Review Article

Natural teeth wear opposite to glazed and polished ceramic crowns: A systematic review

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ABSTRACT

It is a major concern to select a proper ceramic with acceptable strength and esthetic and minimum antagonist wear. Therefore, different ceramics were introduced to obtain these advantages with various surface treatments. The aim of this study is to evaluate and report the wear behavior of polished and glazed feldspathic and zirconia crowns in published articles up to 2020. Five electronic databases which were used in this research were MEDLINE (via PubMed), Web of Science, Cochrane Library, Embase, and Scopus from the starting date of databases to January 2020. The Keywords "zirconia," "feldspathic," "dental ceramic," "enamel," "Y-TZP," "wear," "glazed," and "polished" were used. English articles were selected in this paper. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement was used as a reporting template as much as possible. Among the initially 133 articles, 59 duplicated articles were removed, and finally, 52 articles were screened and among them, only 16 articles remained for full-text regaining. The results showed that zirconia had significantly less antagonist wear than feldspathic groups, and polishing had less enamel wear than other types of surface treatment like glazing. Only one study showed that glazed zirconia can have more antagonist wear than feldspathic porcelain. Monolithic zirconia had less enamel wear than conventional zirconia and low-fusing feldspathic porcelain showed lower antagonist wear in comparing with other types of feldspathic porcelains.

Key Words: Dental enamel, dental porcelain, dental wear, feldspathic porcelain, In-Ceram zirconia, review, Y-TZP ceramic

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INTRODUCTION

Antagonist tooth wear is considered one of the significant problems when using dental ceramics. It is complex and multifactorial process which has some functional and esthetic complications.[1,2] The complexity of tooth wear process makes it difficult to conduct adequate clinical studies on this issue; therefore, *in vitro* studies using wear-simulator machines which simulate oral conditions in controlled-experimental way were introduced in 1996.[3-5] These machines can reduce confounding variables such as pH, review viscosity, and flow rate of the saliva that affects enamel wear.[6]

Determining a dental ceramic that simultaneously has enough strength without the disadvantage of

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increased enamel wear, has important clinical role in prosthodontics and the science of dental materials.[7,8] Some studies showed that the amount of antagonist enamel wear opposing dental ceramics is strongly material dependent.[9,10] For example, Stawarczyk *et al*. showed that conventional zirconia resulted in significant higher antagonist wear than monolithic zirconia[9] and Rosentritt *et al*. concluded that feldspathic porcelains provided higher wear than zirconia specimens.[10]

Because of increasing patient's demands for having more dental esthetic,[11] veneered zirconia porcelains have been widely used because of their excellent esthetic and mechanical properties,[12,13] however, high wear rate of their antagonist teeth have been reported by many *in vitro* studies.[14-16] In order to reduce enamel wear of veneered zirconia, translucent, and no veneered zirconia porcelains have been established.[17,18]

The wear behavior of zirconia has not been understood completely.[19,20] Many studies have evaluated the effects of different polishing and glazing techniques on the enamel wear opposing dental porcelains.[2,21,22]

Since there is a controversy about the effect of different ceramic systems on the wear of enamel because of different environmental and testing conditions, this systematic review was undertaken to evaluate and report the wear behavior of polished and glazed feldspathic and zirconia crowns in published articles up to January 2020.

MATERIALS AND METHODS

This systematic review was Performed Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[23]

Inclusion criteria

Participants

Studies assessing tooth wear process in the experimental condition.

Intervention

Studies using Y-TZP zirconia.

Comparison

Studies comparing feldspathic porcelain with Y-TZP zirconia

Outcomes

Studies which evaluated the antagonist's enamel or steatite.

Types of studies

All *in vitro* studies were included in this review.

Studies published in English and published the starting date of databases to January 2020 were considered for inclusion in this review.

Exclusion criteria

(1) Incomplete data reporting, (2) systematic review articles, (3) absence of enamel wear evaluation or steatite wear evaluation, (4) use of veneered zirconia, (5) absence of clear method/materials, (6) *in vivo* studies, (7) high bias articles, (8) case reports, and (9) conference papers were excluded from the study.

Search strategy

A systematic search of electronic databases was conducted on Web of Science, MEDLINE (via PubMed), Cochrane Library, EMBASE, and Scopus. Additional hand searching was conducted through the references of included studies. In the primary search, the terms used were "dental ceramic," "enamel," "wear," and "feldspathic," "zirconia," "Y-TZP," "polished," and "glazed." No publication year limits were applied during the electronic searches. English articles were selected in this paper. The search strategies in PubMed, Embase, and Scopus are presented in Appendix I.

Study selection

Related titles and abstracts were screened by two independent reviewers and articles without an available abstract were excluded. Discrepancies between two reviewers were solved by discussion. The Cohen's Kappa value was used for inter-observer reliability and it should be greater than 80%. In case of unsolved disagreements, the third reviewer decided to include the article or not. After appraising of abstracts, potentially eligible articles were regained in full text.

Assessment of methodological quality

Methodological quality regarding the risk of bias in selected articles was assessed by one of the authors according to the criteria as set by the Cochrane collaboration's tool.[24] Allocation concealment was not applicable for this systematic review and therefore its column was removed [Table 1]. A meta-analysis could not be performed, as the test parameters differed from one study to the other. Therefore, the results of included studies were descriptively reported and discussed.

Table 1: Assessment of risk of bias of included studies according to Modified Cochran collaboration's tool

Author (year)[reference]	Adequate sequence generation	Blinding	Incomplete outcome data	Free of selective reporting	Free of other bias	Risk of bias
Ghazal and Kern (2009)[18]	No	No	Yes	Yes	Yes	High
Bai (2016)[26]	Yes	No	No	Yes	Yes	Low
Sabrah (2012)[27]	Yes	No	No	Yes	Yes	Low
Burgess (2014)[41]	Yes	No	No	No	No	High
Mitov (2012)[50]	Yes	No	No	Yes	Yes	Low
Bartolo (2017)[52]	No	No	Yes	Yes	Yes	High
Beuer (2012)[51]	Yes	No	No	Yes	Yes	Low
Chong (2015)[48]	Yes	No	No	Yes	Yes	Low
Hacker (1996)[53]	No	No	Yes	No	No	High
Jung (2010)[25]	Yes	No	No	Yes	Yes	Low
Rupwala (2017)[28]	Yes	No	No	Yes	Yes	Low
Mundhe (2015)[39]	No	No	Yes	No	Yes	High
Kim *et al.* (2012)[14]	No	No	No	Yes	Yes	Low
Kontos (2013)[29]	No	No	No	Yes	Yes	Low
Magne (1999)[54]	No	No	Yes	Yes	Yes	High
Metzler (1999)[32]	No	No	Yes	Yes	Yes	Low
Mormann (2013)[42]	No	No	No	No	No	High
Park *et al.* (2014)[16]	Yes	No	Yes	Yes	Yes	Low
Janyavula *et al.* (2013)[15]	Yes	No	Yes	Yes	Yes	Low
Preis (2012)[55]	Yes	No	Yes	Yes	Yes	High
Preis (2015)[56]	Yes	No	Yes	Yes	No	High
Rosentritt *et al.* (2012)[10]	Yes	No	Yes	Yes	Yes	Low
Stawarczyk (2013)[30]	Yes	No	Yes	Yes	Yes	Low
Stawarczyk *et al.* (2016)[9]	Yes	No	Yes	Yes	Yes	Low
Lawson (2014)[31]	No	No	Yes	Yes	Yes	Low
Ahmadzadeh *et al.* (2014)[11]	Yes	No	Yes	No	No	High
Firooz (2017)[33]	No	No	Yes	No	No	High

The information extracted from the articles is summarized in Table 2.

RESULTS

One hundred and thirty-two articles were identified through electronic database searching and one article was found through hand-searching by checking the references of included articles. Among the initially 133 articles, 59 duplicated articles were removed, and finally, 52 articles were screened and among them, only 16 articles remained for full-text regaining and 11 studies were excluded for inappropriate study design, intervention, and outcome [Figure 1].

There was a great variation of wear-simulator properties among studies as shown in Table 2 along with other information extracted from the articles. The wear simulator types among included studies were: UAB chewing simulator, Alabama wear testing device, Custom-made chewing simulator of Zurich university, pin-on-block wear tester, chewing simulator

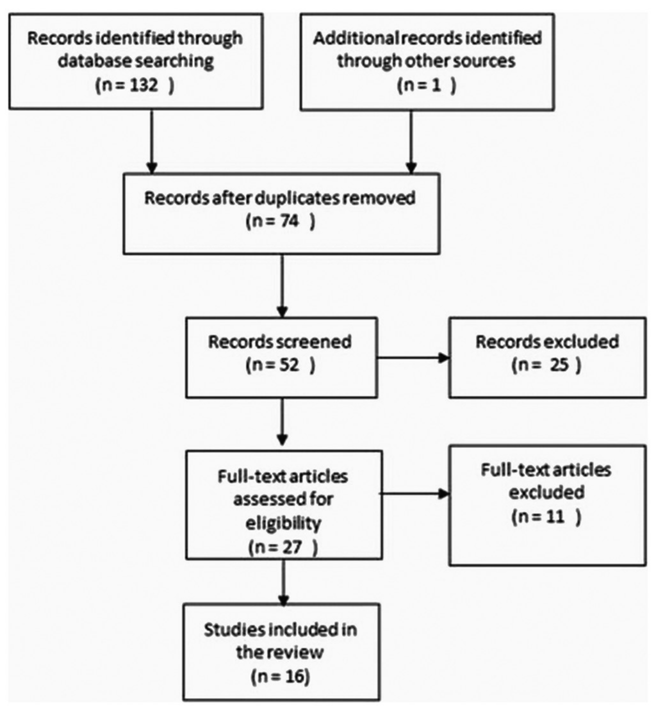

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of the selection process.

Table 2: Extracted information from articles

Author (year) [reference]	Opposing material	antagonist	Wear evaluator	Wear simulator (wear type)	Surface treatments
Bai (2016)[26] (*n*=110)	Pre-sintered zirconia disks (UpCera)	Steatite	Confocal microscopy, SEM	Pin-on-disk wear tester (Tsinghua university), 20,000 cycles, 5 N vertical load, 1.6 Hz, in artificial saliva (3-body)	All disks were abraded with 400-grit, wet SiC abrasive paper, 30 samples were control group, 20 were glazed and 60 samples were polished with Robinson brush and paste
Sabrah (2013)[27] (*n*=32)	Full-contour Y-TZP zirconia (DiaZir) manufactured using CAD/CAM (CEREC)	Sintered disk-shape hydroxy-apatite	Digital micrometer, SEM	Pin-on-disk wear tester, 25,000 cycles, 3 kg load, 1.2 Hz, rotate with a radius of 3–4 mm (2-body)	Glazed, polished with an optrafine polishing kit
Mitov (2012)[50] (*n*=64)	Specimens cut from a commercial hipped dental Y-TZP ceramic (Everest, Kavo)	Cusps of first upper molar	Laser scanner, white light interferometer	Dual-axis chewing simulator (WillyTec), 120,000 cycles, 1.6 Hz, 50 N, Uni-directional antagonist movement (2-body)	Glazed, polished with commercial metallographic preparation system
Beuer (2012)[51] (*n*=12)	Full-contour zirconia crowns manufactured using CAD/ CAM (Everest, Kavo)	Mandibular right first molars	3D laser scanner	Dual-axis chewing simulator (WillyTec), 120,000 cycles, 5 kg load, 0.7 mm Sliding movements (2-body)	Glazed, polished with special polishing kit for all-ceramic crowns, a diamond polishing paste with a brush
Chong (2015)[48] (*n*=48)	Precut Un-sintered Y-TZP specimens (Vita Zanhnfabrik)	Shaped enamel cusps from maxillary and mandibular premolar and molars in 4% formaldehyde solution	3D laser scanner, SEM	Dual-axis chewing simulator (WillyTec), 120,000 cycles, 1.6 Hz, 49 N load, in distilled water (3-body)	Laboratory polished, laboratory polished and glazed
Jung (2010)[25] (*n*=60)	Feldspathic dental porcelain (Vita Omega 900), cuboid zirconia crown (zirkonzahn, Prettau)	Buccal cusps of premolars	3D profilometer system	Dual-axis chewing simulator (WillyTec), 240,000 cycles, 0.8 Hz, 5 kg load, 6 mm vertical movement, 0.3 mm horizontal movement (2-body)	Polished feldspathic porcelain, polished zirconia, polished zirconia with glaze
Rupwala (2017)[28] (*n*=60)	Monolithic zirconia disks (3M Lava)	Maxillary first and second premolars	Profilometer system	Two-body wear machine with artificial saliva, 10,000 cycles, 5 kg load, rotational movement (3-body)	Polished with zircon-brite polishing paste without glaze, glazed
Kim *et al.* (2012)[14] (*n*=100)	Monolithic zirconia specimens (prettau, Lava, Rainbow), feldspathic porcelain (Vita-Omega 900)	Cusps of mandible and maxillary premolars	MTS profilometer, SEM	Chewing simulator (CS-4. SDMechatronik, WillyTec), 300,000 cycles, computer-controlled vertical and horizontal movements, 5 kg load (2-body)	All specimens polished using 600 and 1200 grit SiC papers
Kontos (2013)[29] (*n*=50)	Specimens of zirconia (LavaMulti, 3M ESPE)	Steatite balls	3D profilometer	Pin-on-disk wear tester, 5 N load, 5000 cycles, impact and slide movements in distilled water (3-body)	Only-ground with fine grit diamond bur, ground and polished with Eva ceramic polishing set, ground and glazed
Metzler (1999)[32] (*n*=36)	Blocks of feldspathic porcelain: Low-fusing (Finesse, Omega 900), traditional (Ceramco II)	Premolars and molars of mandible and maxilla	Profilometer system	Pin-on-plate wear model, 600 g load, horizontal movement of 8 mm in distilled water (3-body)	Blocks were polished using SiC abrasive papers with a revolving polishing machine (ECOMET III) and completed by diamond polishing paste
Park *et al.* (2014)[16] (*n*=48)	Y-TZP zirconia disks: Prettau, ZirBlank, ZenoZr Feldspathic porcelain: Cerabien ZR	Maxillary premolars	3D optical profiler	Chewing simulator (SDMechatronik), vertical load of 49 N, 240,000 cycles (2-body)	Polished first with SiC rotary abrasive NTI ceramic polisher, then by 500 and 1500 grit abrasive paper

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Table 2: Contd...

Author (year) [reference]	Opposing material	antagonist	Wear evaluator	Wear simulator (wear type)	Surface treatments
Janyavula *et al.* (2013)[15] (*n*=8)	Monolithic zirconia specimens (IvoclarVivadent) Feldspathic porcelain (Ceramco 3)	Mesio-buccal cusp of molars	Profilometer system, 3D-Scan	Albama wear testing device in 67% distilled water and 33% glycerine, 10 N load, 200,000 and 400,000 cycles, 20 Hz, 2 mm horizontally and 2 mm sliding movements (3-body)	Specimens ground flat with a 400 grit paper on a polishing wheel and finished with a fine diamond rotary instrument
Lawson (2014)[31] (*n*=24)	Zirconia specimens (LAVA 3M ESPE)	Mesio-buccal cusp of mandibular molars	Profilometer system	UAB chewing simulator with glycerin 33% as lubricant, 10 N vertical load, 400,000 cycles, 20 Hz, 2 mm slide movement (3-body)	Adjusted group (A): Roughened with fine diamond bur adjusted and polished (AP): Hand-polished with polishing points (dialite ZR) and paste (zircon-brite) adjusted and glazed (AG): covered with a vita LT glaze
Rosentritt *et al.* (2012)[10] (*n*=146)	Zirconia specimens: ICE zircon Prettau, ICE zircon translucent Feldspathic specimens: Vita Vm7, Vita Vm9, ICE Keramik	Steatite balls, molars cusps	Optical 3D surface profilomete (3D laser scan)	Pin-on-block wear tester, 50 N vertical load, 1,200,000 cycles, 1.6 Hz, in distilled water, lateral movement of 1 mm and mouth opening of 2 mm (3-body)	Specimens were smoothed using SiC grinding paper
Satwarczyk (2013)[30] (*n*=36)	Monolithic zirconia specimens: GZC, GZS, MAZ, MA	Mesio-buccal cusp of maxillary molars	3D profilometer system, SEM	Chewing-simulator (custom-made university of zurikh), 49 N, 1.67 Hz, 120,000, 240,000, 640,000 and 1,200,000 cycles (2-body)	MAZ: Polished with a goat hair brush (DT and shop) and a diamond paste MEZ: Polished with diamond suspension in a polishing device (Accutom) GZS: Glazed with zenostar magic glaze spray GZC: Glazzirox with liquid stain were added twice
Stawarczyk *et al.* (2016)[9] (*n*=108)	Monolithic zirconia: IC (Incoris TZI), CZ, DD (DD Bio ZX2 Hochtransluzent), ZS convetional zirconia: CZI (Ceramill ZI)	Permanent molars	3D laser scanner, SEM	Chewing simulator (CS-4, SD Mechatronik), 1.64 Hz, 100 N, 1,200,000 cycles, 0.7 mm sliding movement (2-body)	Polished with diamond pads with grain sizes of 20 μm and 40 μm with MD-system in a polishing device (Abramin), glazed

N: Number of samples, Y-TZP: Yttrium-stabilized tetragonal zirconia, GZC: Glazed zirconia using glaze ceramic, GZS: Glazed zirconia using glaze spray, MAZ: Manualy polished zirconia, MA: Monolithic base allo, CZ: Ceramill zolid, ZS: Zenostar, CZI: Ceramill ZI, ZI: Zirconia, SEM: Scanning electron microscope, CAD: Computer-aided design, CAM: Computer-aided manufacturing, MTS: A 3D profilometer, UAB: One type chewing simulator, SiC: Silicon carbide abrasive paper, ECOMET III: One type polishing machine, NTI: NTI-Kahla is a German mid-sized company that specializes in the production of rotary dental instruments, AP: Adjusted and polished, DT: A goat hair brush for polishing , MD: One type polishing system, LT: Vita LT glaze, MEZ: Mechanically polished monolithic zirconia

(SD mechatronik), two-body wear machine, pin-on-disk or pin-on-plate, and dual-axis chewing simulator which they were used to mimic human-controlled oral conditions to observe antagonist's wear opposite to zirconia and feldspathic porcelains. The wear-body of experiments were in two models: 2-Body wear and 3-Body wear, which in 2-Body wear, there was no liquid mediator between porcelains and antagonists, and in 3-Body wear, there was mediators such as distilled water, glycerin, or artificial saliva. 3-Body wear simulators supposed to have a better simulation of oral conditions because of the existence of human natural saliva. The range of cycles of wear between simulators was 5000 and 1200,000 cycles and their frequencies were between 0.8 and 20 Hz. The range of loading force used to mimic masticatory force was in a range of 0.6–100 N. Antagonists consist of two types: human natural teeth (upper and lower premolar and molars) and industrial simulated enamel (Steatite).

Among included studies, six studies showed that zirconia groups had significantly less antagonist wear than feldspathic groups,[9,10,14-16,25] and among the different surface treatments, polishing had less enamel wear than other types of surface treatment like glazing.[15,26-31] Only one study showed that glazed zirconia can have more antagonists wear than feldspathic porcelain.[26] Monolithic zirconia had less enamel wear than conventional zirconia[9] and low-fusing feldspathic porcelain showed lower antagonist wear in comparing with traditional feldspathic porcelains but there was no significant difference between the enamel wear of two low-fusing porcelains.[32] A study conducted by Stawarczyk *et al*. showed that although polished monolithic zirconia showed lower wear rate on enamel antagonists, it developed higher rates of enamel cracks[30] [Table 3].

There were different brands of zirconia and feldspathic specimens which are listed in Table 4. Wear evaluators were in four types: scanning electron microscope (SEM), confocal microscopy, digital micrometer, white light interferometer, which they report amount of antagonist's wear in three Types: (1) Vertical wear (µm), (2) Area wear (mm^2), and (3) Volumetric wear (mm^3) [Table 4].

DISCUSSION

Among studies which were critically appraised in this systematic review, 16 were in low level of bias risks, remains were high risks. Near 78% of these studies were free of reporting and other biases and almost 60% had adequate sequence generation, but in 60% of studies, there were incomplete outcome data. In addition, blinding was not applicable in these study designs. The first and second null hypotheses of this study stating that there is no difference in the wear number of antagonists of zirconia and feldspathic specimens, and glazing and polishing techniques do not affect antagonist's wear of zirconia and feldspathic groups. The findings of this study rejected both hypotheses with the following reasons:

One of the reasons that can explain lower antagonist wear of zirconia comparing with feldspathic porcelains is zirconia's smaller particle (fine grain) which can result in smoother and monotonic surface. Another reason is higher fracture toughness of zirconia (9 MPa) comparing with feldspathic porcelain (0.73 MPa). Low fracture toughness of feldspathic porcelain can lead to microfractures on its surface which results in prominences and roughness. This increasing roughness makes stress on enamel antagonist and leads to abrasion.[33]

High fracture toughness in Y-TZP zirconia may be explained by phase transformation from the tetragonal to monoclinic phase due to external pressure, which leads to a volume expansion of about 3%–5%. It creates compressive strength and prevents cracks spreading and therefore makes it less surface roughness.[34]

Glazed zirconia showed greater wear compared with polished zirconia, although the surface of glazed zirconia results in smooth, esthetic, and hygienic surface but the glaze layer can be easily removed during function or occlusal adjustment, and the underlying rough ceramic surface exposed and can cause aggressive damage of enamel antagonists.[15,26-31,35] In some *in vivo* studies the wear behavior of glazed and polished zirconia prostheses are comparable.[36-38] SEM images of polished zirconia showed a surface with a more fine-grained and homogeneous texture, therefore polishing techniques decrease the surface roughness of zirconia and subsequently the wear of natural antagonists.[27]

The low wear rate of enamel antagonist to monolithic zirconia comparing with conventional ones can be explained by lower mechanical properties of this material.[9]

Clinical studies demonstrated disputed wear manners of monolithic zirconia crowns, that some resulted similarity[36-38] or greater[39,40] wear of natural teeth antagonist in compare to enamel-enamel tooth contact.

Although it is a common perception that hardness of a material is directly proportional to its abrasiveness, several studies have shown that hardness alone cannot explain the abrasive properties of a substance.[11] It seems that the wear of a material is more related to the level of its surface roughness than the hardness, and therefore various studies suggest that surface roughness of porcelain is important factor to predict antagonist wear of porcelains.[41,42] Physical grain or crystal size plays an important role in the surface topography and roughness of porcelains, too.

Lohbauer and Reich evaluated the amount of wear on the antagonist occlusal surfaces of clinically placed monolithic zirconia premolar and molar crowns (LAVA Plus, 3M ESPE). They showed mean wear of 200 µm as admissible. The monolithic zirconia crowns (LAVA Plus) showed acceptable antagonist wear rates after 2 years *in situ*, regardless of natural enamel or ceramics as antagonist materials;[43] and of course, monolithic zirconia crowns are well known with low amount of antagonist wear when opposed to monolithic zirconia itself.[44]

The result of Habib *et al*. investigation showed monolithic zirconia has more wear effect to natural teeth in comparison to lithium disilicate and composite resin.[45] Pereira *et al*. demonstrated that the wear of

Table 3: Results of included articles

Author	Antagonist's wear results	Conclusion
Bai (2016)[26]	Polished zirconia with Robinson brush and paste had smallest wear area on antagonists (1.79±0.21 mm^2) Glazed zirconia had 3.34±0.29 mm^2 antagonist wear area	Glazed zirconia is significantly more abrasive than polished zirconia on antagonists (P<0.05)
Sabrah (2013)[27]	Polished group showed significant lower antagonist wear (1.3 mm^3, 14.7 µm) than glazed group (P=0.0001). Enamel wear opposed to glazed group was not reported	Glazed zirconia provides higher wear than polished zirconia on antagonists
Mitov (2012)[50]	Polished zirconia showed the lowest wear of the antagonist enamel with a mean value of 171.74 µm (vertical wear) Finishing technique significantly affected enamel wear (P<0.05)	Polished zirconia showed the lowest wear of the antagonist enamel
Beuer (2012)[51]	Polished full-contour zirconia showed 57 µm enamel wear whereas glazed full-contour zirconia had a mean wear of 78 µm on enamel antagonists Polished full-contour zirconia showed significantly more wear than glazed full-contour zirconia (P=0.016)	Polished full-contour zirconia showed significantly more enamel wear than glazed full-contour zirconia (P=0.016)
Chong (2015)[48]	LP Y-TZP specimens showed 138 µm vertical enamel loss and 0.15 mm^3 volumetric enamel loss LPG specimens showed 128 µm vertical enamel loss and 0.17 mm^3 volumetric enamel loss There was no significant difference between LP and LPG's volumetric enamel loss (P>0.05)	LPG specimens showed more volumetric enamel loss than LP specimens and lower vertical enamel loss. There was no significant difference between LP and LPG's volumetric enamel loss (P>0.05)
Jung (2010)[25]	Enamel volumetric loss of groups Feldspathic porcelain (0.119 mm^3) Polished zirconia (0.03 mm^3) Polished zirconia with glaze (0.078 mm^3)	Antagonist tooth volumetric wear was less in zirconia than feldspathic dental porcelain
Rupwala (2017)[28]	Enamel wear (loss of height) Mechanically polished monolithic zirconia (0.2716 mm) Glazed monolithic zirconia (0.124 mm)	Mechanically polished monolithic zirconia showed the least amount of enamel wear loss, but glazed monolithic zirconia showed the highest enamel wear
Kim *et al.*[14]	Y-TZP specimens contains Prettau, Lava and Rainbow brands which their enamel volumetric loss when polishing with 600 grit paper were 0.04 mm^3 and the amount of enamel loss for 1200 grit paper showed exactly the same result as 600 grit paper Feldspathic porcelain showed 0.13 mm^3 enamel wear for 600 grit paper and 0.11 mm3 for 1200 grit paper	Felsapathic porcelain leads to more wear than zirconia specimens There was no significant difference between the enamel wear of zirconia groups (P>0.05)
Kontos (2013)[29]	Steatite-balls wear opposed to zirconia specimens (vertical loss) Ground zirconia: 84 µm Ground and polished: 66 µm Ground and glazed: 85 µm	Ground and glazed zirconia was significantly more abrasive than ground and polished zirconia (P<0.05)
Metzler (1999)[32]	Enamel volume loss of specimens were Traditional feldspathic porcelain (Ceramco II): 0.78 mm^3 Low-fusing feldspathic porcelain: Omega 900 (0.58 mm^3) Finesse (0.5 mm^3)	Low-fusing feldspathic porcelains showed significantly less enamel wear than traditional feldspathic porcelain (P<0.05) There was no significant difference between the enamel wear of two low-fusing porcelains (P>0.05)
Park *et al.*[16]	Polished zirblank zirconia showed the least enamel wear (1.11 mm^3) Glazed zirblank zirconia showed the greatest enamel wear among zirconia groups (3.07 mm^3) Feldspathic porcelain showed significantly more enamel loss than zirconia groups (4.8 mm3, P<0.05)	Polished zirblank zirconia group showed the least enamel wear among zirconia groups Feldspathic group showed significantly more wear than zirconia groups (P<0.05)
Janyavula *et al.*[15]	Enamel volumetric loss (mm^3) Polished zirconia (0.21) Glazed zirconia (1.18) Polished then reglazed (0.88) Feldspathic porcelain (2.15)	Polished zirconia showed lower wear than glazed group and Glazed-repolished group Enamel wear of feldspathic porcelain was higher than zirconia specimens
Lawson (2014)[31]	Adjusted and polished zirconia showed lower amount of enamel wear (0.33 mm^3) than adjusted zirconia (0.54 mm^3) and adjusted and glazed zirconia (0.68 mm3)	Adjusted and glazed zirconia showed more enamel wear than adjusted and polished zirconia Adjusted and polished zirconia showed lower wear than adjusted zirconia
Rosentritt *et al.*[10]	Enamel loss (µm): Feldspathic porcelain provided wear traces between 71.2 µm and 124 µm and zirconia specimens showed no enamel wear Wear of antagonists were strongly material dependent (P<0.001)	Antagonist wear was higher in feldspathic porcelain than zirconia specimens Wear of antagonists were strongly material dependent (P<0.001)

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Table 3: Contd...

Author	Antagonist's wear results	Conclusion
Stawarczyk (2013)[30]	The least enamel wear was observed for MAZ and MEZ (27.3 μm, 28 μm); GZC showed the highest enamel wear (118 μm) GZS had higher wear than polished groups but lower wear than GZC (62.2 μm)	Polished monolithic zirconia showed lower wear rate on enamel antagonists but developed higher rates of enamel cracks GZC showed the highest wear of enamel antagonists
Stawarczyk *et al*.[9]	The material and the number of chewing cycles had a significant effect on wear results (P<0.001) Within monolithic zirconia groups, glazed specimens showed higher material and antagonist material loss than polished ones (P<0.001) No differences were found for enamel wear between the polished and glazed conventional zirconia (P=0.882) ZS monolithic zirconia showed significant higher wear than other polished or glazed monolithic zirconia groups (P<0.001) Within all specimens, conventional zirconia showed significant higher wear than other groups (P<0.005) except glazed ZS group (P>0.05)	Glazed zirconia specimens showed higher enamel wear than polished ones Conventional zirconia showed higher enamel wear than monolithic zirconia

LP: Laboratory polished, LPG: LP and glazed, GZC: Glazed zirconia using glaze ceramic, Y-TZP: Yttrium-stabilized tetragonal zirconia, ZS: Zenostar, MAZ: Manualy polished zirconia, MEZ: mechanically polished monolithic zirconia

composite resin opposed to monolithic zirconia is greater than opposing bovine enamel.[46] Gundugollu *et al*. conducted that glazed polished monolithic zirconia produce more wear of the opposed enamel in comparison to unglazed polished monolithic zirconia.[47]

The results of Esquivel-Upshaw *et al*. investigation showed that polished monolithic zirconia (Lava Plus) has a similar amount of wearing of opposing enamel to metal-ceramic and enamel antagonists.[38]

Low-fusing feldspathic porcelains showed lower antagonist wear in comparing with traditional feldspathic porcelains but there was no significant difference between the enamel wear of two low-fusing porcelains.[32] These results can be described by large grain particle size of traditional feldspathic porcelain which contributes to a much more irregular surface and therefore an increase in abrasive qualities. The similarity between surface roughness of two low-fusing porcelains can explain the same wear amount of their antagonists.[14,25,32]

Human enamel has been considered the best choice for wear studies, however, there are some complications to using them such as natural variations in shape and physical properties, and therefore natural teeth require extensive preparation and standardization which can be difficult due to their variations. Some studies used industrial hydroxyapatite called steatite as a substrate for human natural enamel and showed that it can be a reliable substrate in wear studies instead of human natural teeth.[26,29] Wear measurement of steatite opposed to zirconia and feldspathic groups revealed the same results as enamel specimens.[10]

We suggest to researchers to use steatite in further wear studies because it allows the standardization of antagonistic conditions, however, it has some differing mechanical properties such as higher hardness (steatite: 680 HV; enamel: 330 HV) or initial roughness (steatite: 1.7 μm, enamel: 0.9 μm).[30]

The wear behavior of ceramics in clinical practice is a combination of 2-Body and 3-Body wear, but evaluation of methods of included studies showed that they use either 2-Body or 3-Body wear simulator, and none of them use combination of them to simulate oral conditions near to reality.[27,28,48] It should be noted that 3-Body wear may reduce the effect of surface roughness due to the presence of a third body, and therefore selecting a proper liquid mediator such as artificial saliva should be considered.[26]

There are two common methods for decreasing roughness, glazing, and polishing. The amount of roughness is related to use polishing system it would be between 0.08 and 0.9 mm. The roughness of polished zirconia is approximate to glazed one.[49]

Different finishing and polishing procedures for zirconia specimens affected antagonistic enamel wear, vertically and volumetrically;[50] although there was no significant difference in antagonist wear of feldspathic porcelains by different polishing techniques.[14] This observation can be explained by their different microstructure and surface properties. It should be noted that not all materials can be made smoothed. Large grain porcelains such as feldspathic porcelains are the good samples of these materials.[14,15,32] Different glazing techniques can cause significantly different antagonists wear

Table 4: Results of all included studies

Reviewed titles	Items related to each title
Wear evaluator types	SEM, confocal microscopy, digital micrometer, white light interferometer
Wear simulator types	UAB chewing simulator, Albama wear testing device, custom-made chewing simulator of Zurikh University, pin-on-block wear tester, chewing simulator (SD mechatronik), two-body wear machine, pin-on-disk or pin-on-plate, dual-axis chewing simulator
Body-wear types	2- and 3-body
Range of cycles of wear simulator	5000-12,00,000 cycles
Range of frequency of wear simulator	0.8-20 Hz
Range of loading force of wear simulator	0.6-100 N
Antagonist types	Sintered hydroxy-apatite, steatite, maxillary and mandibular cusps of human molars and premolars, sintered hydroxy-apatite, steatite, maxillary and mandibular cusps of human molars and premolars in 4% formaldehyde
Opposing material types	Zirconia: UpCera, CEREC, Everest Kavo, Vita Zanhnfabrik, Prettau, Lava 3M, Rainbow, Lava, LavaMulti, Lava 3M ESPE, ZirBlank, ZenoZr, IvoclarVivadent, ICE Zircon Prettau, ICE Zircon Translucent, IncorisTZI, CeramillZolid, DD Bio ZX2Hochtransluzent, Zenostar
	Feldspathic: Vita Omega 900, Finesse, Ceramco II, Cerabien ZR, Ceramco 3, Vita Vm7, Vita Vm9, ICE Keramik, Ceramill ZI
Wear measurement types	Vertical wear (μm), area wear (mm^2), volumetric wear (mm^3)

SEM: Scanning electron microscope

of zirconia groups. For example, using of glaze spray (GS) made significantly less enamel's wear than using glaze ceramic (GC). Both GC and GS can provide a thin smooth layer in comparison with unglazed zirconia, but their glaze layer will be worn in a short period, approximately after 6 months under clinical conditions. SEM analysis showed that after removing the glaze layer, the surface under GS was smoother than GC, therefore results in low enamel wear.[9,30,51]

The zirconia materials show similar composition, but differ in sintering temperature and resulting grain sizes. Especially sintering conditions may influence microstructure, longevity and hydrolytic performance, and finally, wear behavior of material.[9,14,16]

The zirconia or feldspathic specimens should be polished before any surface treatment because when the staining becomes worn, a rough surface may accelerate wear.[15,16,31] Finally, this systematic review recommends using polished monolithic zirconia to reduce antagonist wear in clinical practice.

CONCLUSION

Under the limitations of the present study, there was a significant difference between antagonist wear of zirconia and feldspathic specimens among included studies, which zirconia specimens showed wear-friendly behavior than feldspathic ones, and also among different surface treatments, polishing leads to less enamel wear than glazing.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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