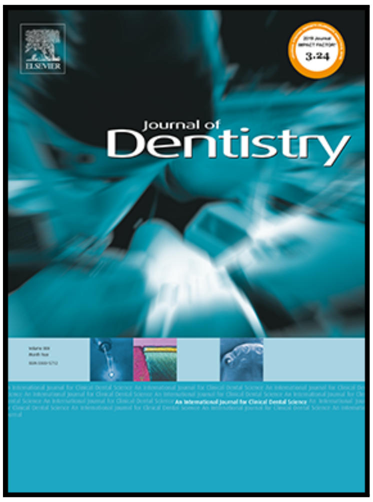

Optical behaviors, surface treatment, adhesion, and clinical indications of zirconia-reinforced lithium silicate (ZLS): A narrative review

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Optical behaviors, surface treatment, adhesion, and clinical indications of zirconia-reinforced lithium silicate (ZLS): A narrative review

Short title: Optical properties, wear, adhesion and indications of ZLS

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Key Words: ZLS; zirconia-reinforced lithium silicate; dental materials; ceramics; zirconia; CAD/CAM.

ABSTRACT

Objectives. The present narrative review was focused on the optical properties, surface treatment, adhesion, and clinical indications of zirconia-reinforced lithium silicate ceramics (ZLS) for Computer-aided design / Computer-aided manufacturing (CAD/CAM) technologies.

Data/Sources. A literature search was performed by 3 calibrated independent researchers on PubMed, Scopus, Embase, Google Scholar, Dynamed, and Open Grey. The criteria for inclusion were: 1) papers addressing at least one of the following variables about ZLS: optical properties, surface treatment, adhesion, and clinical indications; 2) *in vitro, in silico,* or *in vivo* studies; 3) case reports; 4) systematic reviews. The exclusion criteria were: 1) animal studies; 2) non-dental studies; 3) studies only focusing on ZLS used in the heat-pressed process.

Study Selection. 98 records among *in vitro* studies and case reports were included.

Conclusions. Despite the promising microstructure characteristics of ZLS, increased translucency compared to lithium disilicate ceramics (LS_2) was not proven, but acceptable color changes and stability were reported.

Mechanical polishing was the most effective method to reduce surface roughness. Moreover, machinability and handling of ZLS resulted harder than LS_2.

Conventional acid etching procedures seemed effective in conditioning ZLS surface, but no protocol has been established yet. Besides, silane-coupling and dual-curing resin cements were recommended.

Clinical Significance. ZLSs can be used for anterior and posterior fixed single-unit CAD/CAM restorations onto both natural teeth and implants, but do not seem to represent a viable treatment option for endocrowns onto posterior teeth or fixed dental prostheses.

1. INTRODUCTION

The demand for minimum invasive, highly esthetic, and durable dental restorations has led to the development of various Computer-aided design / Computer-aided manufacturing (CAD/CAM) materials. Among these, two different zirconia-reinforced lithium silicate ceramics (ZLS) were introduced in the market, available in a pre-crystallized or crystallized form: Vita Suprinity PC (Vita Zahnfabrik, Bad Säckingen, Germany) and Celtra Duo (Dentsply Sirona, Hanau-Wolfgang, Germany) [1-3]. Suprinity and Celtra Duo are reported to be biocompatible materials and present similar microstructural configuration: tetragonal zirconia grains added to a homogeneous glassy matrix that consists of round and submicrometric elongated grains of lithium metasilicates and lithium orthophosphates [2-6]. Also, lithium disilicate grains are generated after a crystallization process. This structural configuration was made to offer higher optical properties and increased mechanical strength, compared to other glass-ceramics. Nevertheless, data about this topic are controversial [4,7-12].

Although the dimensions of the lithium metasilicate crystallites are different in the two materials, from about 0.5 µm for Suprinity to 1.0 µm for Celtra Duo [6], to date, no significant differences were reported about the mechanical and optical properties of these two materials.

The modulus of elasticity, flexural strength, fracture toughness, hardness, and characteristic strength increase after the ZLS firing procedure, while the Weibull modulus and volume decrease [1,13].

The fracture resistance withstands physiological occlusal forces [7,9,13] and the durability of ZLS-based restorations seems to be promising at 1.0 mm thickness [14].

The optical and mechanical properties of ZLS allow it to be used for single-unit restorations, either for partial or full coverage, tooth- or implant-supported, in both anterior and posterior regions [4,15-16], as well as for table-tops [7,17].

Nowadays, many questions remain unanswered for ZLS-based restorations, such as the proper acid etching protocol, in terms of both concentration and etching times, the choice of the ideal kinetics of cement polymerization (i.e., dual- or light-curing), and the effect of silane treatment on adhesion [18]. Furthermore, in the current state of the literature for ZLS, the wear behavior is not completely clear and there is no scientific evidence that supports one polishing system rather than another.

With the aim of assessing the esthetic properties, clinical indications, and handling procedures of ZLS, the present review was focused on the following points: optical characteristics, surface treatments and cementation, polishing procedures, wear behavior, and clinical indications.

2. METHODS

2.1 Search strategy

An extensive search of the literature for papers related to ZLS was performed on the databases of PubMed (Medline), Scopus, Embase, Google Scholar, Dynamed, and Open Grey. Additionally, the "snowballing" approach was used to identify further papers by reading the reference lists of records that have already be found.

The literature search was performed using combinations of the following keywords: "zirconia-reinforced lithium silicate" OR “ZLS". The queries used for each database were as follows:

- PubMed (Medline), Google Scholar, and Open Grey = “(zirconia-reinforced lithium silicate) or (zls)” was added into each query box.
- Dynamed = ZLS; zirconia-reinforced; zirconia-reinforced lithium silicate; zirconia lithium.

- Scopus = (TITLE-ABS-KEY (zirconia-reinforced AND lithium AND silicate) OR TITLE-ABS-KEY (zls)).
- Embase = 'zirconia-reinforced lithium silicate' OR ('zirconia reinforced' AND ('lithium'/exp OR lithium) AND ('silicate'/exp OR silicate)) OR zls.

To exclude duplicates, the references of the identified records were uploaded as Research Information Systems files into Mendeley (Mendeley Ltd., London, UK).

2.2 Inclusion and exclusion criteria

Studies were considered appropriate if they satisfy the following inclusion criteria:

1) Studies addressing at least one of the following topics about ZLS for CAD/CAM systems:

- optical properties;
- wear behavior;
- polishing and/or glazing procedures;
- surface treatments and/or cementation procedures;
- clinical indications and/or outcomes.

2) studies performed *in vitro, in silico,* or *in vivo*.

3) case reports;

4) systematic reviews.

The following exclusion criteria were used: 1) animal studies; 2) non-dental studies; 3) studies only focusing on ZLS used in the traditional heat-pressed ceramics process.

No restrictions were made to the year of publication or the language of the papers.

2.3 Data extraction

For the present narrative review, the following variables were considered:

1) optical properties;
2) surface treatments;
3) cementation procedures;

4) polishing and glazing procedures;
5) wear behavior;
6) clinical indications.

According to the inclusion criteria, 3 calibrated researchers (F.Z., G.R., and R.S.) independently selected the articles reading the titles, abstracts, and keywords. The full text of each record was read to evaluate if it was eligible for inclusion. In case of disagreement among the investigators, a majority criterion was used (i.e., 2 out of 3).

2.4 Calibration process

To conduct pilot calibration exercises on the collected titles and abstracts, the three reviewers used a common and random set of 20 references, considering the inclusion and exclusion criteria. After this exercise, the reviewers debated about which references were included or not. Before screening the whole set of titles and abstracts recorded, this procedure would have repeated until they had reached an agreement on at least 90% of the articles. After reading titles and abstracts, the calibration system was also used on a random selection of 10 papers for full-text screening of the included papers, with the same agreement level.

3. RESULTS

The search strategy reported 936 records, including duplicates: 184 from PubMed/Medline, 239 from Scopus, 175 from Embase, 294 from Google Scholar, 41 from Dynamed, 0 from Open Grey, and 3 with the “snowballing” approach. The duplicates were eliminated, thus all of the selected databases produced 280 records. After the analysis of titles, abstracts, and keywords, the investigators excluded 143 records since they did not meet the eligibility criteria. Among the remaining 137 records, 39 more were excluded after a full-text examination since these records did not present considerable information about ZLS for dental research and clinical practice. The remaining 98 articles were included in this narrative review.

According to the above-mentioned inclusion criteria, in this narrative review *in vitro* studies and case reports were found but no systematic reviews.

The workflow of the paper screening process is reported in Figure 1, according to the "PRISMA 2009 Flow Diagram" [19].

After just one calibration exercise, the reviewers achieved an agreement level of more than 90% on titles and abstracts screening and 100% on full-text articles screening.

No disagreement was pointed out among the search investigators.

3.1 Optical properties

One of the main strong points of ZLS is, no doubt, the esthetic performance, being the material highly appreciated for its optical properties, such as the translucency. Some *in vitro* studies reported that ZLS exhibits higher translucency than resin nanoceramics (RNC), polymer-infiltrated ceramic networks (PICN), feldspathic ceramics (FC), and lithium disilicate ceramics (LS_2) [15,20-21].

In comparison with LS_2, the higher degree of ZLS translucency has been explained by the presence of smaller silicate crystals, determining a higher glassy content in the matrix [22].

It was also demonstrated that ZLS exhibits better translucency than monolithic highly translucent zirconia ceramics [23-24]. Moreover, as expected, the material showed lower substrate masking ability than zirconia [25] and LS_2 [25-26].

Conversely, other studies reported that ZLS exhibits lower translucency than LS_2 [23,27-28], both before and after thermocycling [24,29], as well as higher opalescence values [27-28], probably due to the larger crystal dimensions and the higher firing temperature of LS_2 [30]. Also, another investigation reported lower translucency and higher opacity values for ZLS than FC, LS_2, PICN, leucite reinforced ceramics (LC), hybrid ceramics (HC), RNC, and nanohybrid composite resins [29].

Various factors negatively influence the translucency in ZLS restorations, such as increased surface roughness [28], ultraviolet (UV) aging [29], and thermal aging [12]. This last factor determines a translucency reduction higher for ZLS than for FC and LS_2 [12]. Conversely, other studies reported that thermal aging improves the translucency of ZLS [24,31].

Color stability is another important element in the long-term esthetic success of ceramic restorations in the anterior sites. According to some i*n vitro* studies, ZLS color stability is higher than composite-containing materials [32], but is lower than LS_2 [21,26,33-34], PICN [21,26], and FC [35]. Color stability is enhanced by the firing technique [35] but is negatively affected by the use of staining beverages [34,36] and thermal aging [24].

Moreover, there is some evidence that, at low thickness, ZLS monolithic restorations are more prone to color changes [23,33]. In particular, at 0.5 mm thickness, the color change was clinically unacceptable for ZLS, but this drawback was not evidenced for zirconia and LS_2 [23]. At the same time, increasing thickness reduces the problem of discoloration after coffee thermocycling [33].

In some cases, it can be desirable masking with restorations dark substrates that cannot undergo or are not responsive to bleaching treatments. As regards such property, ZLS monolithic configuration can be used onto substrates of shade A3.5, in association with opaque resin-based luting agents to improve the masking ability [25]. Additionally, opaque cements exhibited significantly higher color changes than translucent cements over substrate shade A1 for both LS_2 and ZLS (thickness of 0.8 ± 0.01 mm), resulting in whiter optical results [37]. Furthermore, to achieve the ideal masking effectiveness, the minimum thickness of ZLS should be 1.5 mm over a gold background and 2 mm over a C2 background, while it was not possible to obtain an ideal camouflage over silver-colored backgrounds [38].

Manual polishing does not seem to determine a higher color change than glazing [39]. Both the procedures do not induce significant color changes in the material [30,34,39-40], whereas extended glaze firing, providing greater crack healing than conventional glazing procedure, induces clinically unacceptable color changes in ZLS, differently from FC, LC, and LS_2 [40].

Thickness and surface roughness are the major factors affecting ZLS absolute translucency [22,28-29,41]. After thermocycling in staining beverages (i.e., coffee), the relative translucency of ZLS decreased as the thickness increased, by increasing thickness from veneer to crown [33].

The exponential increase of carbonated soft drinks consumption over the years has been demonstrated to have a significantly detrimental impact on oral and general health, not to mention economy, for the high sugar content, sparkling, and acidity [42]. From this point of view, studying the effect of such beverages on dental materials is a hot topic in the current scientific literature, particularly the possible modifications of restoration surfaces exposed to the oral environment (i.e., acid erosion, pigmentations, mechanical degradation).

In vitro investigations evaluating the effect of dark-colored beverages on ZLS restorations reported controversial results: some studies evidenced that thermocycling in cola [36] and coffee [30] decrease the translucency of both glazed and polished ZLS; conversely, other authors did not find that thermocycling in coffee affects the translucent behavior of ZLS [23].

It has been demonstrated that prolonged exposure to carbonated acidic drinks (immersion for 7 days in Coca-Cola) can also negatively influence the mechanical behavior of restorative materials. In an *in vitro* study, compared to RNC, HC, and nano-hybrid composites, ZLS showed lower micro-hardness changes after prolonged experimental exposure to Cola drinks [43].

3.2 Surface treatment and cementation

Due to the hybrid nature of ZLS, proper surface pretreatments should be performed to enhance chemical bonding and micromechanical interlocking mechanisms before cementation [44-46]. ZLS-based materials contain silica and, similarly to the other glass-ceramics, can be modified with hydrofluoric acid (HF), obtaining advantageous micromechanical retention due to the dissolution of the glassy matrix [18].

HF etching, in combination with silane primer application, represents the gold standard for bonding to lithium silicate-based glass ceramics, including ZLS [46]. HF etching produces a honeycomb-like microrough, porous surface, while particle abrasion with glass beads caused abrasion of the glassy matrix [46].

Besides surface conditioning, the bond strength between resin cements and ZLS is also significantly influenced by aging; in fact, it has been demonstrated that thermocycling decreases bond strength [47-49].

The fatigue loading of ZLS could be efficiently increased by HF etching and silane coupling, the latter ensuring an effective chemical interaction between resin-based agents and ZLS [50]. Silica coating was reported not to be effective in maintaining the bond strength over the long term [47] and sandblasting and CoJet were proved to be less effective than HF etching for Suprinity [18]. Furthermore, another *in vitro* investigation reported that acid etching with 10% HF for 20 s shows higher shear bond strength mean value (10.81 MPa) than sandblasting with 50 µm aluminum oxide for 60 s (7.76 MPa) [51].

Tribochemical silicatisation-based treatment protocols were not recommended for adhesive cementation of ZLS, because it was associated with low bond strength after long-term aging, differently from 5% HF for 30 s, which presented acceptable success as to long-term bond strength [48]. HF etching surface treatment of ZLS was more efficient than alumina blasting and erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser irradiation; the latter could not be considered as an effective surface treatment for repairing fractured restorations [52].

Some studies have investigated the possibility of repairing ZLS. From this viewpoint, in terms of microtensile bond strength after surface treatment, the use of nanohybrid composite resin is not promising either with airborne particle abrasion, tribochemical silica coating, or 5% HF for 90 s [53]. Furthermore, repair ZLS bond strength could be improved after sandblasting ZLS surfaces with CoJet sand and silanization [54].

Nowadays, HF etching appears to be the best method for conditioning ZLS surfaces, considering both acid concentration and etching time [45]. Etching with 5% HF for 20 s was characterized by small pores, whereas longer etching time exhibited wider and irregular grooves; as the etching time is prolonged (from 20 to 160 s), the glassy matrix dissolves faster than crystals and both surface roughness and wettability improve significantly [55]. Conversely, other investigations asserted that the roughness of ZLS is not influenced by different etching times, although the contact-angle analysis reveals lower values for 10% HF etching for 60 s, so suggesting protocols with longer etching times (from 40 to 60 s) [56]. Even if most literature agrees in considering HF etching as the most effective surface treatment to provide a high bond strength of ZLS [46], data are quite controversial about etching protocol, such as different values of etching duration and acid concentration were suggested. The manufacturer of Celtra Duo recommended 5-9% HF for 30 s [57], whereas independent studies proposed 5% HF for 20 [58] or 30 s [59-60] and 10% HF for 90 s [50]. Another paper evidenced that to preserve ZLS microstructure, the best finding results from etching the surface with 4.9% HF for 20 s, while 4.9% HF for 40 s and 9.5% for 20 and 40 s cause progressive surface degradation [61]. Similar findings were obtained from another investigation, in which the most efficient etching method is achieved by using 4.9% HF for 20 s, particularly, etching time (i.e., 20, 40, 60, 120 s) do not significantly affect adhesion such as HF concentration, which proves to be better at 4.9% than 9.5% [62].

It is worth noticing that conditioning glass-containing materials with aggressive etching protocols may damage their internal microstructure, negatively influencing the mechanical performances, in particular, for very thin restorations, just like veneers and table-tops [63].

An *in vitro* bond-strength study indicated the application of self-etching ceramic primers containing polyfluoride for etching and trimethoxypropyl methacrylate for silanization, as a new viable alternative to conditioning the internal surface of ZLS restorations [64].

The high translucency of ZLS allows for proper polymerization of light-cured resin cements. Nonetheless, dual polymerization of resin cements results in higher Vickers hardness and depth of cure values than using light polymerization [20]. The biaxial flexural strength values improve increasing etching times from 20 to 60 s at 10% HF, followed by the application of resin cements [56]. Moreover, additional firings allow bond strength maintenance after aging, when ZLS was conditioned with 5% HF for 30 s [49] and the fracture toughness of ZLS crowns could be enhanced by using self-adhesive resin cements rather than glass-ionomer luting agents [65]. Furthermore, higher bond strength in ZLS cementation to dentin was reported by using resin cement with an etch-and-rinse and a universal adhesive agent than a self-adhesive resin cement [66].

To improve the biomechanical behavior of ZLS restorations, it is advisable to use low elastic modulus resin cements due to a reduced stress concentration in the cement layer that could be transmitted to ceramics [67].

Nonetheless, conventional adhesive resin cements are highly recommended especially for occlusal veneers; furthermore, self-etching techniques are not recommended for luting thin and minimally invasive occlusal veneers to enamel, as in this case the long-term survivability was reported to be questionable [68].

3.3 Polishing and wear behavior

Finishing of ZLS restorations can be obtained by both the glaze-firing cycle and the surface mechanical polishing [69].

In a study on the efficacy of different techniques for controlling roughness of ZLS and LS_2, it has been shown that manual finishing plus polishing for 60 s and the use of a glazing paste obtain the best results; moreover, ZLS exhibits higher polishability than LS_2 (namely IPS e.max CAD) [70].

To date, about refining and intraoral adjustments, LS_2 remains one of the most difficult materials to polish [45,71].

As regards the influence of professional dental prophylaxis protocols, it has been shown that the glossy surface of ZLS is only slightly affected by the conventional oral hygiene treatments, differently from resin composite blocks, that undergo a significant increase in surface roughness [72].

Machinability of CAD/CAM materials is an important mechanical property because it strongly affects the final quality of the restoration. Some studies reported that, in its crystallized form, ZLS is characterized by a higher machinability index than in the pre-crystallized one [73]. Consequently, after crystallization, it is more difficult to be machined and polished for the harder microstructure and improved strength [73].

Contrary to these findings, in another investigation, the brittleness index analysis estimates greater machinability after the crystallization process than in the pre-crystallized form [74].

Although mechanical polishing has been addressed as a very effective method to reduce ZLS surface roughness [28,30,70], for this purpose LS_2 has been shown to take better advantage using glaze firing (i.e., glaze powder and liquid in a vacuum furnace) [28].

As regards the resistance to wear, glaze-fired ZLS exhibits a wear depth and a volume loss statistically similar to those of type III gold alloy; such resistance is reduced when the material is milled and unglazed. Wear depth and volumetric loss of glaze-fired ZLS do not differ statistically from human enamel [75-76]. These *in vitro* results seem to emphasize the importance of the glaze-firing process to improve the wear resistance of ZLS.

Moreover, ZLS was reported to be more resistant to wear than LS_2 [77] and PICN [78]. According to an *in vitro* study, ZLS can induce a significant amount of enamel tooth wear after 1 year of intraoral function [79]. Additionally, a higher amount of wear onto ZLS is caused by zirconia ceramics rather than tested steatite and acrylic resin [80].

Machinability is one of the weak points of high strength silicate-based glass-ceramics, exhibiting both ZLS and LS_2 high machinability indexes and brittle fracture mechanisms induced by high grinding forces and energy with diamond tools. In particular, in an *in vitro* investigation, ZLS machinability was reported to be poorer than LS_2, ranked as the most difficult to machine among glass-ceramics, due to the materials' tendency to edge chipping damage [81].

Finally, as regards ZLS wear resistance, an in vitro study reported better results with the use of microwave energy during firing procedures rather than conventional firing processes [82].

3.4 Clinical indications and outcomes

To date, the available studies regarding the clinical performance of ZLS are quite scarce and mainly limited to case reports. ZLS was employed for monolithic full-contour crowns [58], monolithic partial crowns [58-59], laminate veneers [83], and screw-retained implant-supported monolithic crowns in the anterior sites [84].

Some authors recommended the use of ZLS for tooth-supported monolithic anterior [11] and posterior crowns [14,16,85-87], thanks to the advantageous mechanical and optical characteristics of such materials, showing fracture strength values above the clinically expected loading forces [14]. Indeed, according to ISO-6872:2015, the mechanical properties of ZLS enable the use of such hybrid materials for anterior and posterior single-unit adhesive crowns, but not in the case of fixed partial dentures [88-89].

Furthermore, ZLS has been advised for molar no-prep occlusal veneers [7,17] and implant-supported single crowns [90-91], although the insertion of a screw channel might reduce the stability of ZLS restorations [92].

As regards endodontically treated molars, mean fracture loads of 886.9 ± 195.7 N were reported for ZLS endocrowns [93]. Other investigators showed that the fracture resistance of monolithic ZLS endocrowns (1859 N) was worse than that of zirconia ceramics (6333 N) [94]. However, the high number of irreparable failures occurring in ZLS endocrowns has to be taken into account for their use onto posterior teeth [95].

To date, a small number of clinical studies were performed to evaluate the clinical success and survival rates of ZLS.

ZLS-based restorations onto the posterior tooth, for inlays or partial crowns, showed a high clinical success rate (96.7%) after 1 year of clinical service and a failure rate of 3.3% as a result of bulk fractures [96]. In a short-term clinical study, a survival rate of 100% was reported with ZLS partial coverage restorations onto 23 premolars and molars after 1 year of observation [97]. Similarly, a promising 3-year success rate of 98% was noticed onto 88 premolars and molars partial crowns [98]. In 2-year follow-up examinations of 61 partial crowns made on vital premolars and molars, it was observed that, out of 31 restorations made with a thickness of 0.5-0.74 mm, two failures were detected due to ceramic fracture (survival rate = 94.0%), while for the other 30 restorations with a thickness of 0.75-1.0 mm no losses were recorded (survival rate = 100%) [99].

Moreover, ZLS anterior crowns were reported to be a safe and valid restorative solution after 2 years of service [100].

Finally, a clinical study evaluated the esthetic outcomes of ZLS full coverage restorations, showing very positive results, according to the modified United States Public Health Service (USPHS) criteria, as to shade matching (100% alpha ranking) and patients’ satisfaction (100%, according to Visual Analogue Scales - VAS) [101].

3.5 Limitations of the search methodology

The present paper is a narrative review. This approach offers a summary of the current literature rather than a synthesized finding or response to a particular question.

With the narrative review, the presence of statements about the formal synthesis and the quality of evidence is excluded. Moreover, the narrative reviews are susceptible to bias from a variety of sources since a critical assessment of the risk of bias is not needed in this type of paper.

Therefore, the present article does not provide any statistically proven findings such as a systematic review or meta-analysis. Differently, it qualitatively summarized evidence, displaying a synthesis of optical properties, surface treatment, adhesion, and clinical indications about ZLS in CAD/CAM systems.

4. CONCLUSIONS

According to the present narrative review, the following conclusions can be drawn:

- there is no indisputable evidence demonstrating the improved optical properties compared to LS_2, notwithstanding the peculiar microstructural configuration, that is characterized by a glassy matrix and the presence of zirconia grains;
- ZLS presents clinically acceptable color changes when it is treated with conventional glazing or polishing, whilst extended and/or repeated glaze firing cycles can affect negatively the final color of restorations; no significant differences in color stability were pointed out between manual polishing and glazing;
- ZLS exhibits lower color stability than LS_2 and FC but higher than composite-based materials;
- ZLS shows poorer machinability than LS_2. After crystallization, mechanical polishing is the most effective method to reduce its surface roughness;
- ZLS can be conditioned with conventional acid etching techniques. However, to date what is the best etching protocol is still under debate; in any case, silane coupling and dual-curing polymerization of resin cements are strongly recommended;
- ZLS can be used for anterior and posterior single-unit adhesive crowns, molar table-tops, monolithic partial crowns, laminate veneers, and implant-supported single crowns. It does not seem to be a viable option for endocrowns onto posterior teeth or fixed partial dentures;

Although ZLS can be considered a highly promising hybrid ceramic material for CAD/CAM technologies, further *in vitro* and *in vivo* studies are needed to define accurately the optical properties, the operative procedures for surface treatment and cementation, as well as the clinical indications and the long-term performance of ZLS-based, both tooth- and implant-supported restorations.

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CAPTIONS TO TABLES AND FIGURES

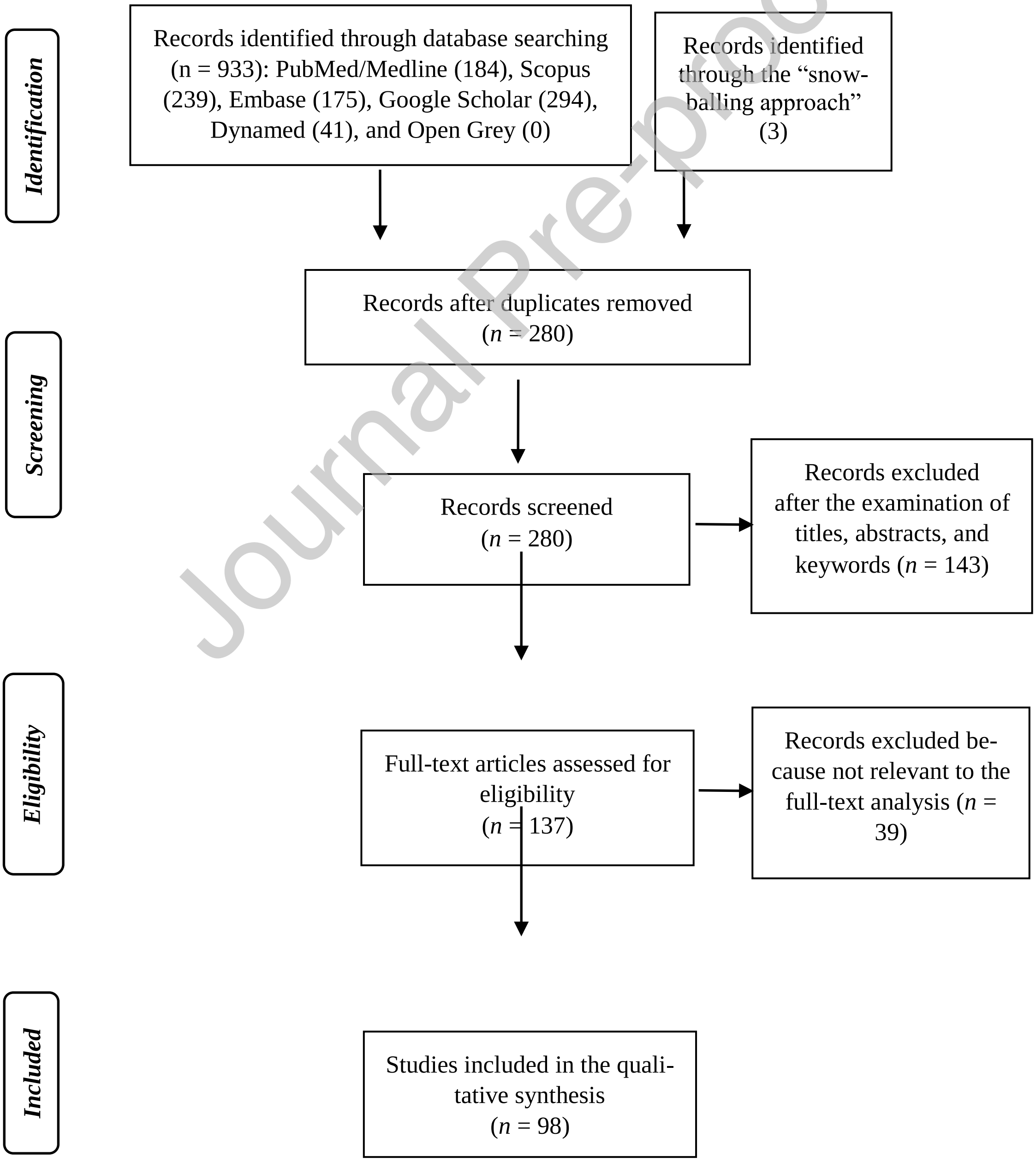
Figure 1 - Title: Search flowchart as described in the PRISMA guidelines.

Caption: (*n* = number of records).

FIGURES

Figure 1 - Title: Search flowchart as described in the PRISMA guidelines.

Caption: (*n* = number of records).



ABBREVIATIONS

CAD/CAM = Computer-aided design / Computer-aided manufacturing

Er,Cr:YSGG = erbium, chromium:yattrium-scandium-gallium-garnet

FC = feldspathic ceramics

HC = hybrid ceramics

HF = hydrofluoric acid

LC = leucite reinforced ceramics

LS_2 = lithium disilicate ceramics

PICN = polymer-infiltrated ceramic networks

RNC = resin nanoceramics

USPHS = United States Public Health Service

UV = ultraviolet

ZLS = zirconia-reinforced lithium silicate ceramics