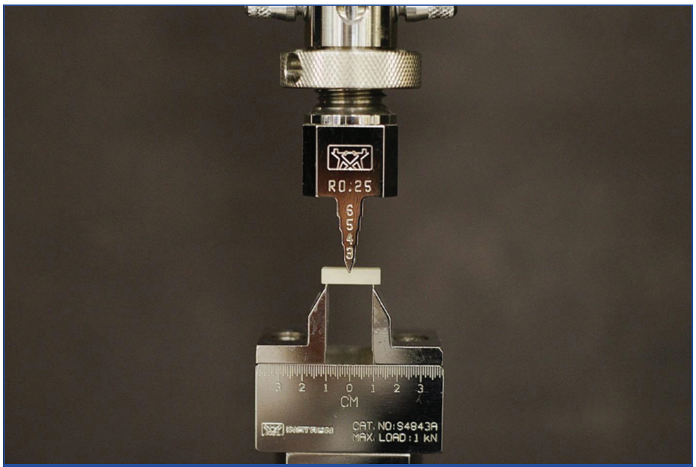


[Table/Fig-1]: Glazed samples.

To determine the flexural strength values of the samples, a three-point flexural test was conducted using an Instron 5965 universal machine according to ISO 6872 standards [Table/Fig-2] [20]. The data were recorded for each sample, and a mean was calculated.

STATISTICAL ANALYSIS

The data were analysed using a t-test with a significance level of α=0.05. The statistical calculations were performed using the Statistical Package for Social Sciences (SPSS) software {International Business Machines (IBM) SPSS Statistics, version 29.0.10}.



[Table/Fig-2]: Test sample subjected to three-point test [20].

Lithium Disilicate (LDS)	Maximum load (N)	Flexure strength at maximum load (MPa)*	Advanced Lithium Disilicate (ALDS)	Maximum load (N)	Flexural strength at maximum load (MPa)
1	1,179.77	433.54	1	531.49	211.47
2	681.30	211.89	2	467.54	188.93
3	661.35	244.97	3	601.60	216.02
4	836.86	335.15	4	576.56	219.37
5	980.26	374.21	5	654.83	222.71
6	725.91	268.70	6	608.35	210.08
7	1,196.40	446.47	7	701.82	234.51
8	878.32	329.90	8	523.16	197.72
9	954.60	341.53	9	560.77	204.36
10	1,036.79	403.48	10	523.74	204.37
Mean	913.16	338.98	Mean	574.98	210.95
Standard deviation	192.09	78.83	Standard deviation	69.312	13.07

[Table/Fig-3]: Flexural strength of the Lithium Disilicate (LDS) and Advanced Lithium Disilicate (ALDS) study groups.
*MPa=MegaPascal

RESULTS

The results of the three-point test for each group are presented in [Table/Fig-3]. The mean flexural strength values for LDS and ALDS were 338.98493±78.83 MPa and 210.94609±13.07 MPa, respectively. A t-value of 5.06706 was obtained, along with a p-value of 0.00008, indicating that the difference between the two groups is statistically significant.

DISCUSSION

The present study aimed to compare ALDS (CEREC Tessera; Dentsply Sirona) with LDS (IPS e.max CAD; Ivoclar Vivadent) based on their flexural strength. The findings showed that the LDS glass-ceramics (e.max CAD/CAM) demonstrated higher flexural strength in the experiment compared to the ALDS (CEREC Tessera). These findings might significantly affect how dental restorative materials are chosen in clinical settings. In clinical practice, a dentist must conduct a comprehensive and methodical evaluation of new dental ceramics to ensure the selection of the most appropriate material for the patient. The marginal fit of the restoration is a critical factor that directly influences the failure rate of the crown in the oral cavity after it is fabricated [21]. However, the choice of material should not exclusively depend on that factor. A comprehensive examination should be carried out to evaluate the mechanical and optical properties of the material, including surface roughness, microhardness, fracture toughness, hardness, flexural strength, elasticity modulus, translucency parameters, colour, and biocompatibility [19].

The higher flexural strength of IPS e.max CAD (Ivoclar Vivadent) in comparison to CEREC Tessera (Dentsply Sirona) can be attributed to several reasons associated with material composition, microstructure, and manufacturing procedures. In 2022, Mullayousef HA conducted a study to assess the mechanical and physical characteristics of various glass-ceramic CAD/CAM systems, such as IPS e.max CAD and CEREC Tessera. The results showed that IPS e.max CAD had superior average flexural strength in different aging situations when compared to CEREC Tessera. The study also observed variations in hardness and fracture toughness, with IPS e.max CAD exhibiting the highest fracture toughness among the tested materials. The discrepancies in mechanical properties may be attributed to the crystalline structure, composition, manufacturing, and postprocessing treatments of the materials [22].

The findings of the present investigation can be corroborated by other prior studies. For example, in a study by Al-Thobity AM and Alsalman A, the flexural strength of LDS has a comparable average value (364.64±66.51) to the findings presented in the present research (338.98±78.83 MPa). In addition to that, the study also reported the higher flexural strength of LDS IPS e.max CAD compared to ALDS CEREC Tessera, as stated in the present study [20].

Although previous studies have compared LD with ALD, the available data on the flexural properties of LD and ALD are limited. As a result, the authors have been unable to compare their study results with a larger body of research. Apart from flexural strength, there are studies that compared the other mechanical properties of LDS and ALDS which in turn can have an effect on flexural strength. These studies reported mixed types of findings. Demiral M et al., found that the biaxial flexural strength of LDS ceramic in their investigation was reported to be 424.3±52.26, indicating a higher strength compared to ALDS [10]. Similarly, a comparative study was conducted to assess the hardness and surface smoothness of LD, Leucite Reinforced (LE), ALD, and zirconia-reinforced lithium silicate. The results revealed that ALD exhibited the highest levels of hardness and surface smoothness [23]. In a comparable study conducted by Nouh I et al., the mechanical properties of LD, ALD, full-contour zirconia, and resin nanoceramic were compared. The study revealed that all three materials exhibited fracture resistance values that were deemed clinically acceptable, regardless of whether vertical or horizontal preparations were employed [24]. The study conducted by Freitas JS et al., examined and compared the surface roughness, translucency, Fatigue Failure Load (FFL), and number of Cycles for Fatigue Failure (CFF) of different materials used for monolithic restorations. These materials included LDS, ALDS, lithium silicate-disilicate, and Yttria-stabilised zirconia. The optical transparency and resistance to mechanical fatigue exhibited by ALD make it suitable for the production of seamless, anterior and posterior single-unit restorations that are bonded using adhesive cement [25]. Lastly, in a recent study, the surface properties and flexural fatigue strength of ALDS ceramic, LDS, and zirconia were compared. The study revealed that ALDS ceramic has lower flexural fatigue strength compared to the other materials tested, as well as higher variability, indicating lower structural reliability [12].

Limitation(s)

There are several limitations inherent in the present study that must not be disregarded. For example, the flexural strength of the desired materials was evaluated in a controlled laboratory setting, without any external influences that could affect the results as they would in the oral cavity. In addition, the other mechanical and optical properties were not examined.

CONCLUSION(S)

Greater flexural strength was obtained by LDS glass-ceramics (e.max CAD/CAM) compared to ALDS (CEREC Tessera). When selecting dental ceramics, dentists should carefully choose the best material. Evaluating the flexural strength of every new available dental material is critical. Henceforth, future research endeavors should focus on assessing and contrasting the mechanical and optical characteristics of LD, ALD, and other ceramic materials within a simulated oral environment.

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