Evaluation of Wear and Hardness of Zirconia with Different Surface Treatment Protocols a Systematic Review

Mostafa Aboushahba*, Hesham Katamish and Mona Elagroudy

Fixed Prosthodontics Department, Faculty of Oral and Dental Medicine, Cairo University, Egypt; m.aboushahba@gmail.com, hkatamish@gmail.com, mokabel@yahoo.com

Abstract

Objective: The objective of this systematic review is to assess the wear and hardness of surface treated zirconia. **Methods**: Two automated databases were investigated till July 2015 with no limits. The scientific terms: "Dental enamel", "Yttria stabilized tetragonal zirconia", "Tooth wear", "Enamel wear", "Hardness", "Translucent zirconia' and "Dental restoration wear" were used in this study. Initially screening was performed for the retrieved articles through title and abstract after that, full-text assessment was done to those articles that fulfilled the inclusion criteria. **Findings**: Sixty-nine potentially eligible studies were retrieved from the data base search; after duplicate removal the studies became sixty-three. Full-text assessment was performed for all titles and abstracts that met the inclusion criteria. Finally, seventeen studies met the inclusion criteria, and so their references were also screened. **Applications/Improvements:** Although studies applied different wear testing methodologies; wear testing devices, number of cycles, magnitude of force, number of samples, sample preparation for zirconia and enamel antagonist surface, as well as hardness measurement protocol, full contoured polished zirconia and human enamel (as antagonist) showed high resistance to wear. It was also concluded that zirconia showed high hardness as a surface property. It is recommended to polish the surface of restorations made of full-contour zirconia because this polishing favours the surface properties (wear and hardness) to opposing enamel.

Keywords: Dental Enamel, Hardness, Translucent Zirconia, Y-TZP, Wear

1. Introduction

Minimizing tooth wear is an important issue to increase the life expectancy, thus an understanding the mechanism of tooth wear is critically important¹. Rate of wear of ceramics should match rate of wear of posterior tooth enamel (range of $20-40\mu$ m per year). Full contoured zirconia may act as an antagonist to enamel, so its behavior as an antagonist material needs to be investigated and it was thought to cause sever wear under high².

Zirconia offers high hardness and structural stability, but its properties including wear differ from veneering porcelain³. Monolithic zirconia can be subjected to several surface treatments (grinding, polishing, glazing and heat), so wear behavior of these differently treated zirconia is of interest.

Hardness and resistance to friction of zirconia strongly affect wear behavior. Partially stabilized zirconia substructures offer high hardness, fracture resistance and structural stability compared to porcelain. So, milled full-zirconia restorations without veneering, are now obtainable for dental practice⁴.

The previous data lead to the formulation of a search strategy (study) question and a PICO worksheet.

*Author for correspondence

1.1 Search Strategy (Study) Question

Whether zirconia crowns will cause wear of opposing dental enamel or not?

1.2 PICO Worksheet

Problem: Wear of dental enamel opposed by Zirconia

Intervention: The use of polished zirconia opposes dental enamel.

Control: The use of veneered zirconia opposes dental enamel.

Outcome(s):

1. Wear

2. Hardness

1.3 Rational of the Study

Systematic evaluation of all the literature of the articles that evaluated the wear and the hardness of zirconia (with different surface treatment protocols) as well as wear of its opposing opposing enamel.

1.4 External Validity of this Systematic Review

Significance depends on external validity; whether the results can be practically applied to a defined group of people in clinical routine practice, or it is only an apprehension of theclinicians⁵doctors and patients must take into account relevant randomised controlled trials (RCTs. In this systematic review, external validity was clinicians concern.

2. Materials and Methods

2.1 PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

Reporting template was used in this systematic review (Figure 1).

2.1.1 Gathering of Data

Automated search was performed through Pubmed

(Table 1) and Google scholar search engines till July 2015 with no limits.

2.1.2 Standards for Choosing Studies

Screening of all retrieved titles was done according to the following criteria:

- a. Inclusion criteria Full contour zirconia ceramic. Enamelantagonist. Wear test Hardness test In vitro studies.
- b. Exclusion criteria Clinical evaluations. Veneered zirconia. Different languages. Studies older than 2006. Antagonist other than human enamel. Different material Performing different test.

Two independent reviewers performed primary screening of titles/abstracts, in order to assess all studies. Consensus agreement between the reviewers was pursued in cases of inconsistencies. Potentially related articles***** were then gained in full text. Trials were made to evaluate full articles of all abstracts that were already published; every effort was performed by direct and electronic contact of the authors when difficulty of obtaining full text occurred, and those abstracts that were published in books or conferences were excluded due to insufficient detailed test method.

2.1.3 Data Extraction

Testing methodologies of the studies were analyzed regarding surface treatment of zirconia, wear testing, antagonist, and hardness parameter. When data were absent N/A was reported in the methodology Table [Table 2].



Figure 1. PRISMA 2009 flow diagram.

Search	Add to builder	Query	Items found
#39	Add	Search (((((Zirconia hardness) AND ((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))) OR ((Tooth wear) AND Translucent Zirconia))))) OR ((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished)))) OR (((Tooth wear) AND Translucent Zirconia))	54
#38	Add	Search (((((Zirconia hardness) AND ((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))) OR ((Tooth wear) AND Translucent Zirconia))))) AND ((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia)) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished)))) AND ((((Tooth wear) AND Translucent Zirconia))	2
#37	Add	Search ((Zirconia hardness) AND (((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))) OR ((Tooth wear) AND Translucent Zirconia)))	5
#36	Add	Search (((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))	54
#35	Add	Search ((Tooth wear) AND Translucent Zirconia)	2
#32	Add	Search (Zirconia hardness) OR ((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))) OR ((Tooth wear) AND Translucent Zirconia))	278
#31	Add	Search Zirconia hardness	229
#30	Add	Search hardness	16628
#29	Add	Search (((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))) OR ((Tooth wear) AND Translucent Zirconia))) AND hardness	5

Table 1. Search strategy Pubmed search through July 2015

Search	Add to builder	Query	Items found
#27	Add	Search (yttria stabilized tetragonal zirconia"[Supplementary Concept] AND hardness)	0
#24	Add	Search ((((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished))) AND ((Translucent Zirconia) AND veneered zirconia)	7
#23	Add	Search ((((Tooth wear) AND Translucent Zirconia)) OR Translucent Zirconia) OR (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished)	54
#22	Add	Search (Translucent Zirconia) AND veneered zirconia	7
#21	Add	Search (Tooth wear) AND Translucent Zirconia	2
#20	Add	Search (((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished)) AND Translucent Zirconia	0
#19	Add	Search ((((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro)) AND polished	3
#18	Add	Search (((("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND ("Dental Restoration Wear"[Mesh])) AND polished	5
#17	Add	Search (("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND ("Dental Restoration Wear"[Mesh]	7
#16	Add	Search "Tooth Wear" [Mesh]	5196
#15	Add	Search ((("Dental Restoration Wear"[Mesh]) AND ("yttria stabilized tetragonal zirconia"[Supplementary Concept])) AND in-vitro	5
#14	Add	Search ((((("Dental Enamel" [Mesh]))) AND Tooth wear) AND in-vitro	456
#13	Add	Search (("Dental Restoration Wear" [Mesh]) AND Tooth wear	329
#12	Add	Search ("Dental Restoration Wear" [Mesh]	794
#11	Add	Search ("yttria stabilized tetragonal zirconia" [Supplementary Concept])	423
#10	Add	Search ((("Dental Enamel"[Mesh]))	17725

Search	Add to builder	Query	Items found
#8	Add	Search (Dental Enamel" [Mesh]) AND Translucent Zirconia	0
#6	Add	Search Tooth wear	6571
#2	Add	Search Translucent Zirconia	51

Table 2.Methodology table

Author, Year	Sample no.	Fabrication of Y-TZP Zirconia		Wear testing	Antagonist	Hardne	ess			
		11	2 ²	3 ³	44	55		Enamel	Nanoindentor	Vickers
Curtis et al, 2006 ⁶	360					Ok ⁶	N/A	N/A	N/A	Ok
Jung et al, in 2010 ⁷	20		Ok	Ok	Ok		240,000 cycles	Ok	N/A	N/A
Pries et al,2011 ¹	144		Ok				50N Load for 1.2X10⁵ cycles at 1.6Hz	Ok	N/A	N/A
Alghazzawi et al, in 2012 ⁸	64	Ok					N/A	N/A	Ok	N/A
Beuer et al, 2012 ⁹	48		Ok	Ok	Ok		120,000 cycles, 1.6Hz, 5Kg	N/A	N/A	N/A
Janyavula et al, in 2012 ¹⁰	32			Ok	Ok		10N Load for 100,000- 200,000 cycles at 0.33HZ	Ok	N/A	N/A

¹Ground (Y-TZP or TZI)
²Glazed full contour
³Polished full contour
⁴Veneered tech.
⁵Others
⁶Zirconia dics either abraded or ground

Kim et al, in 2012 ¹¹	100	Ok				Ok ⁷	5Kg Load, 49N, 300,000 cycles	Ok	N/A	N/A
Mitov et al, in 2012 ¹²	64		Ok	Ok	Ok		120,000 cycles	Ok	N/A	N/A
Rosentritt et al, in 2012 ⁴	144	Ok			Ok		50N Load for 1.2X10 ⁵ cycles at 1.6Hz	Ok	N/A	N/A
Turp et al, in 2012 ¹³	100					Ok ⁸				Ok
Wang et al, in 2012 ¹⁴	N/A			Ok			200 000 and 400 000 cycles	Ok		
Janyavula et al, in 2013 ¹⁵	24		Ok	Ok			200 000 and 400 000 cycles	Ok		
Mörmann et al, in 2013 ¹⁶	132	Ok					49N Load, 1.2X10º cycles at 1.7Hz	Ok	10N for 20 sec (Martins Hardness measurement)	
Stawarczyk et al, in 2013 ¹⁷	36		Ok	Ok	Ok		49N Load for 1.2X10 ⁵ cycles at 1.6Hz	Ok	N/A	N/A
Candido et al, in 2014 ¹⁸	36					Ok9				Ok
Park et al, in 2014 ¹⁹	48		Ok	Ok			240,000 cycles	Ok		
Sripetchda- nond & Leevailoj, in 2014 ²⁰	24	Ok					25 N at 20 rpm for 4800 cycles	Ok		

⁷Zirconia Blocks ⁸Zirconia disc ⁹Bar shaped zirconia

2.2 Methodological Information among the Chosen Studies

Methodologies of all selected studies $^{(1,4,\,6-20)}$ were described in [Table 2].

3. Results

3.1 Study Selection

Seventeen in-vitro studies were evaluated in this

systematic review. 46 studies were assessed through full text, 29 studies were eliminated (Table 3) by applying the inclusion and exclusion criteria. Exclusion was done if Y-TZP was not the zirconia used, when the study was not a laboratory study, and if the antagonist was other than human enamel, revealing seventeen articles.

3.2 Study Features

Studies published between 2006and 2014 with different experimental parameters.

	Title	Reason for exclusion	source
1	Wear resistance of nanofilled composite resin and feldspathic ceramic artificial teeth	Evaluating different material	PubMed
2	State of the art of zirconia for dental applications	Clinical study	PubMed
3	Zirconia: A material science marvel with varied dental applications	Performing different test	PubMed
4	Wear evaluation of porcelain opposing gold, composite resin, and enamel	Evaluating different material	PubMed
5	Antagonist Enamel wears more than ceramic inlays	Clinical study	PubMed
6	Effect of grain size on the monoclinic transformation, hardness, roughness, and modulus of aged partially stabilized zirconia	Evaluation of different criteria of zirconia	PubMed
10	A comparison of all-ceramic restorative systems: Part 2.	Published 2000	PubMed
11	Relative translucency of six all-ceramic systems. Part I	Published 2002	PubMed
12	Translucency and biaxial flexural strength of four ceramic core materials.	Performing different test	PubMed
13	Effect of veneering techniques on color and translucency of Y-TZP.	Evaluating different material	PubMed
14	Translucency of zirconia copings made with different CAD/CAM systems.	Performing different test	PubMed

Table 3.List of excluded studies

15	Crystallization of high-strength fine-sized leucite glass-ceramics.	Performing different test	PubMed
16	Translucency of shaded zirconia core material.	Evaluating different material	PubMed
17	A comparative evaluation of the translucency of zirconias and lithium disilicate for monolithic restorations.	Performing different test	PubMed
18	Monolithic bridges with inCoris TZI and inCoris TZI C.	Performing different test	PubMed
19	Translucency and flexural strength of monolithic translucent zirconia and porcelain- layered zirconia.	Evaluating different material	PubMed
20	Evaluation of Different Polishing Systems and Speeds for Dental Zirconia.	Different polishing test method	PubMed
21	The comparative evaluation of the translucency of crowns fabricated with three different all-ceramic materials: an in vitro study.	Performing different test	PubMed
22	Highly-translucent, strong and aging-resistant 3Y-TZP ceramics for dental restoration by grain boundary segregation.	Performing different test	PubMed
23	Comparative analysis of transmittance for different types of commercially available zirconia and lithium disilicate materials.	Performing different test	PubMed
24	Making yttria-stabilized tetragonal zirconia translucent.	Performing different test	PubMed
25	Translucency of ceramic materials for CEREC CAD/CAM system.	Evaluating different material	PubMed
26	Translucency of dental ceramics with different thicknesses.	Evaluating different material	PubMed
27	Abrasion of human enamel by different dental ceramics in vitro	Published 1991	Google Scholar
28	Zirconia in dentistry: Part 1. Discovering the nature of an upcoming bioceramic.	Evaluating different material	Google Scholar
29	Influence of surface treatment on the wear of solid zirconia	Evaluating different material	Google Scholar

3.3 Risk of Bias within Studies

and hardness testing.

Within the chosen articles some investigational conditions were not clear, and this might have affected the wear

3.4 Results of Chosen Studies

Author, Year	Measurement of wear testing	Measurement of hardness
Curtis et al, 2006 ⁶		Abraded ranging from 1524-1734. Ground ranging from 1590-1729.
Jung et al, in 2010 ⁷	Volume loss of antagonist is: 0.078mm ³ with glazed zirconia. 0.031mm ³ with polished zirconia	
Pries et al,2011 ¹	Zr without veneering showed no wear.	
Alghazzawi et al, in 2012 ⁸		15.5 GPa before Aging. 15.1 GPa after Aging
Beuer et al, 2012 ⁹	Sintered Zr= 60 μm Antagonist = 55 μm Glazed Zr= 40 μm Antagonist= 58 μm Polished Zr= 20 μm Antagonist = 70 μm	
Janyavula et al, in 2012 ¹⁰	Polished: 0.099- 0.177 mm ³ Aged: 0.139-0.202 mm ³	
Kim et al, in 2012 ¹¹	Enamel wear 0.04±0.02 mm ³	
Mitov et al, in 2012 ¹²	Wear of Zr: Polished: 100 Roughened with red ring diamond: 150 Roughened with Green ring diamond: 250 Glazed: 190	
Rosentritt et al, in 2012 ⁴	Zirconia showed no wear Antagonist showed low wear rates	

Turp et al, in 2012 ¹³		Acidic: 1,347±33 V.H.N Neutral: 1,368±28 V.H.N Alkaline: 1,350±30 V.H.N
Wang et al, in 2012 ¹⁴	 -Furrows and granular debris on enamel while sliding against rough zirconia. -Chipping flake and pit-like structure and cracks on enamel surface while sliding against polished zirconia 	
Janyavula et al, in 2013 ¹⁵	no measureable loss on polished zirconia, moderate loss on the surface of enamel. significant loss on glazed zirconia, significant loss on the enamel surface	
Mörmann et al, in 2013 ¹⁶	TZI no material wear and low wear of enamel antagonist.	TZI 7996Mhz other ceramics 745-4156 Mhz
Stawarczyk et al, in 2013 ¹⁷	Vertical material loss: Glazed 30-38 µm Veneered: 12.7µm Polished: 0.3µm Vertical Loss of antagonist: vs Glazed: 24-51µm vs Veneered: 26µm vs polished: 17µm	
Candido et al, in 2014 ¹⁸		1299.58-1316.60 VHN
Park et al, in 2014 ¹⁹	Polished Y-TZP group demonstrated the least wear $(1.11 \pm 0.51 \text{ mm}^3)$ while Y-TZP with staining and glazing produced the great enamel wear $(3.07 \pm 0.98 \text{ mm}^3)$	
Sripetchdanond & Leevailoj, in 2014 ²⁰	enamel wear depth between monolithic zirconia (2.17 ±0.80, 1.83 ±0.75 μm)	

3.5 Risk of Bias Across Studies

It was difficult to make meta-analysis since the testing procedures differed from study to another. Randomization of samples was done in the seventeen selected studies but neither of them mentioned a concealment mechanism nor mentioned blind participants for sample selection and grouping.

4. Discussion

4.1 Wear

Usually wear and gradual elimination of a material is the result of contact between contacting surfaces. Wear is a complex process that depends on the abrasiveness of food, the antagonistic material and its nature, thickness and hardness of enamel, mastication performance, parafunctional habits and neuromuscular actions. Abrasive wear defines how hard surfaces affect softer ones^{1,4}.

In dentistry, in vivo procedures are time-consuming and very difficult, so as regarding the dental testing of wear of different dental that can apply different forces and allow investigation of several wear mechanism principles. But, wear results from dissimilar wear simulators are not comparable because of the application of different wear testing concepts⁵.

Among the seventeen selected studies, twelve studies dealt with wear evaluation^(10,14,17,19,20), while the other five studies evaluated hardness⁽¹⁸⁾. Differences among the selected studies were found in number of specimens, wear-simulating devices, number of wear cycles and amount of force applied, direction of lateral movements, preparation of human enamel samples and hardness testing methods.

Regarding the wear loading force, an average rate of normal biting forces (5 kg or 49 N) was used with nearly all studies, one study applied 25N, and another applied10N. The loading cycles ranged from 4800 to 300,000 cycles, and wear rates increased with the higher number of cycles. Within the chosen studies water whether deionized or distilled, glycerin and artificial saliva were examples of fluids that were used as an intermediate medium to facilitate mechanical sliding under the lubricated conditions⁶. Different types of surface treatment of zirconia affected the wear behavior and hardness measurements.

4.2 Enamel Antagonist

Monolithic zirconia dental restoration shaves a major disadvantage which is its abrasiveness specially when it contacts natural enamel. Restorative materials used in the dental practice should have microstructural and bio-tribological properties close to that of natural teeth enamel; in order to be able to use them for fabrication of crowns and FDPs and to allow them to function intra orally and to oppose teeth enamel without excessively wearing it out. Wear of natural enamel by ceramic restorations is a progressive phenomenon associated with physical, chemical, surface and microstructural characteristics of these dental ceramics. Veneering ceramics are claimed to own enamel-like tribological potentials compared to monolithic zirconia but results did not state that, but numerous researchers denoted that dental ceramic substrates show higher wear rates of human enamel compared to dentalalloys¹².

Studies evaluating antagonist other than natural human enamel were excluded, in order to minimize the variation in wear data among the studies. Wear that occurs between enamel and zirconia should be investigated properly, and zirconia should show wear values close values of contacting natural enamel to be able to use it as an antagonist⁷. Among all the wear testing articles, the enamel antagonists showed stress marks and scratches. Polished zirconia showed the lowest wear rates of natural enamel antagonist in comparison to the other surface treated zirconia due to the extremely smooth surface that was obtained by polishing which maximized the polished zirconia biologic compatibilities and minimized its abrasiveness¹¹.

4.3 Finishing Technique

The surface of a full contour zirconia restoration can undergo several surface treatments; polishing, grinding, glazing, and heat. The result of these surface treatments on strength of zirconia-based materials should be properly investigated since the effect of strength is connected to the percentage of the transformation of zirconia into the further unstable monoclinic phase, the amount of surface change, and the temperatures used¹².

The included articles that dealt with zirconia with different surface treatment regarding grounding, polishing and glazing revealed that glazing reduced wear resistance of the opposing enamel, in comparison to polished zirconia. So, polishing of zirconia must be performed since it creates surface as smooth as or even smoother than glazed porcelain after the layer of glaze is removed during function or even by chair side occlusal adjustment and so reduces the wear of the opposing enamel²¹.

4.4 Hardness Testing of Zirconia

Full-contoured zirconia to be used without veneering porcelain is the most recent all ceramic restoration in the dental field and with lots of advantages; no possibility of veneering porcelain fracture, more strength, and high hardness in comparison to older all-ceramic restorations. Full-contoured zirconia has polymorphic construction, it is chemically and volumetrically stable, and it stops propagation of cracks by its volume extension that is due to its transformation toughening during transition phase. While regarding its disadvantage wear of contacting natural enamel comes in lead^(7,13).

Among the five studies that evaluated hardness three preformed Vickers Hardness testing, and the other two used the Nano indentor device. Hardness testing was done because it might be a possible explanation to similar contact wear of zirconia and because hardness and friction coefficient were found in several studies to be used to evaluate the rate of wear of dental ceramics⁹.

The use tough of yttria-stabilized tetragonal zirconia (Y-TZP) in dental field has increased. Y-TZP ceramics may comprise mixtures of tetragonal and cubic phases according to its composition, firing time and temperature. Yttria-stabilized tetragonal zirconia experiences a negative transformation known as "Low Temperature Degradation" (LTD), which is characterized by tetragonal-to-monoclinic (t–m) phase transformation that occurs with water in the initial stages at low temperatures (65–300°C), gradually the degradation procedure proceeds from the surface into the bulk of the ceramic

material, then micro and macro cracks due to volumetric expansion that occurs with the phase transformation³.

LTD is also characterized by reduction in transformation rate by decrease ingrain size and increase in concentration of stabilizer. LED degradation proceeds faster at higher temperatures (200 C and 300 C), itis also the cause of grain push-outx⁸. LTD as a result leads to surface roughening and it destructively affects the Y-TZP's mechanical properties(wear, hardness, strength; since it causes 20% decrease in the fracture strength) which will lead to performance deterioration.

High hardness was claimed to cause, so higher wear rates were anticipated from full contoured zirconia since it possesses high surface hardness. But among the five studies that investigated the zirconia hardness and the wear rate of opposing natural enamel no relation was seen, but wear rates were influenced by surface treatment of zirconia, its roughness and by the surrounding environmental factors.

5. Conclusions

In this systematic review, full contoured zirconia specimens revealed the lowest wear values when they were polished together with promising wear performance when they contacted natural enamel. Wear of enamel contacting full-contoured zirconia needs further investigations regarding the enamel sample preparation standardization. Zirconia has excellent Surface properties (Hardness) together with great resistance to subcritical crack propagation (because of the transformation toughening) in aqueous environment but this needs long term research. Full contoured zirconia has the highest hardness among dental ceramics and it doesn't undergo wear and causes least wear of the antagonist. It can be used safely in the oral cavity as an alternative to veneered restorations.

6. Recommendations

1. Funding and organizational searching for large amount of data that should be collected to conduct a systematic review would be of greater help rather than individual data searching and self-funding.

- 2. Recent studies and clinical trials that evaluate different wear testing procedures and mechanisms should be periodically systematically reviewed in order to insure collectable data. (21, 22, 23)
- 3. Other hardness testing studies should also be evaluated. (23)
- 4. Zirconia as an esthetic ceramic restoration should always be constantly investigated to be able to fully understand its behavior. (24)

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