WEAR RESISTANCE OF CAD/CAM ZIRCONIA REINFORCED LITHIUM SILICATE VERSUS CAD/CAM LITHIUM DISILICATE GLASS CERAMICS: A SYSTEMATIC REVIEW & META-ANALYSIS

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ABSTRACT

Aim and Background. The purpose of this systematic review and meta-analysis was to evaluate the difference in wear resistance between CAD Zirconia reinforced lithium silicate and CAD Lithium disilicate glass ceramics. Different CAD/CAM ceramic materials for prosthetic rehabilitation are manufactured but which material has better wear resistance for durable outcomes needs to be evaluated.

Methods. Two independent reviewers searched the MEDLINE/ PubMed, and EBSCO databases and the Google Scholar search engine for in-vitro studies published from January 2010 to March 2023 to identify relevant studies evaluating the wear resistance between CAD Zirconia reinforced lithium silicate and CAD Lithium disilicate glass ceramics. Meta-analysis was performed to evaluate the quantitative data on the amount of volume loss to measure the wear properties of both materials.

Results. A total of 364 titles were obtained by electronic database search, of which 27 were duplicates. A total of 337 abstracts were screened, and 274 not relevant to the topic were excluded. Forty-two articles were eligible for full-text assessment. After the screening of full-text articles as per the selection criteria, 30 studies were excluded (18 studies with inappropriate outcomes measured, 6 studies done on monolithic zirconia, and 6 studies measured surface roughness). For qualitative synthesis, 12 studies were included. For the meta-analysis, 12 studies were included. A statistically significant difference in wear resistance was observed between the CAD Zirconia reinforced lithium silicate and CAD Lithium disilicate glass ceramics (P=.01, pooled mean difference=-0.03[-0.05,-0.01], CI=95%).

Conclusions. CAD Zirconia reinforced lithium silicate showed statistically higher wear resistance than compared with CAD Lithium disilicate glass ceramics.

Clinical Significance. For anterior and posterior fixed dental prosthesis clinicians can opt for CAD Zirconia-reinforced lithium silicate as an esthetically durable prosthetic material.

KEYWORDS
Zirconia reinforced lithium silicate, Lithium disilicate, computer-aided designing, computer-aided manufacturing, glass ceramics, wear resistance, wear, in vitro studies

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CLINICAL IMPLICATIONS

For successful esthetically durable results CAD ZLS can be used as a material of choice for fixed prosthetic rehabilitation.

Computer-aided design/computer-aided manufacturing (CAD/CAM) technology is used to fabricate dental prosthesis, ceramic crowns, bridges, veneers, onlays, inlays, post, implant abutments, and implant crowns by direct milling of ready ceramic blocks.[1,2] CAD Lithium disilicate and CAD Zirconia reinforced lithium silicate are widely used esthetic materials for prosthetic rehabilitation.[3,4] Lithium disilicate consists of an amorphous glass matrix made up of 70% of lithium disilicate orthorhombic crystal.[5-8] Zirconia reinforced lithium silicate (ZLS) glass-ceramic consists of 10% zirconia in a highly dispersed glass phase of ceramic. Both materials have good mechanical and esthetic properties.[9-12]

Wear is a physiologically complex phenomenon that occurs when two surfaces are brought into direct or indirect contact and undergo sliding movements under some load application.[13,14] Wear of teeth can occur due to the interaction of biological, chemical, mechanical, and tribological factors.[15,16] Various ceramic materials can exhibit wear due to direct contact with the natural dentition as the wear rate of enamel and other ceramics are different.[14] Numerous in-vitro studies have measured the wear resistance of ceramic materials against the antagonist using a 2-body wear tester with a dual-axis mastication simulator under specific mastication simulation parameters as the evaluation of wear clinically is time-consuming and complicated.[17,18] Various studies have reported the wear properties of CAD ZLS and CAD lithium disilicate.[19,20] D'Arcangelo et al reported comparable antagonist and material wear for CAD lithium disilicate and CAD ZLS.[21] Few studies reported that the wear resistance of CAD ZLS was more as compared to CAD lithium disilicate.[22,23] However, the wear rate of any ceramic material opposing the natural dentition and other restorative material should be closer to that of enamel (20 to 40 µm per year) to maintain stomatognathic balance, periodontal health, and occlusal harmony.[24] No clear evidence was present on the comparison of wear properties of CAD lithium disilicate and CAD ZLS glass-ceramic.

This systematic review and meta-analysis aimed to determine the difference in wear resistance of CAD ZLS and CAD lithium disilicate glass-ceramic against the enamel antagonist under a masticatory atmosphere so as to find a suitable and biocompatible alternative for hydroxyapatite whose property is similar to enamel, which will prevent damage to the opposing tooth structure and can be used for prosthetic rehabilitation. The null hypothesis was that no statistically significant difference would be found in wear resistance between CAD ZLS and CAD Lithium disilicate glass-ceramic.

MATERIALS AND METHODS

According to Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines[25-28] this systematic review and meta-analysis was conducted and registered at the Prospective Register of Systematic Reviews (PROSPERO) database under the code CRD42023421459.[29,30]

The methodology included formulation of the following review question according to population, intervention, comparison, outcome, and study design (PICOS) framework [31-33]: "Does the wear resistance of CAD/CAM Zirconia-reinforced lithium silicate better than CAD/CAM Lithium disilicate glass ceramics used for prosthetic rehabilitation?" The population was Zirconia reinforced lithium silicate and Lithium disilicate samples, crowns, and veneers fabricated using CAD/CAM technology. The intervention was CAD/CAM Zirconia reinforced lithium silicate samples, crowns, and veneers. The comparison was CAD/CAM Lithium disilicate samples, crowns, and veneers. The outcome was wear resistance of CAD/CAM Zirconia reinforced lithium silicate and CAD/CAM Lithium disilicate glass-ceramics evaluated against the enamel antagonist. The study design was in vitro studies evaluating the wear resistance of CAD/CAM Zirconia reinforced lithium silicate and CAD/CAM Lithium disilicate glass ceramics.

Inclusion criteria included in vitro studies that evaluated the wear resistance of CAD/CAM ZLS and CAD/CAM Lithium disilicate samples, crowns, and veneers against the enamel antagonist. Full-text articles published in English between January 2010 and March 2023 were included. Exclusion criteria were studies not in English published before January 2010, measuring the wear resistance of pressable ZLS and Lithium disilicate samples, crowns, and veneers, case reports, case series, questionnaires, surveys, clinical studies, observational studies, and animal studies.

Studies selection was done according to PICOS selection criteria. To determine eligible studies, 2 reviewers (S.P., C.D.) assessed the titles and abstracts with the opinion of a third reviewer (A.B.) to resolve any disagreements.[34,35] The Cohen kappa score was 0.92. The primary outcome measured was the wear resistance of CAD/CAM Zirconia-reinforced lithium silicate and CAD/CAM Lithium disilicate samples against the enamel antagonist. The advanced search of articles was conducted in the MEDLINE/PubMed, EBSCO, DOAJ, and Google Scholar electronic databases using Boolean operators, MeSH terms, and keywords as listed in (Table 1). The following search strategy used for articles search from different databases are specified in (Table 2).[35,36] The terms entered in Google Scholar were Zirconia reinforced lithium silicate, Lithium disilicate, computer-aided designing, computer-aided manufacturing, glass ceramics, wear resistance, wear, and in vitro studies.

Table 1. Terms used in search strategy as per population, intervention, comparison, outcome, and study design framework

Population	Intervention	Control	Outcome	Study design
Adult	Zirconia reinforced lithium silicate, ZLS, Glass ceramics, Computer-aided designing, computer-aided manufacturing, CAD/CAM	Lithium disilicate, LDS, Glass ceramics, Computer-aided designing, computer-aided manufacturing, CAD/CAM	Wear, Wear Resistance	in vitro studies, in-vitro studies

Table 2. Search strategy in different databases

Sr. no.	Search Strategy
1.	Search strategy in PubMed was (((((((Zirconia reinforced lithium silicate) AND lithium disilicate) AND wear resistance) OR wear) AND in vitro studies))
2.	Search strategy in EBSCO was (((((((Zirconia reinforced lithium silicate) AND lithium disilicate) AND wear resistance) OR wear) AND in vitro studies))

The title and abstract of each study were independently reviewed and critically assessed by two authors (S.P., C.D.). The following method was used for selection criteria: assessing searched outcomes to delete duplicates, examining titles and abstracts to delete irrelevant articles, establishing relevant full-text articles, examining the degree of compliance of full-text articles as per the eligibility criteria, study inclusion, and gathering of data.[37,38] Twelve articles were included from all the databases and 2 reviewers (S.P., C.D.) independently conducted data extraction with a Cohen kappa score of 0.92. The following main characteristics of the included studies appeared in the evidence table in spreadsheets (Excel; Microsoft Corp) for all primary outcomes: study identification, study design, sample size, wear resistance for the intervention group, wear resistance for the comparison group, conclusion, statistical analysis, and other relevant data.[39]

Methodological Index for Non-Randomized Studies (MINORS) tool was used for the quality assessment of selected in-vitro studies done by 2 reviewers (S.P., C.D.) and included the key domains of clearly stated aim, the inclusion of consecutive patients, prospective data collection, endpoints appropriate to study aim, unbiased assessment of study endpoint, follow-up period appropriate to study aim, <5% lost to follow-up, prospective calculation of study size, adequate control group, contemporary groups, baseline equivalence of groups, and adequate statistical analyses.[40] A software program (Review Manager Version 5.4; Cochrane) was used for quality assessment.[41] Meta-analysis was done for the quantitative data obtained on the amount of volume loss due to wear for both materials from the studies. The forest plot was obtained using measured effects of mean, standard deviation, and total at a 95% confidence interval with a P value<0.05 as statistically significant.[41-44] To measure the heterogeneity I^2 test was used. If the I^2 value was >50% random effect model was applied. If the I^2 value was < 50% fixed effect model was applied. [41-44] To detect the publication bias Funnel plot was used.[41-44]

RESULTS

A total of 364 titles were obtained by electronic database search, of which 27 were duplicates. A total of 337 abstracts were screened, and 274 not relevant to the topic were excluded. Forty-two articles were eligible for full-text assessment. After the screening of full-text articles as per the selection criteria, 30 studies were excluded (18 studies with inappropriate outcomes measured, 6 studies done on monolithic zirconia, and 6 studies measured surface roughness). For qualitative synthesis, 12 studies were included and for meta-analysis, 12 studies were included as shown in the PRISMA flow diagram (Fig. 1).

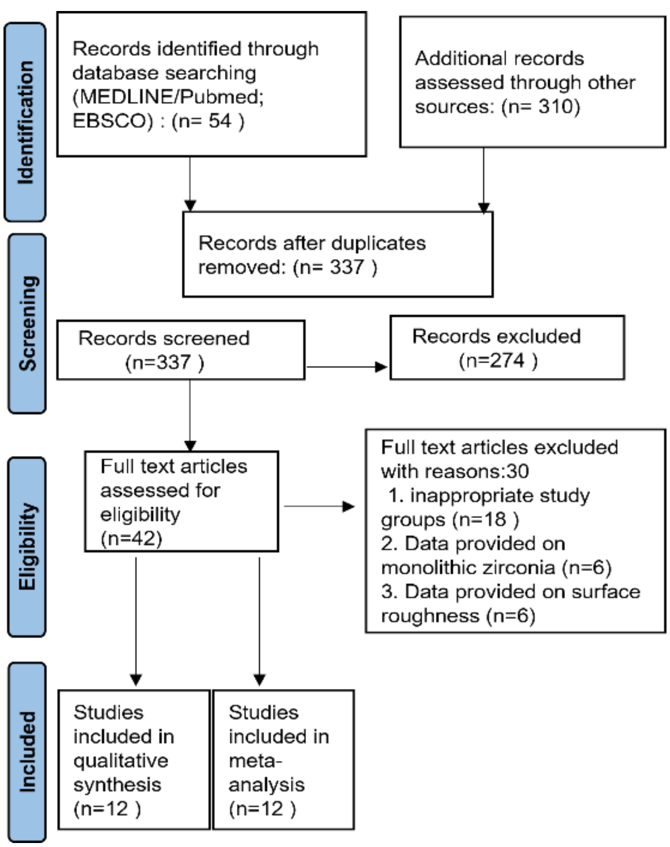

Figure 1. Preferred Reporting Items for Systematic Review and Meta-Analysis flow diagram.

The qualitative characteristic data of all selected studies were mentioned in (Table 3). Twelve included studies were in-vitro studies.[22-24,45-53] In this review, 108 samples each of CAD ZLS and CAD Lithium disilicate were included. All 12 in-vitro studies reported comparative data on the amount of volume loss due to wear for both materials. [22-24,45-53] The quality assessment done using MINORS tool for 12 in-vitro studies was good as shown in (Table 4).[40]

Twelve studies were included for meta-analysis. [22-24,45-53] The I^2 statistic test was used to quantify the inconsistency between studies with the application of the effect model depending upon the I^2 value.[42-44] As the I^2 value obtained was 88%, the random effect model was applied.[42-44] Statistically significant difference in wear resistance was observed between the CAD ZLS and CAD Lithium disilicate glass ceramics (*P*=.01, pooled mean difference=-0.03 [-0.05,-0.01], CI=95%) as shown in the forest plot (Fig. 2). CAD ZLS showed statistically higher wear resistance than compared with CAD lithium disilicate glass ceramics.

DISCUSSION

To measure the wear resistance of CAD ZLS and CAD lithium disilicate the amount of volume loss was recorded using a scanning profilometer in mm for both materials after being subjected to a simulated two-body wear test using a chewing simulator.[13,14] The present systematic review and meta-analysis was conducted to compare the wear resistance of CAD ZLS and CAD lithium disilicate glass ceramics. The null hypothesis was rejected as a statistically significant difference in wear resistance was observed between the CAD ZLS and CAD Lithium disilicate glass ceramics with CAD ZLS showing higher wear resistance than CAD Lithium disilicate glass ceramics. This result was in accordance with studies conducted by Ozkir et al,[52] Tantrachoti et al,[23] and Yilmaz et al[24] reported a statistically higher wear resistance for CAD ZLS than CAD Lithium disilicate glass ceramics. However, Ludovichetti et al[49] reported a statistically lesser wear resistance than CAD Lithium disilicate glass ceramics. However, Arcangelo et al,[22] Attia et al,[46] Aziz et al,[45] Asaad et al,[47] Cakmak et al,[53] Fouda et al,[48] Salem et al,[50] and Wille et al[51] reported no statistically significant difference in wear resistance between both groups. Higher wear resistance

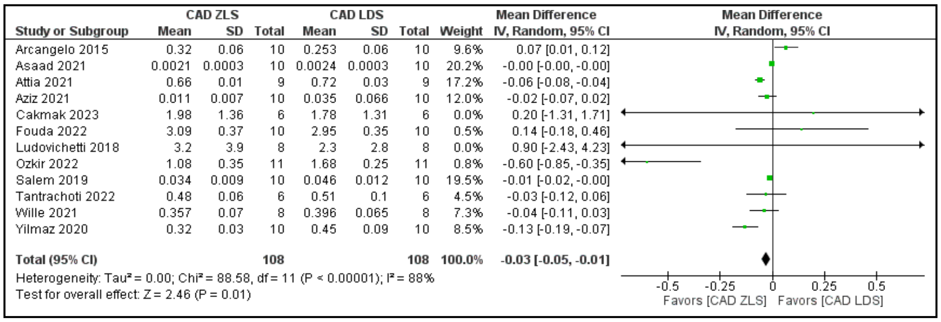

Figure 2. Forest plot comparing wear resistance of CAD Zirconia-reinforced lithium silicate and CAD Lithium disilicate glass ceramics

Table 3. Data extraction table of included studies

Sr. no.	Study ID	Sample size (n)	Volume loss of ZLS samples (mm^3) (Mean and Standard deviation)	Volume loss of Lithium Disilicate samples (mm^3) (Mean and Standard deviation)	Conclusion
1	Cakmak 2023[53]	6	1.98 (1.36)	1.78 (1.31)	Glazing and polishing had similar effects on the volumetric loss of materials and antagonists. No correlation was found between the wear of materials and the antagonists.[53]
2	Ozkir 2022[52]	11	1.08 (0.35)	1.68 (0.25)	ZLS had statistically higher wear resistance than Lithium disilicate.
3	Fouda 2022[48]	10	3.09(0.37)	2.95(0.35)	No statistically significant difference was observed between IPS e.max CAD and Celtra Duo.
4	Tantrachoti 2022[23]	6	0.48(0.06)	0.51(0.10)	Emax demonstrated the highest specimen volume loss, followed by ZLS.
5	Attia 2021[46]	9	0.66(0.01)	0.72(0.03)	No statistically significant difference was observed between IPS e.max CAD and Celtra Duo.
6	Asaad 2021[47]	10	0.0021(0.0003)	0.0024(0.0003)	ZLS and lithium disilicate showed insignificant difference in wear.
7	Aziz 2021[45]	10	0.011 (0.007)	0.035 (0.066)	ZLS Celtra ceramics had insignificant less wear with enamel antagonist compared to E-max CAD.[45]
8	Wille 2021[51]	8	0.357(0.070)	0.396(0.065)	No statistically significant difference was observed between IPS e.max CAD and Celtra Duo and showed wear resistance that seems appropriate for clinical application.[51]
9	Yilmaz 2020[24]	10	0.32 (0.03)	0.45 (0.09)	Zirconia-reinforced lithium silicate revealed higher two-body wear resistance compared with IPS e.max CAD glass-ceramic.[24]
10	Salem 2019[50]	10	0.034(0.009)	0.046(0.012)	No statistically significant difference between weight loss of the occlusal antagonist against IPS e.max CAD and Celtra Duo.[50]
11	Ludovichetti 2018[49]	8	3.2 (3.9)	2.3(2.8)	Vita Suprinity exhibited higher statistically significant wear than IPS e.max CAD.[49]
12	Arcangelo 2015[22]	10	0.320 (0.060)	0.253 (0.060)	The Celtra Duo showed a small but significantly increased wear depth compared with human enamel.

CAD/CAM: Computer-aided design computer-aided machining; ZLS, Zirconia reinforced lithium silicate; LDS, Lithium disilicate

Table 4. Risk of bias assessment using Methodological Index for Non-Randomized Studies (MINORS) tool

Sr. No.	Study Id	Clearly Stated Aim	Inclusion of Consecutive Patients	Prospective Data Collection	Endpoints Appropriate to Study Aim	Unbiased Assessment of Study Endpoint	Follow-Up Period Appropriate to Study Aim	<5% Lost to Follow-Up	Prospective Calculation of Study Size	Adequate Control Group	Contemporary Groups	Baseline Equivalence of Groups	Adequate Statistical Analyses	Total Score
1	Cakmak 2023[53]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
2	Ozkir 2022[52]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
3	Fouda 2022[48]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
4	Tantrachoti 2022[23]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
5	Attia 2021[46]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
6	Asaad 2021[47]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
7	Aziz 2021[45]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
8	Wille 2021[51]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
9	Yilmaz 2020[24]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
10	Salem 2019[50]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
11	Ludovichetti 2018[49]	2	NA	2	2	2	2	NA	2	2	2	2	2	20
12	Arcangelo 2015[22]	2	NA	2	2	2	2	NA	2	2	2	2	2	20

*NA: Not Applicable

for ZLS occurred may be due to the presence of 10% of zirconia particles and comparatively lesser silica particle size.[9]

CAD ZLS can be an esthetic choice of material for the clinician for fixed prosthetic rehabilitation of root canal treated teeth, missing teeth, single crowns, multiple crowns, full mouth rehabilitation, and implant crown for the posterior and anterior region of an arch which can resist the direct or indirect contact wear with opposing natural teeth providing a durable prosthesis to the patients.

Limitations of this review were the inclusion of in-vitro studies, laboratory errors, human errors, and studies published only in English. However, for more precise, validated, and clinical results clinical trials can be performed with a longer follow-up period to assess the wear resistance of ceramics in natural oral habitat.

CONCLUSIONS

The following conclusion was drawn based on the findings of this systematic review and meta-analysis:

1. A statistically significant difference in wear resistance was observed between the CAD ZLS and CAD Lithium disilicate glass ceramics.
2. CAD ZLS showed statistically higher wear resistance than CAD lithium disilicate glass ceramics.

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